



OECD Reviews of Innovation Policy

COLOMBIA



OECD Reviews of Innovation Policy: Colombia 2014

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Foreword

The OECD Review of Colombia's Innovation Policy is part of a series of OECD country reviews of innovation policy.* It was requested by the Colombian authorities, represented by the National Planning Department (DNP) and was carried out by the OECD Directorate for Science, Technology and Industry (DSTI) under the auspices of the Committee for Scientific and Technological Policy (CSTP). The review draws on the results of a series of interviews with major stakeholders of Colombia's innovation system and on a background report commissioned by the Colombian authorities. This background report was prepared by Lisbeth Fog, Monica Salazar, Carlos Nupia and Rafael Vesga. It contains a broad range of information that is drawn upon in this report.

This report was drafted by Erik Arnold (consultant to the OECD; Director, Technopolis Group, United Kingdom, and professor, University of Twente, the Netherlands), Martin Bell (consultant to the OECD; professor emeritus, SPRU, United Kingdom), Dimitrios Pontikakis (Country Studies and Outlook Division [CSO], DSTI, OECD), with contributions from Caroline Paunov (CSO, DSTI, OECD) and Verena Weber (at the time Information, Communications and Consumer Policy Division [ICCP], DSTI, OECD) under the supervision of and with contributions from Gernot Hutschenreiter (Head, Country Innovation Policy Reviews, CSO, DSTI, OECD). Fernando Galindo-Rueda, Vladimir Lopez-Bassols and Pedro Herrera Gimenez (all Economic Analysis and Statistics Division [EAS], DSTI, OECD) as well as Andrés Barreneche (CSO, DSTI, OECD) provided valuable contributions. Catherine Moreddu (TAD/PTA, OECD) and her team provided useful input on aspects of agricultural innovation. Diego Chavarro (SPRU, United Kingdom) and Lihan Wei (at the time CSO, DSTI, OECD) provided statistical support.

The purpose of this review is to obtain a comprehensive understanding of the key elements, relationships and dynamics that drive the Colombian innovation system and the opportunities to enhance it through government policy. More specifically, the review will:

- provide an independent and comparative assessment of the overall performance of Colombia's National Innovation System (NIS).
- recommend where improvements can be made within the system.
- formulate recommendations on how government policies can contribute to such improvements, drawing on the experience of other OECD countries and evidence on innovation processes, systems and policies.

The review is intended to be relevant to a wide range of stakeholders in Colombia, including government officials, entrepreneurs and researchers as well as the general public. It also aims to use the OECD as a communication platform to provide an accessible and comprehensive presentation of Colombian innovation to a global audience. The Overall

* www.oecd.org/sti/innovation/reviews

Assessment and Recommendations of the review were presented for a peer review to the Working Party for Innovation and Technology Policy (TIP) of the CSTP in June 2013 and launched in Colombia by OECD Secretary-General Angel Gurría in October 2013.

The review owes much to the support and co-operation of Colombian government officials, in particular Javier Antonio Villarreal Villaquiran followed by Rafael Puyana Martinez-Villalba (DNP and delegate to the CSTP), Sara Isabel Araujo Santos (Colciencias and delegate to the CSTP) as well as Johana Moreno Kuratomi (Second Secretary of Foreign Affairs, Embassy of Colombia to France) in their respective capacities, all of whom provided invaluable support at all stages of the review process. Libardo Andres Gutierrez Mengual, Ricardo Laverde and Ivan Clemente Montenegro Trujillo (all Colciencias) and Edwin Javier Ramirez (DNP) provided information, helped with the interviews during the fact-finding mission in Colombia, and supported the OECD review team throughout this process. The report has benefited from comments and additional information received from numerous stakeholders in Colombia, delegates of the CSTP and participants in the TIP peer review – in particular Fernando Merida-Martins (Ministry of Economic Affairs and Competitiveness, Spain) and Christopher Palmberg (TEKES, Finland) who acted as peer reviewers – and distinguished experts in the field.

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Executive summary

Colombia has a strong imperative to innovate

- Colombia has made much progress in its economic and social development, underpinned by prudent macroeconomic management and an improved business environment, and a progressive opening of the economy. It has achieved high economic growth over the past decade and shown resilience during the crisis.
- Further efforts are needed to make growth sustainable and ensure that future international competitiveness is based not only on commodities, but also on agriculture, manufacturing and tradable services.
- Innovation is essential to tackling the challenges Colombia faces. It can help develop new economic activities, boost productivity to sustain income and employment growth for the rising urban population, foster agricultural diversification to improve rural livelihoods, and raise the environmental sustainability of growth.
- Colombia's innovation system is still small, and lacks a strong business core. R&D expenditure is only 0.2% of GDP, compared to 1.2% in Brazil and 2.4% in the OECD area. Other measures of innovation such as patent registrations and scientific publications per capita place Colombia below neighbours such as Argentina, Brazil, and Chile. Much can be learned from other emerging economies that are important actors in global innovation.

There is a window of opportunity for effective action

- The internal conflicts, governance weaknesses and difficulties for shifting to a more formal economy that have hindered Colombia's development are being overcome. Although inequality persists, poverty has been reduced significantly.
- Framework conditions for innovation have improved significantly, though there remains scope for improvement. This entails continuing the regulatory reform process, increasing public-sector efficiency, further stimulating competition, including in the telecommunications sector, and strengthening the intellectual property system's contribution to innovation. Stronger competition provides a powerful incentive for businesses to innovate; firms will need to strengthen their innovation capabilities to succeed in a more competitive environment.
- Colombia has also become more open internationally, including through a number of free trade agreements. New opportunities arise from Colombia's integration in global value chains, knowledge and innovation networks.
- Colombia has stepped up its efforts in education and innovation in the past decade, as reflected in the prominence of science, technology and innovation (STI) in the National Development Plan 2010-14 and in policies such as the ICT strategy "*Vive Digital*".

- The new system for distributing royalties allocates 10% of non-renewable resource revenues to an STI fund. This implies a significant increase in the resources available for STI. If well managed, this can significantly strengthen the innovation system and address imbalances between public and private innovation and between the regions.

Put business at the heart of the innovation system

- Business is the principal source of dynamism in all high-performing innovation systems, and helps leverage the activities of universities and research institutes. Colombia needs to make a concerted effort to develop a business-centred innovation system – as successful emerging economies have done.
- Colombian firms engage only little in innovation. During the past decade, just a third of manufacturing firms introduced innovations. Only 30% of total R&D is performed by the business sector, compared with 65-75% in leading OECD countries and China.
- Tackling the low levels of innovation in industry and services is the key task for STI policy, and can have large impacts on productivity. Policy has thus far emphasised support for science and research-driven enterprises and university-industry linkages. This is important, but the potential for innovation is not limited to such firms.
- To strengthen innovation across the business sector, support for business innovation needs to be a priority and aimed at building the in-house innovation capabilities of firms, notably through investment in human resources.

Invest in human resources for innovation

- Human resources are the key to innovation. The access to and quality of secondary level education has improved and tertiary level education has expanded. Nevertheless, Colombia still lags the regional average in tertiary education, especially in doctoral degrees. Inequalities in the access to education mean that Colombia's talent pool is not being fully utilised.
- In addition to a focus on doctoral graduates and other high-level skills, more attention should be devoted to professional technical degrees, e.g. in areas such as design, logistics and management. This will require changes in funding priorities within tertiary education.
- Raising the level of business innovation will require further investment in human capital and in embedding skilled people within those knowledge-intensive business activities (e.g. engineering, design, management and IT) that require innovative solutions. Policy should encourage mobility between firms and public research organisations, facilitate student placements in industry and foster increased business investment in human resources.
- As highlighted in the OECD Skills Strategy, governments can influence the demand for high-level skills by encouraging economic diversification, facilitating inward investment, rewarding employer ambitions and occupational standards. Support for inter-firm networks centred on large firms (e.g. in the petrochemical sector) has also been useful in other emerging economies.

Strengthen the role of universities and public research institutes

- Strengthening the contribution of Colombian universities to the innovation system requires that they be supported in their transition from a primary focus on teaching to more research-based education institutions. This involves capacity building, including doctoral training for faculty, creating and funding “centres of excellence” to build critical mass in research and teaching, and encouragement for universities to develop their own strategies.
- Policy can nurture durable academic-industry links through information platforms, by giving priority to collaborative projects, and by funding longer-term “competence centres” that bring industry and academia together to work on areas of mutual importance. Regulatory and other impediments to collaboration with industry and to the creation of spin-offs should also be investigated and addressed.
- The public research institute sector needs to be modernised. Much of it has a narrow stakeholder focus and is not well suited to the task of facilitating diversification into new economic activities. Reform and consolidation can facilitate a reorientation towards technologies rather than branches of industry and enlarge the range of stakeholders and funding.

Adapt governance and the policy mix

- Increased STI funding from the new royalties system offers an opportunity to rebalance, expand and address regional disparities in the innovation system. However, it also raises new governance challenges which may jeopardise effective absorption. It will be important to strengthen the capabilities of sub-national authorities so that they can define and implement suitable projects, whilst ensuring coherence at national level. Moreover to maintain coherence in the system, royalty funding must not crowd out existing funding streams for R&D and innovation.
- Effective innovation policy will require better co-ordination across the various parts of government and between the central government and the regions. This can also help deal with “horizontal” challenges, such as environmental issues, that affect many ministries and parts of society.
- While the National Development Plan (NDP) highlights the demand for social innovation, the precise demands, e.g. from socially disadvantaged urban and excluded rural communities, can be better articulated. Policy initiatives should be clearly defined and their development gradual and contingent on evaluation.
- A strong knowledge base for policy making is crucial and requires internationally comparable STI indicators. To strengthen accountability and enable learning about policies, better monitoring and evaluation are necessary.

Chapter 1

Overall assessment and recommendations

This chapter presents an overall assessment of Colombia's innovation system and policy, reflecting key analytical findings of the review. It identifies strengths and weaknesses of the innovation system and key tasks of innovation policy, and develops specific policy recommendations for improving framework conditions for innovation, strengthening the intellectual property system, intensifying diversification, fostering business innovation, strengthening the role of the Internet and ICTs, strengthening human resources, fostering critical mass and excellence in public research, increasing and diversifying the sources of knowledge for enterprises, and improving the governance of innovation and the knowledge base in support of policy.

1.1. Achievements and challenges

Colombia's economic and social development has reached the point at which important decisions must be taken. Following the recession at the turn of the millennium, the country's economy expanded between 2003 and 2011 at rates that were, with a brief interruption in 2008-09, much higher than those of the previous two decades. Per capita income also rose much faster. By 2012 Colombia – the region's third most populous country after Brazil and Mexico – was the fourth largest economy in Latin America after Argentina. Growth in income per capita helped reduce the share of the population living in poverty by nearly 10 percentage points between 2002 and 2010. Yet income inequality, especially in rural areas, remained at the high end of the range for Latin America and high compared with most countries in other world regions. Although growth was strong, especially compared to many OECD countries, labour productivity and GDP per capita still lag other countries, including in Latin America.

The 2013 OECD Economic Assessment of Colombia identifies three areas for policy attention: adjusting to the commodity boom, boosting productivity growth and reducing income inequality. Innovation can play a part in all three areas, as the Colombian authorities are well aware. Prudent macroeconomic management and improvements in framework conditions have been accompanied by an increasing effort on education and innovation, all areas that are essential to the country's future development. However, the Colombian innovation system is still small, overly centred on state actors and performs well below the level required for its sustained development.

Reorienting long-term paths of economic development

Along with the expansion of output and average incomes over the past three decades, the sectoral composition of the Colombian economy has also changed substantially. The share of GDP due to non-manufacturing industry (mining, including petroleum; construction; utilities) increased rapidly, from less than a tenth to over a fifth of output, while the manufacturing sector either stagnated or contracted, falling from just over a fifth to about a sixth of output. This may reflect a significant long-term trend of relative “de-manufacturisation”, which mirrors to some degree the experience of other Latin American countries, as the scale and scope of manufacturing exports, especially from Asia, has increased.

The shift towards an economy heavily based on the production of commodities has been driven by rapid growth in mineral exports (especially oil) and rising commodity prices and has been supported by large capital inflows, primarily to the minerals industries. Sluggish growth in manufacturing after the slowdown of 2008-09 has prompted concerns about the sustainability of the current growth path and the international competitiveness of agriculture, manufacturing and tradable services. This is seen as a potential hindrance not only to rapid growth in employment and income, but also to the achievement of a more inclusive growth path, notably in view of the low intensity of direct employment in the minerals sector.

Colombia's innovation imperative

Colombia's economic history and the emerging signs of its future point to the importance of boosting innovation to raise productivity not only in manufacturing and agriculture but also in service industries, an area in which Colombia's progress has been weak. Both infrastructure, including advanced information and communication technology

(ICT) infrastructure, and transport services have a pervasive influence on the competitiveness of other economic sectors. Innovation offers possibilities for entering new activities as part of a cumulative process of economic diversification. New kinds of increasingly skill-, capital- and knowledge-intensive activities will add to the productivity growth achieved through the increasing efficiency of existing activities. Innovation-driven diversification into higher value-added production can sustain employment growth in a commodity-intensive economy with a tendency towards currency appreciation. It will sustain income and employment growth in a steadily rising urban population and expand the range of agricultural products produced in rural contexts. Agricultural diversification through innovation will be especially important as trade agreements with the United States and others come fully into play, opening new opportunities for some types of agricultural production while putting competitive pressures on others. It will help achieve the massive changes needed to improve rural livelihoods in the wake of the hoped-for cessation of rural conflict and insecurity. More broadly, means of strengthening the links between social needs and innovation processes will have to be found.

As the OECD Innovation Strategy has argued, innovation, from incremental improvements to radical novelty, can raise the environmental sustainability of growth, especially in view of Colombia's immensely rich biodiversity and the rising stresses of climate change.

Intensification of innovation does not simply mean expanding the scale of the innovation system. It also requires profound changes in its structure and scope. Broadly, innovative activity needs to become a pervasive part of production enterprises of all kinds in all parts of the economy. For this to happen, far-reaching changes will have to be made in the range of stakeholders addressed by STI policy, especially in the business sector, and in the modalities of support offered to them.

A window of opportunity

In the past, internal conflicts, weaknesses in governance and difficulties in shifting to a more formal economy have hindered Colombia's development. While many of these issues persist, some are being overcome. This has underpinned good macroeconomic performance driven by a boost in mineral exports and associated investment. Overall, framework conditions for innovation have improved, notably through the opening of the Colombian economy. The commodity-based export boom, while it has slowed recently, offers a window of opportunity to tackle some of the major issues facing the Colombian innovation system.

Significant alterations to the political framework and institutional system in recent years have indicated an increasing commitment to boost innovation:

- The potential significance of innovation for Colombia's socioeconomic transition has been acknowledged and given prominence in the National Development Plan (NDP) 2010-14.
- A noteworthy increase in resources for science, technology and innovation (STI) was built into the restructured regime for distributing the royalties from mineral exploitation (the General Royalties System, set up in 2011).
- This new funding regime was designed to ensure that participation in and the benefits of STI activities would be more widely distributed across all regions of the country.

- In order to advance these plans, new governance structures were developed and new methods and mechanisms were established to manage resource allocation and programme implementation in these areas, not only at the national but also at the regional level, such as the “Ruta N” initiative in the city of Medellin.

The substantial minerals royalties that accrue to the state provide an opportunity to accelerate and re-balance the development of the innovation system. Well managed, this could allow Colombia to increase its capabilities, integrate further the world economy, become more competitive, strengthen social and economic development, and move rapidly towards OECD levels of productive capacity and income. This will depend crucially on expanding human capital and other innovation capacities, particularly those available to and developed within firms, as well as on improving the management and governance of research and innovation.

1.2. A brief diagnosis of the Colombian innovation system

Basic characteristics

At the end of the last decade, the Colombian innovation system was relatively small. Overall expenditure on STA (science and technology activities) (including but not only R&D) has grown slowly and, as a share of GDP, lags well behind that of a number of other Latin American countries with comparable GDP per capita. Expenditure on R&D as a share of GDP was about one-quarter of the regional average in 2010. Similarly, while the numbers of STI workers have risen significantly, they constitute a smaller share of the workforce than in the rest of the region.

The traditional measures of STI output are also modest. The volume of scientific publications has been growing in recent years, but Colombia is about two-thirds as productive as Latin America overall and well under the OECD average. Like the scientific output of most Latin American countries, Colombia’s is far less frequently cited than that of OECD countries and lags most comparable Latin American and Caribbean (LAC) countries. While the national system naturally has some strong points, Colombia faces a strong challenge in terms of scientific production, productivity and quality. The picture is much the same for patents and trademarks. Colombia ranks behind a number of LAC countries in terms of patents granted per capita as well as trademark applications at the US Patent and Trademark Office.

Business innovation

Innovation surveys suggest that innovation in manufacturing increased little during the past decade. Only about a third of manufacturing firms have introduced innovations in recent years. Yet business innovation is crucial for building endogenous capability, enabling networking with other firms and wider sources of knowledge and innovation, and establishing the absorptive capacity to support these interactions.

Since the primary source of growth and jobs is the innovation activities of firms, these need to account for the dominant share of national innovative activity. However, while business R&D in Colombia represented 30% of the total a decade ago, it dropped to 20% around 2005, and has only now returned to about 30%. This is well below the share not only of leading OECD economies but also of major emerging economies in Asia and Latin America. By comparison, it represents 65-75% of total R&D in Finland, Japan and the United States and stands at around 55% in Spain. The share in Latin America as a whole is around 40%.

Innovation institutions: Universities and (public) research institutes

“Innovation institutions” in Colombia comprise a growing and evolving university sector and three sets of non-university research institutes, whose number, scale and functions have changed relatively little.

Colombia has a total of 81 universities (32 public and 49 private). Three-quarters of the student population attends public universities. Only a small share of teachers in tertiary education have a PhD and they are concentrated in the elite universities. Rising external funding from the middle of the last decade and the government’s new impetus for research and innovation appear not only to have driven a rise in the national production of PhDs but also to have encouraged universities to “professionalise” research management with vice-rectors for research. Modern legislation on intellectual property (IP) in the spirit of the Bayh-Dole Act in the United States has further encouraged the creation of technology transfer offices (TTOs) and other specialised functions, but employment conditions and regulations hamper the creation of spin-offs.

Universities’ research funding comes from several sources. A small proportion of core funding is now allocated on the basis of the number and quality of the universities’ scientific output. Project-based income comes from Colciencias-managed grants and other external contracts. Income from industrial contract research is minimal. The intensity of links between universities and industry is similar to that of a number of other Latin American countries, but is nonetheless regarded by industry and many in the universities as inadequate.

As in other countries there are three types of autonomous research institutes:

- Basic research institutes such as FIDIC (immunology). Colombia has few of these. An example of this type of institution often referred to is Germany’s Max Planck institutes.
- Some 19 government laboratories that primarily produce knowledge for making laws, regulations or other government purposes. The outputs are often public goods. The oceanographic and hydrographic institute CIOH, for example, provides information both to the navy and to industry. Their funding is “lumpy” and the system is fragmented, with regulatory obstacles hindering current attempts to link them more closely to universities and industry.
- Research and technology organisations (RTOs), whose main purpose is to produce knowledge and services for industry. The agricultural CENIS institutes are funded by production levies and focus on single crops or clusters of crops. Tending to the immediate needs of a narrow set of stakeholders makes it hard to address longer-term or cross-cutting R&D needs. Industrial RTOs such as ICIPC, in the rubber and plastics area, are similarly branch-focused. Industrial RTOs tend to be fragmented and have similar problems of governance.

At the international level, instead, the work of government labs and RTOs is converging. They address technologies rather than branches, are serving a wide range of customer needs, and are diversifying their sources of funding as insurance against lock-in.

The economic and social relevance of public research is conditioned by other aspects of the system. In a weak business innovation system, there is limited demand for innovation from producers: non-innovative companies do not ask their suppliers to innovate. There is some interaction between business and the institutes, but there is relatively little co-operation between business enterprises and research-performing

institutions. While the NDP emphasises the demand for social innovation, there are so far few ways in which potential demand (for example from socially disadvantaged urban and excluded rural communities) can be articulated or made effective.

Development of human resources

There has been considerable progress in developing human capital over the last decade:

- At the secondary level, enrolment rates increased rapidly between 2002 and 2009. Scores on the OECD's PISA exercise improved significantly between 2006 and 2009, not only in reading but also in maths and science. However, many high school graduates are still not "college-ready" in terms of their attainments in science and maths.
- At the tertiary level, student enrolments expanded from about 1 million in 2000 to nearly 1.7 million in 2010, and the proportion of the university age cohort (17-21) enrolled as undergraduates increased from 24% to 37%.
- A larger share of these students enrolled in science and engineering than in other LAC countries. However, despite the rising levels of participation in tertiary education, Colombia lagged six other LAC countries in terms of overall tertiary-level participation in the late 2000s.
- The disparity was even greater at the PhD level where, per 100 000 inhabitants, the number of doctoral graduates, in general and in science and engineering, lagged ten other LAC countries.
- SENA, the long-established and nationally prominent vocational education and training agency, which is funded by a payroll levy, plays a major role in training the workforce below tertiary level. It provides some tertiary-level education (to about 3.8% of those aged 15-24) but its main task is to develop vocational skills. In 2011 it provided training to 7.9 million through its 116 training centres.

The importance of gender, income and regional inequalities in access to tertiary education has declined but remains an issue. Other inefficiencies also hamper the transition from school to university. As there is no national clearinghouse for university applications, the process is complex and the outcome uncertain for students; universities are unsure of the size of their intake because good students receive several offers. It is hard to switch from technical or vocational training to university. Tertiary education suffers from an overall dropout rate of 45%, which rises inversely with parental income. In 2011 it was still not possible to provide all talented university applicants with a grant. Education at university level therefore continues to depend heavily on parental income.

The balance between technical education and higher education is problematic in much of Latin America, often with 70% of a cohort in higher education and 30% in technical education. This "inverted pyramid" exists in Colombia. The ratio in OECD countries (especially in parts of Europe) is typically the opposite. Given Colombian companies' relative lack of middle-level technical occupations, this appears to explain to some degree repeated industry comments about a skills shortage and lack of experience in middle-level functions.

At current levels, flows of human resources from tertiary education do not seem sufficient to allow the country's innovation system to narrow the gap with international competitors rapidly. In fact, in spite of their growth during the last decade, human

resources may constrain the innovation system's capacity effectively to absorb the expansion in STI funding expected to follow from fundamental recent changes in the political and institutional context of the country's innovation system and the strong commitment of the Colombian government.

Colciencias is making sizeable resources available to produce more PhDs, primarily for the higher education sector but also to increase the numbers of PhDs in industry, where they are extremely rare. While SENA is a powerful instrument for vocational education and training and trains at the middle level on a company-by-company basis, the gap in these skills remains, especially in areas such as design, project management and logistics, as well as management. Incentives for companies to train are weak: given the shortages, a company that devotes resources to increasing their stock of these skills risks seeing the beneficiaries seek better opportunities elsewhere. Increased provision of tertiary education and incentives to companies to train more people than they currently need are ways to tackle this issue. The presence of multinational enterprises (MNEs) whose activities go beyond sales and basic manufacturing could help address the shortages. A greater focus by RTOs on training and on encouraging younger staff to move to industry after a time (as the German Fraunhofer Society and other international RTOs do) would also help.

Broadband infrastructure

Broadband infrastructure provides a platform for innovation and for social and economic development. Colombia, like many OECD countries, stresses the positive link between broadband access and use and economic development in its strategy to develop the Colombian digital ecosystem.

Its telecommunications sector has grown rapidly over the past few years, albeit from low levels. While mobile penetration is relatively high and close to the OECD average, the penetration of fixed lines is low, with marked regional disparities; in some major cities Colombia is at the OECD level. Mobile networks fill in where fixed-line networks are not available, but their lack can delay the development of services that require high-speed fixed networks. In terms of overall broadband penetration (mobile and fixed), growth picked up from 2006 but the penetration level is only 8% compared to an OECD average of 26%. In addition, the speed of 92% of broadband connections is below 2 Mb/sec. In terms of broadband pricing, an analysis conducted for an OECD review of telecommunication policy (OECD, 2014a) in Colombia shows that entry-level, low-speed broadband in the fixed broadband market is cheaper than the OECD average but that prices for high-speed broadband are much higher owing to a lack of competition. For wireless broadband, prices are above the OECD average; they are among the highest for data capacities below 2 GB and at about the OECD average for capacities above that threshold.

Acknowledging the need to increase broadband connections, the government aims to expand connections across all regions and to quadruple the number of connections from 2.2 million in 2010 to 8.8 million in 2014. With 7.2 million connections in mid-2013, its target will likely be attained. In addition, a fibre backbone is currently being deployed in a public-private partnership to connect 1 078 municipalities and 96% of the territory by 2014. Through this initiative, the number of connected municipalities grew from about 200 in 2010 to 777 by mid-2013.

Intellectual property

In Colombia, firms and research institutions rely less on patents, trademarks, design rights and utility models to protect their inventions than in most OECD countries and some of the more advanced regional neighbours. Only a few actors, in some universities or large advanced firms, are in a position to file for international patents. The lack of skills, the weak research infrastructure and multiple barriers that hinder firms' operations contribute to Colombia's weak performance in terms of intellectual property.

Because researchers, like public-sector officials, cannot have sources of income other than their salary, they cannot engage in spin-offs. This has hindered several public universities from developing commercial applications based on their IP. Private universities also need to address the question of spin-offs, as the law on non-profit organisations stipulates that they cannot create for-profit activities. Those responsible for IP at universities are aware that payoffs require commercialisation and are interested in finding ways to support it.

STI governance

A national innovation system encompasses a wide range of actors: business, research-performing organisations, government and a variety of other institutions. In Colombia, the strongly regionalised nature of the country also plays a role. At national level, the National Planning Department (DNP) provides overall co-ordination of government policy for economic and social development.

Colciencias is a key player in STI. According to its strategic plan for 2011-14, it has three main activities: co-ordinating, developing and implementing policy for the "national system of science, technology and innovation"; developing innovation and research capacities and programmes in order to support economic and social development in the higher education and research sector and in business; and developing human capital for research and innovation. Colciencias operates a wide range of funding instruments for innovation and research. It runs 11 research councils, two-thirds of which are composed of researchers. It has strong networks with the academic community, but much less so with business. It encompasses the roles of science ministry, research council and innovation agency (so that policy making and execution are not functionally separate) and co-ordinates innovation and research policy across government. As a result, its performance is very important to the success of the research and innovation system.

Colciencias provides the secretariats of the national Advisory Council on Science, Technology and Innovation and the National Programmes Council, which oversees a series of innovation-oriented programmes. The effort to improve competitiveness is co-ordinated by the National Commission on Competitiveness and Innovation through the so-called "national system of competitiveness and innovation". The president of Colombia chairs the annual meeting of the Commission's public- and private-sector stakeholders, which include the sector ministries and the private sector's competitiveness council. The executive and the secretariat of the Commission meet frequently. Counterpart commissions in each region plan the development of the regional innovation systems and provide input to national planning. In effect, there are two parallel governance systems dealing with innovation, one from the perspective of research and the other from that of competitiveness. While the sector ministries are involved in the National Commission of Competitiveness and Innovation, they also maintain separate, individual strategies.

The laboratories of the sector ministries provide mission-related research and technical services. The Ministry of Trade, Industry and Tourism (MCIT) has significant innovation-related activities, including the Productive Transformation Programme, which co-ordinates development activities around human capital development, regulations, infrastructures, sustainability, strengthening industry and innovation in 16 “strategic” industries. It also funds the Innpulsa Programme, operated by Bancoldex, the state development bank, which promotes faster growth of business through a focus on innovation, entrepreneurship and regional ecosystems. SENA is linked to the Ministry of Labour. In addition to its role in vocational education and training, it has 15 technology parks, two dedicated technology development facilities, a small industrial extension service and funds training-related R&D projects. The Ministry of Information Technology and Communications (MinTIC) runs an extensive innovation programme with Colciencias to increase R&D in the information technology (IT) sector, foster innovation in the overall e-governance and ICT use by the public sector and promote innovation in ICT as a lever for economic development.

For their part, the regions produce and implement their own regional innovation and development policies. The complex process of funding projects based on royalties from the minerals sector has revealed the difficulties of thematic co-ordination across regions and between the regions and the state.

The conceptual framing of STI policy

In Colombian governance, the idea of “systems” of innovation is closely tied to institutions, whether formal state organisations or systems of committees. In the NDP, innovation is treated as a strand of development separate from the main economic sectors and branches. This conceptual compartmentalisation is associated with another view that also draws a boundary around STI activities and actors – primarily public and governmental actors – and separates them from other activities and actors in the economy and society more widely. It is the idea that the “system”, defined in this rather narrow way, constitutes the supply side of the innovation process (the presumed “knowledge producers”), with the demand side located in business enterprises in the other sectors of the economy.

Colciencias’ historical origin as a science funder may partly account for the predominance of this “science push” model and the proliferation of interface and commercialisation support instruments in public organisations. These nonetheless fall short of direct support for innovation capacity building in the business sector. This view is reinforced by the understandable reluctance of officials in a country that has historically been plagued by corruption to subsidise businesses. The relatively weak role of industry and the corresponding weight of public research organisations in the innovation system also characterises many other countries at Colombia’s stage of development. Nonetheless, business is the driving force in innovation systems and business innovation involves much more than R&D, as the OECD’s Innovation Strategy emphasises.

Key aspects of the design of innovation policy in the context of an emerging economy include:

- The intensity of design, engineering and related activities in innovation processes, not only R&D intensity, and the importance for business enterprises of accumulating human resources and other capabilities in these and related areas such as architecture and planning, many of them in services rather than

manufacturing. This involves both an increase in the supply of highly skilled human resources and a stimulus for demand for them in the business sector.

- Creating those capabilities not only in education and training institutes but also through expenditure on training and the organised acquisition of experience in business enterprises.

1.3. Scope for improving and further developing innovation policy

The resources made available by the government's decision to allocate 10% of its mineral royalties to STI present a major opportunity to improve and develop policy. They make it possible to scale up the government effort to encourage innovation in industry and services. Today, innovation is limited to a small sub-set of companies. Scaling up involves broadening and deepening this effort to encompass more actors and more parts of society.

While Colombia has recognised the need for co-ordination in the national innovation system, it remains difficult to tackle “horizontal” challenges (such as environmental issues) that affect many ministries and parts of society and to use the collective power of the various parts of the research and university system to solve them. Finding ways to co-ordinate the development of more holistic and more inclusive STI policy is an important policy challenge for Colombia as for many other countries.

Dealing with the low levels of innovation and productivity in industry and services – sectors directly linked to increased wealth creation – is perhaps the most important area for innovation policy development. This will require a combination of policies that encourage and enable producers to build internal absorptive and innovative capacities and put them under competitive pressure to perform. To achieve significant economic impact, the policies will need to be inclusive and pervasive, so as to cater to companies of all sizes and sectors, including the informal sector, not least by increasing support for social innovation. Important as it is, policy to strengthen the relevance, quality and productivity of the universities and research institutes is principally a way to support development in producers through the provision of human capital and knowledge.

Colombian innovation policy has a solid foundation in sectoral research institutes in agriculture and certain parts of industry, and some government laboratories appear to have untapped innovation potential. The agricultural institutes have played an important role in the past growth and exports of agricultural commodities; the performance of the industrial institutes has been more mixed. The institute sector is in need of modernisation, diversification and consolidation, with an increasing orientation towards technologies rather than branches of industry.

Colombia has made a strong effort to expand and improve education and to address inequalities in primary and secondary education, for instance through the computers for education programme. There has also been a major push to upgrade vocational and worker skills. As a next step, it will be necessary to reduce the imbalance in output between technical/technological tertiary institutions and universities in order to address the shortage of middle-level skills. Unequal access to education, including higher education, should be viewed not only as inequitable but also as an inefficient use of human resources and a brake on development. For both reasons, reducing this inequality deserves policy attention.

Recently introduced government programmes and instruments tend to focus on producing PhDs, commercialising knowledge outputs from the (comparatively weak) research base and fostering start-up entrepreneurship. They are largely based on models that are appropriate at top universities such as MIT but less applicable elsewhere,

including many environments in OECD countries. As a result, the thrust of innovation policy bypasses much established industry. Further development will require upgrading the middle- and top-level innovation skills of established industry and diversification into new activities that these enhanced skills make accessible, without of course ignoring the leading edge.

Given the complexity of innovation systems, improving Colombia's innovation policy requires an appropriate balance among the different means of fostering innovation that are appropriate to the Colombian context. The aim of innovation policy is to facilitate the functioning of the national research and innovation system as a whole, which involves a complex interplay of demand and supply among many actors. The business sector, the education and training system, the funding system, governance and a range of institutions, from banks to the patent office, must operate well and be efficiently linked if the research and innovation system is to perform. With development, the various elements of the system need to grow in concert, maintaining a (sometimes shifting) balance among the parts to avoid shortages or excess capacity. The remit of policy is therefore wide – monitoring the performance of the system and intervening to iron out poor performance or imbalances. Focusing on individual parts of the system – e.g. the supply of PhDs or of venture capital – is unlikely to fulfil the need for all parts of the system to perform adequately. Rather, policy should be based on a continuous analysis of which parts of the innovation system are under-performing, and policy interventions should be calculated to ensure that the various needs of the system are addressed in a balanced way. The models underlying innovation policy must be systemic.

1.4. Strategic tasks

The overall objective of innovation policy in Colombia is to drive economic and social development in order to increase incomes and wellbeing and enhance economic and social sustainability. While Colombia has in important respects developed rapidly in recent years, better innovation performance is needed to achieve sustainable growth and higher living standards, improve productivity and international competitiveness, and tackle social challenges. Colombia's convergence to OECD levels requires building on established resource and industry strengths and on extending upstream and downstream and into areas in which Colombian potential can be exploited.

Achieving these goals involves actions in three broad domains. One concerns changes in the overall structure of the innovation system and in its currently limited scale; a second concerns issues of governance of the system; and a third concerns the activities of the main institutional and organisational actors. Important tasks should be carried out in all three domains.

Overall scale and structure of the system

- The total public budget for STI activities (both “normal” and royalties-derived) should be increased to rates comparable to those in other emerging economies that have sought to reach OECD levels. The royalties to be allocated to STI will be insufficient to reach the desired scale.
- Absorptive capacity should be strengthened. The system's limited capacity to absorb even the increased funding from the minerals royalties effectively calls for shifting the allocation of resources towards strengthening the human capital and skills needed to absorb the rapidly rising funding for STI activities.

- At the same time the system needs to be fundamentally rebalanced so that innovation activities become much more deeply embedded in enterprises in all sectors, rather than concentrated in a relatively small number of organisations. The limited resources available could be used to leverage business-sector innovation and induce lasting changes in innovative behaviour and the productive structure of the Colombian economy.

Governance of the system

- Achieving the overall objectives will require maintaining and, as far as possible, institutionalising the political commitment to STI and education as motors of development.
- Both governance structures and planning and policy processes need to be strengthened to reduce the inconsistencies created by the tension between the short-term political cycle and the long-term nature of innovation system change and to reward continuity in policy between successive governments. A high rate of turnover of personnel can also be disruptive.
- The co-ordination and governance power of the state should be used to increase cohesion (by reducing inter-regional disparities) and co-ordination across the “systems” of STI and innovation and the wider set of ministries with an interest in STI matters, so as to minimise fragmentation of the development effort.
- In the medium term, more mainstream sources of STI funding will be needed. The availability of mineral royalties to fund a major increase in the innovation effort is a big opportunity. However, development requires much greater investment in STI by both producers and the government. Eventually, the state’s part of that investment should be a permanent part of its normal budget, so that it is not vulnerable to declining budgets if and when the flow of royalties declines or there is a political decision to reallocate the royalty windfall to other priorities.

Role of the main institutional and organisational actors in the system

- Embedding innovative activities more deeply in society requires stronger competition, a more diverse range of support mechanisms, and raising the share of business expenditure for R&D (BERD) in total R&D to at least 50% within a decade.
- Ensuring the business sector’s absorptive capacity and capabilities to meet this target requires strengthening and broadening the range of mechanisms for developing higher levels of skills and qualifications in the workforce (both mid- and high-level skills), improved business-to-business networking, and access to external sources of knowledge and intelligence.
- While responding to the market-mediated demand for innovation identified in the National Development Plan, the innovation system also needs to develop more effective means of responding to social demand for innovation that is part of the expected development path of the main growth engines, such as environmental protection, good quality low-income housing and associated infrastructures, and increased agricultural productivity.

- As well as shifting the balance between the different innovation actors, substantial measures are needed to enhance infrastructures and institutions (training agencies, institutes, universities) at national and regional levels to achieve the levels of excellence required to meet world standards for research and education and for support for business innovation, both directly and through the provision of human capital.

1.5. Guiding principles

The main purpose of innovation policy is to improve welfare and promote development by raising economic performance. It aims to increase the ability of the various parts of the national innovation system to perform their respective roles. Raising the rate of innovation requires incentives that mitigate market failures where they occur, such as reducing the risks for companies involved in longer-term research. The networked nature of innovation and the resulting interdependence of those concerned call for interventions that promote effective networking. Building a faster car requires not only developing a more powerful engine but also a stronger chassis, an improved transmission system, bigger and more robust tyres and stronger brakes. Similarly, increased innovation requires a systemic policy approach that seeks to ensure the balanced development of the different parts of the innovation system.

- *Take account of the systemic nature of innovation.* Successful innovation and development policy recognises the systemic nature of innovation. The role of policy makers is to monitor the various parts of the innovation system, provide favourable framework conditions for innovation, and intervene where necessary to provide incentives that mitigate market and systemic failures.
- *Put producers at the centre of the innovation system.* In technologically dynamic economies, but not yet in Colombia, it is productive enterprises – private and public in all sectors, including services – that are the core of the innovation system. The innovation undertaken by these enterprises – often in interaction with innovation in other enterprises and occasionally drawing on knowledge inputs from universities and public institutes – translates into higher productivity, new products and new sectors, new jobs, higher incomes and improved welfare. Consequently, the innovation capacities of these enterprises form the central driver of dynamic innovation systems. Policy priorities should focus much more intensively on improving the innovation capacities and activities of enterprises and therefore their economic performance. Other policy measures need to be tuned to developing other components of an integrated innovation system that responds to the needs of innovation in enterprises. This needs to be done more directly than previously.
- *Adopt a broad approach to innovation* by addressing not only technological innovation but also non-technological or “soft” innovation, including organisational, marketing, business models, etc. Avoid a narrow policy focus on “high technology”. Stress innovation in both knowledge-based and other types of services and address the shifting boundary between manufacturing and services in new types of business models. Correspondingly, the scope of innovation policy should be more pervasive and cover institutional and economic sectors more broadly.

- *Strengthen the inclusiveness of the innovation system.* This is desirable not only in itself but also because it supports effective and efficient innovation. Overcoming the effects of income inequality on access to education, for example, would imply a more efficient allocation of Colombia's pool of talent. Social inclusiveness has the same effect and also facilitates translating societal needs into signals about innovation needs and eventual demand.
- *Balance the policy mix for innovation.* Innovation policy measures and objectives need to be balanced. The complementary roles of basic and innovation-oriented research, for example, mean that the one cannot effectively be pursued in the absence of the other. However, in an emerging economy such as Colombia, the balance typically, and for good reason, leans more towards applied research than in most OECD economies. During the "catch-up" phase, countries rely more on spillovers from the global scientific system, but as they approach the "technology frontier" the need for new fundamental knowledge increases. Thus, a balance appropriate to Colombia's development needs to be found between selective and "bottom-up" innovation policies, between new-to-the country and new-to-the-world innovation and between support to business and to universities and technological and research institutes.
- *Avoid over-centralisation.* The endogenous nature of innovation means that innovation and innovation policy cannot be highly centralised. Despite the problems of co-ordination involved in "mainstreaming" research and innovation across the whole of government, the governance of innovation and research should involve all ministries and their agencies. While there is every reason to assign co-ordination tasks to particular parts of the system, a narrow "science ministry" approach that does not sufficiently include and empower others reduces the effectiveness of the innovation system as a whole and the relevance of innovation policy to societal needs.
- *Create objective, independent and transparent resource allocation processes.* Research and innovation policy frequently involves the competitive allocation of resources. The process should be objective, independent and transparent, for reasons of equity but especially because clarity and the use of decision criteria that promote projects of high quality and relevance are more efficient and effective.
- *Build trust in funding organisations and other government institutions.* Trust is created through a combination of openness and probity, with transparency in funding backed by regular audits and public punishment for cheating. It is hard to find examples of successful achievement of trust through bureaucratic rules of procedure and administrative processes.
- *Strengthen "strategic intelligence".* A sound basis for policy makers' "bottleneck analysis" of the performance of the innovation system as a whole requires strategic intelligence in the form of statistics, qualitative analysis and feedback from evaluations on the effectiveness of policy interventions. It is important to make good data collection, independent analysis and a comprehensive and formative evaluation tradition part of national practices for the collection of strategic intelligence.

1.6. Recommendations

In the light of these principles and the underlying analysis, it is possible to make some specific recommendations for Colombia. Their implementation will require further local analysis and the use of processes that involve relevant stakeholders and other actors in their detailed design.

Improve framework conditions for innovation and entrepreneurship

Colombia has experienced high levels of conflict and insecurity. The costs have included huge loss of life and the displacement of large numbers of people. The impact on the country's economic and social development is hard to calculate, but, in addition to the human cost, it has involved: i) a drain on government expenditure due to spending on security; ii) the effect of the widespread displacement of communities on national levels of poverty; iii) disruption of schooling and health-care services; and iv) constraints on investment in agriculture, mining and tourism. Over the past decade, security has improved considerably and there is hope that this trend will continue. Improved security is likely to increase demand for STI activities in agriculture and rural development, and, more broadly, to improve the environment for innovation across the board.

Over time, Colombia has made big strides in opening its economy, including through a number of important free trade agreements. The role of trade and foreign direct investment (FDI) has increased over the last decade. Some industries, especially in the mining sector, have attracted substantial amounts of FDI.

Over the past years Colombia has continuously improved the regulatory environment for business, an important determinant of innovation activity. This has resulted in improvements in various World Bank Doing Business indicators such as paying taxes, protecting investors and resolving insolvency. Overall, Colombia ranks 43rd out of 189 countries. According to the World Bank, Colombia has become “a regional leader in narrowing the gap with the world's most efficient regulatory practices”. However, important weaknesses remain, including in enforcing contracts. In common with other countries, there is little capital available for risky investments. A lack of trust, for example in the effectiveness of legal institutions, is an important issue. Overall, while the legal and regulatory environment has improved in a number of ways in recent years (such as time limits for settling legal disputes, simplification of judicial processes and increased use of ICT in the judicial system), important constraints remain, such as a more burdensome bureaucracy than in the average OECD country. According to the World Bank's Doing Business indicators, the relative position of Colombia with regard to starting a business has improved considerably over the past decade, with sustained reductions in the number of procedures, the time it takes to start a business and in the relative cost of doing so. Moreover, there has been a notable policy focus on innovative entrepreneurship including the activities supported by MinTIC, Colciencias, SENA and Innpulsa. However, as noted in the recent *OECD Economic Survey*, the tax system and regulatory framework for entrepreneurship could be further improved. Moreover, analysis of the OECD Product Market Regulation (PMR) indicator shows that administrative burdens for sole proprietor firms and for some start-ups are relatively high in comparison to OECD economies.

Competitive pressure is one of the most powerful incentives to innovate. In some sectors, however, excessive concentration is an obstacle. Overall, limited competitive pressures on Colombian firms may have significantly restrained innovation. The 2009 Competition Law is part of an effort to reform institutions and processes affecting competitiveness and provides a new framework. While it is too early to assess its impact, there have already been calls to strengthen it.

The government is currently working to increase public-sector efficiency and transparency and has acknowledged the important role of ICTs in this area. As part of an extensive e-government programme, many services for citizens and businesses are provided online and mechanisms have been developed to foster participation of citizens in government activities. The platform “urna de cristal” (crystal urn) was developed to increase the transparency of government activities and to serve as a communication channel between citizens and the government. In addition, a programme to improve the use of ICTs and good governance through ICTs in the public sector has been set up and an agreement for an e-government innovation centre has been signed between the Ministry and the United Nations Department of Economic and Social Affairs (UNDESA).

Colombia’s new fibre network will provide backbone connectivity throughout the country and is an important step in building a digital economy. The rollout to remote municipalities can help close the digital gap between rural and urban areas. While the backbone serves as a high-capacity transport mechanism between municipalities, the next step will be to extend the reach of high-speed access to all businesses and households.

- *Establish and maintain a favourable macroeconomic environment*, while fostering investment in science, technology and innovation.
- *Continue the regulatory reform process*, which has borne some fruit and is now focused on strengthening institutions.
- *Improve the attractiveness of Colombia for investment in innovative activities*. Areas for attention include the administrative burden faced by companies, obstacles to access of finance by small and medium-sized enterprises (SMEs), and problems for funding riskier investments, including from public sources.
- Increase public-sector efficiency through further use of ICTs across all ministries and on national and regional levels and promote innovation in this area. The co-ordination function of MinTIC and its ability to promote relevant innovation should be strengthened and enlarged. The appointment of a second vice minister to co-ordinate the use of ICTs across the Colombian public sector and oversee all e-government initiatives, is a promising step.
- *Continue to increase the number of e-government services and monitor service quality*. The government has increased e-government services rapidly over the past years. These efforts should continue; the possibility to pay taxes online should be included. Besides monitoring the quantity of services offered, the quality of e-services should be evaluated, and improvements should be made as needed.
- *Stimulate competition in the telecommunications sector, in both the fixed and mobile markets*. This will be crucial for further access to and use of broadband services. The 2013 spectrum auction increased the number of mobile operators and 2014 will provide a further opportunity to increase competition in this market. Besides the regulator’s current focus on spurring competition in the mobile

market, it will be essential to work on fixed market regulation and to ensure that the deployment of the fibre backbone by one company will not entail vertical restrictions on competitors.

- *Continue to promote the uptake of broadband by businesses and households* and to connect businesses and households, including in remote areas and beyond municipalities. Continue to deploy Internet access points such as Vive Digital kiosks and Puntos Vive Digital.
- *Ensure affordable Internet access*, especially for lower-income groups. Measures to provide inclusive competitive broadband access, including via fixed and wireless services, should be maintained. In addition, barriers to access handheld devices, especially smartphones, should be lowered to increase access to communication services.
- Allocate sufficient spectrum to mobile communications to meet growing demand for mobile applications.

Strengthen the intellectual property system’s contribution to innovation

Effective intellectual property rights (IPR) can foster invention in the areas of technology (patents), business (trademarks), the arts and software (copyright), and even traditional sectors (geographical indications). National IP systems can encourage domestic firms to invent, domestic universities to transfer knowledge and foreign firms to implement or license out new technology. IP regimes also determine the ability to access existing knowledge on efficient terms. Universities and public research organisations use IP instruments to increase the economic impact of their research, not only as a potential source of income but, more importantly, as a credential for further and deeper collaboration with industry.

The Superintendence of Industry and Commerce (SIC) currently grants industrial property protection and also deals with competition. The Colombian Agricultural Institute (*Instituto Colombiano Agropecuario*) is in charge of protecting plant varieties and the *Oficina de Derechos de Autor* handles copyright. Recent initiatives to improve the operations of Colombia’s IP system promise to raise its quality (e.g. adoption of measures to reduce backlogs, granting IP offices jurisdictional powers to improve enforcement). An analysis of Colombia’s IP system (OECD, 2014b) concludes that commitment to reform of the IP system should continue so that the quality of the IP system effectively encourages innovation. The overall impact of the IP system on innovation will depend on the co-ordination of IP policies and innovation policies.

- *Ensure that the Intersectoral Commission for Intellectual Property moves the “IP for innovation” agenda forward.* Success will also require an explicit focus on innovation, involvement of the private sector, high-level policy buy-in and the implementation of decisions by the relevant public entities.
- In addition to patents, support the use of instruments such as trademarks, copyright, design rights, utility models and the protection of traditional knowledge and geographical indications. Such instruments provide opportunities to include a broader group of innovators, notably SMEs and businesses in traditional sectors. Colombia should also continue to support the geographical indications with largest potential through associations with the capacity to turn geographic identifiers into commercially successful activities. The weak use of utility models should be addressed, possibly with measures targeted to relevant parts of the business sector, as they can contribute to innovation capacities.

- Facilitate broader use of the IP system through regional services for potential users outside of Bogotá and invest in awareness-raising campaigns. Advisory services can show how IP systems can facilitate innovation performance. Simplified IP application procedures and fee discounts are more effective if combined with innovation support policies.
- *Strengthen the commercialisation of existing IP.* This will require giving public researchers more flexibility to engage in spin-offs and encouraging public universities to co-operate with industry. It will also require continued support of institutions that offer technology screening services to identify research areas with potential for commercialisation and help in linking universities with private firms.
- *Simplify support schemes.* A variety of support schemes to encourage the use of IP will have greater impact if application procedures are simplified and shortened and if the information requirements accommodate actors' fear of sharing critical information about their inventions.

Intensify the diversification of production

The rising concentration of exports in mineral commodities over the last decade, combined with considerable currency appreciation, points to the need for faster diversification of production into higher value-added tradable manufactures and services. This is a long-standing policy issue in Colombia as in Latin America more generally. Historically, in Colombia and in the wider region, diversification has usually been framed in terms of manufactures; services have been often neglected.

Recent diversification policy in Colombia has focused less on targeting specific “strategic” industries (such as those classified as high-technology, broadly including activities in ICT, biotechnology, pharmaceuticals aerospace etc.) and more on identifying potential new industries and activities that are “close” to existing areas of comparative advantage and offer opportunities for developing new areas as a basis for exports. Considerable reliance has been placed on facilitation, with government agencies interacting with business to identify areas for diversification. Successive governments have implemented a number of schemes. The NDP 2010-14 emphasised this kind of initiative by focusing the first of five engines of growth and development on so-called innovation-based sectors. The Production Transformation Programme of the Ministry of Trade, Industry and Tourism currently plays a leading role in driving this effort.

Experience elsewhere suggests two possible kinds of limitations on this approach. The first is concentration on diversification in manufacturing (rather than all sectors, including services) and on a narrow range of modes of innovation. The second is the strong emphasis on *ex ante* selection of sectoral targets for diversification rather than on mechanisms for strengthening firms' diversification-generating innovation activities and capabilities and the wider system supporting them.

The focus on manufacturing may unnecessarily constrain diversification opportunities in services and resource-based industries. Australia, Canada, New Zealand and other OECD countries with significant resource bases have clearly benefited from them while largely containing potential negative effects on other parts of the economy. They have done so, to various degrees, by knowledge upgrading and investment in resource-based industries, by leveraging resource bases into related industries, and by investing in knowledge creation via knowledge infrastructures. A growing number of studies of developed and developing economies have indicated that, rather than inevitable, the

negative growth implications commonly thought to be associated with high levels of specialisation in commodity production are contingent on other factors, such as low levels of investment in human capital and the absence of institutions that facilitate the adoption and creation of new technologies. Moreover, Colombian policy concentrates on innovation modes that involve characteristics such as research-based product innovation; intensive use of PhD-intensive knowledge links with universities and research institutes; implementation of innovation via new start-ups that are often best suited to science parks or incubator facilities; and high reliance on access to high-risk, new venture funding. These types of innovation are obviously important. But, even among the modes of innovation used in manufacturing, they concentrate on the science-intensive and R&D-intensive end of the spectrum. They are likely to have relatively little relevance to the kinds of innovation required for diversification in knowledge-intensive services, infrastructure industries, and suppliers to the large, process-based industries such as mining and petroleum and their immediate downstream manufacturing activities.

Nonetheless, the diversification of technologically dynamic innovation systems is primarily driven by such activities and capabilities. The experience of Korea is instructive in this respect. The capabilities that drove Korean firms' rapid diversification between the late 1960s and early 1990s have been described as “project execution” capabilities (or “investment capabilities”). They differ from the largely R&D-based capabilities needed for more novel forms of innovation, but they led to activities almost identical to those commonly described as “self-discovery” of diversification opportunities in areas of potential comparative advantage. In addition, policy needs to pay close attention to the shifting capacity of the system as a whole and to its ability to deal with transitions to new sectors, new technologies and other global developments by catering to emerging needs for training, education, science, support services, and regulation and standards that span traditional disciplinary, technological and sectoral boundaries.

- *Shift the balance towards firm-driven identification and exploitation of diversification opportunities.* This shift in orientation should involve a move away from heavy reliance on policy-facilitated processes that seek to identify diversification opportunities for firms and towards policy measures that reinforce the “autonomous” identification and exploitation of diversification opportunities by firms themselves through intensified R&D and innovation activities. Making this shift necessarily depends on progress in increasing enterprises' R&D and related innovation activities.
- *Consider differentiating innovation incentives* so that public support is weighted towards the diversification-driving innovations for which market and co-ordination failures are arguably much greater than for some other kinds of innovation.
- *Ensure that diversification policy measures encompass a wider range of innovation modes* than is covered by the current emphasis on science-intensive and research-based innovation.
- *Accelerate the exploration of opportunities for cluster initiatives*, especially but not only those linked to supply chains for the extractive and energy industries and the infrastructure and construction sectors.

- To support the extension of the sectoral orientation of policy, provide significant incentives for R&D and other innovation activities by the large core firms in these industries and their major first tier suppliers. For this, the experience of Norway might provide particularly useful insights.

Foster innovation in the business sector

Transformation of the innovation system should focus on the business sector. While continuing to strengthen certain roles and areas of research in public research institutes and universities, Colombia should aim to achieve, within a decade, a very substantial rise in the proportion of expenditure on R&D (GERD) that is funded and performed by enterprises. At present, there is a lack of balance in terms of the organisations responsible for STI funding and performance. In particular, business enterprises play a very small role relative to universities, government organisations, and a range of non-profit institutions, many of which are substantially government-funded.

This requires attention because – differences across industries notwithstanding – when it comes to STI activities of business enterprises driving dynamic and inter-connected innovation systems three facts stand out: i) business enterprises carry out a substantial share of their innovation on the basis of in-house innovation activities and capabilities without significant inputs from other actors; ii) when they obtain knowledge from other actors for their innovation processes they usually draw primarily on the innovative activities of other enterprises; and iii) when they turn to universities and R&D institutes, it is usually activities of the firm, such as design, engineering, technological development and research, that are the source of links to these external sources of knowledge. This essentially means that it is difficult, if not impossible, to compensate for weak innovation capacities in the business sector simply by funding public research.

Despite its importance, the relative scale of enterprise-based innovation differs between high-income OECD economies and emerging and developing economies in Africa, Asia and Latin America. Colombian enterprises seem poorly placed to drive the innovation system. EDIT innovation surveys indicate that more than 40% of manufacturing firms have undertaken no innovation in recent years. Also, business enterprise R&D accounted not only for a very much smaller proportion of total R&D in Colombia than in high-income economies of the OECD but also in several emerging economies in Asia.

The issue is also about changes over time. A striking feature of the faster-growing Asian economies over the last four decades has been the rapid transformation of the structure of their innovation systems. R&D performed by business enterprises has risen from around 30-40% of total R&D to more than 70% in Korea and China and to about 65% in Chinese Taipei. The 25-30% in recent years in Colombia is roughly similar to the level of Korea in the early 1970s or China in the mid-1980s. What Colombia needs is something like the radical re-balancing of government and enterprise R&D that was achieved as part of Korea's rapidly rising total R&D between the mid-1970s and mid-1980s or by China's between the late 1980s and late 1990s. A shift to more than 50% within a decade might be a feasible target.

During the transformation, Colombia should avoid a narrow focus on science-based or R&D-intensive forms of innovation. Not only in manufacturing but throughout the economy measures should be taken to increase the innovation activity of enterprises across the various modes of innovation. The share of non-innovating firms should be reduced by encouraging their exit or their evolution, at the least into new-to-the-firm

types of innovation. The intensity of new-to-the-firm innovation by all firms should increase. A significant share of hitherto new-to-the-firm innovators should be induced to engage in new-to-the-market innovations and help to diversify the structure of production towards more export-intensive directions. Hitherto new-to-the-market innovators should be encouraged to cross the threshold into export-supporting new-to-the-world innovation.

- *Remove the apparent constraints on public funding of R&D in enterprises* that seem to arise from concerns about corruption and related irregularities in the administration of public funds:
 - To the extent that the constraint is due to the prohibition of such funding, it is important to *consider how to change relevant aspects of the regulations*, with other measure to address more directly concerns about corruption and administrative irregularities.
 - To the extent that the constraint arises from misunderstanding or uncertainty about current legal requirements, *take vigorous steps to clear up such misunderstanding and uncertainty* and remove what seems to be a significant impediment to public funding of private R&D and related activities with clear social benefits.
- *Facilitate the development of R&D activities through the transfer of experienced research personnel* (individuals or teams) from public technology institutes to enterprises, with arrangements to combine public and private funding of the employment costs. For example consider ways to:
 - *Second individuals for fixed periods with employment costs shared over the period.*
 - *Encourage the long-term transfer of groups with expertise to support a move into new-to-the-economy activities or industries*, with employment costs gradually shifted completely to the private sector.
- Ensure that the fiscal treatment of R&D is consistent with maximising innovative activity in industry.
- *Substantially increase public organisations' contracting of R&D activities from enterprises*, either as stand-alone projects to meet public needs or as explicit components of contracts to purchase goods and services.
- *Continue and extend activities that publicise and induce a culture of innovation*, such as publicity campaigns, media reports on interesting and lucrative examples of innovation (especially in Colombia), and innovation competitions.
- *Encourage universities to include an explicit entrepreneurship and innovation component* in more degrees, especially in science and technology. International examples include the Stockholm School of Entrepreneurship, which operates across universities in that city.
- Pay close attention to evolving skills needs in the business sector, particularly in occupations that are relevant to innovation, such as engineering, design, marketing and ICT skills.

Strengthen the role of the Internet and the ICT sector as a platform for business innovation

The Internet and ICTs play a strong role in business innovation by increasing efficiency and serving as a platform for innovation that leads to productivity growth. Across all sectors of the economy, the Internet and ICTs reduce barriers to market entry. Firms now reach global audiences and scale quickly and easily. The ICT sector itself is a source of innovation and has multiplier effects in other sectors.

The Colombian Internet and ICT sector is growing, although from low levels in some areas. In addition, an ecosystem of entrepreneurs is developing in this area, especially for applications and services. Start-ups report as barriers the lack of a business angel environment and difficult access to capital, especially seed capital. Overall take-up and use of the Internet and ICTs by businesses is much lower than in OECD countries. There is a wide gap between the use of ICTs by large and small firms and of the Internet by high- and low-income groups.

The Colombian government is aware of the importance of the Internet and ICTs for the economy and understands that policy measures can help address current shortcomings and thus further develop the Internet economy. The MinTIC's "Vive Digital" strategy is a comprehensive set of proactive Internet and ICT policies that address the four main pillars of the Internet economy (infrastructure, services, applications and users) and ICT supply and demand.

- *Undertake a thorough impact assessment of the various ICT policies of the Vive Digital strategy* and their effectiveness in increasing access to and use of the Internet and ICTs across the country (e.g. by monitoring the effectiveness of the programme directed at small enterprises or the impact of the Vive Digital Labs).
- In terms of government spending, while the current focus on access and connecting individuals and businesses to the Internet is justified, the next step should focus on developing IT services and applications as a promising sector for economic development, building on existing initiatives. Promote the development of a business angel community and attract both local and foreign capital for start-ups and entrepreneurs. Government entrepreneurial mentorship efforts, such as in the Apps.co programme, and its re-examination of barriers to small- and large-scale investing can contribute to this.
- *Work to develop ICT skills across the skills spectrum* (on-the-job training, vocational training, higher education) since these are vital for the creation of new jobs. Continue the significant policy efforts already undertaken in programmes such as "Talento digital". Connect the beneficiaries of this programme to entrepreneurs. Encourage the development of technical skills (programming and coding) from an early age, for instance, by integrating the development of these skills in the "computadores para educar" programme.
- *Expand the use of the Internet and ICTs by small firms and micro companies* in order to increase innovation and business efficiency. Current programmes could be broadened. The priorities should be skills in SMEs to make the best use of ICTs and content development for these companies.
- *Foster the development of local content and applications that serve concrete business needs*, including those of small businesses, with a view to a content and services sector that would serve the entire Latin American market and would

encourage businesses to use the Internet and ICTs systematically. Initiatives such as Apps.co could be broadened.

- *Develop a national public-sector information platform* to make public digital content available to businesses and households in a machine-readable format in order to improve access. The platform could also serve as a driver for innovative applications.
- *Analyse the Colombian hosting market and set appropriate conditions for hosting content and applications.* Much Colombian content, including public-sector content, is hosted outside the country. Promoting locally hosted content would foster Colombia's ICT sector and create savings on international data traffic. In this context, *consider the establishment of more Internet exchange points* in Colombia and increase incentives to exchange traffic within the country.

Strengthen and diversify the development of human resources for science, technology and innovation

Investment in increasing the human resources that will be available for future development has progressed strongly over the last decade. In 2002 the government's *Revolución Educativa* promised a major programme of educational improvement. Expansion of tertiary education was seen as a major part of this revolution, along with improvements in quality and accessibility. Those aims were to be underpinned by even more ambitious plans to raise the scale, quality and accessibility of secondary education. Recently, the government has emphasised its wish to raise the country's national education performance to levels typical of OECD countries.

While much has been achieved, important problems remain, not least in primary and secondary education. Organisational inefficiencies, such as the absence of a national clearinghouse, hamper the transition from school to university. Lack of agreement about the value of different forms of tertiary education and the lack of a system of compatible course credits make it hard to switch from technical or vocational training to university. Income inequalities adversely affect opportunities for higher education.

Overall, the flows of skilled human resources appear insufficient to meet the needs of the innovation system and are likely to constrain its development. Efforts are made to produce more PhDs, primarily for the higher education sector but also for the business sector. However, middle-level skills are in short supply. The balance between professional/technical education and higher education is also problematic, as higher education is more popular.

The task of raising the level of business enterprise R&D will require major investment in building enterprises' base of innovation-related human capital. At the same time, creating a stronger basis for autonomous, enterprise-driven diversification towards higher value-added activities will require the expansion of their "diversification capabilities". These vary across sectors, but typically include significant elements of non-R&D capabilities. This will mean substantial expansion of the main conventional routes for creating such resources: i) the tertiary education system, which covers technological and technical training as well as university level education; ii) Colciencias' large investment in developing PhD research capabilities; and iii) the extensive training activities of SENA and private-sector training organisations that have focused primarily on various production-level skills.

Colombia's innovation-related human capital reveals imbalances and gaps. Perhaps the most striking has been the “inverted pyramid”: relatively low levels of professional technological and technical training relative to the amount of university-level education. However, the greatest problem appears to be the limited role of enterprises as creators of the innovation-related human capital they employ, especially in terms of middle-level and higher-level competences and the limited exploitation of opportunities to augment those competences in association with suppliers of services, goods and technology for major investment projects. In addition, publicly funded research and technology organisations appear to play a limited role in transferring technology to enterprises via movement of human capital.

- Reduce inefficiencies in the school-university transition, and in particular:
 - *Set up a national clearinghouse for university applications* to reduce information asymmetries and to link good applicants more effectively with available places.
 - *Ensure sufficient grants and loans to cope with demand for university education.* Given the importance of access to tertiary education for social mobility and the magnitude of its social returns in middle-income countries, this should be a national priority. The system can give some preference to science, technology, engineering and mathematics (STEM) and other subjects in which there are shortages.
- Extend tertiary education in technical disciplines, and in particular:
 - *Ensure that tertiary technical education offerings are aligned with the current and future needs of industry and with good international practice.* Colombia has made good use of the learning opportunities provided by the German system and can continue to do so.
 - *Develop a better understanding* of why the demand for bachelor's degrees is so much greater than the demand for more technical education, given that the system currently produces more bachelor's degrees than the economy can absorb but only about half as many professional/technical qualifications.
 - *Increase funding for technical tertiary education.* There may be a case for shifting some resources from university bachelor's courses or for some universities to undertake more of this type of education and training.
- Develop a portfolio of incentives and funding mechanisms to offset the market and co-ordination failures that lead to underinvestment by enterprises in middle- and higher-level innovation capabilities. Possible measures include:
 - *Competitive schemes for grants to co-fund firms' training and learning projects,* with the scale and facilities to manage the investment.
 - *Schemes to stimulate (large) banks to include funding for investment in human capital and other types of knowledge-based capital* alongside their funding of physical capital in major infrastructure projects, mining and petroleum facilities, energy, water and other utility projects and larger manufacturing projects. Develop means of subsidising the borrowing costs of enterprises and underwriting banks' risks when financing intangible investment.
- *Develop programmes to sensitise senior managers to the value of human capital investment projects,* especially in the areas of the National Plan's development engines. They need to recognise the private and social returns to investment in

innovation-related human capital; to contribute to the development of schemes to offset the problems of externalities and expand this type of investment; to give higher priority to intensifying investment in the innovation-related human capital they use in their major investment projects; and to attach greater importance to incorporating activities in this area in their contracts with suppliers for major projects.

- Intensify efforts to encourage subsidiaries of MNEs to raise their investment in technological, managerial and other innovation-related human resources, with initiatives centred on the creation of social value in connection with their corporate social responsibility activities. Envisage in certain circumstances creating public-private partnerships in human capital development involving elements of public “contracting” of training services from MNEs.
- Enhance the role of publicly funded research and technology institutes in developing innovation-related human resources for enterprises:
 - Redefine their mandates to encompass responsibility for developing human resource capabilities in selected technology areas, with a view to transferring these competences to enterprises. Undertake pilot experiments in this area.
 - Establish lines of funding focused on these activities, to be made available on a competitive basis.
 - Consider creating a high-level unit within Colciencias or another appropriate body to co-ordinate all the exploratory analysis, identification of skills needs (the experience of OECD countries can be instructive), experiments and programme implementation in these and other activities focused on creating innovation-related human resources (broadly defined) for enterprises, largely in and by enterprises.
 - Provide incentives for institutes to co-operate with universities in research and PhD education and link them to industry needs for human capital and knowledge.
- *Strengthen the market demand for high-level skills.* As highlighted in the OECD Skills Strategy, this can be achieved by encouraging economic diversification, facilitating inward investment, rewarding employer ambitions, and occupational standards. Support for inter-firm networks centred on large firms (e.g. in the petrochemical sector) has been successful in other emerging economies.

Foster critical mass, excellence and relevance in the universities and public research institutes

The creation of Colciencias in 1968 triggered internal changes in the universities aimed at making better use of external research funding opportunities. While the universities see themselves in the Humboldtian tradition of combining independent research with education, the volume of research conducted until recently was modest and most PhDs were trained abroad. Primarily teaching institutions in the past, the universities today have broader capabilities. They have many small groups that conduct research rather than the fewer, bigger ones needed in many areas of science. Colciencias ranks formally registered research groups on the quality and quantity of their research outputs (papers, patents, designs, etc.) and aims to capture both their scientific and their societal value. The highest-ranked groups are concentrated in the big cities. Bibliometric

output suggests that research capacity is concentrated, with six universities (out of a total of 81) accounting for over 60% of international publications over 2000-11. The existence of many research groups and modest overall bibliometric performance is typical of a rapidly growing system. Increased funding and competition will to some degree improve performance but there is also a need for incentives for consolidation into centres of excellence, competence centres or similar programmes.

Only a small share of teachers in tertiary education have a PhD; the share is much higher in the leading universities. The fact that many have taken their PhDs abroad means that international research links are good, as evidenced by a significant amount of international co-publication.

The Observatory of Science and Technology (OCyT) has started to classify and monitor public and non-profit research institutes outside the universities. The institutes are concentrated in the major cities and are very diverse in terms of purpose, funding, capabilities and scientific production. OCyT covers 85 centres and provides an important resource for considering how to develop policy across the institute sector. There may be a need not only for the kind of statistical information being generated by OCyT but also for evaluation of their industrial relevance and usefulness.

Industrial RTOs provide a mixture of research, development and technical services such as testing. While they focus mainly on technology, some also cover the social sciences. Some appear to be more successful than others. Their governance is closely tied to their industry sector; they tend to depend heavily on contract work rather than statutory funding. While not all are RTOs in the classical sense, they are clearly quite specialised. Typically, branch-oriented arrangements focus on comparatively short-term work and need the support of universities to set research agendas and capture the results from longer-term and more fundamental work. Firms are keenly aware that they pay for the research and tend to be sensitive to any sign that their resources are being diverted to issues that they do not find immediately relevant.

The lack of a scientific career path in the civil service makes it difficult for some institutes to maintain a complement of full-time researchers; many rely on contractors. Institutes often focus on a single sector or need; this has led to a proliferation of institutes and to relative fragmentation of the institute sector as a whole. Links with universities appear to be increasing, but administrative restrictions limit their freedom of action in dealing with other organisations and may make it hard to produce knowledge for the benefit of industry or innovation more generally.

Internationally, there has been a strong trend towards merging sector-oriented institutes and refocusing them on technologies rather than industry sectors. RTOs have become increasingly multidisciplinary in order to serve the varied problem-solving needs of their clients. Government labs and RTOs are converging, with the labs increasingly taking on RTO functions and RTOs contracting to do government work. Finland's VTT and the Netherlands' TNO span both functions in order to use resources more effectively across different social functions and technologies. In international comparisons, the Colombian system appears fragmented. It could achieve better use of resources and provide better service to customers through more co-ordination and coherence, for instance by regrouping some RTOs into larger entities or by creating means of co-operation.

- Support the universities’ transition from primarily teaching to research-based teaching institutions by initiating the required changes in internal structure. Colciencias and the Ministry of Education should promote this in the following ways:
 - Create and fund “centres of excellence” that build critical mass and scale in research and teaching (including at the PhD level).
 - *Encourage universities to develop their strategies along thematic lines* (beyond the unspecified “pursuit of excellence”). This can be done through negotiations among universities, appropriate national research infrastructure funding policy and incentives in the form of technology R&D programmes.
 - *Continue to fund university faculty to take a PhD degree*, if they do not have one, in order to build the capacity to operate a research university.
- *Build durable academic-industry links.* These depend both on personal relationships between individuals and on the creation of institutional structures that are conducive to co-operation:
 - *Develop relationships through a “bilateral” funding scheme that pays for university or institute research to support company innovation*, while updating the existing system of support for collaboration to promote links of this kind.
 - *Fund longer-term “competence centres”* – on the National Science Foundation’s (NSF) Engineering Research Centres (ERC) model – that bring industrial consortia and academic research together to work on important industrial research areas. The ERC model requires quite advanced technological capabilities and may currently be overly ambitious for Colombia. However, smaller-scale, less technologically ambitious schemes have been developed, for example by the Knowledge Foundation in Sweden and the Research Promotion Agency FFG in Austria.
- More broadly, reflect the emergence of national thematic priorities (even if these are not yet well defined and subject to interpretation) in the allocation of some of Colciencias’ R&D funding to create incentives to align public-sector research with national priorities.
- Examine employment conditions and career paths and remove obstacles that impede research-industry co-operation in universities and government laboratories.

Increase and diversify the sources of knowledge for enterprises

International evidence suggests that the most important source of business innovation is firms’ own efforts. Indeed, even if some of the knowledge used is produced externally it is hardly possible to innovate without internalising and developing that knowledge. External sources of knowledge therefore complement internal innovation efforts. Even when external knowledge is a significant input, the innovation is at least co-produced. Nonetheless, research institutes and universities can, and as a matter of fact often do, support individual innovations and help companies increase their internal capabilities over time.

While advanced companies access world science directly, many companies only do so through the mediation of partners in (local) universities and research institutes. In addition to producing human capital, these organisations need to be engaged in world science in order to access knowledge. This means that they must operate at relatively high levels of scientific and technological quality. In this respect, and despite the introduction of an element of performance measurement in determining university core funding, Colombia will need to make a greater effort to create scientific output of sufficiently high quality.

Rising external funding levels from the middle of the last decade and the new impetus for research and innovation appear not only to have driven growth in national production of PhDs but also to have encouraged universities to professionalise the management of research, with vice-rectors for research, TTOs and other specialised functions becoming more common.

In spite of these improvements, the quantity and quality of academic-industry links are limited. OECD-country innovation surveys show that innovating firms are more likely than others to maintain partnerships with research performers. It is therefore important to enable such relationships to develop and to remove bureaucratic obstacles to commercialising research results. As the faculty in public universities cannot draw more than one salary, they are, in effect, not allowed to set up spin-off companies.

Many academic-industry links are small-scale and informal and are therefore difficult to perceive. There is nonetheless evidence (especially in major cities outside the capital) that more formal and substantial links are emerging, although their innovation potential – and the potential for industry to signal its needs to universities – is clearly underexploited. The system will benefit from increased interest in, and incentives for, building such links. Colciencias already funds some joint projects but there is scope for more and for schemes that place people with bachelor's and master's degrees in industry, in addition to the programme that funds industrial PhDs. International experience also shows that exploiting teacher-student relationships as students move into industry is a powerful way to increase companies' absorptive capacity and to exchange knowledge.

The vested interests of those who govern (and sometimes fund) research institutes is likely to make it difficult to respond to the changing needs of industry and to tackle the increasingly “horizontal” and multidisciplinary nature of research. There seems therefore to be scope to consider merging a number of RTOs and government laboratories, as has been done in several European countries. It would involve not only reorganisations and mergers but also reconsidering the institutes' funding mechanisms. The Swedish model of consolidating RTOs and government labs in thematically focused clusters may be attractive, because it copes with funding diversity. More centralised solutions, in the Dutch or Finnish style, are also possible.

- *Organise a comprehensive study and review of the research institutes* by Colciencias, with a focus on their functions and missions and identification of opportunities for better meeting the needs of industry and economic and social development through reorganisation and adjustment of their tasks. The review should address means of *increasing the availability of industrial extension services*.
- Explore possibilities for the Colombian diaspora to contribute short periods of technical/marketing assistance and advice to Colombian firms. This should take place as part of a revival and re-balancing of earlier Colciencias initiatives to

mobilise the Colombian diaspora to support the development of innovation-related competences and to facilitate the internationalisation of the Colombian innovation system.

- *Review the adequacy of measures that facilitate firms' access to sources of technical knowledge abroad*, from training by experts from universities, to secondments to overseas collaborators, to outward FDI in technical outposts in key knowledge-rich locations abroad.
- Consider mechanisms to facilitate the provision of technical advice and support by subsidiaries of MNEs in order to upgrade process efficiency or product performance of local suppliers, for example along the lines of the LIUP scheme used successfully in Singapore some years ago.
- Further increase the use of the Internet and ICTs as knowledge platforms in firms.

Continue to extend, simplify and integrate the governance structure for STI activities

The organisation of Colombia's national system differs from that of most OECD countries, which typically allocate major responsibility for university and basic research to the "education ministry" and the funding of innovation and more obviously industrially relevant research to the "industry ministry". The other "sector" or "mission" ministries organise the research they need for their sector and sometimes also play a role in building and maintaining the national research capacity. For about the last 30 years, this has mostly been done through agencies. Education and industry ministries delegate innovation and research funding to innovation agencies and research councils, which run competitions and award funding for the best projects. Sector ministries vary in the degree to which they operate specialised funding agencies, but the great majority have government laboratories or public research institutes that supply the research they need (and often also provide them with other technical services).

At the national level, Colombia's National Planning Department provides overall co-ordination of government policy for economic and social development. The planning process appears to be inclusive: individual organisations contribute to it rather than act on the basis of a top-down document. The director of Colciencias answers directly to the president of Colombia, and Colciencias has its own line in the national budget. The Ministry of Trade, Industry and Tourism also has significant innovation-related activities, as does the Ministry for Information Technology and Communications.

The regions ("departments", of which there are 32) provide another important dimension of governance. They have the autonomy to produce and implement their own regional innovation and development policies, and this autonomy has been further strengthened by the new system of royalties. The central state cannot impose either a division of labour or co-operation on the regions. The royalty income is distributed to the regions using a formula based on population and relative wealth, so that the poorer regions get more income per capita than the richer ones (even if, as the national plan points out, income disparities within individual regions are very large). Each region has its own advisory council for science, technology and innovation (Codecyt or Codeti), normally chaired by the governor, with the participation of regional industry, research and education institutions, and the regional representatives of Colciencias and SENA. Each region also has a regional competitiveness council.

Initial experience with distributing the 10% of the royalties dedicated to STI underscores some of the difficulties involved in co-ordinating across the regional and national levels. Project proposals are developed and prioritised at the regional level before being passed to Colciencias, where they are assessed for conformity with the rules, quality and feasibility. A collective management and decision-making body composed of national, regional and municipal representatives gives final approval at the national level. However, the capacity to use the royalties for STI activities is currently limited. In the first round, there were not enough STI projects to absorb all the money (the experience of the European Structural Funds may be instructive in this respect). Absorptive capacity needs to be increased. While the royalties have the potential to make a big contribution to improving the capacity of the STI system, they are not enough on their own to allow Colombia to catch up with the investment of more advanced countries, including some near to home (e.g. Brazil). Over time, additional investments in STI by the “normal” budget will be needed, and absorption capacity expanded in parallel.

Regional capacity for elaborating and implementing development plans varies greatly (so that some of Colciencias’ budget goes for regional capacity building). Regions with limited STI capacity have difficulty formulating STI projects, and often propose investment and other projects that fall outside the mission of the STI royalties fund. While the fund encourages cross-regional co-operation, little is proposed. The regions optimise locally, aiming to spend all the available royalties within their boundaries. As a result, opportunities to develop capacity across regions are missed, projects are fragmented, and opportunities to build critical mass and resources that follow the boundaries of natural resources or clusters of industry rather than administrative boundaries are likely to be lost. Overall, the innovation policy mix risks losing coherence, especially when other types of funding do not expand along with royalty funding.

In addition to handling its own budget, Colciencias makes use of its skills and experience with research funding to assess research and innovation projects funded from other sources, notably for medical research and the “regalias” (royalties). It provides a natural location for co-ordination in the government system because it manages to varying degrees a substantial share of state funding for innovation and research.

Recent reforms require ministries to spend at least 1% of their budget on R&D. Experience elsewhere suggests that this will encourage them to develop clearer strategies and to give more priority to research and innovation, especially if the spending is vigorously evaluated. However, in the absence of evaluations, expenditure-based objectives may lead to inefficient use of increased resources.

Colciencias plays a key co-ordinating role by providing secretariats to various high-level committees in a governance structure that is partly duplicative and appears overly complex. In effect, innovation has two parallel governance systems, one from the perspective of research and the other from that of competitiveness. Apparently, many people sit on committees in both structures, which reduces the scope for the emergence of contradictory policies. While the sector ministries are involved in the National Commission of Competitiveness and Innovation, they also maintain separate, individual strategies. The process of co-ordinating horizontally across Colciencias and the sector ministries to tackle wider issues such as climate change and the other problems increasingly being discussed as the “grand challenges” appears to be at a fairly early stage.

There are indications that certain aspects of regional and sectoral planning could be improved to facilitate national coherence. There is so far limited co-ordination among the regions and not just in terms of their royalty projects. The Private Competitiveness Council recently analysed regional innovation and industry priorities and found a total of 80. At the national level, too, strategic priorities proliferate. The NDP sets out five “locomotive” priorities. The Productive Transformation Programme of the Ministry of Trade, Industry and Tourism has gradually defined 16 priority sectors. In practice, therefore, the extent to which there are strong national thematic priorities is not clear.

The DNP has proposed a national innovation strategy. It considers innovation performance inadequate and sees a need to intervene to improve companies’ innovation performance and the production of human capital for science and technology. It allocates responsibilities for implementing the improvements needed to specific ministries and agencies, including the regions. However, the issue of thematic priorities must be dealt with at the national level while respecting the needs and autonomy of the regions.

- *Consider integrating STI into the body of the next National Development Plan.* STI needs to be an integral part of wider policy and understood as such by the sectoral ministries. Providing a strong rationale for the role of STI in macroeconomic performance, long-term structural change and social challenges can help improve its recognition across government.
- When developing relevant national STI strategies to address major societal challenges, provide scope for sub-sets (variable geometry) of ministries to align their efforts to meet these challenges through multi-ministry strategies, rather than expecting them to be entirely prepared by Colciencias. This already occurs to some extent, but the effort should be broadened to improve problem definition and implementation capacity, while supporting the wider co-ordinating role of Colciencias.
- Devise more collective planning arrangements so that there is “many to many” discussion among the regions around potential co-operation poles, platforms, clusters or technologies rather than the current “many to one” negotiations between the regions and the state. Inspiration for possible co-ordination mechanisms can be sought in the “smart specialisation” approaches to regional STI policy that are popular in Europe. This is especially important for the effective use of the royalty income, since many STI-related investments would be more efficient at the supra-regional scale. The spatial dimension is especially important in Colombia, as the multiplicity of regions with different resource endowments and at various stages of development tends to fragment the national innovation effort.
- Integrate the innovation and competitiveness “systems” and better integrate the interests of other sector ministries in the formulation and execution of national strategy. Overall, the current governance structure of STI is complex and duplicative. Alignment should be fostered through greater interaction and the establishment of a common vision.
- *Consider co-programming policy intervention, initially on a pilot basis.* Colciencias has demonstrated its ability to manage multiple funding streams, perform assessments and manage programmes. While the resulting “multi-principal” arrangement involves certain risks (notably of lock-in by principals), the examples of the Research Council of Norway (RCN) and the Research

Promotion Agency FFG in Austria show that co-programming interventions can achieve useful synergies. In a country where the capacity to develop and implement STI programmes may be in short supply, there is a further incentive to have a common organisation carry out these tasks.

- *Integrate the various public tenders into one digital platform.* To promote and finance innovation, many parts of the government open public tenders (“convocatorias”). Since these are spread across public agencies such as Colciencias, Innpulsa or Fonade, it can be hard for businesses, especially small ones and entrepreneurs, to be aware of these tenders, which are often only open for a short time. The government should create a national digital platform that lists all tenders and is searchable in a user-friendly way. In addition, there should be an off-line communication channel for entities without an Internet connection.

Develop the role of Colciencias

Colciencias encompasses the roles of science ministry, research council and innovation agency and also co-ordinates innovation and research policy across government. Its performance is therefore very important to the success of the research and innovation system.

It operates a wide range of innovation and research funding instruments, some of them well established, and appears to have a strong influence in the innovation and research communities. As discussed earlier, Colciencias (along with others in the innovation funding system) appears to pay much attention to imitating aspects of what could be called an “MIT/Stanford” model of research-driven spin-off and IPR generation. This is not necessarily well adapted to an emerging economy that needs to build “catch-up” technological capabilities and innovation strengths in existing industries. Instead, more emphasis should be put on the more routine functions of innovation agencies, such as support for innovation capacity development within companies and direct funding for innovation, which would appeal to a much larger share of the Colombian business sector.

The beneficiary communities, as elsewhere, would like to see less bureaucracy and paperwork and shorter assessment processes. The success rate for research proposals from universities is very low (around 7-8%), as Colciencias’ budget has not grown: the actual – and very substantial – growth in funding has come through the royalties system.

Colciencias should:

- *Disentangle the mixture of policy-making and implementation functions within Colciencias.* At the least, these need to be separated internally so that there is, on the one hand, a policy-making and co-ordinating function to address national needs and reach out to ministry departments and, on the other, an explicit and transparent principal-agent relationship in policy implementation.
- *Balance the increasing focus on innovation-related activities (for development) with its mission to use competition to sustain quality in Colombian science.* A degree of traditional “bottom-up” funding of “basic” investigator-initiated research remains important for the health of the overall system and Colciencias should have the resources to fund this more generously than seems possible today.
- *Overcome its reluctance to support the development of innovation capacities in the business sector.* The mission of an innovation agency goes beyond support for science and for bridging mechanisms at the periphery of public institutions.

Business-sector support for the overwhelming majority of Colombian companies should be more direct, take a greater variety of forms, and – without compromising quality – be more concerned with new-to-the-firm and new-to-the-market innovation than with shifting the global knowledge frontier. It should include support for skill generation, circulation and permanent changes in the in-house capabilities of Colombian companies. Other forms of support may include the direct funding of new-to-the-firm and new-to-the-market innovation and the support of inter-firm linkages (in addition to current efforts on university-firm linkages) as a way to leverage capacity development. If Colciencias cannot take on such innovation agency functions to a sufficient extent, the establishment of a separate agency operating at arm's length and with an explicit mandate to support innovation should be considered.

- Similarly, create incentives that connect research to national thematic priorities and to industrial clusters rather than putting more effort into spin-offs, TTOs or start-ups. Colciencias should be reluctant to bet on individual firms rather than clusters or networks unless they actually are “locomotives” in the sense of pulling networks of other firms along and facilitating structural change.
- *Rebalance the current focus on PhD training to give sufficient attention to middle-level professional skills.* While PhD training is an important element of the portfolio of interventions it is overemphasised. There is a need to complement current policy with measures in line with the guiding principle of balance enunciated earlier. In keeping with this principle, the development of human resources should not come at the expense of support for R&D and innovation programmes and projects.
- Strengthen the development of social innovation as an increasingly explicit and well-defined component of the overall innovation system. Colciencias should establish a distinct unit to take responsibility for the emphasis on social innovation in the National Development Plan and follow the initial steps taken in association with the DNP and National Agency for Overcoming Extreme Poverty (ANSPE). Initial activities of this unit might include:
 - In consultation with the sectoral ministries at national level and with similar relevant bodies at departmental and municipal levels, *identify the social innovation programmes and projects being incorporated in the various sectoral plans associated with the NDP engines*, and examine the relative balance between bottom-up and top-down initiatives..
 - *Ensure that these and other social innovation activities do not become marginalised during the implementation of the development programmes.*
 - *Also ensure that social innovation activities incorporate significant enablement and empowerment dimensions* at the start and sustain them over time, so that disadvantaged groups are able to make demands on the innovation system in the future and are better able to participate in associated projects.
 - *Develop a programme to survey social innovation activities in order to compile social innovation indicators* to complement existing compilations of STI indicators. First steps in this direction might focus on compiling data on the channels through which social demand impinges on the innovation system.

- Strengthen the development of other areas of knowledge to support policy, notably:
 - *Support the further development of OCyT's STI indicator-based work*, and encourage it to provide more internationally comparable analysis in its main compilations of indicators and to consider undertaking supplementary studies to enhance the policy-related value of data derived from the EDIT surveys.
 - *Develop a programme of funding support for studies in important areas of STI about which little or no information is available*. This would include studies to identify the innovation and development-related roles of: i) knowledge-intensive business service suppliers, especially those concerned with ICT-related services and various forms of design, engineering and related consultancy; ii) the large and rapidly growing extractive industries, energy and utility sectors, the construction industry and agriculture; and iii) scientific field evaluations to supplement bibliometric studies of performance, as they can generate nuanced and specific recommendations for development.
 - *Develop a programme of studies on social innovation* that would complement the broader indicator-related initiatives mentioned above by monitoring and analysing organisation and process characteristics that influence the outcomes of social innovation.
- Seek ways to streamline the evaluation of project proposals to reduce delays and to improve communication and stakeholder satisfaction.

Further improve the knowledge base in support of policy

In order to intervene intelligently, selectively and effectively, it is important to have a broad knowledge base that supports policy making and implementation. While the categories overlap, at least three types of knowledge can be distinguished:

- Statistics and indicators that describe the innovation and research system.
- Evaluations and evaluative studies that systematically use experience with intervention:
 - For accountability to test whether interventions make a difference.
 - In order to learn how to develop and improve policies and individual interventions.
- Prospective or foresight studies that explore alternative future opportunities and policies.

The first of these consists of compilations and analyses of internationally comparable statistical indicators on key characteristics of STI systems. These can help to identify at least the broad outlines of problems to be addressed by the policy agenda. They can also help to benchmark aspects of the system's development against locally determined aims and international experience in comparator contexts. Colombia seems to be fairly well served in terms of the production of information about the national system but there is only a limited amount of internationally comparable data. OCyT collects a wide range of STI-related statistics and provides syntheses via a comprehensive set of indicators that is made available in various media. OCyT has played a leading role in the development of

STI statistics in the region and actively participates to the Ibero-American and Inter-American network of STI indicators (RICyT). In addition, the National Administrative Department of Statistics (DANE) undertakes regular innovation surveys covering manufacturing industry and compiles accessible data sets. These are used both by OCyT and Colombian researchers and international studies undertaken by bodies such as the Inter-American Development Bank (IDB).

An area requiring development is the very narrow scope of available information on R&D and innovation, which focuses on innovation in the manufacturing sector, and the analytical work that draws on that information to deepen understanding about manufacturing innovation. Apart from a certain amount of data and analysis relating to agricultural innovation, there appears to be at present very little information about innovation in other areas of the economy, although efforts are being made to address this, requiring improved statistical registers.

In terms of the gap in the understanding of STI beyond the manufacturing and agricultural sectors, two domains seem particularly important. One is knowledge-intensive and innovation-related services, activities that are increasingly important. The second (and much larger) domain is science, technology and innovation in the non-manufacturing components of industry, which account for about one-quarter of the economy: the extractive industries, the energy and utility sectors, and the construction industry. These have grown rapidly over the last decades. The gaps in policy-related understanding in these areas are not unique to Colombia, as they are poorly understood in other countries too. Yet the information that is available suggests that there are substantial differences in the key features of innovation in these sectors and in manufacturing.

A different kind of limitation on the understanding of important aspects of science, technology and innovation in Colombia is likely to be found in the area of social innovation. In particular, although a wide variety of participatory approaches to innovation have been undertaken in many countries and over many years, especially in agriculture, there has been little systematic monitoring of the processes and outcomes associated to new initiatives in this area. This also appears to be the case in Colombia. Consequently, there is little by way of even very basic understanding of how to achieve different kinds of outcome in different kinds of contexts. Given the significance currently attached to these modes of innovation, it would be important to gain understanding of their organisational and process-related characteristics.

The second category – evaluative studies – is less well developed in Colombia. There is a tradition of quantitative analysis of interventions that affect companies, normally based on surveys and econometric techniques. These are typically done by international funding bodies, especially the IDB, and are valuable in terms of accountability. However, they are not designed at present to generate the necessary insight into the mechanisms of intervention, alternative means to reach the desired goals, or identification of further needs for intervention. They need to be supplemented by more qualitative, “soft” approaches that enable learning. Evaluation needs to be better incorporated into national practice.

The third category, prospective studies, has been addressed over the past decade via a range of foresight studies, including a national foresight programme. This does not appear to have been well integrated into national planning processes in recent years. Renewed efforts will be needed to develop a common vision and adequately integrate it in STI policy.

- Encourage OCyT and the national statistical agency to extend the collection, dissemination and analysis of STI-relevant data and information and provide the necessary resources. In particular the policy-relevant knowledge base of indicators and analysis should be extended beyond manufacturing. This would preferably involve more internationally comparable data and indicators in the OECD framework of STI statistical manuals. The adoption of international standards can also improve OCyT's ability to serve national policy evidence interests, e.g. for the development of policies on services innovation.
- Develop and extend current ex post evaluation practices (of Colciencias and other policy actors) to involve elements that enable policy learning in addition to accountability.

Table 1.1. SWOT analysis

Strengths	Opportunities
Strong economic performance over most of the last decade. Strong political commitment to education and increasing participation rates. Strong commitment to strengthen innovation as a sustainable and inclusive driver of development. Some research institutions with strong research capacities and international linkages. Confidence, enthusiasm and willingness to innovate among the national STI policy leadership. Similar qualities at departmental and municipal levels in some areas. Strong political commitment to grow the Colombian digital economy and the deployment of a fibre backbone throughout the country.	Improved security and framework conditions for innovation and commitment to further integration of Colombia in the global economy. To focus policies on making business the main driver of the innovation system. The prospect of rising levels of royalty-derived funding for STI activities. Inclusion of a wider spectrum of stakeholders in the allocation of resources and capability development across regions. To provide incentives for companies to enhance local development of operating skills and innovative capabilities. To establish an infrastructure of strong government laboratories, research and technology organisations and universities with evolving interaction with business. Recent initiatives to raise the quality and capability of Colombia's IP system to encourage innovation.
Weaknesses	Threats
Low levels of business innovation capabilities and productivity, with a long “tail” of weak companies. Increasing reliance on mineral commodities and slow diversification into new economic activities. High levels of inequality in income and opportunity, in particular in access to tertiary education. The small scale of the formally organised innovation system and its concentration in an “island” of academic and research institutions. Resource and human capital constraints in research-performing institutions resulting in a small (although rising) research output of variable quality. Shortcomings in technological, technical training and learning in production enterprises. High levels of social need for innovation that are insufficiently articulated in demand and poorly linked to innovation. An unbalanced STI policy mix overly focused on a narrow range of innovation modes of limited relevance to most businesses and to social innovation. Limited policy co-ordination among ministries and across regions.	Failure to diversify and move into higher-value segments, to exploit the up- and down-stream opportunities of the minerals boom. Failure to embed innovation pervasively in businesses and in the fabric of society. Failure to reorient STI policy towards addressing a broader range of firms with different needs and to provide support more directly. Cumbersome project application and lengthy decision procedures that weaken resource mobilisation and project impacts. Insufficient mobilisation of human capital and capacity to exploit the window of opportunity offered by the STI royalties fund. Inability to upgrade skills and quality sufficiently to support the needs of the wider innovation system for human capital and knowledge. Failure to pursue agendas that serve wider societal and economic needs.

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Chapter 2

Macroeconomic performance, framework conditions and innovation performance in Colombia

This chapter provides an overview of Colombia's macroeconomic and innovation performance. It begins with an examination of Colombia's recent growth in the context of its long-term economic trajectory, notably in terms of productivity. It next looks at international trade and investment and structural change in production. The chapter then considers the current state of framework conditions for innovation and concludes with an assessment of Colombia's aggregate innovation performance.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Colombia's economic development has been based on exports of agricultural and, more recently, mineral commodities, and from the 1950s to the mid-1970s, its manufacturing largely focused on protected domestic market. Although the economy has grown strongly, productivity and gross domestic product (GDP) per head lag that of OECD countries, including in Latin America. Internal conflicts, governance weaknesses and difficulties in shifting to a more formal economy have hindered its development. However, especially over the past decade, these difficulties have increasingly been overcome. A major effort has been made in education, and increasing attention is paid to innovation. Important steps have been taken in the areas of public research and information and communication technology (ICT) infrastructure, both of which are critical for the country's future development. Yet the country's innovation system is still small and performs well below the level required for successful further development. The substantial minerals royalties that accrue to the state provide an opportunity to accelerate a balanced development of the innovation system, increase incomes and reduce inequalities and the incidence of poverty. Well managed, they will allow Colombia to increase its capabilities, integrate better the world economy and become more competitive, and in turn to strengthen social and economic development and move rapidly towards OECD levels of productive capacity and income. This will depend crucially on expanding human capital and capacities in innovation and on systemic improvements in management and governance in both the private and the public sector.

2.1. Macroeconomic performance and productivity growth

By the start of the current decade Colombia had a population of about 47 million, the third largest in Latin America after Brazil and Mexico. In 2011, the country's GDP, at USD 467.7 billion (in purchasing power parity), ranked fourth in the region after Argentina, and its GDP per capita ranked seventh among South American economies. Colombia has natural resources, a young and growing population and rising living standards, particularly over the past decade. Since the early years of the 20th century, it has undergone several phases of economic growth with different drivers and modes of interaction with the international economy. There have been several persistent limitations – in particular, relatively slow productivity growth, strong inequalities in the distribution of income, and faltering adoption of knowledge-intensive manufacturing. Profound changes will be needed in the country's science, technology and innovation (STI) system to address these continuing challenges.

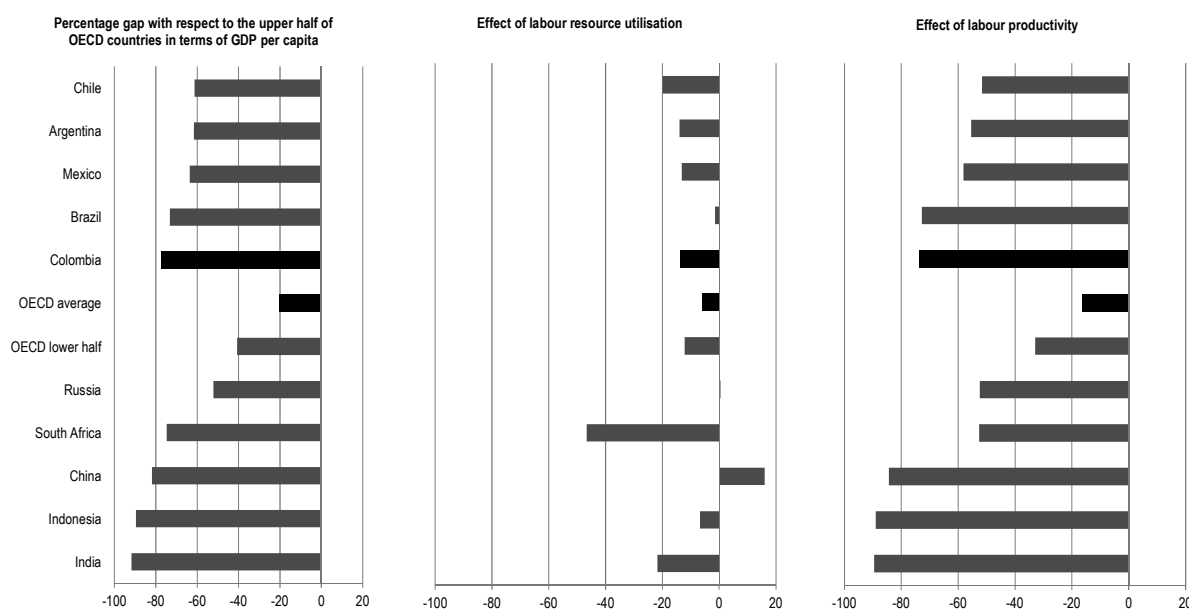
Long-term paths of economic development

The origins of modern economic growth in Colombia are usually linked to the emergence and expansion of the coffee sector in the early 20th century. The economy then expanded rapidly between the 1930s and the mid-1970s, with rates of growth that were sometimes among the highest in the world. These trends were accompanied by substantial changes in the composition of production, the most striking feature of which was a threefold increase in the share of manufacturing, which reached 23% by the mid-1970s. In achieving this structural transformation, Colombia avoided some of the distortions in several other Latin American economies. In particular, although it implemented protectionist measures to foster manufacturing development, "outward-oriented" measures also facilitated exports of manufactures and non-traditional agricultural products.

After slowing during the debt crisis of the 1980s, growth accelerated again through most of the 1990s when rising oil production and public expenditure became significant drivers of growth. Significant policy reforms since the early 1990s have facilitated economic modernisation. The sharp recession of 1998-2002 was followed by rates of expansion between 2003 and 2011 that were, with an interruption in 2008-09, much higher than anything experienced over the previous two decades. Per capita income also rose at much higher rates. However, as in Latin America as a whole, these high rates of growth were lower than those in the East Asia/Pacific and South Asia regions.

Despite its strong economic growth in the recent past, Colombia still lags OECD levels of income and those of the regional OECD members, Mexico and Chile (Figure 2.1). The gap is overwhelmingly due to differences in labour productivity, rather than labour utilisation; this underscores the economic relevance of innovation.

Figure 2.1. Income and productivity levels

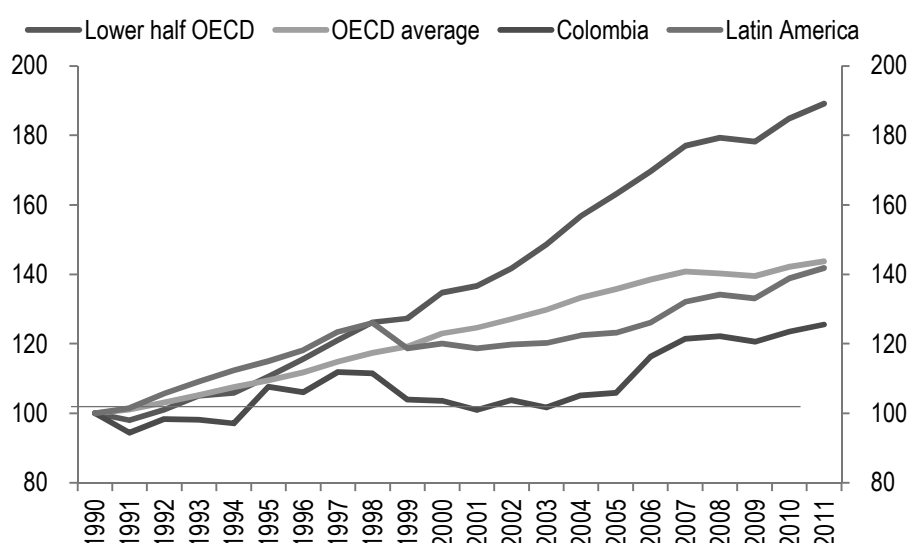


Source: OECD (2013a), *OECD Economic Surveys: Colombia 2013, Economic Assessment*, OECD Publishing, http://dx.doi.org/10.1787/eeco_surveys-col-2013-en.

A large part of the Latin American region's lagging long-term growth in per capita income has its roots in poor productivity performance relative to other world regions, especially in Asia. According to the Colombian National Development Plan (NDP) 2010-14, labour productivity is close to 24% of US labour productivity (DNP, 2011). OECD member countries, particularly the lower half (in terms of income per capita) enjoyed strong and sustained productivity improvements for most of the 1990-2011 period (Figure 2.2). Latin American countries had weaker productivity improvements over the past decade. Colombia's labour productivity stagnated from the mid-1990s to 2005, during which time levels were not much higher than they were in 1990. The sectors with the strongest labour productivity improvements over the past decade were non-tradables, such as personal services, construction and retail and restaurants (OECD, 2013a).

Figure 2.2. Evolution of labour productivity, 1990-2011

GDP per hour worked relative to 1990 (=100)



Note: Lower half OECD represents the ten OECD member countries with the lowest GDP per capita in 1990. These are Chile, the Czech Republic, Estonia, Hungary, Korea, Mexico, Poland, the Slovak Republic, Slovenia and Turkey. Chile and Mexico are also part of the Latin America group, along with Argentina, Brazil and Colombia. Data for 2011 are estimates for all countries except Colombia.

Source: OECD (2013a), *OECD Economic Surveys: Colombia 2013: Economic Assessment*, OECD Publishing, http://dx.doi.org/10.1787/eco_surveys-col-2013-en.

In contrast to a number of Asian economies, all Latin American economies except Chile experienced slower growth of total factor productivity (TFP) – which measures the increase in efficiency in the use of production factors – than the United States between 1960 and 2005. At the end of that period, the gap between Colombia's TFP and that of the United States was greater than that of seven other economies in the region including Chile, the regional leader, and Argentina, Uruguay, Brazil and Mexico (Pagés, 2010). Like the rest of the region, and as would be expected for a country of its level of income, Colombia's growth has been largely driven by the accumulation of physical and human capital. TFP has been a less dependable source of growth in Colombia over the past five decades (Table 2.1).

Table 2.1. Sources of output per worker growth composition

Average annual growth, %

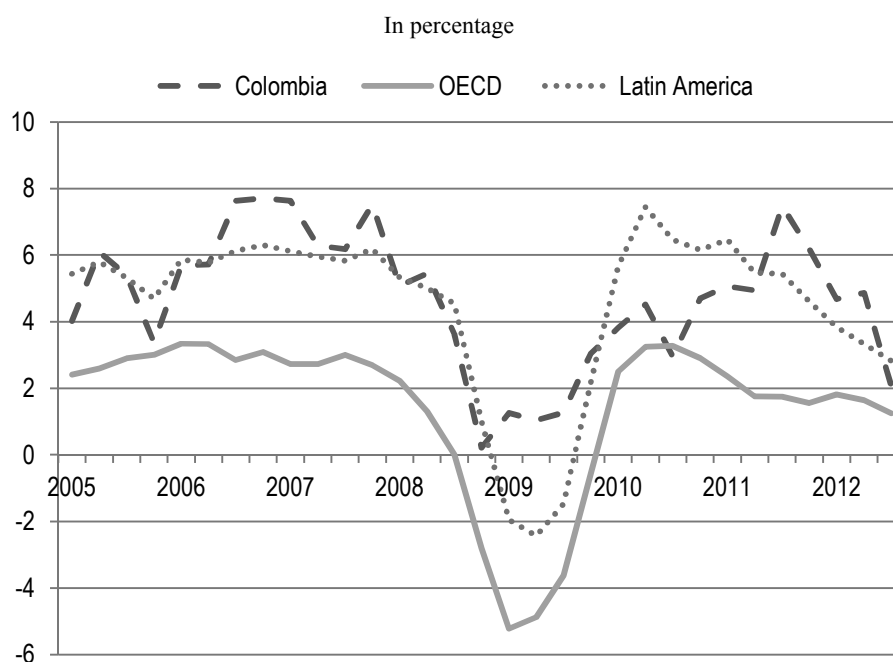
	Physical capital	Human capital	Total factor productivity
1962-70	0.7301	0.7631	1.1862
1971-80	0.9001	0.6944	0.6789
1981-90	0.3598	0.7307	-1.5072
1991-00	0.2718	0.5815	-2.3617
2001-07	-0.0440	0.4328	1.5604
2008-10	0.8803	0.8117	-0.4087

Source: OECD (2013a), *OECD Economic Surveys: Colombia 2013: Economic Assessment*, OECD Publishing, http://dx.doi.org/10.1787/eco_surveys-col-2013-en.

Recent macroeconomic developments

Colombia's economy went through a severe recession in 1998-2002. From 2003 the Colombian economy gained momentum and real GDP growth peaked in 2007 at 7.5%. Overall, Colombia's GDP grew at an average annual rate of nearly 6% between 2003 and 2007, well above that of most Latin American and Caribbean economies (Figure 2.3). Colombia's favourable macroeconomic performance was driven by a boost in exports and by investments in the mining sector. Like other countries with primarily resource-based exports, Colombia was adversely affected by the financial and economic crisis, which led to a rapid deceleration in 2008 and stagnation in 2009. The economy has rebounded quickly but growth returned to pre-crisis levels only transitionally.

Figure 2.3. Real GDP growth rate



Source: OECD (2013a), *OECD Economic Surveys: Colombia 2013: Economic Assessment*, OECD Publishing, http://dx.doi.org/10.1787/eeco_surveys-col-2013-en.

Macroeconomic policies have been prudent and have helped sustain growth. Inflation has been maintained below the 3% target and the state of public finances has made it possible to continue much-needed public investments. With growth, employment increased rapidly, by almost 15% over 2011-13. It has grown particularly strongly in the non-tradable services sector (retail trade, hotels and restaurants, and finance, insurance and real estate) (OECD, 2013a). The government foresees far-reaching structural reforms in taxes, labour, pensions and the health-care sector; these could further underpin growth (OECD, 2013a). Although tumbling commodity prices have weakened investment in the mining sector, public construction projects could help maintain momentum into the medium term. According to recent World Bank projections, real GDP is expected to grow in the low 4% range or slightly above to 2016. This means stronger growth than in the Latin America and Caribbean (LAC) area as a whole, but lower than in the pre-crisis period and somewhat less than in Peru and Chile.

While Colombia has weathered the crisis better than some other countries, the crisis has exposed its long-term reliance on the primary sector and drawn attention to the need to diversify into higher-value-added activities. Innovation policy will be a central element of a sustained drive to improve the competitiveness of manufacturing and to facilitate the wide-ranging diversification into new activities that seems necessary if Colombia is to converge with OECD levels of income.

Social challenges: conflict, poverty and inequality

High levels of insecurity and rural conflict have been frequent in Colombia. Among the enormous social costs are not only the loss of human life but also the long-lasting imprint of violence on society. Also among these costs are the considerable impacts of displacement, the disruption of schooling and health care, constraints on public investment in many areas but especially infrastructure, the related diversion of government expenditure to security, and the impact on the climate for private investment and the conditions under which it is realised. However, the situation has improved considerably over the past decade and a lasting cessation of hostilities is now anticipated.

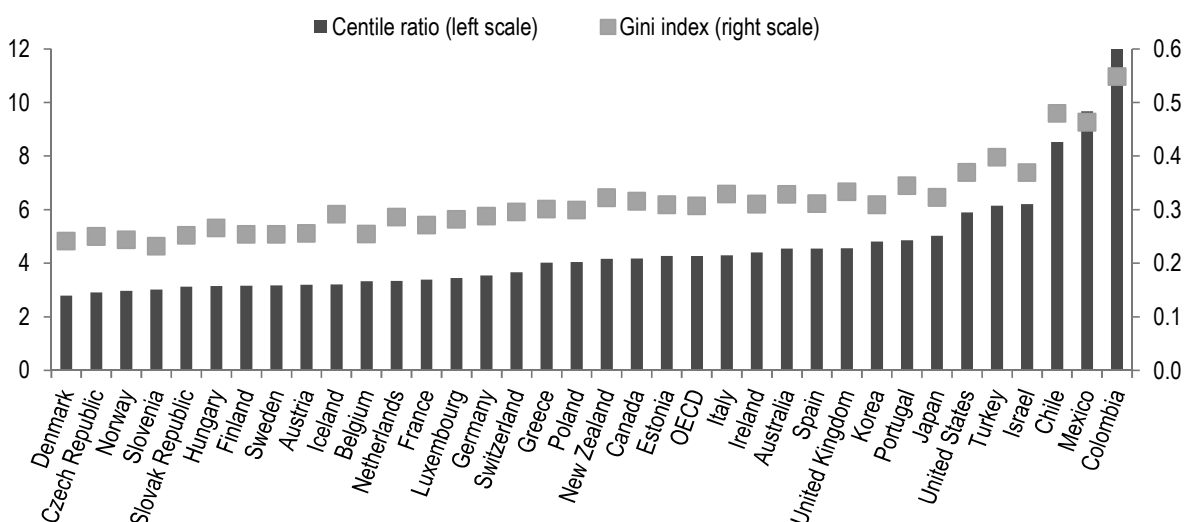
Strong growth in income per capita over the past decade has led to a reduction in poverty of nearly 10 percentage points between 2002 and 2010 (ECLAC, 2011). Nevertheless, Colombia remains a very unequal society and economy. By various measures, inequality of household disposable income was high compared to OECD countries (Figure 2.4) and to most countries in other world regions and at the high end of the range for Latin America¹ (ECLAC, 2011). Moreover, inequality has been persistent. With the exception of a drop in the 1980s, Colombia's historically high rate of growth in income per capita only marginally reduced income inequality (Cornia, 2012). Income disparities between the country's regions were also among the widest in the larger Latin American economies (ECLAC, 2012) and social mobility is very low.

A significant indication of the challenge raised by lack of social mobility is the relatively high rate of emigration, which continued even in years of increasing prosperity and improving security (OECD, 2009). Remittances from Colombian emigrants account for a significant and increasing proportion of the country's GDP. In 2007 they represented 2.2%, close to three times the proportion in 2000 (OECD, 2009). These can be seen as signals of shortcomings in the current growth model in terms of inclusiveness and particularly in its ability to harness the potential of Colombia's human resources.

In spite of improvements in access to higher education, entry to university is still determined by parental income (see Chapter 3). The country's response to the challenge of social mobility could have far-reaching implications for the innovation system. Patterns of social stratification and social mobility can have a pervasive and persistent influence on the scale and quality of STI-related human resources developed by the education and training system. They can significantly enhance the development of the innovation system, as in Korea since the 1970s, or they can constrain that development, as in South Africa even since the 1990s. More immediately, vigorous responses in the areas of education and innovation are needed to ensure that small producers and the underprivileged households that depend on them for employment are able to benefit from recent trade policy developments.

Figure 2.4. Colombian inequality in international perspective

Household disposable income: gap between the 10th and the 90th centile and Gini index in the late 2000s



Note: Data for France and Ireland refer to the mid-2000s instead of the late 2000s. Data for Colombia are for 2011.

Source: OECD (2013a), *OECD Economic Surveys: Colombia 2013: Economic Assessment*, OECD Publishing, http://dx.doi.org/10.1787/eeco_surveys-col-2013-en.

2.2. International trade, foreign direct investment and structural change

The recent economic history of East Asian countries and examples of successful development in other world regions reveal the importance for economic development of an international market orientation. International openness, by increasing the size and scope of the market, provides opportunities for both firms and consumers. Openness can also benefit a country's innovation system: international trade and foreign direct investment (FDI) are well-documented channels of international knowledge and technology transfer (Keller, 2004). Recent evidence highlights the importance of knowledge transferred through imports (Acharya and Keller, 2007; Keller, 2010). More broadly, increasing openness to international trade and investment can raise competitive pressures and thus improve the attractiveness of innovation, of increasingly more ambitious scope, relative to alternative sources of profitability.

International trade

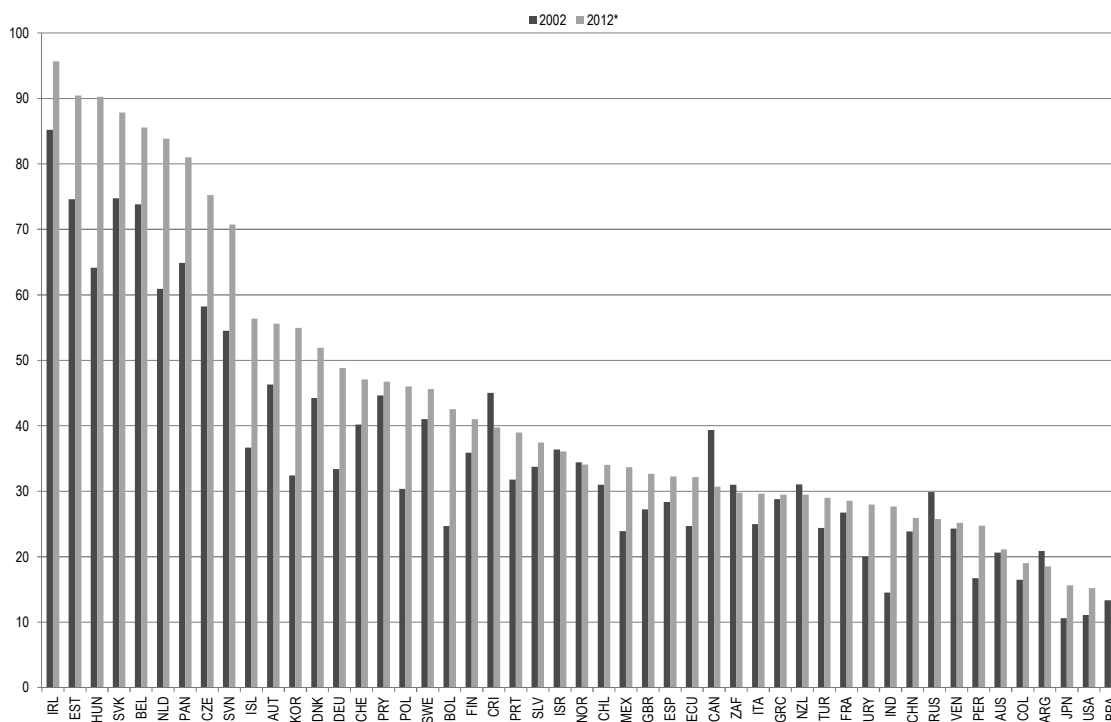
International trade accounts for a still comparatively low but increasing share of Colombia's economic activity. About 19% of GDP is internationally traded, up from 16% a decade ago (Figure 2.5). The Colombian economy is moderately more open than that of Argentina and Brazil but is considerably less open than that of Chile and Mexico. Colombia participates in free trade and economic integration agreements with its fellow Pacific Alliance members (Peru, Chile, Mexico) and with the United States. Moreover, it is member of the customs union of the Andean Community (*Comunidad Andina*), composed of Bolivia, Ecuador, Peru and Mexico, and has free trade agreements with Canada and the Central American Northern Triangle (Guatemala, El Salvador and Honduras). A number of trade agreements of the last few years (with the European Union in 2013 and with the United States, China and India in 2012) are likely to spur further

international integration. Investments in infrastructure and improvements in framework conditions (discussed below) that impinge on trade will be necessary to reap fully the gains from increased openness. Innovation will be critical for international competitiveness, diversification and improving the position of Colombian producers in global value chains.

The United States and other markets in the region are the principal destinations of Colombian exports, although Colombian exports have gone to a larger number of countries over the past decade. The importance of neighbouring Venezuela, traditionally one of the principal destinations of Colombian exports, diminished after 2010 (DANE, 2014). Exports are dominated by primary commodities particularly petroleum and mining products; the share of high-technology exports is small compared to other LAC countries and has changed little in recent years (Table 2.2). Fuelled by an international commodity boom, Colombian exports surged in recent years, doubling in current prices over 2006-13 (DANE, 2014). Various sources indicate that the composition of exports has not diversified over the past decade (OECD, 2013a; Simoes and Hidalgo, 2011; Hausmann et al., 2011). Indeed, change has been in the direction of an increasing reliance on commodity exports (see below).

Figure 2.5. Trade openness

Average of total exports and imports of goods and services as a percentage of GDP, 2002 and 2012*



Note: *2011 for Hungary, the Slovak Republic and Slovenia.

Source: World Bank (2013), *World Development Indicators*, <http://databank.worldbank.org/data/home.aspx>.

Table 2.2. High-technology exports as a share of total exports
In percentage

	Colombia	East Asia-Pacific	LAC	South Asia	OECD
2007	1.75	30.73	3.54	0.01	19.07
2008	1.82	28.04	11.42	1.92	18.21
2009	2.03	30.82	12.28	7.62	20.22
2010	1.44	28.38	11.34	6.30	19.24
2011	0.98	26.41	9.96	1.57	17.90

Source: OECD (2013a), *OECD Economic Surveys: Colombia 2013: Economic Assessment*, OECD Publishing, http://dx.doi.org/10.1787/eco_surveys-col-2013-en.

The commodity boom has had important side effects. The rapid growth in mineral exports (especially oil) and rising commodity prices have been accompanied by large capital inflows, primarily to the minerals industries, and have contributed to a shift towards an economy heavily based on commodity production. Since 2003 the Colombian currency has appreciated significantly, despite government monetary policy to offset it. Combined with the slow growth of manufacturing after the economic contraction of 2008-09, this has prompted concerns over the persistence of slower growth and a decline in the international competitiveness of agriculture, manufacturing and tradable services. These are seen as potential threats to a more inclusive growth path. The problems tend to be exacerbated by the low intensity of direct employment in the minerals sector.

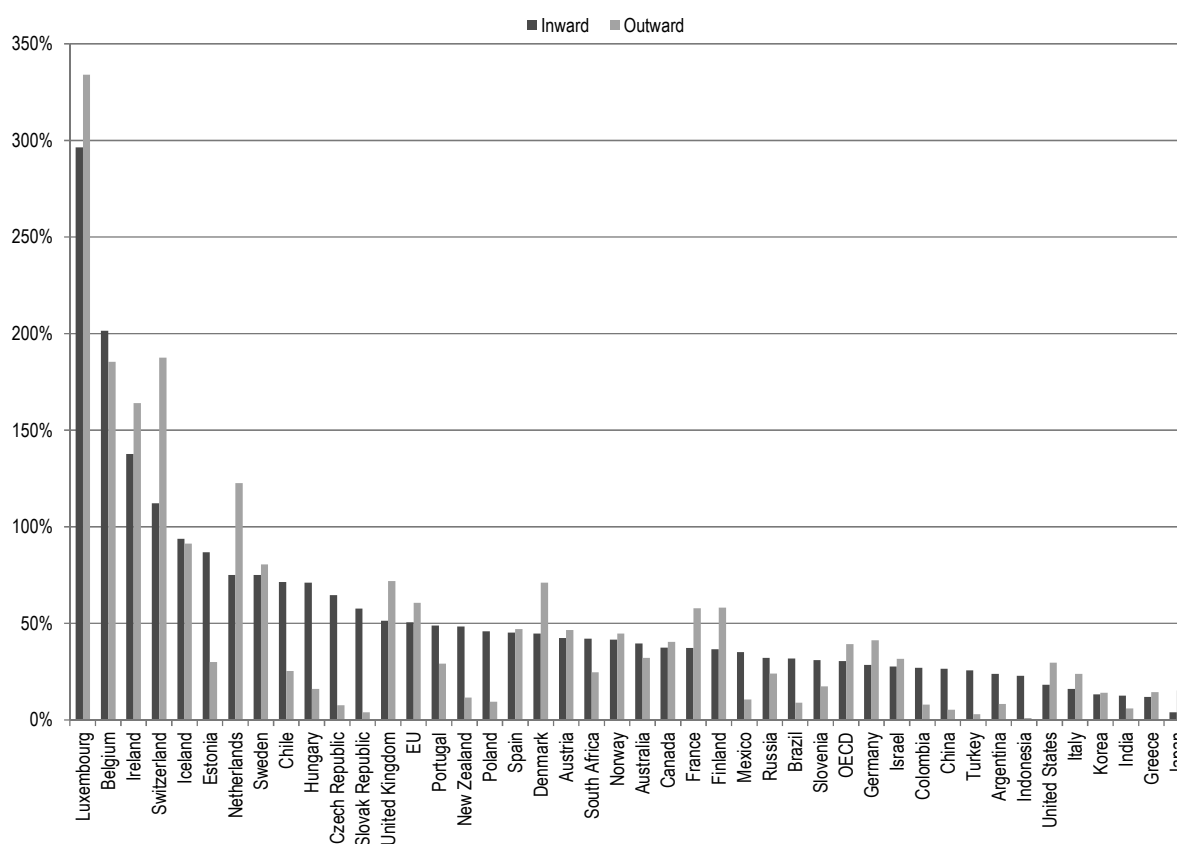
Foreign direct investment

Foreign direct investment can have a formative influence on the development of an innovation system. The effects of investment in productivity-enhancing, organisational and management methods, human resources and infrastructure can be said to “transfer” knowledge or technology from abroad directly, even if its application requires considerable adaptation to the local context. By integrating local production in global production chains, FDI facilitates finer specialisation and thus further productivity improvements. In addition, economically useful knowledge introduced as a consequence of FDI may spill over to the wider population of domestic firms. Like trade, FDI can stimulate innovation as a result of increased competition. However, international evidence suggests that this depends on the national context. The conditions that appear to distinguish success in this respect relate to characteristics of the national economic environment and innovation system, such as framework conditions for innovation (including intellectual property rights), the availability of high-quality human resources, the presence of carefully designed and adaptable industrial, education and regional policies, and related implementation capacities.

In Colombia the considerable improvement in the business climate stemming from political stabilisation, sound macroeconomic policy and increases in mineral prices has encouraged a stream of FDI. Net inflows increased considerably after 2004 and resumed following a brief interruption in 2009-10 owing to the global economic crisis (OECD, 2012). FDI stocks in Colombia accounted for 27% of GDP in 2010 (Figure 2.6), ahead of Argentina (24%) but behind Chile (71%) and Mexico (35%). In absolute terms, however, Colombia is one of the largest recipients of FDI in Latin America. The most important investors are the United States, Panama and Spain. The country has made progress in regulatory openness and in providing an investment-friendly business climate. Its relatively limited FDI stock as share of GDP partly reflects investors’ wariness when evaluating Colombia’s achievements owing to its past political and security problems (OECD, 2012).

Figure 2.6. FDI stocks

FDI stocks as a percentage of GDP, 2010



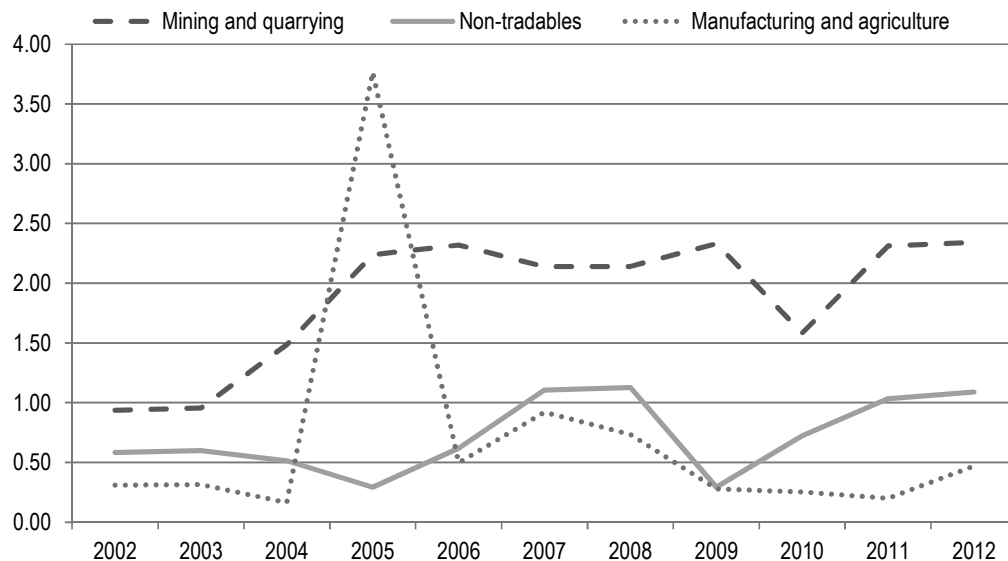
Note: OECD country data as of October 2013. LUX: 300% and 333%; BEL: 201% and 185%; CHE 112% and 188%.

Source: OECD (2013b), "Most recent FDI statistics for OECD and G20 countries", www.oecd.org/daf/inv/;
for Colombia: OECD (2012), *OECD Investment Policy Reviews: Colombia 2012*, OECD Publishing,
<http://dx.doi.org/10.1787/9789264167742-en>.

Variations in FDI across sectors can signal opportunities for profitable investment and the extent to which market forces favour particular patterns of industrial development. Over 40% of the FDI stock in Colombia is invested in the primary sector (oil and natural gas and mining). Mining continues to absorb the largest part of international investment; investment in manufacturing is weaker and more volatile (Figure 2.7).

Figure 2.7. FDI inflows

As a percentage of GDP



Source: OECD (2013a), *OECD Economic Surveys: Colombia 2013: Economic Assessment*, OECD Publishing, http://dx.doi.org/10.1787/eco_surveys-col-2013-en.

Structural change of production

Behind the expansion of Colombia's GDP since the 1970s have been significant differences in growth in the main sectors of the economy, with substantial changes in the sectoral composition of GDP. As might be expected, the share of agriculture in total GDP fell steadily from 20% in 1980-81 to 7% in 2010-11, while the share of services increased from 49% to 57%. More striking have been the contrasting trends in two components of industry:

- The share of GDP accounted for by non-manufacturing sectors (mining, including petroleum; construction; utilities) increased rapidly in two periods. It almost doubled from 9% to 17% between 1980-81 and 1990-91, and it rose sharply to 23% in the last decade. The increase stemmed not only from the growth in mining and petroleum, but also from high rates of growth in the construction sector.
- The manufacturing sector has moved in the opposite direction. Manufacturing output stagnated in real terms between 1980 and 2000. Following slow growth in the 1980s and even negative growth in several years and an overall contraction during the 1990s, the sector's share of GDP fell from 23% to 15% over the two decades. The decline slowed during the following decade to 14% by 2010-11. This last phase reflects the outcome of two different trends: relatively high rates of manufacturing growth in the early part of the decade and slow growth in the latter part, including a relatively slow recovery after the contraction in 2008-09.

These two trends are not, as sometimes argued, evidence of "de-industrialisation" but may reflect a significant long-term trend of relative "de-manufacturing" that mirrors to some degree the experience of other Latin American countries in the wake of the increase in the scale and scope of Asian, and in particular Chinese, manufacturing exports.

Table 2.3 shows the general pattern of change in the sectoral composition of manufacturing value added between 2001 and 2010. The sector groups are based on aggregations of the Colombian industrial classification used by DANE, and these are ranked by the total change in value added over the decade. Two features of the changing structure seem important. First, manufacturing growth was dominated by the expansion of downstream processing of petroleum and mineral products, and their share of total manufacturing increased substantially. Second, if one sets aside the petroleum products and metallic mineral product sectors, with their extremely high levels of value added per employee, there was no systematic shift in the other sectors towards higher productivity. Some sectors with relatively low levels of productivity (e.g. furniture, metal products and machinery and equipment) experienced relatively rapid growth. By contrast, some of the slower-growing industries (e.g. chemicals, non-metallic minerals, pharmaceuticals, and wood and paper products) had relatively high levels of productivity at the end of the period.

Table 2.3. Change in the sector composition of manufacturing, 2001-10

Value added in constant 2005 USD

Manufacturing sectors (2-digit)	Value added					
	2001		2010		Change 2001-10	Per employee (2010)
	million	%	million	%		
Coke and petroleum products	1 426	(8.9%)	4 057	(14.8%)	184%	461 931
Basic metals	534	(3.3%)	1 298	(4.7%)	143%	77 080
Furniture	159	(1.0%)	346	(1.3%)	118%	15 621
Fabricated metal products	323	(2.0%)	685	(2.5%)	112%	19 255
Motor vehicles transport eq.	402	(2.5%)	855	(3.1%)	112%	30 980
Machinery and equipment	323	(2.0%)	591	(2.2%)	83%	18 997
Publishing and printing	551	(3.4%)	988	(3.6%)	79%	27 719
Electrical and electronic	334	(2.1%)	582	(2.1%)	75%	25 668
Food beverages	4 840	(30.1%)	8 303	(30.2%)	72%	45 868
Chemicals	1 738	(10.8%)	2 807	(10.2%)	61%	54 183
Rubber and plastic	775	(4.8%)	1 231	(4.5%)	59%	24 194
Non-metallic minerals & glass	1 255	(7.8%)	1 880	(6.8%)	50%	44 800
Pharmaceuticals	835	(5.2%)	1 030	(3.8%)	23%	40 503
Garment leather	946	(5.9%)	1 098	(4.0%)	16%	12 355
Wood, paper products	883	(5.5%)	1 012	(3.7%)	15%	40 335
Textiles	503	(3.1%)	501	(1.8%)	0%	10 777
NEC	231	(1.4%)	198	(0.7%)	-14%	15 236
All manufacturing	16 058	(100)	27 462	(100)	71%	37 883

Source: Colombia, DANE (Manufacturing Industry Survey. Employment data are derived from the EDIT V. Table C .4.1).

Different classifications are used to analyse the composition of production by technology content or characteristics. One of these is the classification developed by the Economic Commission for Latin America and the Caribbean (ECLAC)² (Table 2.4) in order to highlight types of inter-industry differences that may be more important in the Latin American context. Table 2.5 examines structural change in Colombia on the basis of the technological intensity of the ECLAC framework (Table 2.4) and the OECD classification of industries according to technology content (see Chapter 3 for an examination of sectoral innovation patterns).

Table 2.4. ECLAC technology-based framework of sector categories

Technology-based categories	Types of industry included
Engineering-intensive industries	Metal products; machinery and equipment; office machinery and computing equipment; electrical machinery; radio, TV and communications equipment; medical, precision and optical equipment, etc.
Vehicles and transport equipment	Vehicles and transport equipment (considered separately here but sometimes included in above).
Labour-intensive industries	Textiles and garments; leather and leather products; wood and wood products; publishing, printing, etc.; other chemical products; furniture.
Natural-resource-intensive products	Food, beverages and tobacco; paper and paper products; coke and petroleum products; rubber and plastic products; non-metallic minerals; basic metals, basic chemicals.

Source: OECD, based on ECLAC sources (e.g. Katz and Stumpo (2001), “Sectoral regimes, productivity and international competitiveness”, *CEPAL Review*, Vol. 75, pp. 131-52).

On the basis of the OECD classification, there has been a shift in the technology intensity of manufacturing over the decade towards greater concentration in the medium-low-technology category, away from both the relatively slow-growing low-technology industries and the even slower-growing high-technology industries.³ However, there also seems to have been a shift towards industries with relatively high average levels of labour productivity (value added per employee) compared with the much lower levels in both the low-technology and high-technology groups. This may appear paradoxical, but it should be borne in mind that in modern global value chains, industries classified as “high-technology” on the basis of standard international classifications may actually perform low-value-added assembly (often using high-value imported intermediates). In this case these industries do not perform sophisticated work.

In the ECLAC framework, the pattern of structural change is somewhat different. There is again a significant shift away from the labour-intensive (and relatively “low-technology”) industries but it goes in two directions: natural-resource-intensive manufacturing, where the already large share increased by 2010; and engineering-intensive industries, which grew rapidly but from a very low base so that they still accounted for just some 6% of manufacturing in 2010. At the same time, this group of technology-intensive industries had on average the lowest level of labour productivity of all four categories in 2010.

Table 2.5. Change in the sectoral composition of manufacturing production by “technological” categories
Value added in constant 2005 USD

	Value added			Total number of firms 2010*	No. of employees (2010)		Value added (2010)	
	2001	2010	% change		Total *	Per firm	Per firm	Per employee
All manufacturing	16058	27 462	71%	8 643	724 914	84	3.177	37 883
<i>By OECD “Innovation Intensity” categories</i>								
High technology	1 169 (7.3%)	1 613 (5.9)	38%	483	48 128	100	3.339	33 509
Medium-high technology	2 464 (15.3)	4 253 (15.5)	73%	1 315	110 490	84	3.234	38 488
Medium-low technology	4 314 (26.9)	9 151 (33.3)	112%	1 953	154 038	79	4.685	59 405
Low technology	8 112 (50.5)	12 446 (45.3)	53%	4 892	412 258	84	2.544	30 190
<i>By ECLAC sectoral categories</i>								
Vehicles/transport equipment	215 (1.3)	387 (1.4)	81%	18	3 650	203	21.5	106 160
Engineering-intensive	752 (4.7)	1 537 (5.6)	104%	1 157	73 132	63	1.3	21 017
Labour -intensive	6 649 (41.4)	9 775 (35.6)	47%	5 274	398 705	76	1.9	24 518
Natural-resource-intensive	8 442 (52.6)	15 762 (57.4)	87%	2 194	249 427	113	7.2	63 193

Source: Colombia DANE, Manufacturing Industry Survey. (Employment data for 2010 are derived from the EDIT. V, Table C.4.1).

2.3. Framework conditions for innovation

Framework conditions with an important influence on national innovation performance include the macroeconomic and general business environment, government regulation of product and factor markets, and legal and institutional frameworks such as those for intellectual property rights (IPR). There are several reasons why framework conditions are important for innovation performance:

- As economically useful innovation can take a long time to materialise, it requires a steady allocation of resources. This will only happen in a stable, or at least a predictable, economic environment.
- The legal and regulatory framework can play a defining role in determining the attractiveness of innovation relative to other sources of firm profitability.
- The success of explicitly designed STI policies crucially depends on the quality of framework conditions.

Innovation policy is unlikely to compensate for major shortcomings in framework conditions. The economic framework conditions are shaped in part by areas of government policy that may appear to have little connection with science, technology and innovation. But their influence on innovative activity can sometimes exceed that of explicitly STI-related policy measures. In particular, they have a major influence on the effective demand for innovation.

Regulatory environment

Since the introduction of regulatory commissions in the 1990s, the regulatory framework in Colombia has become more predictable, coherent and transparent. Reforms in recent years have aimed for a more professional, transparent and citizen-oriented public administration (OECD, 2013c). According to the National Development Plan 2010-14 (DNP, 2011), the Colombian government has embarked on a concerted effort to reduce the administrative burden and improve the business climate.

Indeed, Colombia has achieved continuous improvement over the previous decade in several areas that affect the business environment. This has led to improvements in a number of the World Bank's *Doing Business* indicators. In 2014 Colombia ranks 43rd overall out of 189 countries (Table 2.6), next to Peru (42). The regional average for Latin America and the Caribbean is 100. Colombia compares favourably with Argentina (126) and Brazil (116) and Costa Rica (102), and is somewhat ahead of Mexico (53) (World Bank and IFC, 2013). Colombia's rank (79) for starting a business is better than some of the comparator countries but nevertheless shows significant scope for improvement. Chile, for example, ranks 22nd. Despite the rapid progress of the past decade, enforcing contracts, paying taxes and getting electricity remain problem areas for Colombia. Trading across borders also encounters important obstacles, principally related to inadequate infrastructure. Overall, while the legal and regulatory environment has improved in various ways in recent years (such as time limits for settling legal disputes, simplification of judicial processes and increased use of ICT in the judicial system), important constraints remain, including a more burdensome bureaucracy than in the average OECD country (OECD, 2013a).

Table 2.6. Doing Business rankings, 2014

Indicator	Colombia	Argentina	Brazil	Chile	Costa Rica	Mexico	Peru
Ease of doing business	43	126	116	34	102	53	42
Starting a business	79	164	123	22	102	48	63
Construction permits	24	181	130	101	82	40	117
Getting electricity	101	80	14	43	47	133	79
Registering property	53	138	107	55	46	150	22
Getting credit	73	73	109	55	86	42	28
Protecting investors	6	98	80	34	170	68	16
Paying taxes	104	153	159	38	136	118	73
Trading across borders	94	129	124	40	44	59	55
Enforcing contracts	155	57	121	64	130	71	105
Resolving insolvency	25	97	135	102	124	26	17

Note: Rankings out of a total of 189 economies.

Source: World Bank and IFC (2013), *Doing Business 2014*, The World Bank/International Finance Corporation, Washington, DC.

A number of changes have facilitated entrepreneurship. Starting a business has become easier over the past decade, in terms of the number of procedures, the time it takes to start a business and in relative cost. Also worth noting are policy efforts to stimulate innovative entrepreneurship, such as the activities supported by MinTIC, Colciencias, SENA and INNpulsA. However, as the recent *OECD Economic Survey* (2013a) notes, there is room for improvement in the regulatory framework for entrepreneurship. In particular, analysis of the OECD indicator on product market regulation suggests that administrative burdens for sole proprietor firms and for some start-ups are higher than in OECD economies (OECD, 2013a).

According to DNP (2011), future reforms will seek to reduce the costs and formalities for social contributions and taxes and to improve co-ordination among agencies in charge of trade procedures in order to reduce time-consuming and costly procedures. Despite progress on regulatory reform, Colombia still lacks a systematic, whole-of-government policy for regulatory quality. The absence of a single institution responsible for regulatory reform is one manifestation of the piecemeal approach to regulatory management (OECD, 2013c).

Competition

Competitive pressure can provide one of the most powerful incentives to innovate. Colombia was among the first countries in Latin America to enact a competition law. In the latter half of the 20th century, the law was less enforced to preserve competition than to apply price controls (OECD and IDB, 2009). Free competition was enshrined as a constitutional right in the 1990s and economic liberalisation was accompanied by the creation of regulatory bodies (telecommunications, water and sanitation, electricity and gas, public services).

According to OECD and IDB (2009), with few exceptions, Colombia's regulatory framework for competition does not differ much from the international norm in terms of the legal provisions defining a dominant position and the rules governing mergers. However, the listing of anticompetitive agreements that may be deemed illegal is too extensive. The study also found that more could be done to ensure the independence of the main competition authority, the Superintendence of Industry and Commerce (*Superintendencia de Industria y Comercio*) from political interference. The 2009 Competition Law is part of an effort to reform institutions and processes affecting competitiveness and provides a new framework. While it is too early to assess its impact, there have already been calls to strengthen it.

Overall, limited competitive pressures on Colombian firms may have significantly constrained the intensity of innovation in some areas. Though no direct measures are readily available, the fact that so many Colombian firms have managed to survive with no or little innovation activity (see Chapter 3) strongly suggests a lack of tendency to compete on these terms. The relatively limited (effective) international openness of the economy and the fragmentation of regional markets probably set limitations that are beyond government regulation. More effective international openness and inter-regional market integration will depend on infrastructure investments. The integration of regional markets will also depend on government policies that facilitate service provision and entry at the regional level.

Public-sector efficiency

A recent study of the effectiveness and efficiency of the public sector in LAC countries, which uses a variety of alternative measures, places Colombia close to the regional average on both dimensions (Afonso et al., 2013). The study finds that countries

with smaller public sectors tend to score better in terms of public-sector efficiency. The Colombian public sector performs comparably in terms of outcomes to those of Bolivia and Uruguay and only lags that of Mexico slightly. However, the difference with Mexico is more marked in terms of the efficiency with which public resources are mobilised and a long way from the regional leaders, Guatemala, Chile and Peru (Afonso et al., 2013).

The government is currently working to increase public-sector efficiency and transparency and has acknowledged the important role of ICTs in this area. Colombia has introduced an extensive e-government (Online Government) programme, which is recognised as one of the most extensive initiatives of its kind in Latin America (OECD, 2012, p. 77). Many services for citizens and businesses are now provided on line. Online services of interest to businesses offered by the programme include one-stop shops, information on regulations, an integrated platform for international trade procedures (International Trade Single Window), judicial records, tax records, payment of social security contributions, import documents for phytosanitary products, certificates of free sale, consultation of patents and an e-procurement system (OECD, 2012). As a result, the programme has helped to remove procedural barriers and facilitated private-sector development, as it has streamlined processes, reduced response times and allowed for more effective control over the quality of information made publicly available (OECD, 2012).

In addition, the platform “urna de cristal” (crystal urn) was developed to increase the transparency of government activities and to serve as a communication channel between citizens and the government. A programme to improve the use of ICTs in the public sector has been set up and an agreement for an e-government innovation centre has been signed between the Ministry and the United Nations Department of Economic and Social Affairs (UNDESA).

Infrastructure

Colombia has relatively little infrastructure compared to other emerging economies. While utility services (water and domestic electricity supply) have improved, extensive investment is needed in transport infrastructure services (roads, railways and ports) (OECD, 2012). Insufficient transport infrastructure is an obstacle to further international openness and to the integration of national markets and represents a productivity penalty for goods producers across sectors. The National Development Plan includes a multi-year investment plan, which is the main tool for determining the country’s infrastructure investment needs. Despite progress in rationalising resources, there is still considerable room for improvement, particularly in planning and monitoring public infrastructure policies (OECD, 2012).

The need for infrastructure investment goes beyond transport. This is well recognised by the Colombian authorities. Four of the “growth locomotives” described in the NDP 2010-14 concern major infrastructure investments (e.g. housing, transport infrastructure, mining and energy production) and in all cases the government counts on private sector co-funding. However private-sector participation in infrastructure development is low⁴ compared to other emerging economies.

Large-scale infrastructure projects have important innovation potential as well. Given the current problems with procurement procedures it may be premature to launch fully fledged demand-side innovation initiatives along the lines seen in OECD countries. Nevertheless, it would be important to raise awareness of the ability of such projects to upgrade innovative capabilities. These investment projects can create a sense of purpose

and chart a path for the development of a vibrant ecosystem of financiers and highly skilled innovative service providers and manufacturers. Large-scale infrastructure projects can provide critical links with international firms and act as potential vehicles not only for investment in physical capital (new mines, roads, refineries, urban transport systems, water supply, sanitation facilities, broadband connectivity) but also for investment in various forms of technological learning to develop and deepen the human capital and knowledge capital of local enterprises.

ICT Infrastructure

A high-speed Internet infrastructure provides a platform for social and economic development and for innovation. Like many OECD countries, Colombia highlights the positive link between Internet access and use and economic development in its “Vive Digital” strategy to develop the Colombian digital ecosystem (see Chapter 4). In 2010 compared to other Latin American countries, the Colombian market had about the size of the Venezuelan telecommunications market, and the two countries ranked after Brazil and Mexico (ITU, 2013). In that year, compared to OECD countries, the size of the Colombian telecommunications sector was between that of Belgium and Poland (OECD, 2013d).

In terms of overall broadband connections (mobile and fixed broadband), growth picked up from 2006 but lags OECD countries. Fixed-broadband penetration was 8% in 2012 and 9% in June 2013, significantly below the OECD average of 26.3% and below the lowest OECD penetration rate in 2012 (10.4% in Turkey) (OECD 2014a, forthcoming)

In addition, a fibre backbone currently being deployed through a public-private partnership is to connect 1 078 municipalities and 96% of the territory by 2014. The rollout to remote municipalities can help close the digital gap between rural and urban areas. While the backbone serves as a high-capacity transport mechanism between municipalities, the next step will be to extend the reach of high-speed access to all businesses and households.

Intellectual property

Intellectual property rights can play an important role in creating a business environment conducive to investment in knowledge. They can provide incentives to invent in fields relating to technology (patents), business (trademarks), the arts and software (copyright), and even a wide variety of traditional sectors (geographical indications). National IP systems can encourage domestic firms to invent, domestic universities to transfer knowledge and foreign firms to implement or license out new technology. IP also determines how easily and efficiently domestic actors in the formal and informal sectors can access knowledge. Universities and public research organisations also use IP instruments to increase the economic impact of their research results as a potential source of income and, more importantly, as a basis of further and deeper collaboration with industry.

To briefly describe Colombia’s IP system (see OECD, 2014b for a detailed assessment), Colombia is a party to several international agreements to protect IPR and is actively engaged in related bilateral and multilateral negotiations (OECD, 2012). The current authority for industrial property is the Superintendence of Industry and Commerce (SIC), which also deals with competition regulation. It is in charge of industrial policy, the *Instituto Colombiano Agropecuario* of plant variety protection and the *Oficina de Derechos de Autor* of copyright.

Recent initiatives to improve Colombia’s IP system have helped improve its quality (e.g. adoption of measures to reduce backlogs, granting IP offices jurisdictional powers to improve enforcement). To strengthen IPR protection under its WTO obligations and free

trade agreements, Colombia has strengthened customs controls and increased the severity of sanctions for IPR breaches. Nonetheless, some long-standing implementation problems persist. Colombia should remain committed to these reforms so that the IP system becomes an effective incentive for innovation. The overall impact of the IP system on innovation will also depend on the co-ordination of IP policies and innovation policies.

Further policy steps are needed to ensure greater uptake of IP instruments and to ensure that the IP system serves a broad range of innovators. In Colombia, firms and research institutions rely less on patents, trademarks, design rights and utility models to protect their inventions than in most OECD countries and in some of its more advanced regional neighbours. Only a few actors, in certain universities and large advanced firms, are in a position to file for international patents. A lack of skills, a weak research infrastructure and barriers that hinder firms' operations also contribute to Colombia's weak performance in terms of intellectual property.

Regarding the uptake of IP by universities for commercialisation, since public officials cannot have sources of income other than their salary, researchers of public universities in Colombia cannot participate in spin-offs. This has hindered several public universities from developing commercial applications based on their IP. Private universities also need to address the question of spin-offs, as the law on non-profit organisations stipulates that they cannot create for-profit activities. Steps undertaken to address regulatory constraints faced by researchers should be continued.

2.4. Innovation performance

Innovation inputs

Starting from a very low level, gross domestic expenditure on R&D (GERD) has grown strongly, more than quadrupling in nominal and per capita terms over 2003-11 (Table 2.7). The period coincided with strong economic growth. By 2012 GERD as a percentage of GDP (commonly referred to as national R&D intensity) stood at 0.17%. Though R&D intensity also grew during that time, it grew more moderately and has slowed in the last five years. The pattern is the same for expenditure on scientific and technological activities (STA)⁵ as a percentage of GDP. In 2010, the Colombian government set a target of 0.5% of GDP invested in R&D by 2014. Despite the additional resources from the new STI fund based on mining royalties (see Chapter 4), this target is likely to be missed. While the royalties funding system can contribute significantly to improving the capacity of the STI system, it cannot, on its own, allow Colombia to catch up with the expenditures of its more advanced neighbours. Over time, additional investments in STI by the "normal" budget will be needed.

Table 2.7. Colombia's gross domestic expenditure on R&D and science and technological activities
Current prices 2003-12

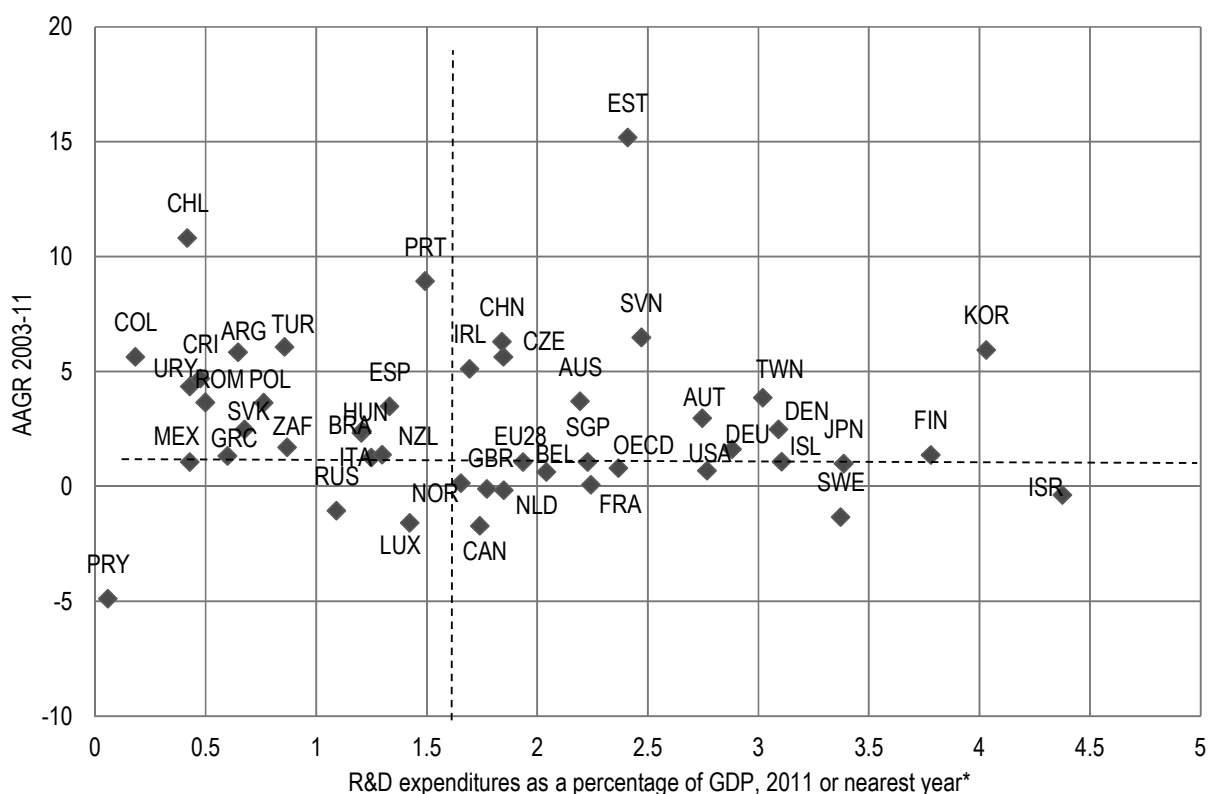
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
In million USD	132.9	166.4	210.1	230.6	353.7	443.8	416.1	518.4	615.4	637.1
GERD per capita	3.2	3.9	4.9	5.3	8.1	10.0	9.3	11.4	13.4	13.7
STA % of GDP	0.35	0.39	0.42	0.38	0.44	0.47	0.44	0.46	0.47	0.45
R&D % of GDP	0.14	0.142	0.143	0.142	0.171	0.182	0.178	0.181	0.185	0.173

Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá, pp. 18-19.

Figure 2.8 plots national R&D intensity against its average annual growth rates for 2003-11. OECD averages for these two indicators are marked with dashed lines. Colombia's national R&D intensity is well below the OECD average of 2.36% and, according to RICYT, was about one-quarter of the regional average in 2010. Naturally, R&D intensities partly reflect the level of economic development, and other types of innovation expenditure can be more profitable at earlier stages.⁶ Nonetheless, R&D remains a peripheral activity in Colombia, even relative to countries of similar income per capita. Brazil (1.21%), Argentina (0.65%), Mexico (0.43%) and Chile (0.42%) all had considerably higher R&D intensities.

At 5.6%, the increase in national R&D intensity over the period was strong, but not as strong as that of some other developing countries. For instance, Chile (10.8%), Argentina (5.8%), Turkey (6.1%) and China (6.3%) all experienced stronger increases, even though they started from higher levels of R&D intensity.

Figure 2.8. R&D intensity, 2011 level and average annual growth rate 2003-11, selected countries



*Latest figures in brackets: Australia (2010), Chile (2010), Ecuador (2008), Greece (2007), Iceland (2009), Netherlands (2010), Switzerland (2008).

** Chile 2008-10; Paraguay 2003-05; South Africa 2004-09. Peru and Ecuador omitted owing to a lack of continuous data.

Source: OECD (2013e), *Main Science and Technology Indicators Database*, www.oecd.org/sti/msti; and RICYT.

Strengthening innovation in the business sector would be an essential part of industrial development policy in order to increase productivity, position Colombia in higher-value segments of global production chains, foster diversification and reduce reliance on commodities. Indicators on the distribution of expenditures between the public and the business sectors and the flows of funds between the various actors of the system give an overview of the progress made in building a business-centred innovation system. Two observations immediately stand out. The first is that businesses account for a minority of both R&D and other STI expenditures. This is not surprising, as building a business-centred innovation system is a formidable challenge. The second, and more striking, observation is that, despite the policy commitment to innovation, only a small share of public resources, particularly for R&D, appears devoted to strengthening business innovation.

At around 30%, the proportion of GERD financed by the business sector is not only well below the OECD average but also low compared to other Latin American countries (Figure 2.9). Government organisations provide 1.69 times more funds for STA activities than firms (Table 2.8). The relatively low involvement of the business sector in Colombia's innovation system is more evident in terms of BERD as a percentage of GDP (Figure 2.10). It amounted to 0.04% of GDP in 2011, whereas total OECD BERD intensity was 1.57%. Businesses in Brazil (0.55%), Mexico (0.17%), and Chile (0.16%) also invested relatively more. The low level of resources committed to business innovation reflects certain features of the Colombian business sector, notably the prevalence of small and inward-oriented firms. Moreover, it may indicate a lack of competitive pressure in Colombian firms. In markets with restricted competition, firms rely less on innovation to ensure their survival.

Table 2.8. Expenditure on science, technology and innovation activities (STIA)

Million COP, 2011 prices

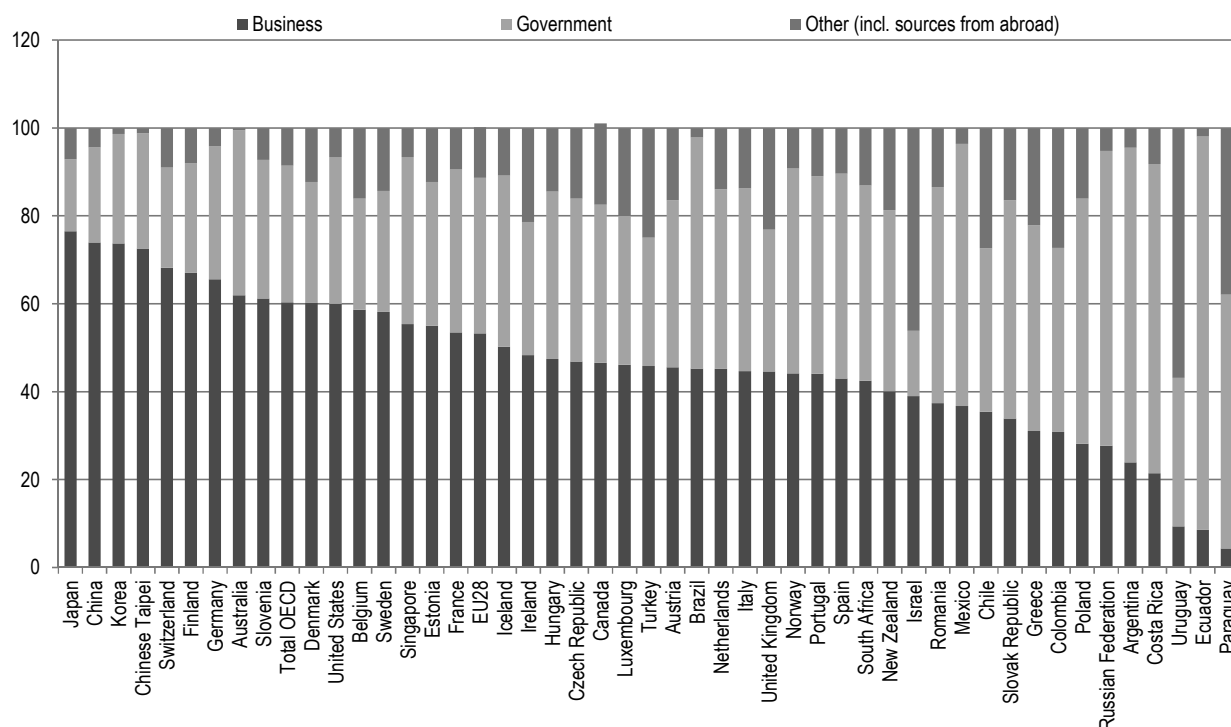
<i>Funding →</i>									<i>Total performed</i>
<i>Performing ↓</i>	Government organisations	Firms	HEIs	International	R&D centres	Hospitals and clinics	Private and non-profit organisations that serve firms	NGOs and professional associations	
Firms	227 211	716 276							943 487
Government organisations	759 112	49		13 255					772 416
HEIs	195 967	111 304	282 656	46 314					636 241
R&D centres	258 342	37 895		14 009	75 845				386 092
Hospitals and clinics	18 280	22 610		110	284	33 975			75 258
Private and non-profit organisations that serve firms	42 653	4 687		3 946	82		16 301		67 669
NGOs and professional associations	14 075	5 261		4 956	1 570		4	11 910	37 775
Total funded	1 515 640	898 082	282 656	82 590	77 781	33 975	16 305	11 910	

Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá, p. 22.

The fact that 20% of business funding for STA activities was allocated to non-firm performers (half of it to higher education) is encouraging, as it suggests at least some degree of articulation in the system. Similarly, information on shares of R&D funding by industry, supplied by OCyT, suggests that industry accounts for about 10% of funding for higher education institutions or for research and technological centres. Taken at face value, this share appears encouraging, though it likely reflects the concentration of R&D funding in a few institutions set against the low levels of R&D expenditure nationally.

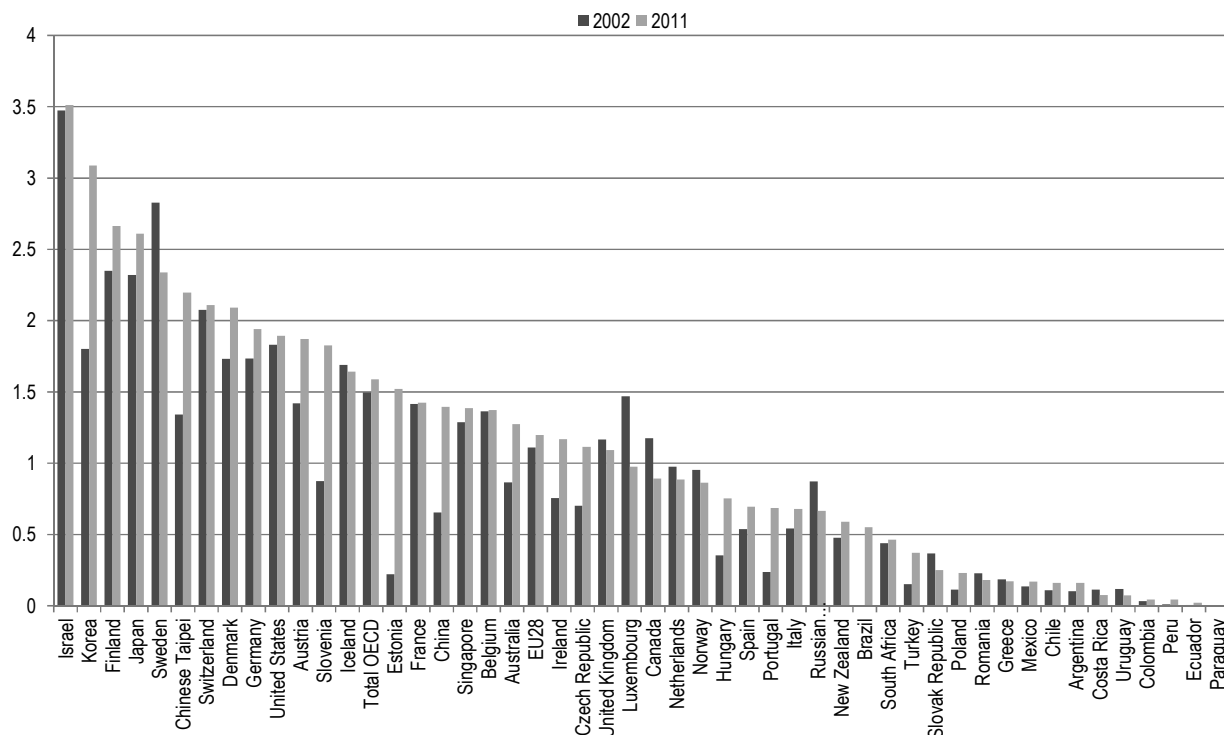
Past studies have highlighted the scarcity of interactions between different types of actors in Colombia's innovation system. Monroy Varela (2006) found that while the universities and public research organisations were familiar with the STI policy framework, business owners were mostly unaware of it. That study, along with that of Malaver Rodríguez and Vargas Pérez (2006), showed that interactions between different types of agents are scarce. Table 2.8 confirms this feature of the Colombian system: most STI activities are funded by institutions of the same type and government organisations in particular seem insulated from the business sector.

Figure 2.9. R&D expenditure by source of financing, as a percentage of national total, 2011 or nearest available year*



*Latest figures are from 2010 for Chile, France, Germany, Italy, Portugal and Spain; 2009 for Belgium, Iceland, Israel, the Netherlands and South Africa; 2008 for Australia, Ecuador and Switzerland; 2005 for Greece.

Source: OECD (2013e), *Main Science and Technology Indicators Database*, www.oecd.org/sti/msti; RICYT and OECD Secretariat estimates based on RICYT.

Figure 2.10. BERD intensity, selected countries, 2002 and 2011, or nearest available years

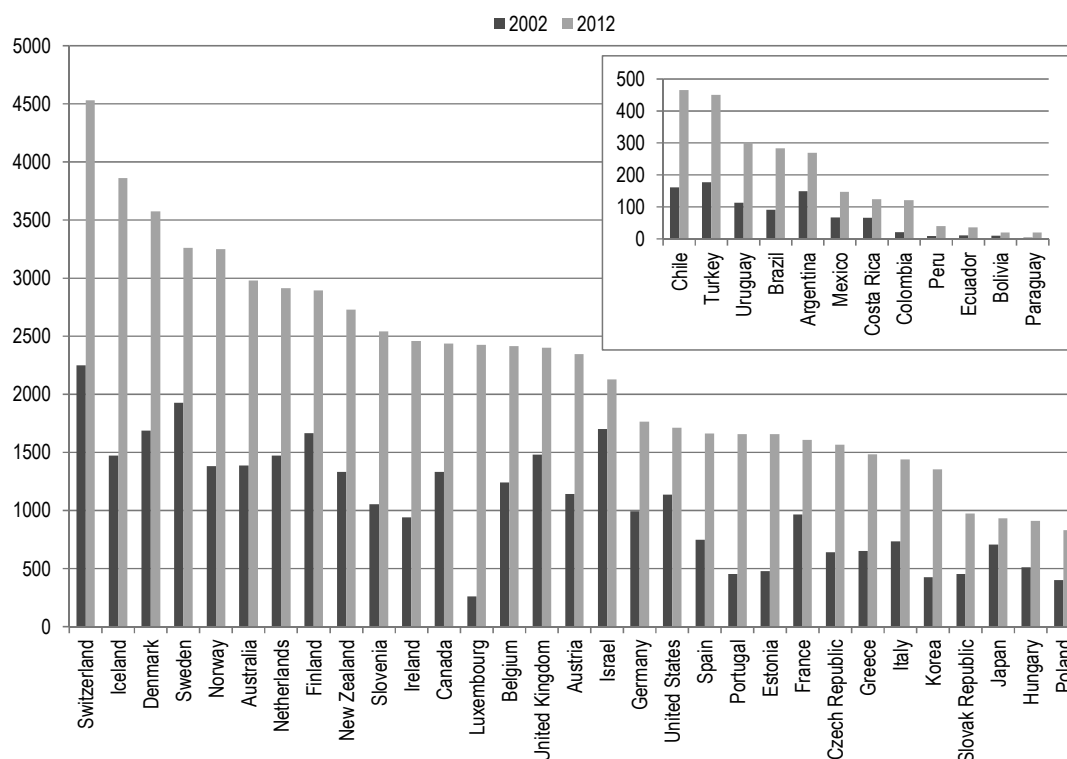
Note: Australia: 2010, Chile: 2007 and 2010, Greece: 2007, Iceland: 2009, Luxembourg: 2003, Netherlands: 2010, New Zealand: 2003, Sweden: 2003, Switzerland: 2004 and 2008, South Africa: 2003 and 2009.

Source: OECD (2013e), *Main Science and Technology Indicators Database*, www.oecd.org/sti/msti; and OECD Secretariat estimates based on RICYT.

Innovation outputs

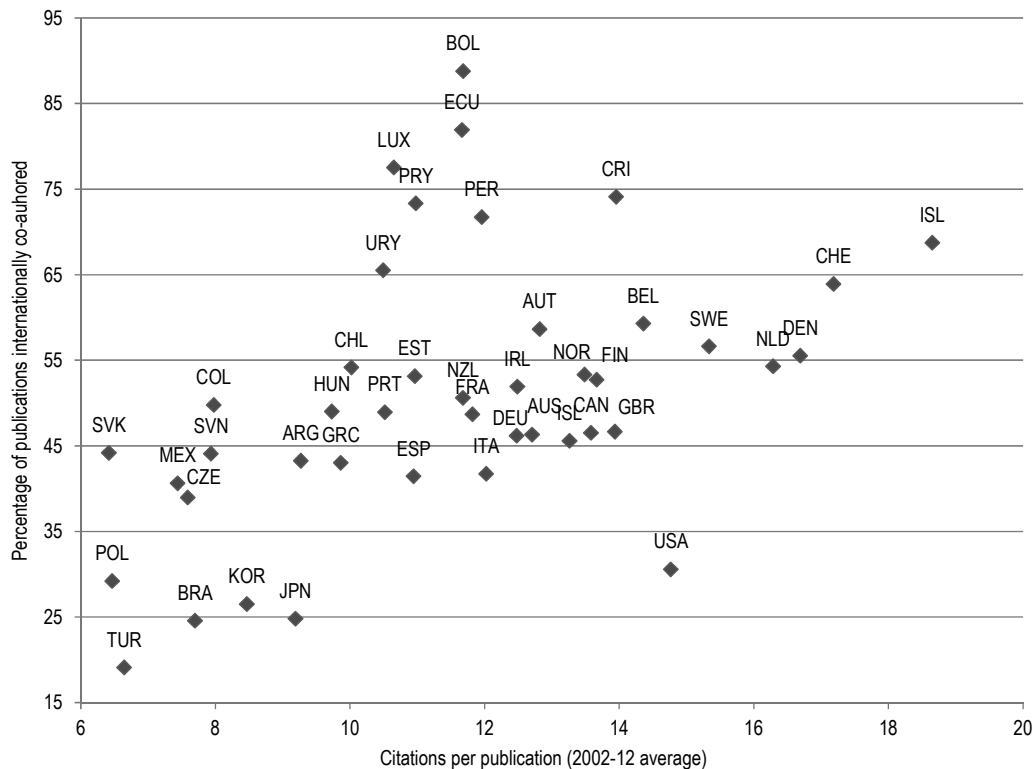
The output of innovation is notoriously difficult to measure. Existing indicator frameworks inevitably rely on partial and imperfect proxies, such as scientific publications and patents. Despite obvious disadvantages, these measures can be compiled in ways that are comparable across countries and are by definition related to scientific or technological novelty.

Two measures of national scientific output based on scientific publications suggest that Colombia's performance is weak. An international comparison by the IDB (2010) based on a normalised measure of publications in the ISI database, suggests that, with a normalised score of four, Colombia is about two-thirds as productive as Latin America overall and well under the OECD average of a little less than nine. Figure 2.11 uses scientific publications per million population in the Scopus database to confirm Colombia's lagging position. Nevertheless, the number of publications per inhabitant has increased rapidly during the past decade. The distribution of bibliometric output by university (see Chapter 3) suggests that research capacity is highly concentrated, with six universities (out of a total of 81) accounting for over 60% of international publications over 2000-11.

Figure 2.11. Scientific publications per million population, 2002 and 2012

Source: Scimago Journal and Country Rank and OECD, obtained from OECD IPP.Stat.

The percentage of internationally co-authored scientific publications is an indication of international linkages. These raise the visibility of national science, provide significant learning opportunities and support international knowledge transfer. In addition, citations per publication provide a measure of the relevance and international impact of the country's research system. Colombian science has become increasingly internationalised over the past decade (Chaparro, 2013). While the level is low compared to most countries it is similar to that of other countries in Latin America. Figure 2.12 shows the positive correlation between the percentage of internationally co-authored publications and the amount of citations per publication. About half of Colombia's scientific publications are internationally co-authored, higher than the regional average. This may be partially due to the fact that many of the country's PhDs completed their degrees abroad. It also likely reflects the increasing integration⁷ of Colombian research teams in international scientific networks.

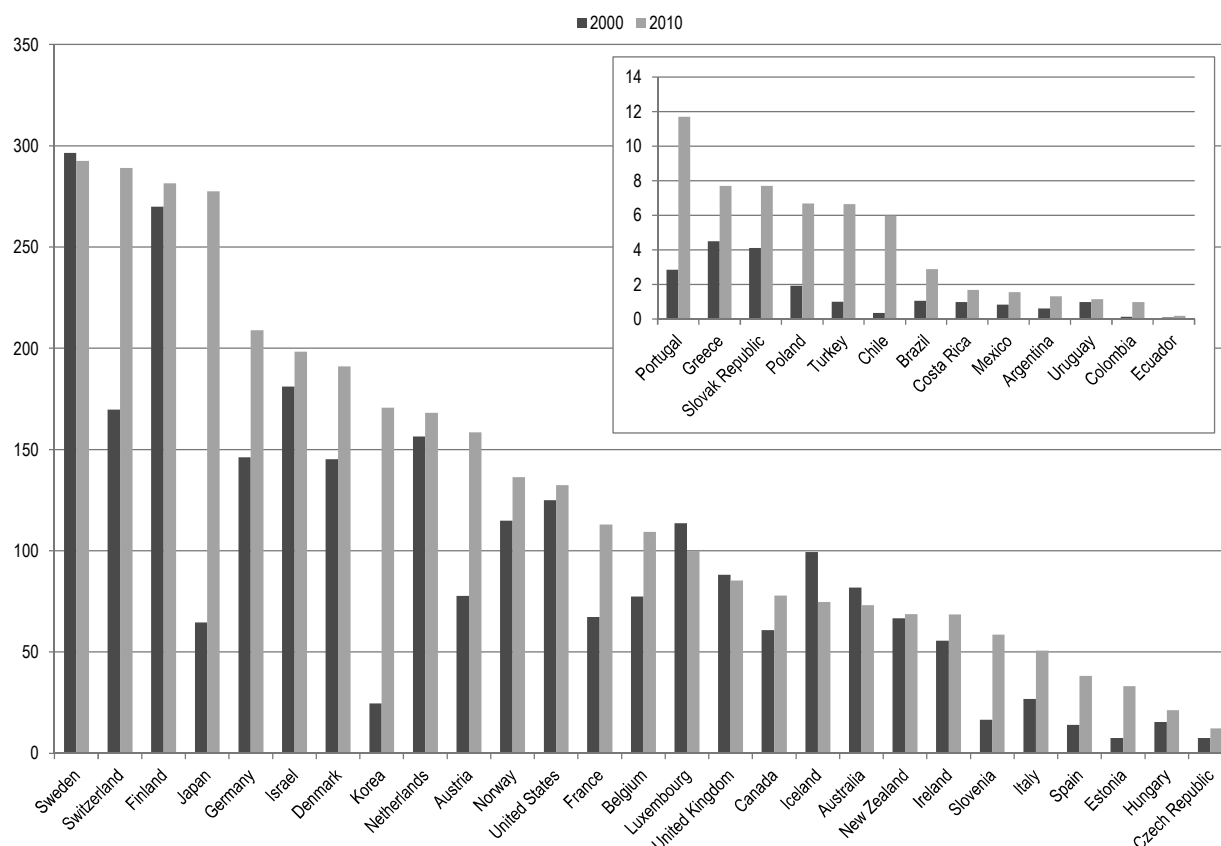
Figure 2.12. International co-authorship and citation impact

Source: Scimago Journal and Country Rank, obtained from OECD IPP.Stat.

Figure 2.13 shows Patent Cooperation Treaty (PCT) applications. The PCT system allows simultaneous filing in patent offices in 148 countries, and therefore dissemination of inventions on a global scale. PCT patent applications provide an internationally comparable proxy for inventive activity that is potentially new to the world. An evaluation of national PCT output may make it possible to appreciate how close inventive activity is to the global technological frontier and therefore the ability of the business sector to compete and collaborate at that level.

In 2010 Colombia applied for about one PCT patent for every million inhabitants (Figure 2.13). While this figure increased since 2000 (0.14), it is still very low by international standards. The 2010 average for OECD countries was 120.93. Colombia's recent performance on this indicator also lags that of Latin American countries such as Chile (5.98), Brazil (2.90), Costa Rica (1.69), Mexico (1.55) and Argentina (1.31). Colombia's poor performance on this indicator is in keeping with the low amounts of R&D expenditure. The share of internationally co-invented PCT patents has fluctuated between a third and a fifth and shows no clear trend over time.

Figure 2.13. PCT patent applications per million population, 2000 and 2010



Source: Scimago Journal and Country Rank, obtained from OECD IPP.Stat.

Patent applications to the national office by non-residents can be suggestive of international expectations regarding the development of the domestic technology market. Each application portrays the interest of a foreign agent (including firms) in exploiting a technology in the domestic market that is protected by national law. In Colombia, such applications only increased by 2.7% during 2000-10. In contrast, Brazil had an increase of about 40% in the same period and Mexico close to 8%.

Patent applications to the national office by residents provide an indication of new-the-country technological innovation. During 2000-10, national applications by residents increased in Colombia by 77.3%, faster than in Chile (36.1%) and Brazil (-12.2%). However, this occurred from a low starting point and the number of Colombian patents remains small.

Collectively, the above indicators suggest that Colombian technological performance is improving, albeit slowly. There remains much room for progress before Colombia's technological development capabilities are internationally relevant.

2.5. Reorienting long-term paths of economic development: The role of innovation

Colombia's economic history and the emerging signs of its future make clear the importance of increasing innovation to raise productivity growth not only in manufacturing and agriculture but also in services, an area in which progress has been weak. It will be especially important in infrastructure and transport services, which affect the competitiveness of other sectors.

Innovation will also help to enter new activities as part of a process of economic diversification. New skill-, capital- and knowledge-intensive activities will add to the productivity growth achieved through rising efficiency in existing activities. Innovation-driven diversification into higher-value-added production will be required to sustain employment growth in a commodity-intensive economy with a tendency towards an appreciating currency. It can also sustain income and employment growth in the steadily rising urban population and expand the range of agricultural products produced in rural contexts. Agricultural diversification will be especially important as trade agreements with the United States and other important international partners come fully into play, putting competitive pressures on some types of agricultural production while creating new opportunities for others. It will also be an important part of the changes needed to improve rural livelihoods following the hoped-for cessation of rural conflict and insecurity. More broadly, mechanisms will be needed to link social needs, not only market demands, to innovation processes.

Finally, innovation can help to tackle societal challenges more effectively. Innovation across the spectrum – from incremental improvement to radical novelty – will be required to raise the environmental sustainability of growth, especially in view of Colombia's immensely rich biodiversity. It will also be needed to achieve the required incremental and radical adaptations to the rising stresses of climate change, notably on the eastern coastline of the tropical Pacific Ocean.

Notes

1. Colombia's position in Latin American inequality at the end of the decade is also reflected in a range of other inequality indicators (ECLAC, 2011, Figure 1.9, p. 51).
2. The ECLAC framework was an extension of earlier analysis of Latin American experience that identified commodity industries based directly on natural resources (e.g. mining, petroleum, export-oriented agriculture) as being technologically mature: they had limited internal innovative dynamism, and provided few inducements for innovation in other sectors. The extension of these ideas in the 1990s applied similar arguments to manufacturing industries that were indirectly linked to the natural-resource-based industries. These too were characterised as technologically non-dynamic and transmitting few impulses to innovation in other sectors. Instead, it was argued, the technologically dynamic components of manufacturing were concentrated in the machinery and engineering industries, and especially in the parts of those industries that were connected most directly with electronics and information technology.
3. Colombia's small high-technology category includes only some of the industries present in advanced country contexts: pharmaceutical products and a number of 3-digit industries covering office machinery, electrical and electronic equipment, instruments, etc.
4. OECD (2012) has made a number of recommendations in this direction along the lines of *the OECD Principles for Private Participation in Infrastructure*. See: www.oecd.org/daf/investment/ppp.
5. STA – an indicator developed by UNESCO that is commonly used in Latin America – captures expenditures on a much wider set of knowledge activities than R&D, such as expenditure for S&T education. It is defined as “systematic activities which are closely concerned with the generation, advancement, dissemination, and application of scientific and technical knowledge in all fields of science and technology. These include such activities as R&D, scientific and technical education and training (STET), and the scientific and technological services (STS).” (OECD, 1995, p. 67)
6. Naturally, this concerns the opportunity costs of (usually public) R&D expenditure, not the desirability of R&D in general. In the case of a well-governed and business-centred system, strong arguments can be made for increasing R&D expenditures earlier in the development process as part of a balanced portfolio of innovation inputs, arguments that are to some extent backed by the industrialisation experience of Asian countries.
7. A bibliometric analysis performed for the review using the Thomson Web of Science database (Chaparro, 2013), shows that during 2001-07 the number of internationally co-authored articles increased at about the same rate as national co-authorship. In 2008-10 international co-authorship increased at a faster pace than national co-authorship. This suggests a distinct process of integration in international scientific networks, rather than just an increase in the incidence of co-authorship.

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Chapter 3

Innovation actors in Colombia

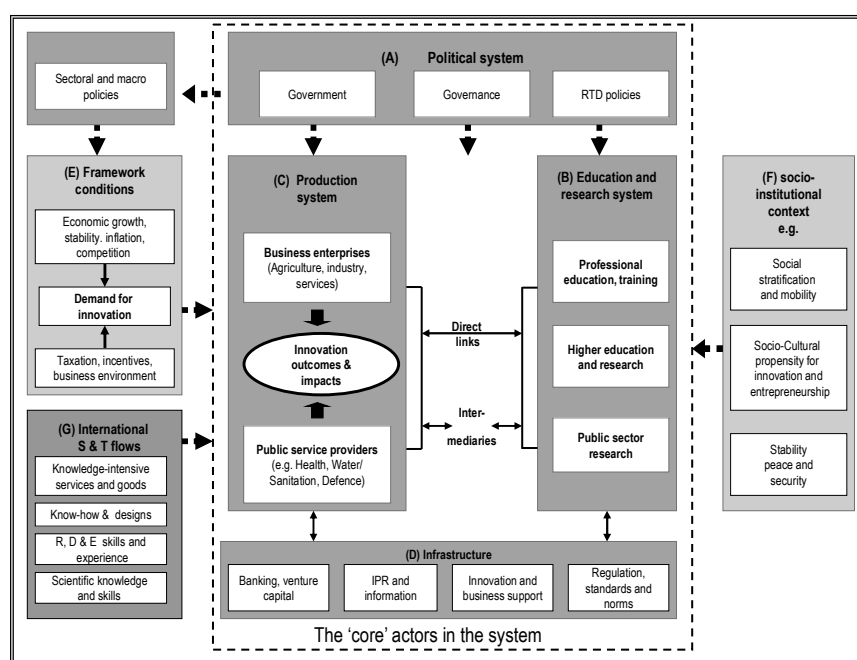
This chapter describes the main actors in the Colombian innovation system – business enterprises, agriculture, the organisations that make up the emerging ICT sector, higher education institutions and public research institutes – highlighting their respective roles in the development of the innovation system in recent years. It looks first at the overall innovation system in which these organisations are embedded and then reviews scientific, technological and related functions carried out by the main actors within the system and their contributions to innovation. The final section focuses on human resources for science, technology and innovation, which play a critical role in further developing Colombia's economy. Related policies have to take into account current and emerging needs, especially of the business sector.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

3.1. Innovation systems and innovation actors

Some reports and data sources identify the national science, technology and innovation (STI) system in Colombia primarily (and sometimes only) in terms of the public-sector actors that engage in STI activities. In this definition – which differs from that used in this review – the system would have three main components: the government organisations formally mandated to deal with the governance and funding of STI activities (Figure 3.1, Box A); the public and quasi-public organisations that provide STI-related education and training or undertake research or development activities (Box B); and the public-sector parts of what is often described as the STI “infrastructure” (Box D). These last include the organisations responsible for regulations, standards and norms that relate to STI activities; agencies that provide elements of support for business and business innovation; those that deal with procedures and regulations concerned with intellectual property and associated information services; and public components of commercial financing for innovation such as credit subsidies or risk underwriting.

Figure 3.1. A national innovation system heuristic



Source: OECD, based on Kuhlmann S. and E. Arnold (2001), “RCN in the Norwegian Research and Innovation System”, Background Report No 12 in the Evaluation of the Research Council of Norway, Oslo: Royal Norwegian Ministry for Education, Research and Church Affairs.

OECD countries rarely take such a narrowly “public” view of national STI systems, and broader perspectives are also quite common in Colombia. However, owing perhaps to government’s historical involvement in S&T policy, there is a strong emphasis on the system’s public components in policy debate and policy practice. For example, Law 1286 of 2009 sought not only to change the status of Colciencias within the government structure but also to strengthen the national STI system. It primarily addresses the strengthening of the system’s public components and makes little reference to business enterprises.

More common system perspectives both in OECD countries and in Colombia give a prominent place to organisations that may engage in innovation alongside their primary activity as producers of goods and services (Box C).¹ Frequently, these are private-sector business enterprises in agriculture, services and industry. While these are central actors in the innovation system, so are public-sector producers of a wide range of services: services to individual consumers (e.g. personal health-care services); infrastructure services to communities (e.g. water and sanitation services); and services at the national level (e.g. security and defence). Innovation in these areas is often omitted from innovation system frameworks although it contributes substantially to the total innovation “output” of a national system and hence to the system’s overall socioeconomic impact.

A framework that includes components (A), (B), (C) and (D) helps policy makers to identify key characteristics of the overall structure in which the different actors are embedded and to identify their relative contributions to activities such as R&D or the interactions between actor categories, e.g. between business enterprises and public research organisations. Later sections of this chapter therefore describe the main actors in the Colombian innovation system and examine some of their structural characteristics.

In developing and emerging economies it is particularly important to understand not only the current characteristics of actor-centred structures but also the ways in which they are changing – or not changing – over time. How are the relative R&D roles of business enterprises, universities and public organisations changing? How are the innovation-related interactions between universities and enterprises changing? However, the limited data available make it difficult to explore the dynamics of these changes.

National conditions influence the activities of the core actors (Boxes A-D) in innovation systems and affect the nature and effectiveness of government strategies and policies. It is common to distinguish between contextual conditions that are essentially economic, often described as framework conditions (Box E), and those that involve “softer”, but no less influential, socio-institutional features (Box F). The international dimension of national innovation systems typically has relatively low priority on the STI policy agenda and is commonly omitted from innovation system frameworks. Of course, the flows of scientific knowledge and technology from international sources (Box G) play an extremely important role in domestic innovation systems.

All innovation system frameworks suffer from simplifications and omissions. Two of these are particularly important in the case of the framework outlined in Figure 3.1: sector diversity within national innovation systems and the incorporation of STI-related functions.

First, Figure 3.1 omits all sectoral differentiation from the actor categories. This is an important gap because one of the most useful insights to emerge from the analysis of innovation systems is that no type of innovation process is efficient for all sectors. Instead, there is considerable diversity in the relative importance of the different actors, the interaction between them, the types and sources of knowledge they use, and the forms of innovation they develop and implement. These differences reflect different ways of innovating that are effective and efficient in different sectors, value chains or clusters. Effective innovation styles also change with stages of development. As sectors and companies approach the “technology frontier”, their knowledge needs and relationships with extra-mural knowledge and research change. The implication is that for many types of policy purposes a “national” innovation system may not exist except as an aggregate of sector systems. National STI-related policy may need to be differentiated to deal effectively with this diversity. This issue seems insufficiently emphasised in Colombia.

Second, in Figure 3.1 the core of the system only concerns organisations (enterprises, universities, public research centres, etc.) and ignores STI-related functions (e.g. research, education and training, or technology development). It is difficult to incorporate the functional dimension because functions are not neatly aligned with organisations: universities perform many STI functions and technological development may take place in several types of organisation. This may be less obvious for functions such as developing STI-related human resources, which are commonly viewed almost exclusively as the province of specialised education and training organisations. Yet important innovation-related human capital emerges from the research process in universities and is created in firms and by investment on the part of firms. This issue, which is also insufficiently emphasised in Colombia, is discussed below.

Even when the functional dimension of innovation system frameworks is taken into account, some important functions may be under-emphasised or ignored. This is commonly the case of the design and engineering functions that create the specifications (designs, plans or configurations) of the technological or organisational changes that are at the heart of innovation. They include the work of: architects who determine the specifications of buildings and other elements of the built environment; engineers who set the specifications for infrastructure facilities such as roads, railways, docks and airports; mining or petroleum engineers who design the plans for mining operations or the drilling configuration for oil wells; and designers and engineers who produce the specifications for manufactured products such as automobile bodies, agricultural machinery, garments or chocolate bars. Some of these design and engineering (D&E) activities are an integral part of R&D and are implicitly included in innovation system frameworks as part of “D”. But much of D&E takes place in the absence of a close connection to R&D and is typically omitted from innovation system frameworks.

Some OECD countries see this omission as a matter of considerable importance, in part because the role of D&E activities and capabilities in innovation is better recognised. It is also because of the growing awareness of the scale of resources committed to these activities. As Table 3.1 shows, more scientists and engineers in the United States in the early 2000s were engaged in various kinds of “design” activity than in R&D. Similarly, a recent UK study estimated that expenditure on “architectural and engineering design” was equivalent to 2.7% of GDP compared to 1.7% for R&D (Galinda-Rueda et al., 2010)

Table 3.1. The main activities of scientists and engineers in the United States, 2003

Types of scientific and technological activity	Proportion of all scientists and engineers
Research and technological development	10%
Design (of equipment, processes, structures, models, plus computer programming and systems development, etc.)	13%
Management/supervision, (of people, projects, quality, productivity, etc.)	19%
Business, administrative and production activities (in accounting, personnel, sales, maintenance, etc.)	21%
Professional services, teaching and other	37%
All above	100%

Note: Scientists and engineers are personnel with degree qualifications in science and engineering disciplines and/or employed in scientific and engineering occupations.

Source: US NSF SESTAT, aggregated from more detailed categories in the original.

Yet STI-related policy often pays enormous attention to developing and strengthening R&D activities and capabilities and little or none to D&E. The absence of relevant statistical and other information is an obvious obstacle to giving it more prominence in the policy agenda (see discussion below).

3.2. Business enterprises

Business enterprises in innovation systems

The review of Colombia's overall innovation performance in the previous chapter suggested that the development of innovative activity in business enterprises had not been strong over the last decade. As the development of an innovation system has been a subject of public policy in Colombia since at least the 1960s, it is useful to consider the role of the business enterprise component of innovation systems in other countries over similarly long periods of time. The basis for such an overview is now substantial. A large body of information has been accumulated about the role of business enterprises and other actors in innovation systems. It encompasses a spectrum from rich case studies to extensive and comparative analyses of national-level innovation surveys, and it spans advanced, emerging, transition and developing economies.

A message that has clearly emerged is the importance of multiple actors and the links among them in generating many types of innovation. However, other important generalisations can be drawn about the specific role of business enterprises in this respect:

- First, most of the innovation implemented in enterprises is driven by their own in-house activities, without significant inputs from actors such as universities or research institutes. In both technologically advanced and developing economies, this is what drives improvements in performance along cumulative paths of relatively “incremental” steps of product/process upgrading and adaptation. It also plays a significant role in ensuring the dynamic absorption of technologies imported from elsewhere.
- Second, a large share of the innovative activities of enterprises occurs as a result of ideas and knowledge gained through network interactions, primarily with other enterprises, especially suppliers and customers, which are incorporated into their innovation processes. Instead, links between enterprises and universities and R&D institutes account for relatively small proportions, though these are sometimes qualitatively very important.
- Third, whether enterprises collaborate with other enterprises or with universities or research institutes, a critical basis for the relationship is the complementary existence of the enterprises' own innovative activities and capabilities. Innovators seem to interact with innovators; without this complementarity innovation networks tend to be thin or non-existent. Various kinds of supply chains thus play an important role in innovation.
- Fourth, intra-enterprise innovation activities are not merely necessary complements to externally sourced inputs to innovation. They are often the initial drivers of the search for links to external sources of knowledge. Internal activities such as design, engineering, technological development and research, and the innovation capabilities on which they rely, generate demand for externally sourced knowledge inputs.

Enterprise-based innovation activities play a central role in the functioning of effective innovation systems in the short term and in their long-term development. Moreover, the evidence suggests that specialised research organisations and technology development centres can only “push” very limited amounts of relatively simple innovations into production enterprises unless they are themselves active innovators and have a demand for knowledge from other system actors.

It is therefore not surprising that enterprise innovation differs across the spectrum from technologically dynamic, high-income to less technologically dynamic, lower-income economies, although differences in the structure of the economy and in country-specific patterns of institutional development also play a role. This is evident in the differences between higher- and lower-income European countries in terms of the share of firms identified as active innovators in innovation surveys. It is also apparent in the differences in the share of R&D performed by business enterprises: 65-75% in Japan, Finland and the United States, 50-55% in Spain, Canada and South Africa, 20-40% in Latin America and the Caribbean, and 10-20% in most African countries.

Over the last half-century, the structure of innovative activity in many developing countries has shifted. Initial efforts to strengthen innovation capabilities in the 1950s and 1960s and even earlier in several Latin American countries, typically concentrated on developing R&D capabilities in public or quasi-public organisations such as universities and central research institutes. Subsequently, R&D activities in business enterprises increased in importance. In some cases these structural transitions have been extremely slow, especially in Latin America, but in others they have been very rapid. A striking feature of the faster-growing Asian economies over the last 40 years has been the speed at which R&D performed by business enterprises rose from 30–40% of total R&D in the 1970s to around 65-75% in recent years. These structural changes have occurred at somewhat different rates and in different ways: by a relatively gradual evolution over more than 30 years in Chinese Taipei, by a more rapid evolution over about 20 years in Korea, and by a radical deconstruction and re-shaping of the centralised system in the People’s Republic of China.

Singapore is an exception to this pattern in that it did not initially create a substantial structure of centralised public R&D institutes. It chose instead to concentrate on strengthening innovation capabilities in business enterprises. Consequently, in the late 1970s when total R&D was still only around 0.2% of GDP, private enterprises accounted for more than 60%. The share fell a little during the 1980s as public expenditure on R&D in universities and specialised institutes grew rapidly to support the increasingly advanced innovative activity of enterprises, but it quickly returned to its previous level and has remained at 60-70% for the last two decades.

Colombia has taken faltering steps along the more evolutionary path of structural transition. By the end of the 1990s, enterprise-performed R&D had increased to around 30% of total R&D. Since then, as suggested in Chapter 2, the main changes have been as follows:

- The proportion of total Colombian expenditure on S&T activities accounted for by firms fell from nearly 45% to less than 35%.
- The share of R&D accounted for by business enterprises fell to around 25% by 2002-03 and remained at more or less the same level in 2011-12.
- The share of government funding of S&T activities increased, and the government doubled its relatively small share as performer.

- Government's share of R&D funding rose from 35% to 45% and the share of R&D performed by public or quasi-public research and technology development centres increased from 22% to 28%.

In relative terms, the weight of responsibility for Colombia's innovative activities seems to have been shifting from enterprises to government and quasi-government bodies. In effect, if the statistics reflect reality (see below), Colombia has been moving in the opposite direction from that followed by some of the more dynamic Asian economies in the late 20th century.

Enterprise innovation in Colombia: an overview

It is important to take account of several limitations on the available information to analyse business enterprise innovation in Colombia. Two of these exclude from the analysis a very large share of Colombian business enterprises. Although such exclusions exist in most countries, the extent and significance of what is left out may be very great.

- The first is the sectoral scope of the main sources of statistical information. Data about R&D and more general scientific, technological and innovation activities are assembled from two sources: the innovation surveys of the National Administrative Department of Statistics (DANE) that currently only cover manufacturing² industry and the survey of universities, research and technology development institutes, central government organizations, NGOs, and hospitals and clinics by the Colombian Observatory of Science and Technology (OCyT). This means that information about business enterprises is restricted to manufacturing, which only accounts for around 14% of GDP. Innovation by business enterprises in services, construction, the utility industries, mining and (partially) agriculture is typically not very R&D-intensive but is extremely important.
- The second is the kinds of enterprise included and excluded. Micro-enterprises in the informal economy are not covered, largely because the sectors with the most informal enterprises (agriculture and services) are excluded. Even for manufacturing, informal enterprises are not covered and firms with fewer than 10 employees are not included in the DANE innovation surveys.

Very few Latin American countries report expenditure on S&T activities other than R&D separately. This section therefore focuses on R&D expenditure and on innovation by enterprises in the formal sector of manufacturing industry. While Colombia has increasingly used innovation surveys to assess a range of innovation activity beyond R&D, it has also not been possible to compare Colombian data with other innovation survey data.³ More generally this section offers very little comparison of Colombia with other countries, owing to the lack of internationally comparable statistics (except for R&D).⁴

As seen in Chapter 2, firms only perform about 30% of all R&D expenditure in Colombia, whereas in OECD countries with more developed innovation systems, firms dominate R&D activity. These simple aggregates overshadow the highly skewed distribution of R&D expenditure by firm size, a common feature of innovation systems (Table 3.2). On the basis of the DANE survey of innovation in manufacturing firms in 2007-08 (EDIT IV), small firms (11-50 employees) accounted for two-thirds of all surveyed firms and for about half of all those identified as "innovative", but for only 2% of all R&D expenditure. In contrast, large firms (>200 employees) accounted for only 10% of surveyed firms and for 16% of innovative firms, but for 84% of all R&D expenditure.

R&D expenditure per employee was nearly ten times greater in large innovative firms than in small innovative firms, and expenditure per firm was more than 100 times greater.

Table 3.2 Colombia's business enterprise R&D expenditure by firm size, 2008

	Firm size groups			
	All > 10 employees	Small 11-50 employees	Medium 51-200 employees	Large > 200 employees
No. of firms	7 683	5 194	1 760	729
(%)	(100)	(68)	(23)	(10)
No. of "innovative" firms *	3 317	1 748	1 023	546
(%)	(100)	(16)	(31)	(53)
As proportion of all firms	(43)	(34)	(58)	(75)
Total employees ('000)	694	96	171	427
(%)	(100)	(14)	(25)	(61)
R&D expenditure (millions of current USD)				
Internal**	141.3	3.0	23.1	115.2
External***	33.1	0.6	2.1	30.5
Total	174.4	3.6	25.2	145.7
(%)	(100)	(2)	(14)	(84)
External as % of total	(19)	(17)	(8)	(26)
R&D expenditure per employee (current USD)				
	252	38	147	341
R&D expenditure per innovative firm (current USD)				
	52 596	2 064	24 576	266 872

Notes:

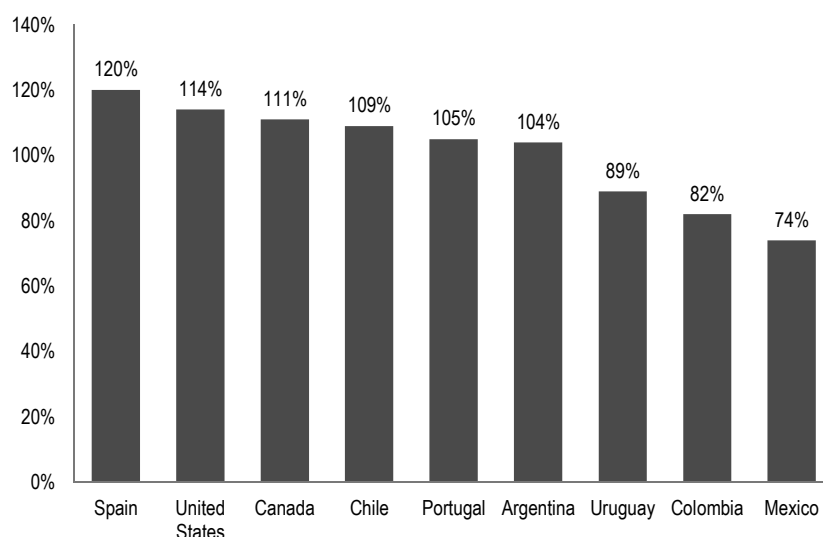
* Innovative firms in this table include "potential" innovators (firms that reported R&D expenditure but not the implementation of innovation).

** Large firms invest significantly more in internal R&D than medium ($p < 0.01$) and small ($p < 0.001$) firms, but there are no significant differences between medium and small firms. The results are valid at the 0.001 level using the Kruskal-Wallis rank-based ANOVA. Post-hoc pairwise comparisons using the Wilcoxon rank sum test were used to test differences between the groups.

*** The only significant difference in terms of investment in external R&D is between large and small firms ($p < 0.01$)., The results are valid at the 0.01 level using the Kruskal-Wallis rank-based ANOVA. Post-hoc pairwise comparisons using the Wilcoxon rank sum test were used to test differences between the groups.

Source: Dane (EDIT IV, Table C 2.4).

Table 3.2 also indicates that a considerable proportion of enterprises' R&D expenditure does not fund R&D that they perform themselves. Overall, about a fifth is for externally performed R&D, and in large firms the share rises to about a quarter. This low performance/funding ratio is another way in which Colombia differs from other countries (Figure 3.2). In OECD countries enterprises typically perform considerably more R&D than they fund because their spending for extra-mural R&D is less than their funding inflows from external sources, mainly various forms of government funding. The ratios exceed 100 for Canada, the United States and Spain as well as Chile and Argentina but not for several other Latin American countries, notably Colombia.

Figure 3.2. Ratio of business R&D performance to R&D funding, selected countries, 2010

Source: RICyT (2013), *Comparative Indicators*, The Network of Indicators of Science and Technology Ibero-American/Inter-American, www.ricyt.org/index.php?option=com_content&view=article&id=149&Itemid=3.

As Table 3.3 shows, the performance/funding ratio of slightly more than 80% was roughly constant from 2007 to 2010. Enterprises allocated nearly a fifth of their R&D funding to the performance of R&D in universities and in public research and technology development centres.⁵ These funding outflows were only marginally offset by government funding of R&D performed by business enterprises, which amounted to some 1.3% of all R&D performed by enterprises, and to only about 1% of all government funding of R&D.⁶

Table 3.3. Funding of business enterprise R&D in Colombia, 2007-11

	Million COP (constant prices: 2010)	
	2007-08	2010-11
Business enterprise funding of R&D	298 698	388 743
Business enterprise performance of R&D	246 754	319 501
Performing/funding ratio (%)	(83%)	(82%)
Business enterprise funding of R&D by:		
Higher education	38 185	45 344
Public R&D centres	15 229	23 283
Other organisations	1 950	4 558
All as proportion of total BE funding (%)	(19%)	(19%)
Government funding of BE-performed R&D	3 500	3 975
As a proportion of:		
BE-performed R&D (%)	(1.4%)	(1.2%)
All government funding of R&D (%)	(1.1%)	(1.0%)
Government funding of HE-performed R&D	135 270	160 630
As a proportion of government funding of all R&D (%)	(42%)	(41%)
Government funding of R&D performed by RTDCs	127 983	145 828
As a proportion of government funding of all R&D (%)	(39%)	(38%)

Source: Data supplied by the Colombian Observatory of Science and Technology (OCyT) in May 2013. Differences with previously published OCyT data are due to revisions.

It is not clear why Colombian firms allocate such a large share of their R&D budget to the performance of R&D by other actors and even less clear why large firms do so more than smaller firms. The low level of government funding for enterprise-performed R&D is also surprising, especially in view of the overall structure of government R&D funding, which only allocates about 1% to R&D by enterprises (with the qualification noted above), while 99% is allocated to R&D in other organisations, including about 41% to universities and about 38% to quasi-public research and technology development centres (RTDCs). The tax incentive for R&D is probably not reflected in the figures on government funding of R&D, but the scheme is small (see Chapter 5).

In effect, public support to quasi-public research centres is nearly 40 times the amount allocated to supporting enterprise-based R&D. While such centres play an important role by providing specialised inputs that complement the innovative activities of enterprises⁷ – supporting the public service and regulatory roles of government and providing flows of experienced human resources for enterprises’ innovation activities – it is unlikely that the benefits, relative to those from supporting and strengthening enterprise R&D, justify the disparity in resource allocation.

Enterprise innovation in sectoral contexts

As indicated in Chapter 2, there have been significant changes over time in the relative significance of the major sectors of the Colombian economy. Agriculture and manufacturing in particular have grown relatively slowly and now account for smaller shares of GDP. Other sectors have grown relatively rapidly and increased their shares of GDP. These include the mining and petroleum sector, the utility industries (electricity, gas and water), the construction industry and some segments of the services industry, in particular transport and communications. Three features of these more rapidly growing sectors are important.

First there is considerable overlap between them and three of the five “engines” (*locomotores*) of development identified as priorities in the National Development Plan:

- Development of the transport infrastructure, as current inadequacies seriously constrain the competitiveness of most economic sectors. This involves both improving the operation of transport services and a massive programme of construction-intensive investment.
- The development of the mining and energy sectors, which involves the construction- and engineering-intensive expansion of upstream mining, hydro-carbon and hydro-electricity industries and the expansion, diversification and improved efficiency of the downstream conversion and energy supply industries.
- The development of housing and the urban environment, which calls for expanding and improving housing and the transformational and environmentally sustainable development of other aspects of the urban built environment such as water supply, sanitation facilities and urban mobility systems.

Second, these sectors and priorities generate strong demand for scientific and technological capabilities and activities and call for intensive innovation across the whole spectrum of investment and operational activities. The need for innovation arises not only from “normal” concerns about raising productivity, reducing costs and improving the quality of products and especially service delivery but also from concerns about environmental sustainability, such as the environmental impact of mining, infrastructure and urban expansion. In addition it arises from the need to adapt technologies in these

areas to the expected impacts of climate change (e.g. the design and specifications of roads) and to achieve the goal of more socially inclusive production activities and urban environments. At the same time, the growth of these industries generates, in principle, opportunities for firms, both domestic and foreign-owned, to produce innovative “new-to-the-economy” goods and services, via start-ups, spin-offs and the diversification of existing firms.

Yet much of this demand is for scientific and technological capabilities and for modes of innovation that are likely to differ substantially from those usually discussed in connection with STI-related policy.⁸ In particular, while R&D inputs are important, they are usually less important than for innovation in other sectors. Instead, this type of innovation relies more on various design and engineering activities.⁹ While highly trained research scientists with PhD qualifications obviously are important, well-trained technologists, architects and engineers, whose formal professional training is supplemented by experience-based and firm-trained competence in engineering and associated areas of process and project management are much more important. At the same time, while there may be opportunities for new start-ups that draw on research-based innovation and even spin-offs from universities and research institutes, it is more likely that such spin-offs, start-ups and diversification will depend on experience-based entrepreneurial managers and engineers working in, or spilling over and spinning out from, existing firms: procurement managers in mining companies, software engineers in petroleum companies or architect partnerships, design engineers in equipment suppliers and engineering contractors, or project management specialists in construction design and engineering companies.

Manufacturing industry – sectoral patterns of innovation

Enterprise innovativeness in different sector categories

Biennial surveys of technological development and innovation (EDITs) have obtained information on the innovation activities of Colombian manufacturing firms and sectors. The surveys have modified in minor ways the conventions of the *Oslo Manual*. In particular, for one of the most widely used indicators of “innovativeness”, firms are asked to report whether they have produced goods or services that are new or significantly improved in ways that are new to the world, new to the (national) market, or new to the firm (Table 3.4, Column A, rows 1-3). However, the published survey results do not correspond to these categories but adopt two levels of aggregation (Table 3.4, Columns B and C) and add a new category, “potentially innovative” (Columns B and C, Row 5).¹⁰

Table 3.4. EDIT innovation survey categories

Basic survey categories		Categories of published data	
A		B	C
1. New-to-world innovation	}	Innovation in the strict sense	} Innovative
2. New-to-market innovation		} Innovation in the broad sense	
3. New-to-firm innovation			
4. Non-innovative (residual)	}	Non-innovative	Non-innovative
5. (No category)		Potentially innovative*	Potentially innovative*

Note: * Firms reporting R&D but not a category of innovation.

Classification (C) has commonly been used to show change over time between 2003-04 and 2009-10 in the basic innovativeness of manufacturing firms, as in the Background Report for this review (Fog et al., 2012, Figures 2-10). It suggests that: the proportion of potentially innovative firms has fallen to less than 10%; the proportion of innovative firms rose to more than one-third in 2007-08, and then fell slightly in the last survey period; and the proportion of non-innovative firms increased from about 50% to nearly two-thirds.

If reliable, the last observation would be somewhat alarming. However, it is widely considered that the trends indicated by these survey data may be misleading because of changes in firms' response patterns and in the design of the survey instrument. This review therefore relies primarily on the results from EDIT V, which covers 2009-10.

Table 3.5 shows the distribution of innovative and non-innovative firms across the OECD sectoral classification of manufacturing industries by technology intensity (with categories based on [direct] R&D intensities observed in OECD countries [OECD, 2001; OECD, 2011]) and across the classification of manufacturing industries by the Economic Commission for Latin America and the Caribbean (ECLAC).

As one might expect, in the OECD classification the proportion of firms identified as innovative increases when moving from low- to high-technology sectors. However, even in the high-technology sectors almost half of all firms are non-innovative, as are nearly 60% in the medium-high-technology category. Combined, these categories account for only about a quarter of all innovative firms and about a fifth of manufacturing value added.

Within the ECLAC framework, again as one might expect, only about a third of firms in the labour-intensive category were innovative. However, contrary to expectations, the proportion of innovative firms in the engineering-intensive industries was only marginally higher, while the highest proportion was in the natural resource-intensive industries.

Two qualifications should be added. The first is that “innovative” here refers specifically to product innovation (the introduction of new or significantly improved products); the inclusion of process innovation might increase the incidence of innovation.¹¹ The second is the inability to assess whether the particular types of innovation identified by firms play a significant or trivial role in their economic activities.¹²

Table 3.5. Distribution of manufacturing firms by “innovativeness” and technological categories, 2009-10

Manufacturing sectors		All firms *	Innovative firms	Non-innovative firms	Share of all innovative firms	% of manufacturing value added (2010)
All manufacturing	No.	8 643	2 969	5 237		
	% *	100%	34%	61%	100%	100%
By technology intensity categories						
High technology	No.	483	223	235		
	%		46%	49%	8%	6 %
Medium-high technology	No.	1 315	509	747		
	%		39%	57%	17 %	16 %
Medium-low technology	No.	1 953	676	1 140		
	%		35%	58%	23 %	33 %
Low technology	No.	4 892	1 561	3 115		
	%		32%	64%	53 %	45 %
By ECLAC sectoral categories**						
Vehicles and transport equipment	No.	18	8	10		
	%		44%	56%	0%	1.4 %
Engineering-intensive	No.	1 157	411	688		
	%		36%	59%	14 %	6 %
Labour-intensive	No.	5 282	1 704	3 315		
	%		32%	63%	57 %	36 %
Natural resource intensive	No.	2 186	846	1 224		
	%		39%	56%	28 %	57 %

* The few “potentially innovative” firms are excluded, and row proportions do not sum to 100%.

** Differences between the ECLAC categories are not significant at 0.5 level using the Kruskal-Wallis rank-based ANOVA ($p=0.7267$).

Source: Colombia, DANE (EDIT V, compiled from Tables C 1.2 and C 2.1).

EDIT V data on inputs to innovation casts further light on sectoral patterns of innovativeness (see the selected indicators in Table 3.6). One general observation is the absence of clear and consistent patterns that match expectations about sectoral differences underlying the OECD and ECLAC classifications:

- With respect to R&D intensity (the ratio of R&D expenditure to value added), the levels in the four technology-intensity categories differ only marginally from the level for manufacturing as a whole. Also, the slightly higher levels in the two high-technology categories do not differ as expected, and at 0.6% they are far below the levels expected in supposedly innovation-intensive industries.
- With R&D intensities of 0.8% and 1.0%, the two engineering-related categories in the ECLAC framework come a little closer to the expected level, but the difference between those levels and the other sectoral categories does not consistently carry over to the patterns of skill intensity in employment: there is little inter-sectoral difference in the intensity of employment of staff with either high-level postgraduate skills or tertiary-level training more broadly.

- Such limited inter-sectoral difference in the intensity of employment of postgraduate skills is also evident across the technology-intensity categories. Although firms in low-technology sectors employ few people with PhD and master's qualifications, the levels are the same for the other three groups. It is only the differences in the broader measure of skill intensity, which covers all levels of tertiary training, that conform to the expected pattern of rising knowledge-intensity of production as one moves from low- to high-technology sectors.

Table 3.6. Inputs for innovation in manufacturing by technological categories

Technological sector categories	Expenditure as a proportion of value added		Employee categories as a proportion of all employees	
	R&D	Engineering and design	With PhD or master's training	With any tertiary training*
All manufacturing	0.4 %	0.1 %	0.5 %	32 %
<i>By technology intensity categories</i>				
High technology	0.6 %	0.1 %	0.7 %	49 %
Medium high technology	0.6 %	0.3 %	0.7 %	43 %
Medium low technology	0.3 %	0.1 %	0.7 %	33 %
Low technology	0.4 %	0.1 %	0.3 %	27 %
<i>By ECLAC sectoral categories</i>				
Vehicles and transport equipment	1.0. %	0.2 %	0.3 %	27 %
Engineering-intensive	0.8 %	0.3 %	0.4 %	35 %
Labour-intensive	0.4 %	0.1 %	0.4 %	35 %
Natural-resource-intensive	0.4 %	0.1 %	0.6 %	33 %

Note: * Covers technician/technologist, and all levels of university training – including PhDs and masters.

Source: Colombia, DANE, (compiled from EDIT V, Table C.4.1 and from Manufacturing Industry Survey for value added.

Enterprise innovation and knowledge links

While the STI-related policy debate pays considerable attention to the intensity of inputs to innovation, such as those covered in Table 3.6, it also looks at the links between innovation actors and in particular at the strength or “importance” of links between enterprises and other actors such as universities and research institutes.

Most countries' innovation surveys address this issue, but because cross-country comparison is difficult because of differences in sector coverage and in the wording of the survey questions, only a loose juxtaposition of data about Colombia and Europe is attempted here.¹³ Despite the limitations, four main observations can be drawn from Table 3.7.

- The most highly ranked source of knowledge for innovation in enterprises in both Colombia and the EU countries is the innovating enterprise itself.
- Among external sources (not used by about 20% of Colombian innovating firms), other enterprises are much more frequently identified as important/highly

important in both Colombia and the EU than public and quasi-public institution (universities and R&D institutes).

- In particular, clients/customers and suppliers in Colombia were identified as important about ten times more often than such institutions, although universities were considered important by 14% of firms (but technology development and research centres were only mentioned by 3-4%).
- In Colombia, between 45% and 75% of innovating firms found publicly accessible sources (e.g. the Internet, publications and fairs or exhibitions) important, probably because of the dominance of types of manufacturing innovation that draw more heavily on existing than on newly created knowledge.

Table 3.7. Innovation-related links between business enterprises and other system actors: Colombia (2009-10) and Europe (EU27, 2002-04)

Proportions of innovating enterprises* considering various sources as important (Colombia) or highly important (EU)		Colombia (manufacturing)	EU27 ("All" sectors)
Sources within the enterprise		97%	47 %
External sources		81 %	
Of which:			
Other enterprises / Market sources	Competitors	32 %	12 %
	Clients or customers	40 %	26.7
	Suppliers	49 %	23 %
Institutions	Universities	14 %	4 %
	Training centres and SENA technoparks	1 %	
	Technology development centres	4 %	Together
	Research centres	3 %	3 %
	Incubators	1 %	
Others	Internet	73 %	
	Publications	50 %	8 %
	Fairs and exhibitions	45 %	12 %
	Scientific and technological databases	17 %	

Note: * The Colombian respondents include "potential innovators".

Source: Colombia: DANE (EDIT V, Table C.5.1 and C.5.2); Europe: Parvan (2007), "Community Innovation Statistics: Weak Link Between Innovative Enterprises and Public Research Institutes/Universities", *Statistics in Focus, Science and Technology 81/2007*, Eurostat, European Commission, Luxembourg.

The position of Colombian universities merits further comment, because their relatively high ranking is substantially different from experience elsewhere; in the more advanced economies only 3-4% of firms rate universities as very important. This might be considered an achievement on the part of Colombian universities, and in one sense it is. However, in a context where manufacturing firms' innovation typically involves limited technological novelty, it seems likely that only a limited amount of the knowledge acquired from universities is new, research-based knowledge and that only a small fraction of these university-industry links are "science-based". If so, it raises questions, as in other countries, about whether universities should not be encouraged to concentrate

instead on strengthening university research and raising its international standing and on developing a stronger flow of appropriately research-trained human resources.

Table 3.8 provides a more detailed picture of manufacturing firms' links to knowledge for innovation and shows similarities and differences among the different categories.

Table 3.8. Sources of ideas for innovation considered important by manufacturing enterprises

Technological categories	Proportion of innovative and potentially innovative firms identifying selected sources of ideas for innovation as important				
	External sources			Internal sources	
	Universities	Customers	Technology development centres	R&D	Production department
All manufacturing	14 %	59 %	4 %	33 %	72 %
<i>By technology intensity categories</i>					
High technology	17 %	63 %	10 %	54 %	75 %
Medium-high technology	19 %	72 %	5 %	45 %	78 %
Medium-low technology	14 %	59 %	4 %	31 %	74 %
Low technology	11 %	55 %	4 %	27 %	70 %
<i>By ECLAC sectoral categories</i>					
Vehicles and transport equipment	50 %	63 %	13 %	38 %	75 %
Engineering-intensive	14 %	63 %	6 %	34 %	70 %
Labour-intensive	12 %	61 %	3 %	32 %	72 %
Natural-resource-intensive	16 %	54 %	6 %	34 %	74 %

Note: * Technician/technologist and all levels of university training, including PhDs and masters.

Source: Colombia, DANE (EDIT V, compiled from Tables C.5.1 and C.5.2).

It is important to bear in mind that indicators of the “strength” of links between firms and their sources of innovation-related knowledge do not necessarily reflect anything about differences in the intensity or effectiveness of enterprises' innovative activity.¹⁴ They simply reflect differences in how they do innovation and the fact that different modes of innovation may be effective in different kinds of firms and sectors.¹⁵

Table 3.8 points to two broad observations relating to similarities and differences across sectors. The striking similarity is that almost all categories in both frameworks show the same broad ranking of the relative importance of the different sources of ideas for innovative activities:

- With one exception (the small number of firms in the vehicle and transport equipment sector), firms in all categories identified their own internal R&D as important much more frequently than they identified external institutes and universities.
- With no exception, they identified other enterprises (their customers, in the selected data here)¹⁶ as important sources much more frequently than their own R&D.
- Particularly striking is the similarity across all categories in both frameworks in the degree to which enterprises identified their internal production departments as important sources of ideas for innovation – much more frequently than any other type of source.

Sectoral differences and innovation: Some policy questions

Within these broad patterns of cross-sectoral similarity, there were considerable inter-sectoral differences in the apparent importance of knowledge sources.

- In some cases there appears to be a clear association between the expected innovation intensity of sectors and the frequency with which particular sources were identified as important. In particular, the proportion of firms identifying internal R&D as an important source increases from low- to high-technology categories.
- In other cases the association was only partially evident: high-technology firms were more likely than others to consider technology development centres as an important source, but still a very low level, while firms in the low-technology sector were less likely than those in the other technology intensity categories to consider universities as an important source.
- Within the ECLAC framework, there were also a few differences between sectors. For example the few firms in the vehicle and transport equipment sector were more likely than other groups to identify both technology development centres and universities as important sources. But there was no difference in this respect between the supposedly innovative and non-innovative engineering-intensive and natural resource-intensive groups.
- In other areas there was little inter-sectoral difference. The frequency with which firms identified their production departments as important sources of ideas did not vary among sectors in either the OECD or ECLAC classifications. Nor was there any difference between the ECLAC groups in the frequency with which R&D departments were thought important, while customers were thought important sources by similar proportions of firms across three groups.

In sum, there appears to be little association between the types of innovation-focused links considered important by Colombian firms and the different categories of the OECD and ECLAC classifications. While some indicators varied in line with the arguments underlying the frameworks (the rising proportions of innovative firms and the rising levels of tertiary-skills intensity of employment from low- to high-technology categories in the OECD framework), many more aspects did not match expectations:

- Labour productivity was lower in high-technology industries than in the other OECD technology intensity categories except the low-technology group, and it was also lower in the engineering-intensive group than in the labour-intensive and natural-resource-intensive groups in the ECLAC framework.
- Around 50-60% of firms in the two OECD high-technology groups were non-innovative in even the broadest possible sense, as were a similar proportion in the engineering-intensive ECLAC group.
- There was little difference in R&D intensity among the OECD technology intensity categories.
- The intensity of postgraduate (PhDs and masters) employment was similar for three groups in the OECD classification and across the ECLAC categories.

Hence, it seems clear that manufacturing sectors that may be more or less innovation-intensive in some economic contexts do not have those characteristics in Colombia. Instead, the innovation-related characteristics of given categories of manufacturing vary widely. Of course, this is not just a Colombian issue. The same kind of heterogeneity has been found in studies of innovation in high-, medium- and low-technology industries in Europe. In Germany, for instance, high-, medium- and low-technology firms are spread across high-, medium- and low-technology industries (Robertson et al., 2009; Kirner et al. 2009). This variability has important policy implications. In particular it undermines the idea that policy measures designed to accelerate entry into supposedly “higher-technology” areas of production that are new to the economy should be used as a means of raising the levels of innovation intensity and productivity. On their own, such approaches to industry policy may simply extend existing patterns of innovation and productivity into new areas of production. It might be more effective to focus policy on measures to stimulate innovation intensity and productivity in existing types of industry. As discussed in Chapter 4, greater innovation intensity may be an important source of the kinds of diversification that lead to changes in the structure of production.

What seems likely to be more effective is close interaction between structure-changing industry policy and innovation-raising STI-related policy, provided that the combination recognises the diversity of modes of innovation used by business enterprises. Differences in how innovation is done are important not only in manufacturing, they are also important across wider sectors of the economy such as those at the heart of the sector-centred “engines” of development identified in the National Development Plan.

3.3. Agriculture

Agricultural innovation is crucial to the sustainability of an important Colombian export sector and to structural diversification into related economic activities. It involves innovation not only within activities such as primary farming and ranching but also in downstream and upstream activities such as food processing and resource management. In Colombia, as elsewhere government plays a central role in agricultural innovation systems as funders and performer of agricultural R&D. In most developed countries, 70-90% of agricultural R&D is performed in public universities and public research institutions (OECD, 2013a).

The context for agricultural innovation

The following features of Colombia’s agricultural sector are of particular relevance to its innovation activities:

- Over the decade to 2010 the agricultural sector grew at about 2% a year, roughly half the average annual rate for the economy as a whole, and much more slowly than in other Latin American countries, including Peru (5.6%) and Chile (4.2%), now partners in the newly established Pacific Alliance.
- The sector’s share of GDP fell to about 7%, and it still accounts for slightly under a fifth of total employment in the economy.
- Agricultural and food products have a significant position in Colombia’s exports. While imports of these products accounted for only about 4%-5% of total exports between 2006 and 2011, exports at the start of the period accounted for about one-fifth of all exports. Agricultural and food exports grew, although slowly, and in

2011 they still accounted for 12% of a very much larger total, following the massive increase in exports of mineral products in the second half of the decade.

- It is expected that the Free Trade Agreement with the United States will have substantial impacts on the sector in both the export and domestic markets, and the development of the Pacific Alliance and its tariff reduction programme will no doubt intensify and extend them. While the effects are much debated, the sector will have to make extensive and often profound changes in what it produces and how efficiently it does so.
- The basic characteristics of farms differ significantly. With a considerable oversimplification, the sector can be said to have two main groups. Small farm households (“smallholders”)¹⁷ account for a large proportion of the rural population and for around two-thirds of total agricultural production, with “medium and large” firms accounting for the other third.

These features suggest increasingly strong demand pressures for innovation, differentiated to reflect demand for innovation in “smallholder” agriculture and in “commercial” or “larger-scale” agriculture.¹⁸ This differentiation of demand for innovation in agriculture has been common for some time. It usually refers not just to differences in the kinds of technology needed, but also to differences in the institutional and organisational structures able to interact with the two categories of farming activity to generate the kinds of technology needed, in effect a dual agricultural innovation system.¹⁹

However, this dual perspective has been thought to give excessive emphasis to farm size as a basis for differentiating among modes of agricultural innovation. This is especially important for Latin America where risk-prone and capital-poor farms that are weakly connected to markets and to supporting knowledge systems are often considerably larger than the scale conventionally used to define smallholder production. Therefore, Berdegúe and Escobar (2002) distinguished smallholder production on the basis of differences between farms’ high and low assets, and their favourable and unfavourable environments or contexts. They argue that this structure of production conditions calls for correspondingly differentiated policies for agricultural innovation.

The importance of such differentiation has been highlighted in several recent World Bank studies of agricultural innovation systems. Sometimes the emphasis has been on the differentiation noted above (e.g. Figure 7.2 in World Bank, 2006), although it is generally less tightly structured. For example, the *World Development Report 2008* (World Bank, 2007) emphasised the need to “design appropriately differentiated policies across settings” both between and within countries. This was seen as involving the development of more varied extension systems²⁰ and more varied ways of linking farmers’ demands to agricultural research. The need for organisational and institutional innovation in these and other areas was seen as especially important in connection with supporting smallholder agriculture in order to reduce the inefficiencies, inequities and human costs of the existing institutional gaps (p. 157).

The need for pluralism and differentiation of agricultural innovation policy and innovation systems is particularly significant in Latin America (Berdegúe and Fuentabla, 2011) and seems especially so in Colombia:

- On the one hand, the main commercial responses to emerging changes in Colombia’s domestic and export markets for agricultural and food products will have to rely on types and intensities of innovation that are not usually feasible in smallholder agriculture.

- On the other hand, smallholder producers and their typically fragile livelihoods will be at the heart of pressures for change arising from trade policy developments, perhaps in ways that will lead more of them deeper into poverty and exclusion from the development process. At the same time, issues related to small-scale rural production and provision of technical support for the disadvantaged may have greater socio-political and economic significance. They appear to have a prominent place in the current peace negotiations with the FARC and, if the negotiations prove successful, the ability to follow through effectively and deliver a sustained, long-term positive impact in these areas will have implications that go beyond the smallholder agricultural sector.

It is likely to be difficult to address both those challenges effectively through a single strategy for agricultural innovation, and high-level commitment to a dual strategy may be needed to ensure that neither is swamped or diluted by the other.

Organisations and organisational change in the agricultural innovation system

The creation of the Colombian Agricultural Institute (ICA) in the 1960s established an organisational basis for a modern agricultural research infrastructure. It integrated agricultural research, extension and education in a single organisation, and it changed little until the mid-1980s when the ICA was split into sub-directorates for research and technology and for services and extension. Since then, there have been two strands of organisational change, one concerned with research and technology organisations, the other with downstream organisations responsible for extension and support services.

In the first strand, the ICA was divided into two institutes in the 1990s. One was responsible for plant and animal health and quarantine, regulations, etc. The other, embodied in a newly created organisation (CORPOICA), was responsible for research and technology transfer. CORPOICA later became formally independent of the Ministry of Agriculture and Rural Development (MADR) from which it derives most of its funding, primarily through a revolving package of relatively short-term contracts.

In addition to the organisations associated with the evolution of the old ICA structure, a number of research and extension centres or departments developed by producer associations evolved over time. These cover such sectors such as coffee (CENICAFE), sugar (CENICANA), oil palm (CENIPALMA), bananas (CENIBANANO), aquaculture (CENIACUA), potatoes (FEDEPAPA-CEVIPAPA), or cereals (FENALCE-CENICEL). Although described in terms of crops, these and other “CENIs” often encompass more than agricultural production by extending their activities along the production chain to cover some of the early stages of processing and marketing. Their mode of funding relies heavily on various forms of “levy” on association members or their traded products, with varying components of co-funding from public sources, mainly the Ministry of Agriculture and Rural Development.

In addition to the organisations involved in these two paths of change, there are a number of other government actors. They include several R&D centres associated with the Ministry of Environment and Sustainable Development (MADS). In particular, the work of the Institute for Marine and Coastal Research includes research related to fisheries and the environment; the Research Institute for Biological Resources covers natural resource and biodiversity issues; and three other smaller institutes address agriculture-related issues. The National Institute of Fisheries and Aquaculture, a department of the National Institute of Rural Development (INCODER), is another government centre under the MADR.

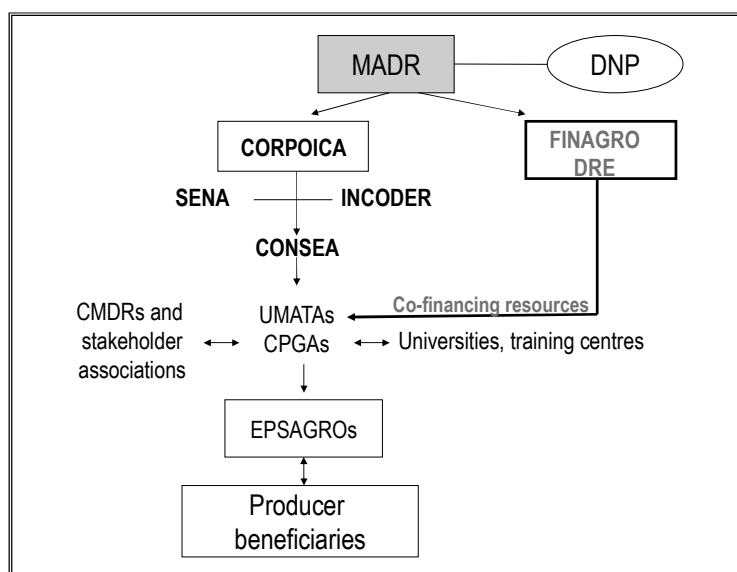
There are two other closely linked organisational actors: several Colciencias programme areas play a significant role in funding research concerned with agriculture; and universities, drawing heavily on Colciencias funding, undertake a considerable amount of agricultural research.

There has been a similarly long sequence of changes in the organisation of the downstream agricultural extension and technical services. As part of the steps towards organisational de-integration in the 1980s, the government decided to decentralise the delivery of agricultural support services. It established a framework in which the municipalities took over responsibility for providing those services through municipal units for agricultural technical assistance (UMATAs)²¹ with the support of the MADR and the governors at departmental level. This approach was given legal form in Law 101 of 1993, and Law 607 of 2000 reiterated the commitment to provide public rural technical assistance services through the UMATAs and later through provincial agribusiness management centres (CPGAs). Through the 2000s considerable efforts were made to develop and strengthen UMATAs and CPGAs across the country and to provide education and training for technical assistants linked to the UMATAs and CPGAs

An important further step was taken in 2010 when the MADR launched the Direct Technical Assistance Programme. A significant feature of the programme was that the implementation of UMATAs plans, and of rural technical assistance more generally, would be implemented by private-sector companies (EPSAGROs).

Also in 2010 the National Subsystem of Agricultural Technical Assistance was put in place. Its basic features are summarised in Figure 3.3. In conjunction with the National Planning Department (DNP), MADR defines the broad guidelines and policies for technical assistance, sets the levels of resource allocation, and monitors and evaluates implementation.

Figure 3.3. The organisation framework of the national subsystem of agricultural technical assistance



Source: Adapted from MADR, Política Nacional de Asistencia Técnica Agropecuaria (presentation).

A complex body of actors then develops, co-ordinates and approves the detailed programmes and plans. CORPOICA provides technical support for the subsystem and acts as its link with the wider body of agricultural research organisations by disseminating research results, providing technical support for service providers and collecting information about producers' needs; SENA, along with universities, designs and implements training programmes for technical assistants; the National Institute for Rural Development (INCODER) supports local authorities in developing technical assistance plans; and sectional councils of agriculture (CONSEA) approve plans and co-ordinate inter-agency activities.²²

The UMATASs and CPGAs act as local managers of the subsystem, interacting with municipal councils of rural development (CMDRs) and other stakeholders and actors. They appoint and monitor the EPSAGROs, the final service providers. Departmental and other local financial resources are defined, approved and distributed through this structure. Co-financing support from the central government (MADR) is channelled via the Fund for Agricultural Financing (FINAGRO) and the Rural Development Equity programme (DRE).

International organisations also play an important role in the agricultural innovation system. Organisations such as UNDP (United Nations Development Programme), the FAO (Food and Agriculture Organisation of the United Nations), IICA (Inter-American Institute of Cooperation for Agriculture), the World Bank and IDB (Inter-American Development Bank) have provided finance, evaluation, administrative and technical support, information and networking (Fonseca-Martinez and Rugeles, 2004).

CIAT (the International Center for Tropical Agriculture) is an important performer of agricultural R&D in the CGIAR international network (formerly the Consultative Group on International Agricultural Research). CIAT performs research in areas of relevance to Colombian agriculture to complement the work of national actors such as CORPOICA. It is funded mainly by international donors and a small (but rising) share of its funding comes from Colombian actors (including Colciencias).

Agricultural R&D expenditure

The funding and performing of agricultural R&D thus involves a complex set of organisations and channels. The most recent available source of an integrated overview is Stads and Romano (2008). This study covers a single year and is organised in terms of the main groups of R&D-performing, rather than R&D-funding, organisations. The results, reproduced in part in Table 3.9, show that the two main R&D-performing actors were CORPOICA and the producer associations (CENIs and the like), each accounting for about a third of the total. Other government organisations and the universities account for the other third.

Table 3.9. The scale of agricultural research in Colombia by type of R&D-performing organisation, 2006

Type of agency	Total research staff FTE, 2006	Total expenditure, 2006		
		2005 billion COP	2005 million international (PPP) dollars	Share
CORPOICA	273	60.0	55.5	34.2
Other government	190	20.0	18.5	12.6
Producer associations	353	53.4	49.4	34.0
Higher education	183	31.5	29.1	16.7
Total	999	164.9	152.4	100

Source: Agricultural research: Stads and Romano (2008), “Colombia”, *ASTI Country Brief No. 39*, International Food Policy Research Institute, Washington, DC. All R&D: OCyT, in 2006 COP.

Then as now, the main funding organisations were MADR, enterprises (via the para-fiscal levies and related arrangements), Colciencias and international sources, with the scale of funding probably ranked in that order. However, integrated information about the relative scale and purposes of the funding does not seem to be publicly available. Nor does it seem possible to assess the trends since the mid-2000s with respect to either the funding or performance of R&D.²³ However a partial picture is available for R&D funding by MADR, which undoubtedly accounts for a very large share of the total. As Table 3.10 indicates, this component of public funding rose steadily (in current prices) from the mid-2000s, but slightly less rapidly than total expenditure on all R&D activities in Colombia.

Table 3.10. The scale and composition of agricultural R&D expenditure by the Ministry of Agriculture and Rural Development, 2003-10

Billion COP at current prices

	2003	2004	2005	2006	2007	2008	2009	2010
All MADR R&D	53.7	57.8	49.7	66.8	72.9	130.7	123.8	101.7
Composition of MADR R&D								
(A) CORPOICA (%)	73	61	68	64	59	38	45	46
(B) Fondo Concursal (%) ¹		8	10	23	28	56	48	43
(C) Asignación Directa (%) ²	27	31	22	13	13	6	7	13

Notes: 1. This consists largely of co-funding by MADR for programmes and projects undertaken jointly with universities, enterprises and research institutes. 2. This consists of direct funding of CORPOICA costs in undertaking strategic national programmes.

Source: MADR (2010, p.28), *Informe de Rendición de Cuentas – Gestión 2002 – 2010*, Ministry of Agriculture and Rural Development, Bogota.

An interesting feature of the composition of MADR funding is the continuation of a trend with respect to the position of CORPOICA. In the early 2000s funding for CORPOICA under rows (A) and (C) accounted for all MADR funding. In subsequent years MADR began to increase co-funding for projects and programmes of universities and business enterprises. This accounted for more than 40% of the total by 2010, with CORPOICA's share falling to about 60%.

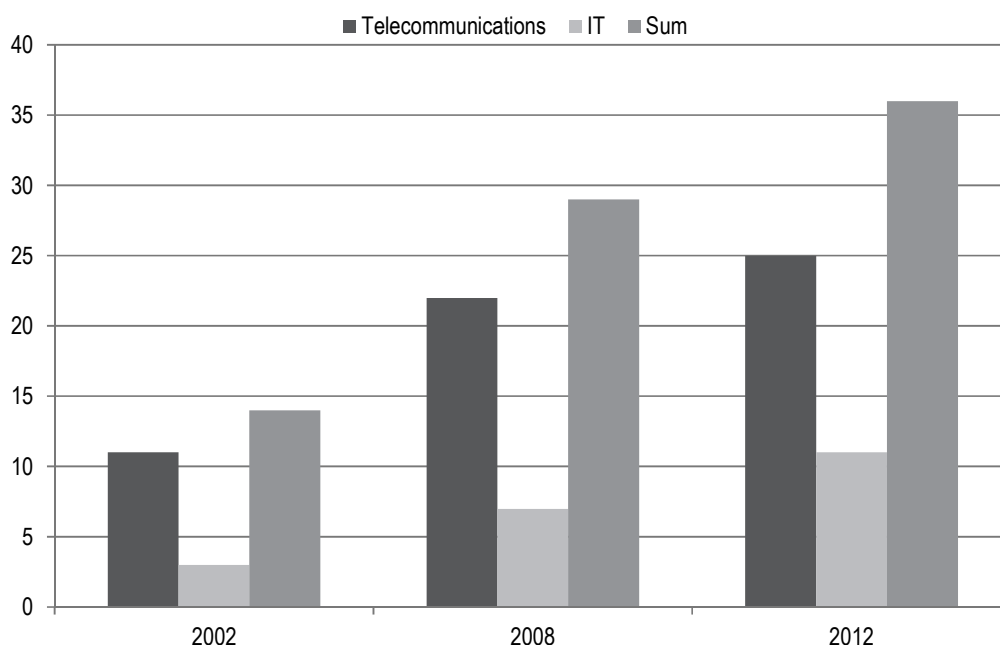
3.4. The ICT sector

The Internet and ICTs can play a key role in innovation by increasing business and government efficiency, enhancing communication and serving as a platform for innovation that leads to productivity growth across all sectors. In addition, the Internet and ICTs reduce barriers to market entry for small firms; such firms can now easily reach global audiences and scale quickly. The ICT sector itself is a source of innovation and has multiplier effects in other sectors.

Several studies have shown and quantified the positive economic impact of the Internet and related ICTs, both at the micro- and macroeconomic levels (see OECD 2012a for a detailed overview of studies). On the micro-level, evidence of the positive effects is mainly provided through cases studies. On the macro-economic level, several studies highlight the positive relationship between increased adoption of the Internet and ICTs and economic growth (OECD, 2013b). The *OECD Internet Economy Outlook*, for example, illustrates that up to 13% of business sector value added in the United States could be attributed to Internet-related activities (OECD, 2012b).

According to CCIT-Fedesarrollo (2012) over the 2002-12 period, Colombian ICT sector revenues grew by annual average of about 10%. While total revenues amounted to 14 trillion pesos in 2002, they reached 36 trillion pesos in 2012 which amounts to 5.4% of GDP (CCIT-Fedesarrollo, 2012). The share of telecommunications revenues amounted to over three quarters (79%) of total revenues in 2002 and fell slightly to 69% in 2012 due to increasing revenues from the IT sector (see Figure 3.4). Overall, the ICT sector is growing but from rather low levels in some areas compared to OECD countries.

Figure 3.4. The Colombian ICT sector: Share of telecommunications and IT revenues



Source: OECD based on CCIT-Fedesarrollo (2013), *Informe Trimestral TIC - El Sector TIC: La Nueva Locomotora de la Economía Colombiana*, CCIT, Bogotá.

In terms of use of the Internet by businesses in Colombia, overall adoption and use is much lower than in OECD countries. There is a wide gap between the use of the Internet by large and small firms which is currently narrowing but still significant. In 2010, all large companies had Internet access but only 7% of micro-companies, which represent 96.4% of all Colombian companies, had access to the Internet (MinTIC, 2011). By the end of 2012, 20% of micro-companies have been connected to the Internet (MinTIC, 2013).

Evidence from a survey of micro-enterprises commissioned by MinTIC in 2010, found that lack of perceived utility was the most commonly mentioned reason for lack of internet access (60.6% of companies surveyed), followed by a lack of access to computers (17.6%) and affordability (12.9%). The results are suggestive of the relative importance of demand- versus supply-side obstacles to corporate internet adoption and underscore the need for comprehensive interventions in the ICT eco-system including internet services of relevance to more businesses and appropriate finance and infrastructure.

An ecosystem of entrepreneurs and start-ups is emerging, especially in the area of IT applications and services which are also being promoted by the plan Vive Digital. Some of these start-ups are known outside of Colombia²⁴. Important barriers reported by start-ups in the IT sector are the lack of a business angel environment and difficult access to capital, especially seed capital and a lack of the right developer skill sets which, according to some entrepreneurs, are insufficiently taught by Colombian universities.

3.5. Higher education institutions

This section discusses post-secondary education in universities and technical institutions. However, little information is available on the latter.

Types of institutions

In 2011 Colombia had 288 higher education institutions (HEIs) (Table 3.11). They can be grouped into four main categories (OECD et al., 2012):

- *Professional technical institutions* that offer short-term postsecondary technical education in a wide range of vocational fields.
- *Technological institutions* that offer higher-level technological and professional education leading to careers or to higher-level tertiary education.
- *University institutions* that offer programmes leading to undergraduate degrees, and sub-doctoral graduate degrees in selected areas. University institutions or schools of technology are authorised to conduct teaching for professional disciplines or occupations at both degree and diploma levels, specialised graduate programmes, and applied or technological research.
- *Universities* that offer the full range of academic programmes in all disciplines and at all levels. Their undergraduate and graduate programmes cover all academic disciplines, including the social sciences and the humanities. They conduct research at the postgraduate and post-doctoral levels.

Table 3.11. Higher education institutions by type of institution²⁵

	Public		Private		Total	
	2007	2011	2007	2011	2007	2011
Universities	32	32	44	48	76	80
University institutions	23	27	72	88	95	115
Technological	16	12	43	42	59	54
Professional technical institutions	11	9	38	30	49	39
Total	82	80	197	208	279	288

Source: OECD et al. (2012, p. 33), *Reviews of National Policies for Education: Tertiary Education in Colombia 2012*, OECD Publishing. <http://dx.doi.org/10.1787/9789264180697-en>.

Table 3.12 shows the size of each type of HEIs in terms of number of students and staff.

Table 3.12. Students and staff in different types of higher education institution, 2011

	Average number of students enrolled	Average number of students graduated	Average number of teaching staff	Average number of administrative staff	Teaching staff per student
Universities	11 190	904	951	372	11.77
University institutions	2 558	196	158	50	16.18
Technological	6 446	675	45	15	143.37
Professional technical institutions	949	96	47	31	20.39
Total	5 467	469	342	130	15.98

Source: SNEI (National System of Higher Education Information).

Universities

Colombia's universities were formerly essentially teaching institutions and they are currently building up their research activities. The legacy of their teaching mission is a fragmented structure with many small research groups. Overall, research is increasing but remains limited, owing to the low level of research funding available. As indicated in Chapter 2, there is also scope to raise the quality of research. While there are many universities, six of them carry out some 60% of research. Because many people have taken their PhD abroad, the Colombian research community has good international links but the proportion of foreigners working in Colombian universities remains low.

The rather traditional governance of the universities hinders the development of strategies and specialisation and encourages the fragmentation of the research community. Owing to the discontinuous nature of Colciencias' funding, university income for research is "lumpy"; this makes it hard to manage research and to implement a research strategy. Modernisation of university governance and management and an increase in the amount and continuity of external research funding are crucial policy needs.

A key role of the external funding system is to provide incentives, particularly in relation to scientific quality. However, incentives can also drive structural change, notably by funding centres of excellence and competence centres but also by giving large grants to research groups rather than small ones to individual researchers. The Research Council of Norway, the Academy of Finland and the National Natural Science Foundation of China, among others, have used these tactics in recent years.

Currently, the University of the Andes ranks in the 351-400 range in the *Times Higher Education Supplement*. In 2011, it was in the 400-450 range in the Shanghai index but is no longer listed. In the QS Latin America rankings, the University of the Andes is No. 4, the National University is No. 9, the Pontificia Universidad Javeriana is No. 20 and the Universidad Rosario is No. 38.

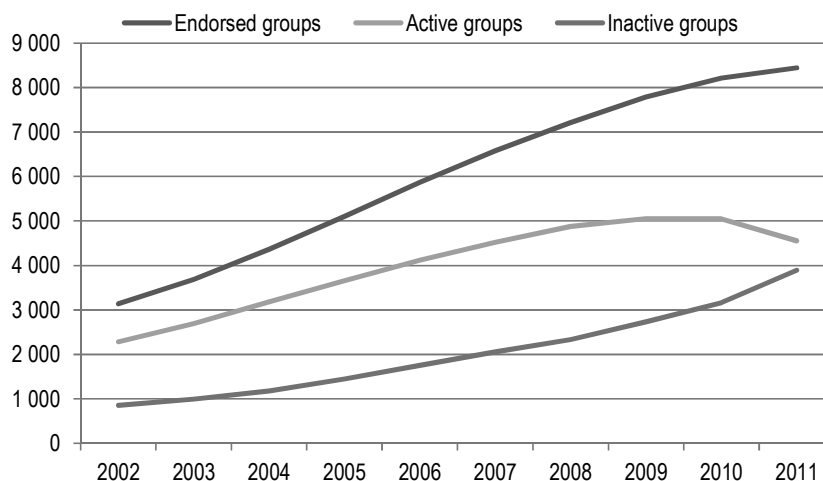
The university system

The creation of Colciencias in 1968 triggered internal changes in the universities in order to make better use of external research funding opportunities. While the universities regard themselves in the Humboldtian tradition (combining independent research with education), the volume of research conducted was modest, and until about 1990, the universities were still primarily teaching organisations. With the aid of an IDB loan, government policy sought to increase their research.

Colombia currently has a total of 81 universities (32 public and 49 private). Three-quarters of students attend public universities. Rising external funding levels from the middle of the last decade and the new government impetus for research and innovation appear not only to have driven growth in national production of PhDs but also to have encouraged the universities to “professionalise” the management of research with vice-rectors for research. Bayh-Dole-style legislation has further encouraged the creation of technology transfer offices (TTOs) and other specialised functions but university employment conditions and regulations hamper spin-offs, e.g. by prohibiting academics from holding a second post.

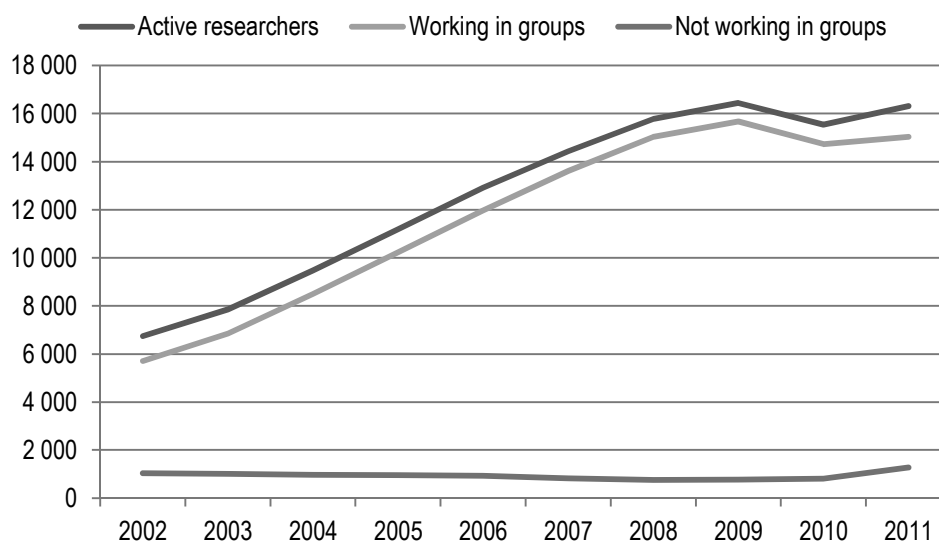
To encourage the development of research, Colciencias began in 1991 to register, recognise and categorise research groups. To date it has registered almost 13 000 research groups across the universities, research institutes and (to a lesser degree) industry and classified 8 442. Registration entitles groups to apply for funding. The number of research groups has grown dramatically over the last decade, presumably owing to a combination of growth in the number of research-active people and organisations and to increasing coverage of the research population by Colciencias (Figure 3.5). Figure 3.6 shows that almost all active researchers work in research groups.

Figure 3.5. Number of recognised research groups, 2002-11



Note: The dip in the number of active groups is caused by the introduction of a more stringent definition.

Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Figure 3.6. Number of active researchers, 2002-11

Note: The dip in the number of active researchers is caused by the introduction of a more stringent definition.

Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Of the total research groups in 2012, 4 555 are active. Colciencias ranks research groups according to the quality and quantity of research outputs (papers, patents, designs, etc.) and seeks to capture both their scientific and their societal value. Of the 4 068 groups that have been ranked, almost half fall into the bottom category (D), 10% are in the top band (A) and 5% in the highest category (A1). The A1s are strongly concentrated in the big cities. Table 3.13 shows that over 90% of the research groups are in the universities and are split equally between public and private institutions. In comparison, the RTDCs and private non-profit organisations (PNPs) serving industry and the government labs have small numbers of groups. (This is in striking contrast to Europe, where these categories together account for about 40% of public research.) Average group size is very small, even in the non-university organisations. The small number of industrial research groups regarded as active may be due to a focus on academic production in the definition of an “active” research group and the fact that – since the state funds almost no R&D in private industry – there is little incentive to seek the endorsement necessary to qualify for state research funding.

Classifying the research groups by discipline (Table 3.14) similarly points to small group size. Surprisingly, groups in the humanities, an area generally characterised more by individual scholarship than by team efforts, are comparatively large. The “hard” sciences and agriculture account for 54% of both the active groups and the active researchers.

Table 3.13. Research groups and researchers in various kinds of institution, 2011

	Active groups		Inactive groups		Active researchers		Active researchers per active group
	Number	%	Number	%	Number	%	Number
Research groups, 2011							
Public universities	2245	46.8%	1699	42.5%	7455	45.7%	3.3
Private universities	2073	43.2%	1502	37.6%	7367	45.2%	3.6
RTDCs	164	3.4%	178	4.5%	633	3.9%	3.9
Professional associations and NGOs	96	2.0%	186	4.7%	256	1.6%	2.7
Hospitals	79	1.6%	89	2.2%	228	1.4%	2.9
Firms	47	1.0%	120	3.0%	129	0.8%	2.7
Government organisations	44	0.9%	139	3.5%	91	0.6%	2.1
PNPs serving business	23	0.5%	29	0.7%	44	0.3%	1.9
Other educational institutions	16	0.3%	47	1.2%	51	0.3%	3.2
International	7	0.1%	3	0.1%	47	0.3%	6.8
Not classified	4	0.1%	3	0.1%	5	0.0%	1.2
Total	4798	100.0%	3995	100.0%	16306	100.0%	3.4

Source: Calculated from OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Table 3.14. Active research groups and researchers by OECD discipline groups, 2011

	Active groups	%	Active researchers	%	Researchers per group
Natural sciences	932	20.5%	3 646	22.4%	3.9
Engineering and technology	580	12.7%	2 130	13.1%	3.7
Medical and health	691	15.2%	2 095	12.9%	3.0
Agriculture	257	5.6%	983	6.0%	3.8
Social sciences	1 612	35.4%	5 076	31.1%	3.1
Humanities	319	7.0%	2 033	12.5%	6.4
Other	164	3.6%	342	2.1%	2.1
Total	4 555	100.0%	16 306	100.0%	3.6

Source: Calculated from OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Colombia's scientific production, measured in terms of papers published in journals indexed by Thomson-ISI in the Web of Science is small. Over 2000-11, Colombia produced 473 papers per million population, compared with 1 708 in Brazil, 1 325 in Mexico, 2 091 in Argentina, 2 905 in Chile and 615 in Venezuela (OECD et al., 2012).

The pattern of many research groups combined with modest overall bibliometric performance discussed in Chapter 2 is typical of a system in rapid growth. Increased funding and competition will to some degree improve performance but there is also a need for incentives that encourage consolidation, such as centres of excellence (CoEs) and competence centres.

A number of CoEs have in fact been established in the university sector (Box 3.1). Rather than physical centres, these are consortia of research groups located in different universities that aim to build “world class” research capacity in specific areas. They appear not to have been evaluated but given their network character they are not likely to have had much effect on reducing fragmentation.

Box 3.1. Consortia of research groups in the university sector

CIEBREG: Centre for Research and Studies in Biodiversity and Genetic Resources.

CENM: Center of Excellence in New Materials.

CCITB: Colombian Center for Tuberculosis Research.

CENIVAM: National Research Centre for the Agro-Industrialization of Tropical, Medicinal and Aromatic Plant Species.

GEBIX: Colombian Center for the Genomics and Bioinformatics of Extreme Environments.

ODECOFI: Colombian Observatory for Comprehensive Development, Peaceful Coexistence and Institutional Strengthening in regions strongly affected by the armed conflict.

CEIBA: Center of Excellence in the Modeling and Simulation of Phenomena and Complex Processes.

ARTICA: Regional Alliance on Information Technology and Applied Communication.

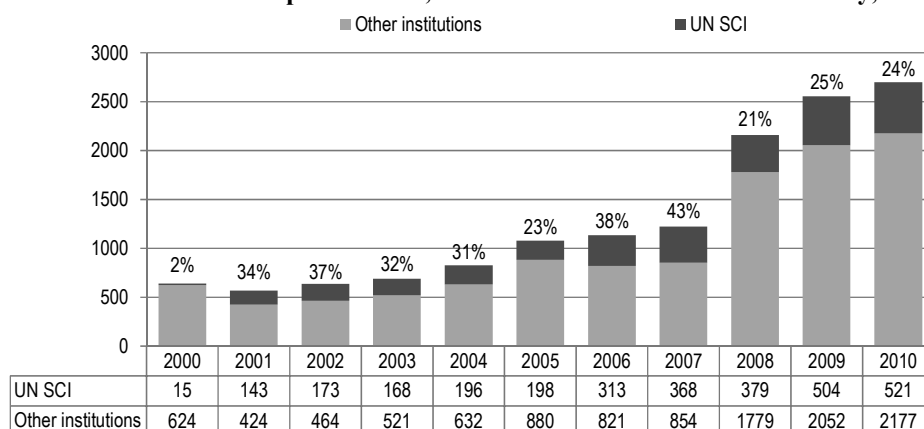
Scientific output is concentrated. Universities account for over 60% of the Colombian articles published in the Web of Science (Table 3.15).

Table 3.15 Articles with Colombian authors listed in the Web of Science, 2000-11

Institution	Number of articles	% of total
Universidad Nacional de Colombia	4 679	22.23
Universidad de Antioquia	2 891	13.73
Universidad de los Andes	2 360	11.21
Universidad del Valle	1 866	8.86
Universidad Industrial de Santander	795	3.78
Pontificia Universidad Javeriana	683	3.25
Total (an article may have several authors)	13 274	63.06

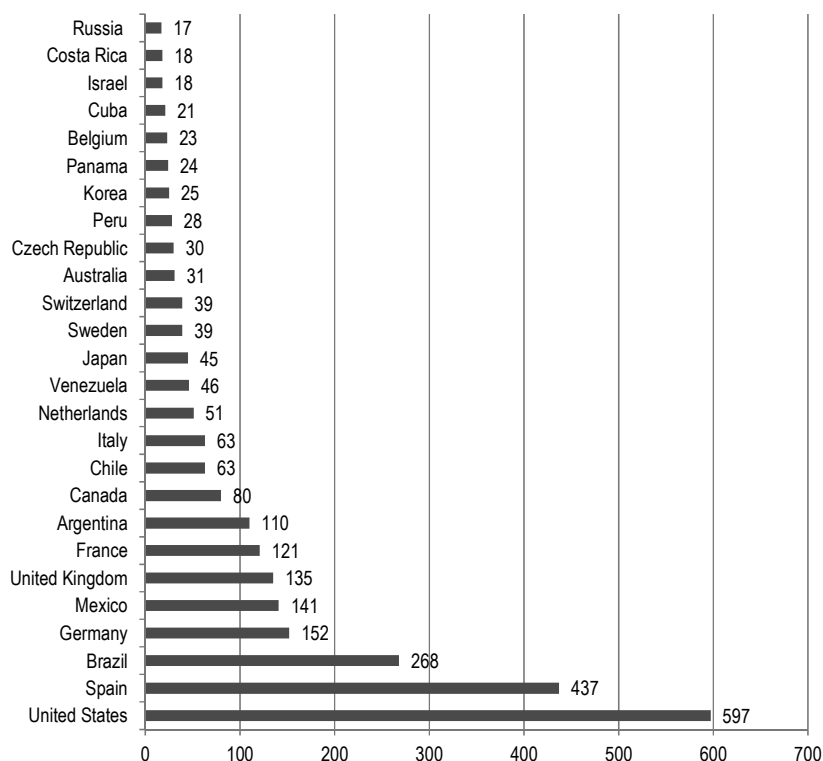
Source: OECD et al. (2012), *Reviews of National Policies for Education: Tertiary Education in Colombia 2012*, OECD Publishing. <http://dx.doi.org/10.1787/9789264180697-en>, based on Thompson Reuters, Web of Science, consulted on 21 December 2011.

Figure 3.7 traces Colombian publications in the Web of Science and shows the substantial proportion produced by the National University of Colombia (UN SCI).

Figure 3.7. World of Science publications, Colombia and the National University, 2000-10

Source: Universidad Nacional de Colombia Vicerectoría de Investigación (2012), “Capacidades de investigación de la Universidad Nacional de Colombia 2000-11: Una Aproximación desde el Capital Intelectual”, Universidad Nacional de Colombia, 2012.

Overall, only 14% of teachers and researchers in tertiary institutions hold a PhD, although the share is much higher in the leading universities. For example, it is 35% at the National University of Colombia (UN) and 62% at the University of the Andes. Because many took their PhDs abroad international research links are good and there is a significant amount of international co-publication (Figure 3.8, Table 3.16). However, the proportion of non-nationals on the faculty of Colombian universities appears to be low. At the UN, only 129 (4%) of the 2 974 *docentes* are foreign.

Figure 3.8. National university co-publications 2010-11, by country

Source: Universidad Nacional de Colombia Vicerectoría de Investigación (2012), “Capacidades de investigación de la Universidad Nacional de Colombia 2000-11: Una Aproximación desde el Capital Intelectual”, Universidad Nacional de Colombia, 2012.

Table 3.16. Countries with which the University of the Andes has over 100 co-authorships, 2000-11

Country	Co-authorship	Citations
United States	687	8 412
Colombia	511	1 614
France	434	5 353
United Kingdom	401	4 123
Brazil	372	5 570
Mexico	348	4 950
India	332	5 110
Germany	326	2 936
Russian Federation	316	4 961
Korea	293	4 449
Netherlands	268	2 830
Argentina	265	3 387
Canada	245	2 153
China	245	2 954
Ecuador	227	2 961
Sweden	216	2 211
Czech Republic	204	1 701
Switzerland	202	1 814
Ireland	188	1 488
Spain	139	639

Source: Villaveces et al. (2012, Table 3.7, p. 46), *La investigación en Uniandes 2011: perspectivas de la internacionalización*, Universidad de los Andes, Vicerrectoría de Investigaciones, Ediciones Uniandes, Bogotá.

Governance

Most Colombian higher education institutions, especially universities, have a governing board that is broadly representative of institutional constituencies (*Consejo Superior*), a rector and staff (*Rectoría*), and an academic council or faculty senate (*Consejo Académico*). As in other countries, academic programme decisions in universities are made in academic committees at the programme level and work their way up through higher-level committees to the rector and governing board (OECD et al., 2012).

The OECD tertiary education review team did not find strong evidence of political intrusion in Colombia, in contrast to some countries with rector-based systems. Institutional governance was rarely raised as a priority issue in the team's fieldwork discussions, and the team did not feel that it was well understood, either on or off campus.

Two European University Association evaluations of Colombian public universities suggest that governance and management are in need of updating. An evaluation of the UN (Soares et al., 2011) notes that while the university is formally and legally autonomous, half of the members of the governing council are representatives of national authorities. The only representatives of external stakeholders are appointed by the authorities. Despite the significant growth in research at the university in recent years, its lack of an overall research strategy reflects the lack of a national science policy. Research is fragmented because the university does not set priorities for the allocation of internal funds, and research activity has increased despite the absence of an increase in institutional funding. While UN is the biggest producer of PhDs, the quality of its output in international comparison remains problematic. Major criticisms are over-centralised

decision making and the crippling level of bureaucracy, both of which make change difficult. An evaluation of the medical University El Bosque (Soares et al., 2010) pointed out that governance was entirely internal, the faculty structure fragmented, the mode of teaching old-fashioned and the research embryonic. Faculty qualifications were low and the university had no strategy for focusing research on areas in which it would wish to be strong. A significant effort would be needed to modernise the structure and management of the university, to improve skills and to develop strategy.

Traditional university governance systems typically have problems of lock-in and inability to develop strategy. To serve their teaching needs, universities need to maintain a wide range of specialist capabilities, and research often involves a fragmented pattern of small groups clustered around specialist professors. Building larger entities with critical mass in particular areas of research may be desirable but can be hard to achieve as it implies an unequal division of resources among a body of equals. Consequently, incremental resources tend to be shared widely, the research effort is fragmented, and it is hard for small research groups to build up either their reputation or their productivity. The same logic that causes fragmentation also makes it hard to allocate “strategic” resources to one area but not to others. It is not impossible, but it is difficult, to build up large areas of research strength under traditional university governance and organisation, and some academics may be unwilling to tolerate the presence of full-time researchers. Restructuring and creating “rules-of-the-game” that permit universities to build uneven patterns of research strength are essential for enabling universities to specialise and, in particular, to address social needs.

Funding mechanisms

The universities’ funds for research come from several sources. A small proportion of their core funding is now allocated on the basis of the number and quality of their scientific outputs. There is also project-based income from Colciencias-managed grants and other external contracts. Income from industrial contract research is, however, limited. The intensity of links between universities and industry is no worse than in a number of other Latin American countries, but is nonetheless regarded by industry and many in the universities as inadequate. The UN does rather well, with 21% of its externally funded projects undertaken for companies or agricultural associations (Table 3.17). Of the top 20 project funders at the University of the Andes, companies are in positions 5, 7, 8 and 17.

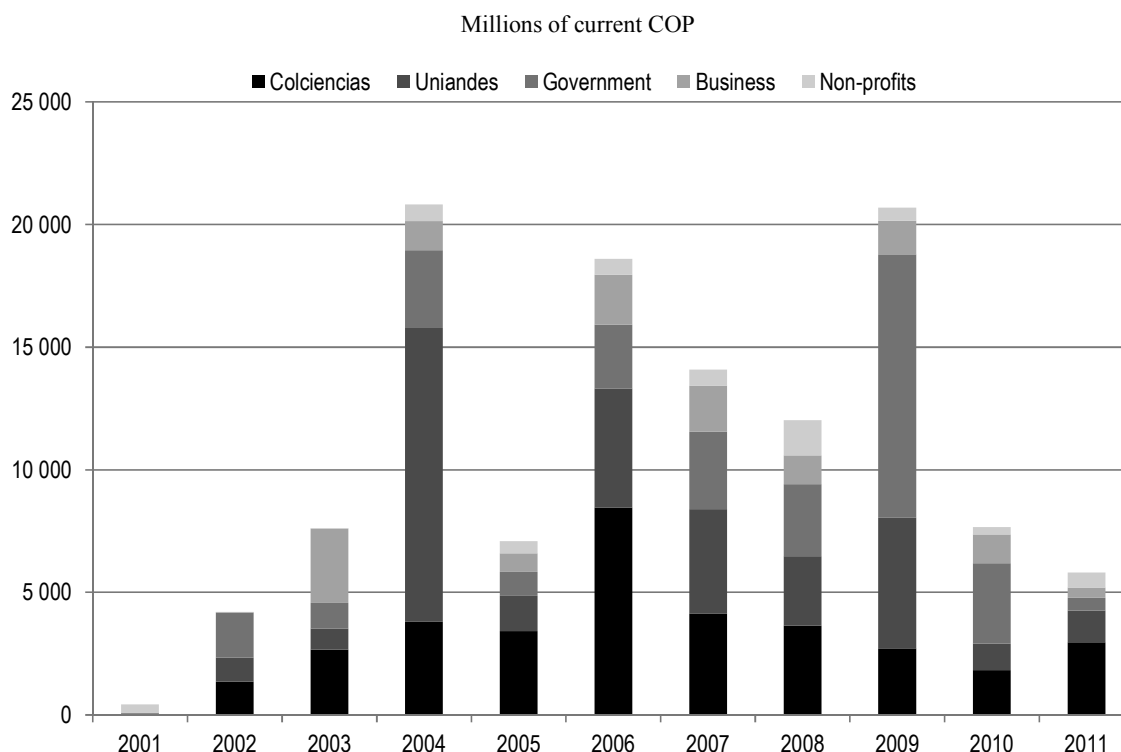
Table 3.17. External funding of active research projects in the National University by national sources, 2011

Funding sources	Number of projects	Percent
COLCIENCIAS	335	70%
Companies	91	19%
Foundations	12	2%
National and Local Government	28	6%
Agricultural associations	12	2%
Universities	4	1%
TOTAL	482	100%

Source: Universidad Nacional de Colombia Vicerectoría de Investigación (2012: p. 108), “Capacidades de investigación de la Universidad Nacional de Colombia 2000-11: Una Aproximación desde el Capital Intelectual”, Universidad Nacional de Colombia, 2012.

Figure 3.9 shows the University of the Andes' research project funding over the past decade. The income volatility is striking, as the university itself accounts for a large sum in one year and the government in another. Colciencias funding is also variable, presumably because of rapid changes in Colciencias' overall spending.

Figure 3.9. Research project funding, University of the Andes, 2000-11



Source: Villaveces et al. (2012, Table 4.7, p. 92), *La investigación en Uniandes 2011: perspectivas de la internacionalización*, Universidad de los Andes, Vicerrectoría de Investigaciones, Ediciones Uniandes, Bogotá.

The universities have increasingly been able to marshal internal resources for research. The University of Antioch is the second largest (public) university in Colombia. Since the early 1990s, it has been able to increase regularly the amount of internal money available to fund research from the university's own budget and external resources from Colciencias and others. From 1994 it has benefited from a "stamp duty" on contracts between private industry and the City that provides a bigger and more reliable source of research income. It added internal "heritage funds" and an industrial extension service in 1997, both of which generated further research income. As of 2003, the university has been able to collect sufficient internal funding to launch a regular internal competition. This model of internal competition is also used at the University of the Andes and elsewhere.

According to World Bank data for 2000, public universities in Colombia received 63% of their income from the national government, 7% from the regional government, 21% from tuition fees, and 9% from other sources (Observatory on Borderless Higher Education, 2007). However, this has changed over the years. In 2011, the proportion of self-generated resources in Colombia's public universities, including tuition fees and research contracts, amounted to 44% of their total income, up from 18% in 1993 and 27%

in 2003 (Table 3.18). The income generation performance of Colombian public universities is above the average of Latin America countries as well as many OECD countries (OECD, 2012c).

The model developed by the Ministry of National Education to calculate the contribution of each university takes account of staff numbers, student enrolment and research output, among other things. All types of tertiary institutions other than universities are funded through direct central or local government contributions from their sponsoring ministry (OECD et al., 2012). The intention is to extend the IT system that accounts for scientific outputs to become an open repository for papers.

Table 3.18. Funding sources of higher education institutions

Type of organisation	Amount (million COP of 2011)	Percentage	Notes
Government organisations	195 967	31%	Public funding, including Ministry of Economy, Colciencias, etc.
Firms	111 304	17%	Private sector
Higher education institutions	282 656	44%	Self-generated resources (e.g. student fees)
International	46 314	7%	International co-operation

Source: Based on OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

3.6. Public research institutes

During the 1960s, as Colombia's universities focused on teaching, large technology institutes were established to meet society's research needs. They met with mixed success and the institute sector underwent a major restructuring in the 1990s. Inspired by the "CENI" model in agriculture, the large institutes were replaced by small, branch-focused organisations governed by their beneficiary communities. The state provided seed funding, which was subsequently reduced. OCyT groups the institutes into the following categories: public research centres; (autonomous) RTDCs; and centres of excellence, which in some cases have become independent entities or joint ventures.

OCyT collects data on the RTDCs, of which there are 189. Table 3.19 shows their expenditure (adjusted for inflation) on STI activities. It includes intramural and extramural expenditure but does not reflect their total operating budgets, since they also undertake other activities. For example, the Research Centre on the Nervous System offers health care, in addition to its research activities. COTECMAR is a science and technology corporation, but also a shipyard, and an important share of its income comes from manufacturing and maintaining boats.

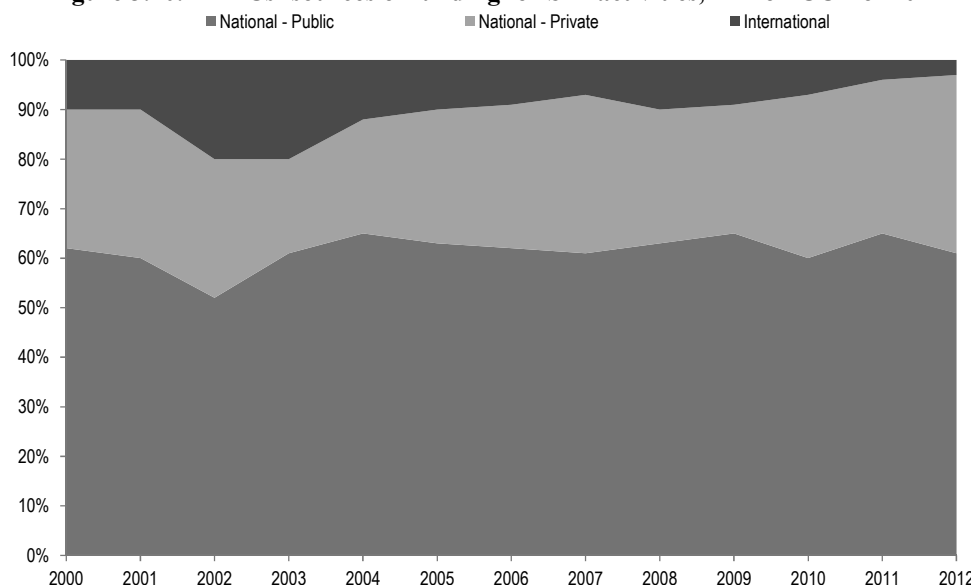
Table 3.19. RTDCs: Expenditure in STI activities by source of funding, million COP of 2011

Year	National		International	Total
	Government organisations	Private (firms and centres)		
2000	60 788	27 247	9 815	97 850
2001	56 737	27 830	9 283	93 851
2002	62 129	31 794	23 291	117 214
2003	125 637	38 950	42 422	207 009
2004	116 245	41 322	20 740	178 307
2005	122 037	47 706	21 279	191 023
2006	124 622	54 289	18 005	196 916
2007	156 430	80 371	14 692	251 492
2008	163 185	69 442	20 542	253 169
2009	194 304	70 779	22 261	287 344
2010	178 593	87 253	14 648	280 494
2011	264 435	107 647	14 009	386 092
2012	241 950	123 633	12 513	378 096
2000-11	1 867 093	808 263	243 501	2 918 857

Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

As Figure 3.9 shows, a large share of the RTDCs' funding comes from government organisations, and this has remained relatively constant (at around 64%) since 2000, the first year for which data are available. Private funding, as defined by OCyT, includes support provided by businesses but also income-generating activities of the centres that follow directly from their research activities. According to figures published by OCyT for 2011, 65% of the budget from private sources comes from the RTDCs themselves and is the equivalent of 18% of their total expenditure.

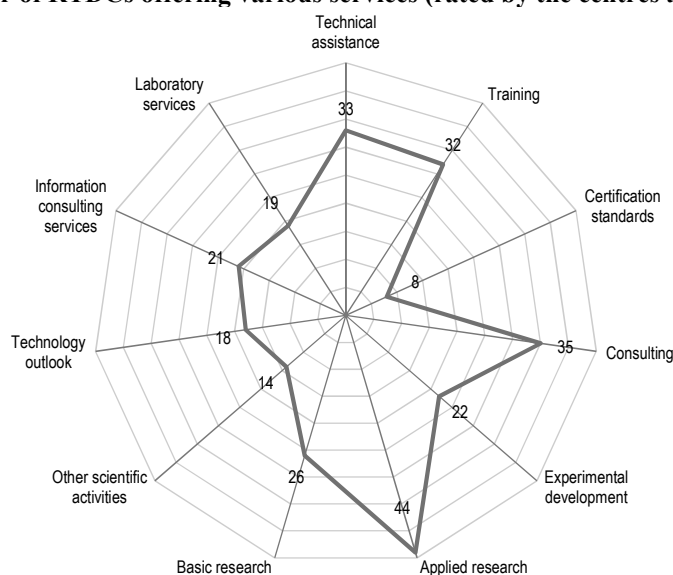
Figure 3.10 also shows that funding from the international community has decreased strongly. This is likely related to Colombia's stronger economic performance in recent years, which has led to a reduction in the funding of international aid/co-operation.

Figure 3.10. RTDCs' sources of funding for STI activities, million COP of 2011

Source: OECD estimates, based on OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Figure 3.11 shows the responses of 60 RTDCs to a questionnaire asking them to rate the extent to which they offer certain services. The service most frequently indicated was “applied research” but many also stated that they did basic research and experimental development. Overall, they cover a wide range of functions from “technology watch” to training, consultancy, lab services and technical assistance.

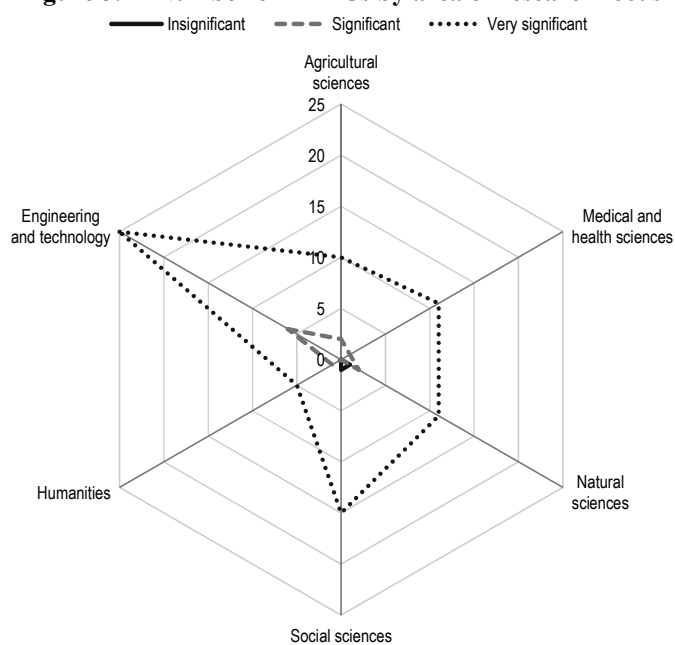
Figure 3.11 Number of RTDCs offering various services (rated by the centres as “very important”)



Source: Salazar et al. (2010), *Diseño y Aplicación de una Metodología para la Caracterización de Centros Autónomos de Investigación y Desarrollo Tecnológico*, OCyT, Bogotá.

Figure 3.12 shows that the main focus of the RTDCs is engineering and technology, but a significant number focus on social sciences.

Figure 3.12 Number of RTDCs by area of research focus



Source: OECD estimates, based on Salazar et al. (2010), *Diseño y Aplicación de una Metodología para la Caracterización de Centros Autónomos de Investigación y Desarrollo Tecnológico*, OCyT, Bogotá.

An alternative way to look at the institutes is to classify them, as in other countries, into three types of autonomous research institutes:

- Basic (scientific) research institutes such as FIDIC (immunology), of which Colombia has rather few. The international model would be Germany's Max Planck institutes.
- Some 19 government laboratories, which primarily produce knowledge for law-making, regulation or other government purposes. Their outputs are often public goods. The oceanography institute CIOH, for example, provides information both to the navy and to industry. Their funding is "lumpy" and the system is fragmented, with regulatory obstacles hindering current attempts to create closer links with universities and industry.
- Research and technology organisations (RTOs) whose main purpose is to produce knowledge and services for industry. The agricultural "CENI" institutes are funded by production levies and focus on single crops or clusters of crops. Stakeholder governance makes it hard to address longer-term or cross-cutting R&D needs. Industrial RTOs, such as ICIPC, which works on rubber and plastics, are similarly branch-focused and fragmented and have similar problems of stakeholder governance. Unlike the CENIs, they do not benefit from a production levy, so their funding is often uncertain. Performance is said to be mixed, which suggests an opportunity to review and reform under-performers. While the best are well linked to university research, others do not appear to be. This creates a significant problem for small organisations in areas that depend upon research in order to remain relevant.

Government policy regarding the institutes has changed frequently. From time to time there have been overly optimistic expectations about their ability to sell commercial services as a way to fund themselves (Wassermann, 2012). In the period up to 2007, Colciencias offered funding to support the institutional strengthening of technological centres on a competitive basis; centres were required to submit a development plan. Resources were allocated to finance the centres' operations and covered expenses for personnel and the purchase and maintenance of equipment.

OCyT's work shows that only 17 of the 60 institutes analysed are outside the five major cities and they are very diverse in terms of their purposes, funding, capabilities and scientific production. They are small: only two have more than 60 staff, and 45 have 17 or fewer. Therefore, many are sub-critical and almost none is able to tackle problems that are multidisciplinary in character.

The lack of a scientific career path in the civil service or government labs makes it difficult for some institutes to maintain a complement of full-time career researchers. Many rely on contractors and generally focus on a single sector or need. Links with universities appear to be increasing but complex administrative restrictions limit their freedom of action in dealing with other organisations and may make it especially hard to produce knowledge for the benefit of industry or innovation more generally.

The RTO systems for agriculture and industry are fragmented. Typically, these branch-oriented organisations focus on comparatively short-term work and need to be supported by close links to universities in order to set research agendas and capture the results from longer-term and more fundamental work. Firms are keenly aware that they pay for the research and tend to be sensitive to any sign that their resources are being diverted to questions that are not immediately relevant to them.

The industrial RTOs provide a mixture of research, development and technical services such as testing, and some appear more successful than others. There is a need not only for the kind of statistical information being generated by OCyT but also for evaluations of their industrial relevance and usefulness. Their governance is closely tied to their sector but they tend to depend heavily on contract work rather than statutory funding. While their major focus tends to be on technology, many cover the social sciences. While not all are RTOs in the classical sense, it is clear that they are rather narrowly specialised.

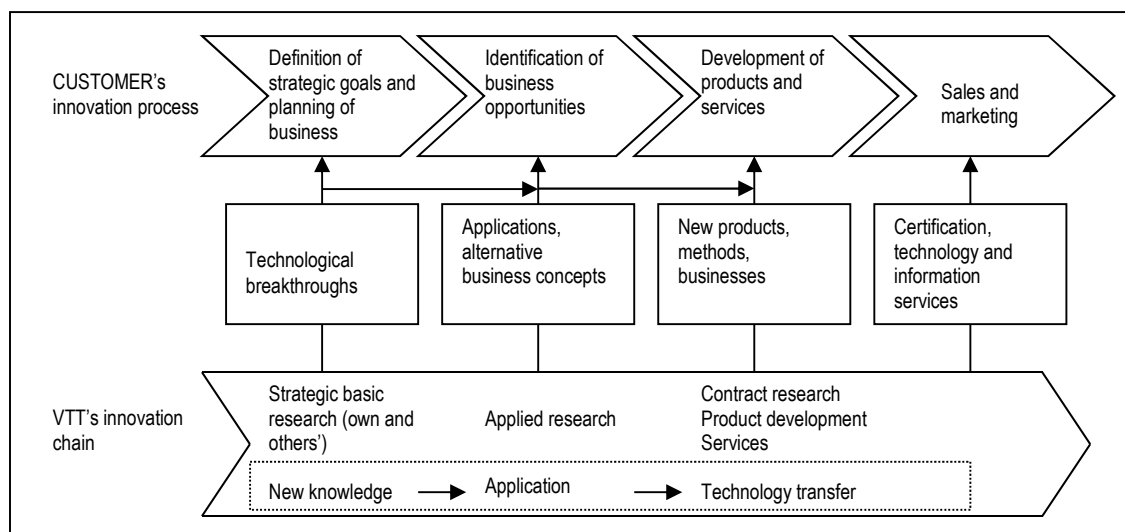
At the international level, however, the work of government labs and RTOs is converging, addressing technologies rather than branches, serving a wide range of customer needs and reducing the role of stakeholders in governance. As these two types of institute converge, the ability of government labs to serve the private sector and to do contract research increases. Their links with universities grow, with exchanges of staff, PhD students from universities doing their experimental work in the institutes and institute researchers teaching part-time at universities (Arnold et al., 2010).

The convergence of government labs and RTOs means that the labs increasingly take on RTO functions in addition to their government tasks while RTOs contract to do government lab work. Organisations such as VTT Finland and TNO in the Netherlands span both functions with a view to making better use of assets that can be applied across different social functions and technologies. The fragmented Colombian system could make better use of resources and provide better service to customers by fostering greater co-ordination and coherence (for instance by regrouping some RTOs into larger entities or by creating vehicles for co-operation). Colciencias' proposed research and innovation policy, *Colombia Reaps and Sows* (2008), included support for such consolidation but does not appear to have been implemented.

RTOs are used in many countries with great success and should be exploited more intensively in Colombia. They operate with an explicit or implicit innovation model that involves: exploratory R&D to develop an area of capability or a technology platform; efforts to refine and exploit that knowledge in relatively novel ways, often in collaborative projects with industry; and more routine exploitation of knowledge through consulting, licensing or formation of spin-offs.

Figure 3.13 shows VTT's version of this model. In principle, RTO core funding is primarily intended to pay for the first, exploratory stage, in which the RTO develops the knowledge and capabilities needed to support its industrial customers. This is what mainly distinguishes an RTO from a technical consultancy. Public money is used to create the capabilities the institute needs to take companies "one step beyond" what they could otherwise do, thereby providing social returns by reducing innovation risks (Sorlin et al., 2009). RTOs normally co-evolve with the economy in which they operate. In unsophisticated systems, RTOs often offer rather simple technologies and forms of support. As industrial development proceeds, the capabilities of the business sector rise and the RTOs have to be increasingly sophisticated to stay one step ahead.

Figure 3.13 VTT's innovation model



Source: VTT.

In principle, if an RTO has more money to invest in research to produce capabilities, it can move beyond its customers' short-term needs to search for technological opportunities and do more fundamental research. Some systems obtain a relatively high proportion of their income in the form of core funding. Thus Fraunhofer, TNO and VTT, with core funding in the 30-40% range, are able to do considerable amounts of applied (and even a small amount of basic) research. Others, such as GTS or the Swedish RISE system, with core funding in the 10-15% range, focus more on experimental development and services (Sorlin et al., 2009).

RTO impacts on company innovation and the economy can be very large. One study estimated that European RTOs collectively turn over about EUR 18.5 billion and trigger between EUR 25 billion and EUR 100 billion in economic activity (Arnold et al., 2012). An impact study of VTT, the Finnish RTO, identified the following types of impact: technical and economic impacts, impacts on investments, on intangible assets, on human resources, on firms' strategy, on information management and on relations with the environment (Loikkanen et al., 2013).

RTOs have the potential to support the development of business in Colombia. However this will require a detailed analysis and inventory of the functions performed by the present organisations, the needs of the different parts of society they serve, and their actual and potential capacity to play bigger roles in innovation. It would probably be necessary to create larger, more multidisciplinary entities and to link their governance less closely to individual beneficiary groups. They would likely need to co-operate closely with the university sector in order to strengthen their access to new knowledge, obtain a source of manpower and to signal industrial needs and potentially interesting research problems to the university system. This would certainly be preferable to having universities try to provide technical services to industry, as the innovation survey material described earlier implies.

Consideration could be given to integrating some of SENA's technological resources into the RTO system in order to connect them to wider demand and to bind them into a larger organisation's development, search for new knowledge and linkages with customers.

3.7. Human resources for science, technology and innovation

There has been considerable investment over the last decade in the development of human resources. In 2002 the government's *Revolución Educativa* promised a major programme of educational improvement. Expansion of tertiary education was seen as a major part of the revolution, along with improvements in its quality and accessibility. These goals were to be underpinned by even more ambitious plans to raise the scale, quality and accessibility of secondary education. More recently, the government has emphasised its wish to raise the country's national education performance to levels typical of OECD member countries. Colombia now spends about the same proportion of GDP on education as Spain or Chile. But given its much lower GDP per capita, investment per person is much lower and will need to increase in absolute terms.

Dropout rates within and between stages of education remain very high. There is clearly some way to go before educational coverage and attainment at primary and secondary levels attain the coverage and quality needed for competitiveness. Raising the competence, qualifications and status of schoolteachers will need to be an important part of the equation.

At their current size, flows of human resources from tertiary-level education are not yet commensurate with what will be needed to improve the country's innovation system in ways that can rapidly narrow the gap with international competitors. Indeed, despite their growth over the last decade, the insufficient flows of human resources may come to be a constraint on the capacity of the innovation system to absorb effectively the large expansion in funding for science, technology and innovation that is expected to follow from recent radical changes in the political and institutional context.

It is striking that, while the thematic focus of PhD education is shifting towards the scientific and technological subjects that would appear to be relevant to the economy, no policy instruments explicitly link the needs of specific sectors to research and higher education. In other systems, this kind of matching is partly done through analysis of aggregate national manpower needs and partly through the interaction of the university system with industrial stakeholders in competence centres, technology programmes, cluster development policies and so on.

Colciencias devotes considerable resources to increasing PhD production, primarily for the higher education sector but also in an attempt to inject more PhDs into industry. While SENA is a powerful instrument for vocational education and training, and has the ability to work on a company-by-company basis to train middle-level personnel, there is a gap in middle-level skills, especially in design, project management, logistics and many aspects of management, all of which have a significant experiential component. Incentives for companies to train such people are weak: given the shortage of these skills, any company devoting resources to increasing their stock of such skills is likely to see the beneficiaries leave for better opportunities. Ways to tackle this issue include strengthening tertiary education provision and offering companies incentives to train more people than they need in the short term. Greater presence of foreign multinationals and the extension of their activities beyond sales and basic manufacturing can also help address the shortages. More focus by RTOs on training and on encouraging younger staff to move into industry after a time (as the Fraunhofer Society in Germany and other international RTOs do) is an additional means.

Driving up the level of business enterprise R&D will require a commitment to major investment in building up in enterprises the required base of innovation-related human capital. At the same time, creating a stronger basis for autonomous, enterprise-driven diversification towards higher value-added activities will require expanding their “diversification” capabilities. These vary across sectors, but typically include a variety of non-R&D capabilities. These activities will in turn require expanding the three main means of creating such resources in the past: i) the tertiary education system, which covers technological and technical training as well as university level education; ii) Colciencias’ investment in developing PhD research capabilities; and iii) the training activities of SENA and private-sector training organisations that have focused primarily on various production-level skills.

There are imbalances and gaps in the structure for creating innovation-related human capital. Perhaps the most striking imbalance has been the “inverted pyramid” of relatively low levels of professional technological and technical training relative to the much larger volumes of university education. However, the largest appears to be the limited emphasis given to the role of enterprises themselves as creators of the innovation-related human capital they employ. This is especially important in connection with middle-level and higher-level competences and the limited exploitation of opportunities to augment those competences in association with suppliers of services, goods and technology for major investment projects. A further gap seems to be the limited role played by publicly funded research and technology organisations in transferring technology to enterprises via the movement of human capital.

Sub-tertiary education

The skills needed in the economy in general need to rest on a solid foundation of school education. Some 86% of young people now complete primary education. At the secondary level, enrolment rates increased rapidly between 2002 and 2009, from 57% to 71% at the lower secondary level, and from 30% to 40% at the upper secondary level. These levels clearly need to rise further. Along with the growing numbers, the quality of pupils’ knowledge and skills has also risen, as reflected in significant improvements in PISA scores between 2006 and 2009, not only in reading but also in mathematics and science (OECD et al., 2012). However, many high school graduates are still not “college ready” in terms of their attainments in science and mathematics. PISA scores in science and mathematics (2009) were about 80% of the OECD average, a sign that Colombian students are poorly prepared to tackle technical and scientific subjects at higher levels (OECD et al., 2012).

Tertiary education

At the tertiary level, student enrolments expanded from about one million in 2000 to nearly 1.7 million in 2010, and the proportion of the university age cohort (17-21) enrolling as undergraduates increased from 24% to 37% (OECD et al., 2012). Tertiary education suffers from an overall dropout rate of 45%, and the rate rises as parental income falls.

In comparison with other Latin American countries, a large proportion of those students were enrolled in science and especially engineering disciplines, and Colombia was one of three Latin American countries (along with Mexico and Chile) in which the share of all new tertiary graduates with degrees in these areas was comparable to OECD countries such as Spain (IDB, 2010). However these were shares of relatively low totals because, despite the rising levels of participation, Colombia lagged behind overall tertiary rates in six other Latin American countries in the late 2000s (OECD et al., 2012).

SENA (which is funded by a payroll levy) plays a major role in training the workforce below the tertiary level. It provides some tertiary-level education (about 3.8% of the total student population) but its main task is to develop vocational skills. In 2011 it trained 7.9 million people in its 116 training centres.

Table 3.20. Educational stages of young people aged 15-24

Stage	Number	Percentage
Enrolled in secondary education	2 290 000	27%
Have not completed upper secondary education and are not studying	1 280 000	15%
Completed upper secondary education	4 704 000	56%
Not enrolled in higher education	2 009 000	24%
Dropouts	1 184 000	14%
Enrolled in higher education institutions	1 511 000	18%
Graduates of higher education institutions	168 000	2%
Total (population aged 15-24)	8 442 000	100%

Source: OECD et al. (2012), *Reviews of National Policies for Education: Tertiary Education in Colombia 2012*, OECD Publishing. <http://dx.doi.org/10.1787/9789264180697-en>.

The importance of gender, income and regional differences in access to tertiary education has declined. Nonetheless, income inequalities adversely affect opportunities for higher education. The University of the Andes, for example, pointed out that given its limited scholarship fund, it has to turn away several times as many low-income students as it accepts, in favour of richer ones with lower grades who are able to pay the fees. Efficient production of university-level skills requires much greater equality of opportunity to go to – and to stay at – university. Table 3.21 shows the average tuition fee charged per semester by private higher education institutions in 2011. The difference in cost between a private university and private technological institute is 138%. In 2010, average yearly fees in public universities were COP 1 194 426 and in private universities they were COP 5 907 429 (OECD et al., 2012).

Table 3.21. Tuition fees, per level of qualification

Type of degree	Tuition fee (in COP) per semester Private HEIs
Professional technical	1 367 179
Technological	1 529 633
University	3 646 358,
Specialisation	4 874 602
Master	8 762 686
PhD	10 053 440

Source: MEN – SNIES.

Other inefficiencies hamper the transition from school to university. The lack of a national clearing-house for university applications makes the process complex and uncertain for the student while leaving the universities uncertain about the size of their intake because good students receive several offers. It is hard to switch from technical or vocational training to university. Lack of agreement about the value of different forms of tertiary education or of a system of compatible course credits makes it hard to switch from technical or vocational training to university.

The OECD/International Bank for Reconstruction and Development/World Bank report on tertiary education in Colombia also gives historical data on students enrolled in tertiary education. Table 3.22 shows the upward trend among young people aged 17-21, with an increase of 13 percentage points over the last eight years. It also shows the increase in the percentage of undergraduates enrolled in a “technical or technological” course in the last eight years, from 20% of total undergraduates enrolled in 2002 to 34.2% in 2010.

As the report notes, “The growth in enrolment was not evenly distributed over all types of institutions in the Colombian system. The greatest increase occurred in the technical and technological institutions, whose enrolment saw an annual average increase of 14.5% between 2002 and 2010. By contrast, the rate of increase at the bachelor’s degree level was a more modest, but still substantial, 4.2% per year. As a consequence of this shift in enrolment patterns, the total share of students enrolled in technical and technological programmes increased from 19.5% in 2002 to 34.2% in 2010.” (OECD et al, 2012)

Table 3.22. Tertiary student enrolments, 2002-10

	2002	2003	2004	2005	2006	2007	2008	2009	2010
Technical and technological	183 319	215 285	263 375	295 290	347 052	394 819	462 646	482 505	542 358
(% of undergraduate total)	(19.55)	(21.6)	(24.77)	(25.95)	(28.45)	(30.22)	(32.47)	(32.31)	(34.16)
Bachelor’s	745 570	781 403	799 808	842 482	872 902	911 701	961 985	1 011 021	1 045 571
Total undergraduate	937 889	996 688	1 063 183	1 137 772	1 219 954	1 306 520	1 424 631	1 493 525	1 587 928
(Coverage as a percentage of the population aged 17-21)	(24.43)	(25.65)	(26.96)	(28.44)	(30.01)	(31.68)	(34.07)	(35.26)	(37.05)
Specialisation	55 133	43 783	39 893	45 970	47 506	40 866	44 706	54 904	60 358
Master’s	6 776	8 978	9 975	11 980	13 099	14 369	16 317	20 386	23 808
Doctoral	350	583	675	968	1 122	1 430	1 532	1 631	2 326
Grand total	1 000 148	1 050 032	1 111 726	1 196 690	1 281 681	1 363 185	1 487 186	1 570 447	1 674 420

Source: OECD et al. (2012), *Reviews of National Policies for Education: Tertiary Education in Colombia 2012*, OECD Publishing. <http://dx.doi.org/10.1787/9789264180697-en>.

The inverted pyramid

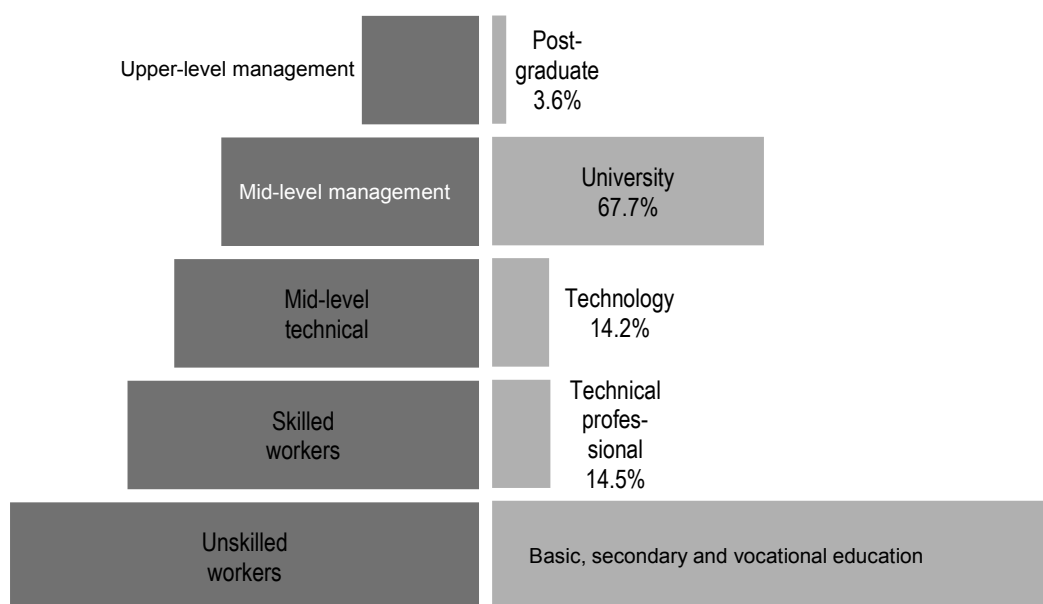
The balance between technical tertiary education and higher education is also problematic, with (often “soft”) higher education having greater social status than technical education. Indeed, the balance between technical education and higher education is problematic in much of Latin America, with 70% of the cadre often in higher education and 30% in technical education. Available evidence suggests that a similar imbalance exists in Colombia (Table 3.23 and Figure 3.14). The ratio in OECD countries (especially in parts of Europe) is typically the opposite (Bitran et al., 2011). Combined with the limited extent to which Colombian companies are able to train people for middle-level technical occupations, this appears to be a factor behind repeated complaints from industry about skill shortages and lack of experience in middle-level functions such as technicians, logisticians, design, project managers and so on.

Table 3.23. Students and staff per type, 2011

	Number of institutions	Absorption rate*	Number of students enrolled	Number of students that graduated	Teaching staff	Administrative staff
Universities	80	49%	895 193	72 329	76 071	29 729
University institutions	115	49%	294 168	22 561	18 185	5 699
Technological	54	72%	348 103	36 426	2 428	790
Professional technical institutions	39	84%	37 013	3 727	1 815	1 193
Total	288	55%	1 574 477	135 043	98 499	37 411

*Absorption rate is measured as the percentage of students that are admitted over the total number of students that apply to the institutions.

Source: SNEI (Higher Education Information System), OECD et al (2012, p. 85), *Reviews of National Policies for Education: Tertiary Education in Colombia 2012*, OECD Publishing. <http://dx.doi.org/10.1787/9789264180697-en>.

Figure 3.14 Occupational versus educational pyramid in Colombia

Source: CONPES document 3582, 2009.

Government policy is to limit the growth of bachelors education but to increase tertiary education, with a special emphasis on engineering and technological training (Table 3.24).

Table 3.24. Undergraduate enrolments, 2010 and 2014 targets

Level	2010 baseline	2014 target	Required 2010-14 absolute growth	Required 2010-14 % growth rate	Required average annual growth rate
T&T	542 358 (34.2%)	980 202 (45.0%)	437 844	80.7%	15.9%
Non-SENA T&T	245 672 (15.5%)	411 202 (18.9%)	165 530	67.4%	13.7%
SENA T&T	296 686 (18.7%)	569 000 (26.1%)	272 314	91.8%	17.7%
University	1 045 570 (65.8%)	1 198 025 (55.0%)	152 455	14.6%	3.5%
Total undergraduate	1 587 928 (100%)	2 178 227 (100%)	590 299	37.2%	8.2%

Source: OECD et al., (2012), *Reviews of National Policies for Education: Tertiary Education in Colombia 2012*, OECD Publishing. <http://dx.doi.org/10.1787/9789264180697-en>.

Higher education

The number of people taking bachelor's, master's and doctoral degrees has been growing steadily over the last decade and growth has accelerated in the last few years. The proportion of people taking first degrees is about at the Latin American average and therefore well below the leading Latin American countries or the OECD (Table 3.25). The share of people taking postgraduate degrees is also low compared with the Latin American average.

Table 3.25. Undergraduate enrolment of people aged 17-21 in Latin America, 2009

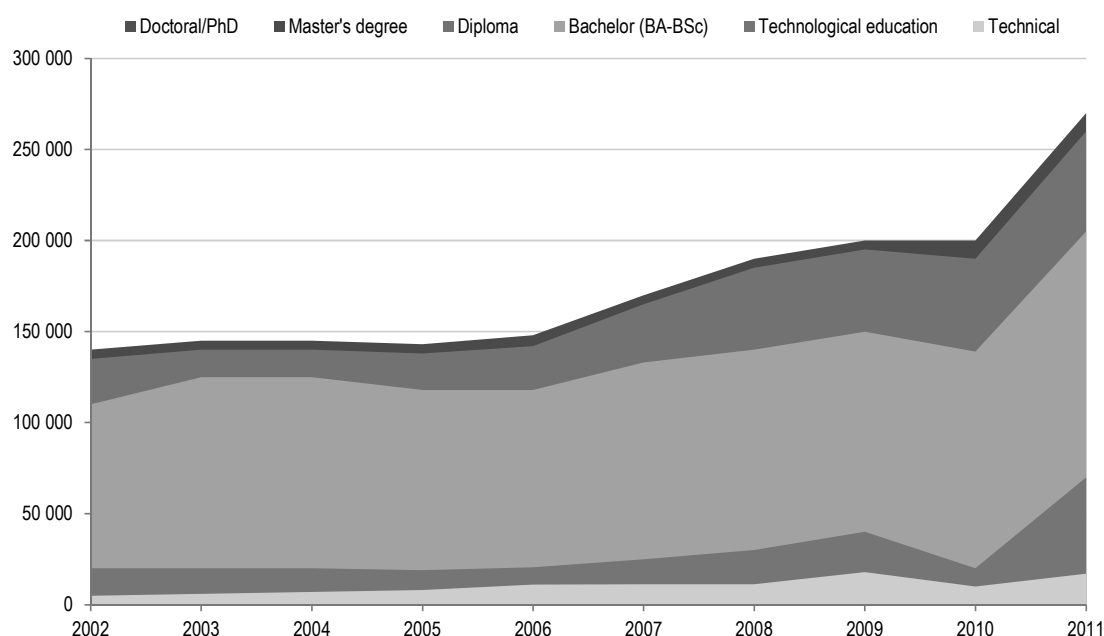
Country	%
Average for Latin America and the Caribbean	37.2
Cuba	115.0
Puerto Rico	80.9
Venezuela	78.1
Argentina	71.2
Uruguay	63.3
Chile	59.2
Panama	44.6
Colombia	37.1
Paraguay	36.6
Brazil	36.1
Mexico	27.0
El Salvador	23.0

Source: UNESCO, SNEI (National System of Higher Education Information).

Three-quarters of students attend public universities. Unsurprisingly, the higher socioeconomic groups dominate in the elite private universities. ICETEX was set up in 1950 to fund international studies and technical training. Its remit has grown from

funding higher education abroad to providing student loans at home, but in 2011 it still did not have enough money to provide all applicants with a grant. There has nonetheless been a steady average 9% increase in the number of university graduates from higher education over the last decade (Table 3.26). In the last year, an increase of 32% was mostly driven by an increase in the number of graduates with a technical degree or who received some sort of technological education (Figure 3.15).

Figure 3.15. Number of graduates from higher education institutions by level, 2002-11



Source: OECD estimates based on OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

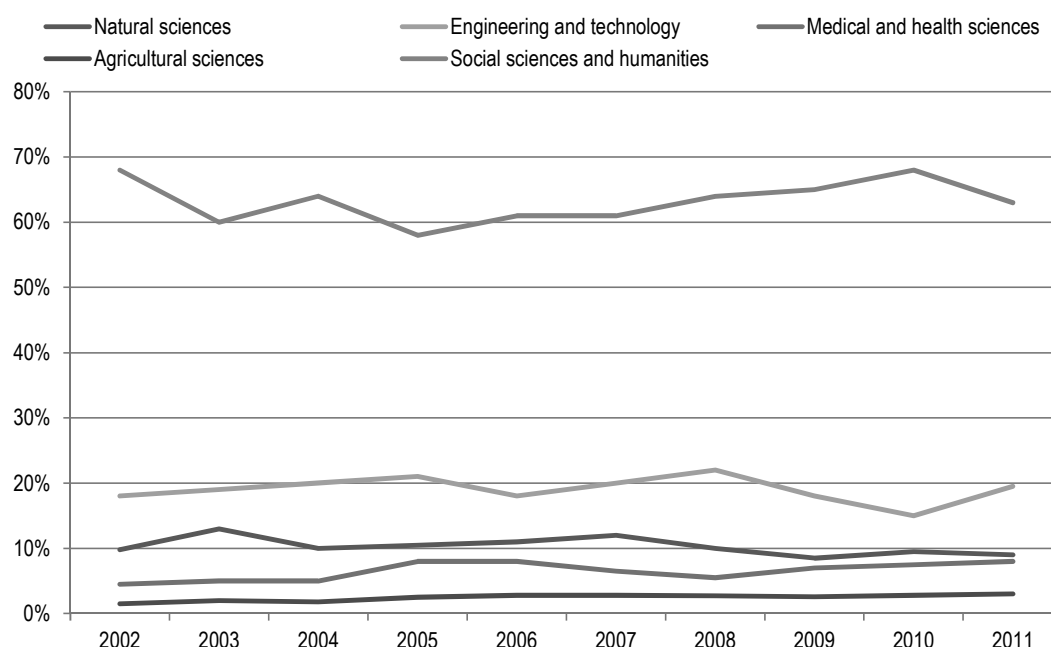
Table 3.26. Graduates from Colombian higher education institutions by level of education, 2002-11

Level	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Technical	4 244	5 185	5 179	5 44	8 672	10 372	14 887	18 07	8 295	18 329	98 673
Technological education	19 005	18 692	17 992	16 04	16 215	21 307	22 265	24 856	23 671	72 292	252 335
Bachelor (B.A. - B.Sc.)	86 22	98 534	97 809	91 998	91 078	104 151	109 143	111 889	111 404	117 746	1 019 972
Diploma	22 077	21 334	23 106	23 82	27 289	35 311	40 311	42 525	52 935	52 673	341 381
Master's degree	1 864	1 848	2 281	2 464	3 288	3 49	4 141	4 79	5 902	6 41	36 478
PhD	32	46	50	48	91	94	139	173	211	258	1 142
Total graduates	133 442	145 639	146 417	139 81	146 633	174 725	190 886	202 303	202 418	267 708	1 749 981

Source: Indicadores de ciencia y tecnología Colombia, OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

The social sciences and humanities are by far the most popular subjects at the master's level. Engineering and technology declined slightly between 2008 and 2010 but recovered in 2011. The percentage of master's graduates in the area of medical and health sciences also rose slightly (Figure 3.16).

Figure 3.16. Graduates from national master's programmes by subject, OECD classification



Source: OECD estimates based on OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Production of PhDs

Efforts in recent years to increase the production of PhDs needs to be seen in a wider context, both because of the special role that PhDs play in the research and innovation system in general and because PhD production is intimately tied up with “basic research”. The term covers research undertaken in view of application, research conducted without knowledge of its likely applications, as well as research driven simply by curiosity. “Basic” research, especially of the university variety, is an important part of the innovation system, but its importance varies over time and at different stages of development.

Studies of the long-term relationships between research and innovation reveal the long delays involved in using research results in innovation, the bi-directional interdependence of applied and basic research, and the importance of being able to bring together pieces of knowledge from disparate sources.²⁶ Innovation is not a linear process. Often ideas are not used until complementary pieces of knowledge are obtained. As emphasised elsewhere, innovation drives the use of knowledge more often than knowledge drives innovation.

In general, as industrial development proceeds, industry's R&D grows faster than that of the state. A certain minimal level of university research is necessary, even at low levels of business R&D, to train researchers to conduct R&D. The state therefore has to make

the initial investment in research and learning. University research needs to grow to support business R&D, but not at as fast a rate. This is one of the reasons why business R&D becomes a larger share of the total R&D effort as countries develop²⁷.

The balance of basic and more applied research varies over time, as shown both in national R&D statistics and in the spending pattern of certain R&D funders at national level. As long as national technologies are behind the technological frontier, companies operate in “catch-up” mode. They need to be supported by a state research infrastructure with significant applied research capability. Once the frontier is in sight, however, companies and countries need to search more widely for knowledge. This typically leads to an increase in the share of basic research in order to generate or absorb new knowledge. The share rises not only in the research sector but also in companies.

China’s research and innovation system was largely destroyed by the Cultural Revolution and has been rebuilt almost from scratch. Since the opening up of China at the end of the 1970s, developing a strong research and innovation system has been a cornerstone of national development policy (NSFC, 2011), and China’s spectacular growth has been built on a massive expansion of the research and innovation system. China is now second only to the United States in the number of scientific papers it publishes each year. Growth in basic research has been equally spectacular, but has remained stuck at 5% of GERD. Overall, R&D is strongly focused on development. In some parts of the system Chinese science and technology are at the leading edge, but for the most part China still operates in catch-up mode. The low share of basic research will become insufficient as science and industry move towards the frontier (OECD, 2007; NSFC, 2011).

Japan’s higher proportion of basic research reflects its more advanced development, although the share of basic research has drifted down very slowly from 14-15% in the late 1980s to 13% in 2009. In contrast, the share of basic research in the United States has increased from the same level as that of Japan in the late 1980s to 19% in 2009, a period during which it has maintained its global leadership in science, technology and innovation. The handful of other OECD countries that report basic research separately from applied research in their returns to the OECD set it around the 20% level and rising (at a very slow rate) (Arnold and Giarracca, 2012).

The implication for Colombia is that university research and PhD education are necessary and important, but that the amount of effort needed in these areas today is less than what is needed in the most advanced countries. The production of PhDs and university research can only be put to social use if complementary skills in design, engineering and production are in place.

The disparity in higher education output between Colombia and other Latin American countries is large at the PhD level, in terms both of doctoral graduates per million population and science and engineering degrees. The gap is particularly large in comparisons with Brazil and Mexico, yet even these countries had only about half the number of PhDs per million inhabitants as OECD countries such as Spain (IDB, 2010). Increased provision of grants and loans, notably through ICETEX and Colciencias, has been important for achieving growth in higher education and a decrease in the inequalities associated with access. But the size of the gap with other countries – and the cost of bridging it – is very large. Master’s graduates would have to double to reach the Latin American average per million population and PhD graduates would have to rise six-fold (Table 3.27).

Table 3.27. Numbers of master's and PhD graduates per million inhabitants, 2010

	Masters	Doctorates
Argentina	74	38
Bolivia	217	
Brazil	205	59
Chile	450	21
Colombia	129	5
Costa Rica	719	22
Cuba		55
Spain	773	183
Guatemala	154	1
Mexico	395	37
Peru	170	27
Puerto Rico	1 684	388
Portugal	1 045	
El Salvador	79	0
Trinidad and Tobago	347	15
United States	2 037	218
Uruguay	102	12
Venezuela	5	1
Latin America and the Caribbean	209	32
Ibero-America	269	47

Source: RICyT (2013), *Comparative Indicators*, The Network of Indicators of Science and Technology Ibero-American/Inter-American, www.ricyt.org/index.php?option=com_content&view=article&id=149&Itemid=3. 2009 numbers were used when 2010 data were unavailable.

PhD education was boosted by an IDB loan in the early 1990s that enabled Colciencias to fund 604 PhD students to take their doctorates abroad between 1992-97. As with other science funding, the level of investment then appears to have declined, with about 50 PhD graduates a year in 2003-05. Since then the figure has risen steadily to some 250. Since 2002, the capacity of the universities to train PhDs has increased with the help of a World Bank loan.

Table 3.28 shows total PhD production for Colombian universities and Colombian PhD students receiving their training abroad. Some 35% of the 644 who obtained a doctoral degree in 2011 were women. Some 40% of PhD graduates in 2011 were in the social sciences and humanities, with the balance in natural sciences and engineering.

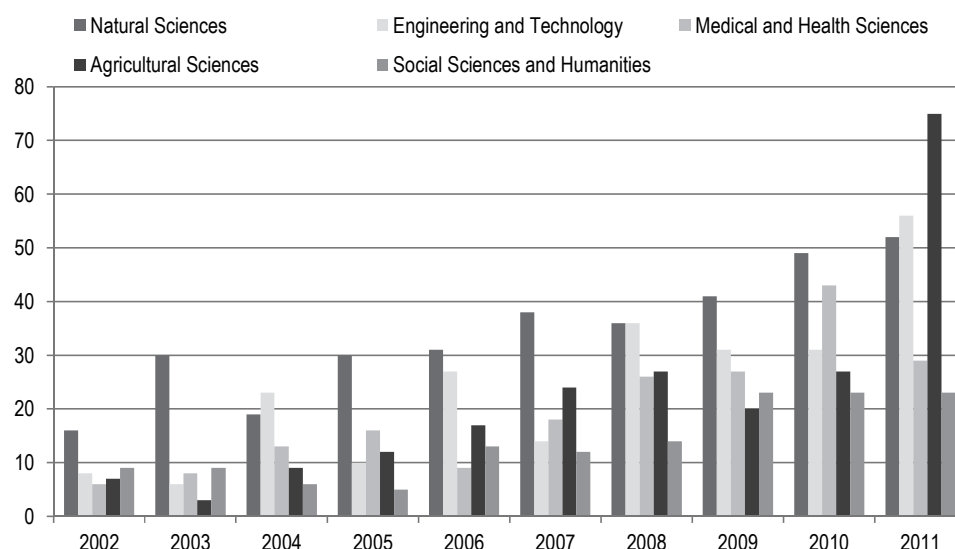
Table 3.28. PhD graduates from Colombian and foreign universities by year, 2002-11

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth
Natural sciences	97	101	113	84	116	115	146	138	152	164	169%
Engineering and technology	53	36	56	83	75	83	92	127	127	124	234%
Medical and health sciences	17	24	24	25	33	38	43	49	65	72	424%
Agricultural sciences	28	31	35	26	36	29	33	51	33	28	100%
Social sciences	70	101	114	121	153	147	179	192	212	200	286%
Humanities	29	24	29	46	41	47	58	42	40	56	193%
Total	294	317	371	385	454	459	551	599	629	644	219%

Source: Indicadores de ciencia y tecnología Colombia, OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Figure 3.17 shows how the proportion of Colombians obtaining their PhDs from a Colombian university has risen over time. PhDs in the natural sciences have grown steadily. Graduates from Colombian universities in engineering and medicine have been more volatile. Agriculture, engineering and medicine all showed dramatic growth in the latest period.²⁸

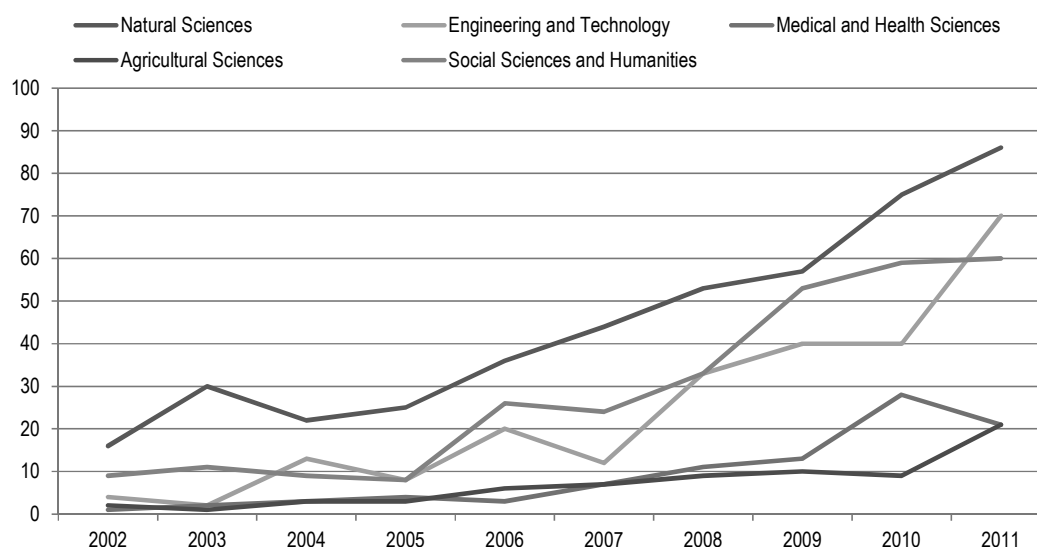
Figure 3.17. Proportion of Colombian PhD graduates receiving their degree from a Colombian university, 2002-11



Source: OECD, based on OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Figure 3.18 shows that the absolute amount of PhD production by Colombian universities is greatest in the natural sciences and engineering, although there has been a significant spurt in the growth of the social sciences and humanities in the recent period.

Figure 3.18. Number of PhDs graduating from Colombian universities, 2002-11



Source: OECD, based on OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Colombia currently has 155 PhD programmes. Table 3.29 shows the split among broad disciplines and the numbers and shares of their graduates in 2011. It suggests that the graduate programmes are on average rather small, which confirms that the research community is fragmented. As is generally the case, the graduate programmes in the hard sciences are bigger than those in the soft sciences and humanities.

Table 3.29 No of graduate schools and PhD graduates by broad discipline, 2011

	Programmes		Graduates		Graduates per programme
	No.	%	No.	%	
Natural sciences	38	25%	86	33%	2.3
Engineering and technology	34	22%	70	27%	2.1
Medical and health sciences	15	10%	21	8%	1.4
Agricultural sciences	10	6%	21	8%	2.1
Social sciences and humanities	58	37%	60	23%	1.0
Total	155	100%	258	100%	1.7

Source: OECD, based on OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

A key driver of the growth in PhDs has been the availability of scholarships and loans (Table 3.30). Colciencias has been the major funder, followed by Colfuturo²⁹ and ICETEX. More widely, increased funding opportunities lie behind the expansion in master's-level education (Figure 3.19).

Table 3.30. Doctoral scholarships and loans by funding institution, 2002-11

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total ⁴
Banco de la República	5	6	7	12	10	10	8	13	4	4	79
Colciencias ¹	120	77	173	165	166	127	136	319	462	571	2 316
Colfuturo	27	26	24	18	24	34	69	82	112	107	523
Ecopetrol - ICP	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1	2	n.d.	1	4
Fulbright-DNP-COLCIENCIAS	9	8	9	10	9	13	7	12	11	n.d.	88
Fulbright	5	12	13	7	10	23	23	21	49	6	169
Fundación Mazda	n.d.	n.d.	n.d.	n.d.	1	2	3	3	6	2	17
ICETEX ²	18	19	45	29	28	26	104	27	84	141	521
MAEC-AECID ³	n.d.	n.d.	n.d.	n.d.	18	4	5	0	3	4	34
Total	184	148	271	241	266	239	356	479	731	836	3 751

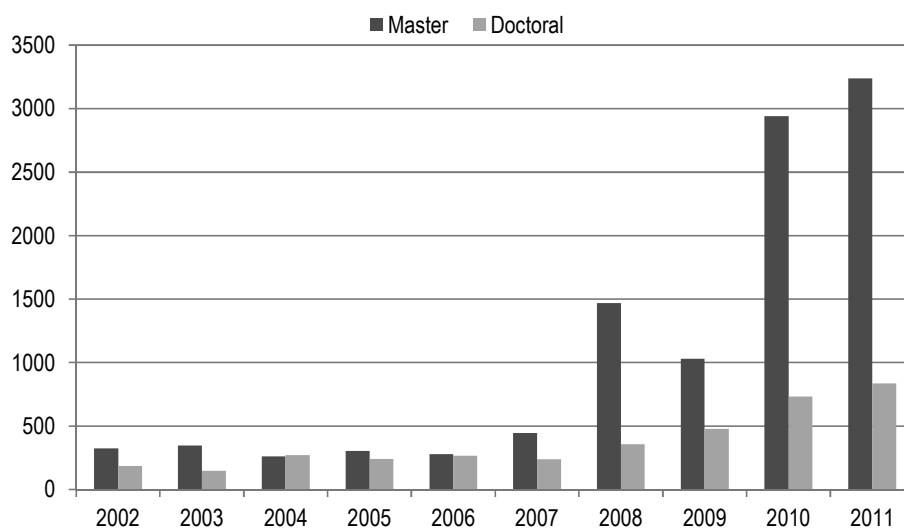
1. 2010 includes the beneficiaries of the program “Becas para las Regiones”, a joint effort of Fulbright, Ministry of Education, DNP and Colciencias.

2. In 2008, 2010 and 2011 ICETEX reported scholarships and forgivable credits and in the other years only scholarships.

3. Information from the Ministry for Foreign Relations and Cooperation - Spanish Agency for International Cooperation and Development (MAEC-AECID) is only reported from year 2006.

4. Total refers to the number of scholarships granted and not to the number of persons.

Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Figure 3.19. Total master and doctoral scholarships and loans, 2002-11

Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

There seems to be a strong positive correlation in Colombia between the highest level of education attained and the salary paid by the labour market (Table 3.31). A graduate (in 2010) with a professional technical degree earns a monthly salary that is 130% of the monthly salary of a person who completed secondary school (a percentage considerably higher than that of the gap in tuition fees discussed above). Increments are less significant at higher levels of education until the graduate obtains a specialisation.

Graduates are also very likely to work in the formal sector of the economy, which implies access to a decent salary, access to benefits and some degree of labour stability. In many Latin American countries the problem is not unemployment – everybody works on something – but the split between formal and informal jobs.

Table 3.31. Entry-level monthly salary and formal employment, per level of qualification

Type of degree	Monthly salary (graduates in 2010) (COP)	Percentage difference with prior level	Percentage of graduates working in the formal sector
Secondary education	394 515	NA	NA
Professional technical	909 017	130%	59%
Technological	1 057 062	16%	76%
University	1 441 180	36%	77%
Specialisation	2 701 503	87%	91%
Master	3 396 815	26%	92%

Source: MEN – SNIES.

Notes

1. The strong emphasis on public actors in Law 1286 was later balanced by Conpes document 3528 which gave much more attention to business enterprises.
2. There have also been two DANE surveys of innovation in the services sector but the results of these are problematic and have not been used by OCyT.
3. Innovation survey information is used below to examine sectoral differences in innovation in Colombian manufacturing.
4. This reflects a broader limitation on the use of internationally comparative STI-related data in Colombia. For example, OCyT produces an impressive compendium of S&T indicators. However, unlike equivalent volumes in many other countries, it so far includes no comparative data. OCyT should be encouraged to develop an international comparative component for this policy information tool.
5. Outsourcing of R&D to other firms is likely to be insignificant.
6. This does not include the government funding provided via the tax credit programme. It is difficult to estimate the level of this funding, but it would almost certainly not raise the total government funding for enterprise R&D to more than about 1.5% of all government funding for R&D.
7. This appears to be the role of the R&D co-financing programme of Colciencias. Evaluation of this programme by Crespi et al. (2011) suggests that interaction between the innovation capabilities of firms and institutes has significantly positive effects on the firms involved.
8. For many years understanding of innovation has largely concerned manufacturing. It is only fairly recently that the importance of different characteristics of innovation has been emphasised in discussions of policy and management. See for example, Dodgson et al. (2005) and NESTA (2007, 2009).
9. The term “engineering” is used here to refer to the function of creating specifications for products and facilities in all kinds of industry, and often for managing the realisation of those specifications, e.g. in bridges, garments or oil wells. This differs from the use of the same term (later in this report) to refer to specific manufacturing sectors concerned with producing machinery and equipment.
10. Unfortunately, this loses the “new-to-market” category that could be particularly illuminating in Colombia as it would provide a rough indication of the type of innovation that (at least in principle) involves firms’ entry into new lines of production and thus contributes to their diversification and to wider change in the structure of production in the economy, an important policy aim.
11. Although the survey asks about process innovation, the question is complex and the published data give almost no attention to the responses. This is an important gap, especially when process-intensive industries play such a large role in Colombian manufacturing.

12. In principle this can be illuminated, for example, by information about the proportion of sales accounted for by innovative products, data that are available from EDIT V. However, the information is not used here because about half of innovative firms did not respond to the sales-related questions, and the estimated proportions of firms with innovation-related sales exceeding 10% of total sales seem unrealistically high.
13. The main limitations arise because the Colombian survey only covers manufacturing while the EU surveys cover a broader range of industries. Also, the Colombian survey question asked whether or not particular sources of “ideas for developing or implementing” innovation were important, while the EU survey enquired about “how important” (on a four-point scale) particular sources were “to your enterprise’s innovation activities”. Data for the “highly important” responses are shown here.
14. It is also important to bear in mind the “fuzzy” nature of this kind of information, which simply reflects innovative firms’ identification of certain sources of ideas as important in their imprecisely specified “innovation activities”.
15. This important issue is illuminated in a study of different modes of innovation in business enterprises in Denmark (Jensen et al., 2007), which distinguished two modes of innovation. One was relatively science- and research-intensive and involved strong external links and collaboration, especially with universities and scientific institutes. The other was more engineering-intensive and rooted in problem solving and experience in production and markets; its most important links were within the firm – for example between production and engineering teams. Both modes of innovation were effective in their particular sectoral and market contexts.
16. The same cross-sectoral pattern also applied to firms’ suppliers, which were identified as important sources much more often than their own R&D.
17. The definition of smallholders varies across countries. The average farm size in many Asian countries is less than a hectare, whereas in Latin America operations of ten hectares or more may be considered small (Cervantes-Godoy et al., 2013). A common characteristic of smallholders is lack of access to input and output markets.
18. Although usually couched in language about the size of farms, this distinction has typically been used as shorthand for differences across a wider set of characteristics. For example “smallholder” agriculture involves farming in risk-prone agro-ecological conditions, with poor capital assets; poor access to input and output markets; poor or ineffective connections with agricultural knowledge systems; and livelihoods that depend on both agricultural and non-agricultural incomes, with the former usually critically important for food security.
19. Letty et al. (2012) provide an overview of the development of this perspective and of the differences in practice associated with the “dual” agricultural innovation system.
20. In their contribution to the World Bank “sourcebook” on agricultural innovation systems, Heemskerk and Davis (2012) highlighted this issue in terms of the need for “pluralistic extension systems”. These recognize “the inherent diversity of farmers and farming systems and the need to address challenges in rural development with different services and approaches. It is characterized by the coexistence of multiple public, private, and mixed extension systems and approaches; multiple providers and types of services; diverse funding streams; and multiple sources of information” (p.194).
21. In Colombia the term “municipality” does not carry the urban connotations that it does in some other contexts. Instead, the municipality is simply the second tier of

- local government, whether rural or urban, i.e. within the departments (roughly equivalent to provinces).
22. As formalised in 2004, these bodies co-ordinate agricultural policy at the department level, including representatives of the main stakeholders in the activities and interacting with the CMDRs.
 23. Uribe et al. (2011) does provide information for more recent years. This covers some of the component parts of the picture (several funding and performing organisations) for different years, but it is difficult to pull the components together into a clear overview.
 24. For instance, Grabbity – a mobile phone software application – was awarded one of the three MobilePremierAwards 2013 for innovative applications at the Mobile World Congress in Barcelona (www.mobilepremierawards.com/winners-2013/).
 25. Technological and professional technical institutions provide training in technical and occupational courses and applied specialist courses and may only offer courses in their areas of specialisation. The technological institutions (TIs) and professional technical institutions (PTIs) differ in terms of the length and complexity of their programmes. TI programmes typically last seven semesters and PTIs five. Graduates of a TI are expected to work at a higher technological level and may have engaged in applied research in specialised areas towards the end of their courses, while PTIs prepare technicians (OECD et al., 2012).
 26. See Iserson (1967), Loellbach (1968; 1969), Elg and Håkansson (2011) and Arnold (2012).
 27. The interdependence of different parts of the innovation system is underlined by work showing that high-performing countries such as the United States and Germany publish all types of research: basic, applied, development and engineering (Brusoni and Geuna, 2001).
 28. Given the small absolute numbers, the trend is not reliable without further data.
 29. The Foundation for the Future of Colombia, Colfuturo, is designed to provide the financial and academic support necessary to give Colombia's best and brightest access to postgraduate training in the world's best universities in order to tackle new challenges of knowledge and development.

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Chapter 4

The role of government

This chapter examines public activities that have a bearing on the Colombian innovation system. It begins with an examination of governance arrangements. It then charts the historical evolution of science, technology and innovation policy in Colombia and of attempts to influence the structure of production (in the longer term). The chapter then reviews a range of innovation policy tasks that appear pressing in light of the specific challenges faced by Colombia. It concludes with a summary note on government institutions.

4.1. Governance and the national innovation system

Colombian governance and the idea of a national innovation system

Governance of the national innovation system is the implementation of state-supported actions and the management of research and innovation by organisations that have been allocated responsibilities by the state.¹ An examination of research and innovation governance is therefore concerned not only with policy but also with the interplay of the various actors that together determine the priorities, strategies, activities and outcomes of research and innovation. The focus is on the processes of policy formulation and implementation, rather than on the content. Governance is not just about steering but about how to determine the way to generate consensus-based commitment to move in the desired direction (Kuhlmann, 2001).

In Colombia, the idea of systems of innovation is closely tied to institutions, whether formal state organisations or systems of committees. Innovation is seen as a strand of the National Development Plan (NDP) that is separate from individual sectors or branches. Various aspects of policy debate and policy formulation in Colombia view science, technology and innovation (STI) activities as a distinct domain of the economy. Other perspectives see a central feature of effective innovation systems, and hence also of STI-related policy, as involving STI activities that are deeply and pervasively embedded in all areas of the economy and society.

This compartmentalisation of STI activities is reflected, for example, in their description (e.g. in the NDP for 2010-14) as a distinct sector of the economy. An extension of this idea views the national system of science, technology and innovation as a collection of actors that is distinct from, and provides support to, sectors of the economy such as agriculture, manufacturing or energy. This STI sector or system is then commonly described as consisting of a combination of governance and funding bodies such as Colciencias, plus associated providers of STI support activities such as publicly funded research and technology centres or universities. In contrast, the flows of public funding intended directly to strengthen innovation capacities in enterprises were until recently very limited.² While the reluctance of officials in a country that has historically been plagued by corruption to subsidise private industry is understandable, business is the driving force in innovation systems and business innovation has to be a central focus of policy.

The compartmentalisation of STI activities into a sector or system of largely public organisations is closely associated with the idea that such a system, defined in this narrow way, constitutes the supply side of the innovation process, with the demand side located in business enterprises in the other sectors of the economy.

Three sets of common ideas about the STI sector, national system and supply side of the innovation process overlap in drawing a boundary around a group of largely public organisations. There is some risk of this conceptual boundary becoming a boundary in the real world. As discussed below, this appears to have been the case in the NDP 2010-14.

Traditionally, market failure is the main rationale for public intervention in research (Nelson, 1958; Arrow, 1962). A major source of market failure is the difficulty of appropriating the returns to basic research, as they tend to spill over to the rest of society. Therefore, relative to the social optimum, the business sector tends to under-invest in basic research, but undertake R&D closer to market where they can appropriate more of the benefits. The innovation system perspective stresses that, because the national

research and innovation system comprises fallible organisations with imperfect knowledge but the ability to learn, various kinds of system failures, such as lock-in and failures in institutions or framework conditions, justify intervention. The need for modernisation of university organisation and governance would be an example of such a failure.

Because system failures and performance are highly dependent upon the interplay of characteristics in individual systems, there can be no simple rule-based policy such as is possible in relation to the static idea of market failure (Hauknes and Norgren, 1999). Rather, a key role for state policy making is bottleneck analysis to identify and rectify structural imperfections (Arnold et al., 2001). The balance among different system components needs to be appropriate and the policies need to be mutually consistent. For example, there must be some consistency between the thematic focus of innovation/industry policy and at least part of the national research effort. This is why co-ordination is an important aspect of innovation system governance.

The role of government in innovation system governance

Given the complex and all-embracing nature of an innovation system (Figure 3.1), it is likely to be unable to be governed as a whole. At best, it can be co-ordinated to some degree. The part of the system that is the purview of the state can be governed formally but the variety of mechanisms used internationally to co-ordinate even within government indicates the difficulty of the task. In Colombia, it is further complicated by the regionalised nature of the country. The state's role in governance can be sub-divided into a number of major tasks or functions:

- Collecting and using strategic intelligence about the research and innovation system to carry out bottleneck analysis and identify systemic needs, opportunities and failures as a basis for policy making.
- Using such intelligence to develop research and innovation strategies that transcend the reach of individual stakeholders or organisations.
- Co-ordinating research and innovation policy, so as to maintain an appropriate balance or mix of policies and instruments.
- Combating market and system failures and promoting the development of the system by funding research and innovation.

Strategic intelligence and strategy development

Since the national innovation systems concept took hold, the idea of strategic intelligence has become important to how we think about research, innovation and the institutions in which these take place. National innovation systems are specific not only because of differences in factor endowments, geography and culture but also because they co-evolve with national systems of governance. In the systems view, governance is not a simple matter of top-down steering, in which an all-knowing principal sets agents to work to achieve goals that can be set only from above, but involves competition, consensus building, networking and negotiating decisions in arenas involving multiple actors (Mayntz and Scharpf, 1995). Strategic intelligence – in the sense of the knowledge needed to make strategy but also the deliberate use of evaluation, foresight and technology assessment in policy formulation and implementation – is a characteristic of research and innovation systems that needs to be decentralised, to enable the components of the system to work well. Knowledge must be developed and shared among the actors

involved (Kuhlmann et al., 1999). A system of distributed intelligence therefore needs to be networked, to involve active actors or nodes in the different organisations involved, to be transparent so that as many parts of the innovation system as possible can share intelligence, to be publicly supported, so that there are resources available to provide data and analysis, and to be quality-assured through the participation of multiple providers of intelligence and regular efforts to keep the knowledge up to date (Kuhlmann, 2002).

Strategic intelligence encompasses a statistical understanding of key characteristics of the innovation system such as economic and social activities, innovation and research, and indicators of performance and impacts. These are typically collected by a range of national agencies and may be co-ordinated by national observatories, such as Colombia's Observatory of Science and Technology (OCyT). It also involves qualitative understanding of the structure, needs and strengths of the research and innovation system and its institutions. Actors at different levels need different types of intelligence. A funding agency should understand its beneficiaries and maintain a dialogue with stakeholders, in order to identify changes and needs. Otherwise, it cannot design and operate effective funding instruments. Universities and research institutes need to understand their context and develop competitive strategies, just as companies do. Because some strategic intelligence is specific to particular parts of the research and innovation system, it makes sense to operate with a principle of subsidiarity so that decisions are made at the lowest practicable level in the governance hierarchy. Thus, while a ministry might define an innovation policy purpose, an innovation agency will better understand how to translate this into a detailed design for a funding instrument.

Strategy development in the research and innovation system is a natural function of the state, in so far as markets or institutions are not well placed to implement strategies that involve many actors or to initiate significant changes that involve them. The most obvious form of strategy at this level is overall research and innovation policy. Others include thematic strategies (many countries have nanotechnology, biotechnology or climate change strategies, for example, at the level of funding agencies, ministries or groups of ministries).

Closely allied to the strategy development function is the co-ordination of research and innovation policy. Co-ordination is needed because the size and activities of different parts of the research and innovation system need to be in some sort of balance and since a growing number of types of knowledge use and production span the areas of activity of different institutions (individual companies and other producers, ministries, research performers, educators and trainers). To be effective, co-ordination has to encompass a wide range of stakeholders, not just the state institutions.

Governance as co-ordination

There are many different ways to organise the governance of research and innovation. Figure 4.1 is ideal-typical and does not represent any particular national practice. This scheme has four levels of policy co-ordination:

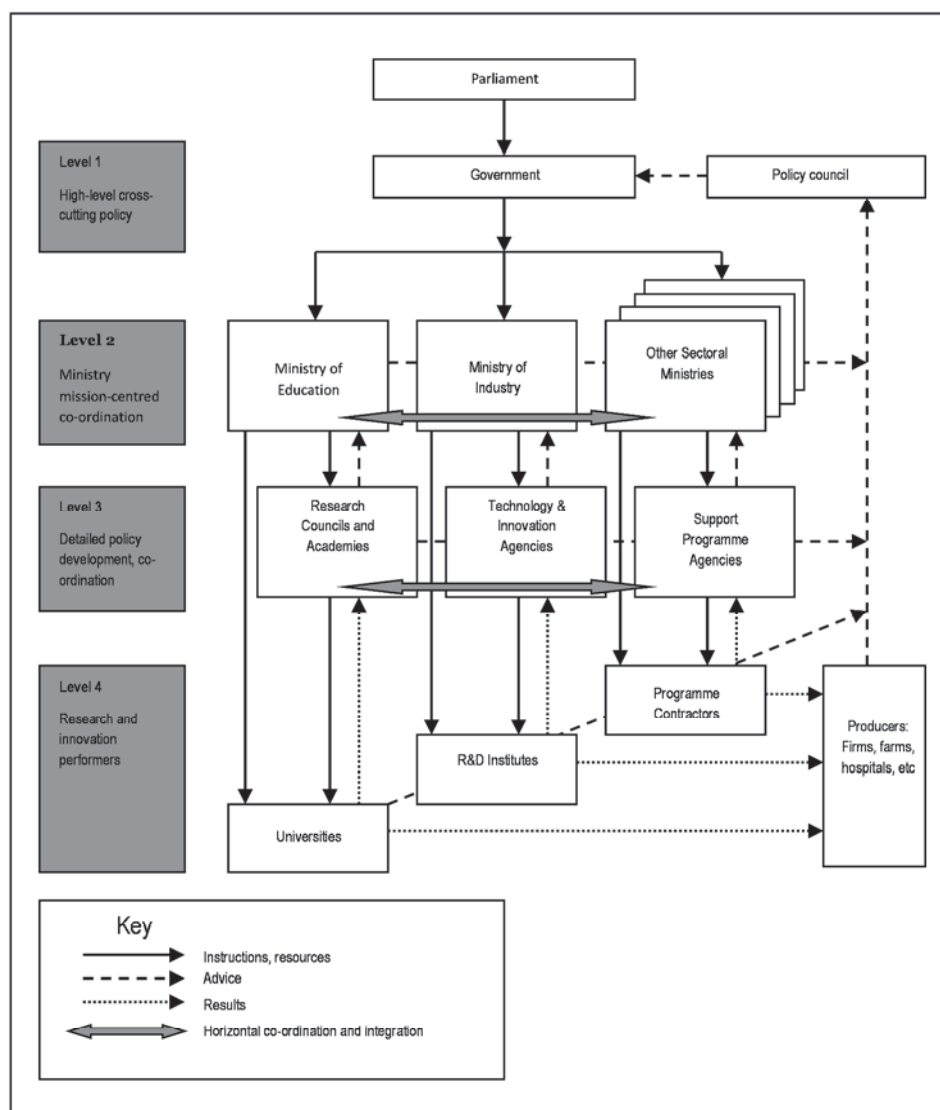
Level 1 is the highest level. It sets overall directions and priorities across the national innovation system through advice to government or by more binding means, such as decisions of a cabinet sub-committee. It needs to incorporate inputs not only from government but also key stakeholder groups, notably – but not only – business. Generally, this appears to be the most powerful level at which to achieve co-ordination. The Finnish Research and Innovation Council (RIC), which operates at this level, has been widely copied. However, it relies on a high level of political commitment to

research and innovation as well as a chair with a strong influence on government policy. These conditions do not obtain in all systems, as evidenced by numerous failed attempts to establish an effective council.

Level 2 is co-ordination among ministries, whose sector responsibilities otherwise encourage them to pursue independent policies. In practice this level of co-ordination may involve administrative or policy issues, or both. Sometimes an inter-ministerial group also functions as the Level 1 co-ordination mechanism. Co-ordination at this level depends upon ministries that are well supplied with strategic intelligence and able to reflect and represent the needs of their respective sectors. In many cases, however, co-ordination at this level is undermined by inter-ministry rivalry and competition for budget.

Level 3 is more operational and attempts to merge the actions of funding agencies into a coherent whole. It can involve administrative co-ordination as well as more substantive co-ordination of funding activities, such as co-programming. Effective co-ordination at this level requires strategic intelligence and a degree of empowerment; agents that lack information or have no freedom to manoeuvre cannot co-ordinate. In Norway, where Level 1 co-ordination has proved difficult, a funding agency with wide responsibilities for both innovation and research has been an effective co-ordinator at this level, working in close co-operation with the Ministry of Education and Research but also administering research and innovation funding from 15 other ministries.

Level 4 is co-ordination among those who actually perform research and innovation. Co-ordination at this level tends to be achieved through self-organisation rather than formal mechanisms. Bridging research and innovation needs can often be achieved through R&D funding programmes and public-private partnerships operating at this level.

Figure 4.1. Generic organisational structure for research and innovation policy governance

Source: Arnold, E., M. Bell, J. Bessant and P. Brimble (2000), *Enhancing Policy and Institutional Support for Industrial Technology Development in Thailand. The Overall Policy Framework and the Development of the Industrial Innovation System*, NSTDA, Bangkok.

Most of the vertical flows shown on the figure are formal. The exception tends to be flows into the policy council, which tend to be people-based rather than paper-based, and therefore to be informal. In many systems, especially in smaller countries, informal co-ordination is also achieved by members of institutions who sit on each other's governing or internal advisory committees. Such networks and interrelationships allow governance to play a number of important roles in the state's funding and management of research and innovation. Key research and innovation governance functions include setting directions, refereeing, horizontal co-ordination, co-ordination of knowledge production, intelligence, vertical steering, and enhancement of the profile of research and innovation (Arnold and Boekholt, 2003).

Ultimately, the variety of mechanisms used internationally amount to different compromises between ideal-typical overall co-ordination and the political, structural and cultural realities of individual countries.

Funding research and innovation

Funding is important. It supports institutions that do research. It compensates for market failures. It creates incentives that affect behaviour and priorities and signals to companies and researchers the availability of opportunities and the presence of needs.

Most research funding systems use a mixture of institutional and project-based (competitive) funding. Low relative levels of institutional funding are normally considered to undermine continuity, the ability to invest in facilities and equipment, and ultimately quality. A degree of institutional funding stability is also necessary to establish good links with industry. Otherwise, it is hard to be a credible research partner for the longer term. A growing number of countries are making institutional funding partly (or more rarely wholly) driven by past performance by using an evaluation and/or indicator system to reallocate money from weaker to stronger performers. The longest-established and best-known is the UK Research Assessment Exercise (Barker, 2007).

Three types of project-based research and innovation funding are commonly found in international practice:

- Bottom-up, investigator-initiated or basic research funding, usually only provided to public research-performing institutions.
- R&D funding related to innovation, normally programmed to address industrial or other societal challenges and opportunities. It may be given to state research-performing institutions, companies or – often – partnerships between the two.
- Business development and innovation funding, which normally is a mixture of general support to start-ups and company development and instruments more specifically focused on innovation (which may often be non-technical or may be new-to-the-firm rather than new-to-the-world). It may involve loans as well as grants and services. Beneficiaries are companies, not state institutions.

Competitive project funding serves both as a quality control and as an incentive to do research in themes or forms (such as centres of excellence) specified by the funders. While the state normally provides institutional funding to state organisations, research councils and innovation agencies provide competitive funds to state research-performing organisations and industry, respectively, and to a mixture of the two.

The role of individual funders in the research and innovation system depends very much on their function and the functions of key organisations around them. The traditional way to organise a bottom-up research funding council has been described as an aggregation machine (Rip, 2000). The council applies peer review and panel assessment to a stream of incoming applications and funds the best. The result is that the projects funded tend to reflect the pattern of demand in terms of disciplines, themes, gender balance, regional mix and so on. An alternative is a research funder as an agent of change, one that prioritises certain themes or groups in order to support change. In reality, most research councils are primarily aggregation machines but build in some change agency in the form of grants for young researchers to prevent established players with long track records from getting all the money. They may also set up centres of excellence to build critical mass and counter tendencies to fragmentation in the research community.

In 1968 Sweden set up a new innovation agency (Styrelsen för Teknisk Utveckling – STU, now VINNOVA) to combat the stagnation in national research identified by the 1964 OECD review of Swedish science policy. STU argued that Sweden needed the conventional research councils to fund on a bottom-up basis and foster excellence across a wide range of disciplines in order to keep university teachers current, keep up with international developments and ensure that any field that proved promising could quickly be expanded, based on the human capital already in place. This it called Programme 2. STU saw its own role as Programme 1: funding research in the parts of the system that underpinned industrial and other societal needs; connecting non-academic actors like the major Swedish companies with the academic research community and making sure that there were enough knowledge and people at the interface of the scientific and other societal systems.

Programme 1 funding is implemented through a range of technology programmes, cluster initiatives, branch programmes and structural interventions such as competence centres. A high degree of stakeholder involvement in programme definition has helped the interventions to operate as focusing devices that signal to research and industry the opportunities for undertaking and exploiting research in areas of industrial and societal need. While Programme 2 ensures quality and continuity in the research-performing system, Programme 1 provides change agency by steering the system towards the satisfaction of societal needs. In the Colombian system, Colciencias – like the Research Council of Norway (RCN) – spans Programmes 1 and 2. However, the financial and human capacities at its disposal are considerably smaller relative to the size of the country: RCN has a budget approaching COP 1.5 trillion, a staff of over 400 and serves a country with a population one-tenth the size of Colombia.

Business development and innovation funding tends to tackle barriers to starting new firms and to address obstacles to the development and growth of existing ones. It therefore covers the provision of capital and expertise needed to start new companies and loan financing for capital investments (including the acquisition of new machinery and equipment that embody technical change). There is a trend (exemplified in organisations such as the Dutch NL Agency, Innovation Norway and the Austrian AWS business services organisation) to merge specialised agencies such as export councils, agencies promoting foreign direct investment (FDI), development banks and providers of training and consultancy to small firms so that this type of funding can be obtained from a one-stop shop.

When these three forms of funding are institutionalised, it becomes hard to draw precise boundaries between them. Each tends to have its own kind of organisation. The research councils have an intimate understanding of science and work in close partnership with members of the research community to select proposals to fund through peer review. In contrast, the innovation agencies may take advice from the research and industrial communities concerning the quality and relevance of proposals, but they make their own decisions on the basis of a wider set of criteria. Normally they have an extensive system for consulting and involving stakeholder groups in policy design. Their staff need to understand both technology and business and be able to identify changing trends so that their programmes evolve as necessary. Business and innovation funders need a different set of more business-focused skills, including aspects of banking, business management and development, market research, innovation management, and exporting. Venture capital is rarely part of their portfolio, as this requires different skills as well as access to risk capital.

These three types of funding tend to be institutionalised in separate organisations, though there are interesting exceptions. The first two types tend to be national. The third is normally delivered at the regional level using local offices; its governance varies between the purely national and mixed national-regional. As Table 4.1 illustrates, Sweden has a research council – the Swedish Science Council (VR) – that exclusively tackles bottom-up funding and is in practice governed by elected representatives of the Swedish research community. VINNOVA, the Swedish Agency for Innovation Systems, funds R&D in universities and institutes that is done in partnership with industry. FAS and FORMAS are hybrids that are organised as research councils but have a remit to address specific areas of societal need. Business and innovation funding is handled by Tillväxtverket, the Swedish Agency for Economic and Regional Growth, which has a national presence through nine regional offices. VINNOVA runs a small number of research centre of excellence programmes in co-operation with the Science Council; and it has regionally focused R&D funding programmes with informal co-operation with Tillväxtverket.

Table 4.1. Examples of the institutionalisation of research and innovation funding roles

Country	Research council	Innovation agency	Business and innovation support
Sweden	VR: Swedish Science Council	VINNOVA FAS* FORMAS*	Swedish Agency for Economic and Regional Growth
Norway	Research Council of Norway		Innovation Norway
Finland	Academy of Finland	TEKES	FINNVERA
Netherlands	NWO	STW (part of NWO) NL Agency	NL Agency
Austria	FWF	FFG	AWS
Colombia	Colciencias		PTP Bancoldex INNpalsa

*These are organised as research councils but have the task of addressing societal challenges.

Norway has integrated the research council and innovation agency into a single organisation (called the Research Council of Norway). The RCN has separate divisions for science, innovation, and two large areas of thematic R&D and innovation that reflect national priorities and generally span basic and applied research and innovation. Business and innovation support is handled by Innovation Norway, an organisation resulting from mergers of organisations that include the old regional development bank, the national business development service, the export council, the tourist board, the fishermen's bank and the agency promoting FDI. It has a central staff and a regional office in each county. The regional offices are co-owned by the state and the counties and governed by regional representatives. To avoid adverse selection, instrument design and the allocation of funding to individual projects are under central control. Finland and Austria have a classical three-part organisation, though FINNVERA includes some venture capital activity in addition to normal business innovation and support. The Netherlands NWO has several traditional research councils plus STW, which funds collaboration between industry and the research sector. NL Agency handles other parts of the innovation agency function as well as business and innovation support. Colombia's organisation somewhat resembles the Norwegian one, though with a less integrated business and innovation support funding function and a more complex way to balance responsibility, capacity and power between the centre and the regions.

4.2. The evolution of science, technology and innovation policy

Policy developments

Salazar (2010) summarised key events in the history of Colombian research and innovation policy (Table 4.2). Colciencias was set up in 1968 as the first state organisation responsible for research and innovation policy and funding. The first Innovation Strategy of Colombia was approved in two policy documents of 1994 and 1996: CONPES Policy Statement No. 2739 of 1994 and CONPES Policy Statement No. 2848 of May 1996. These two policy statements laid the basis for much of the so-called national innovation system.³ The measures that emerged promoted in-company innovation through a combination of credits, public co-funding of private innovation projects, a national Guarantee Fund and the start of venture capital funding, via the Medellín Incubator. The major technological centres established in the 1960s and 1970s were replaced by smaller, branch-focused institutes and a network of incubators was established.

Table 4.2. Key events in the history of Colombian research and innovation policy, 1963-2008

Pre-1968	1968-88
• 1963: UN conference on the application of S&T for development • 1964: OAS conference on S&T policy and planning • 1967: Punta del Este Conference of American Presidents • Latin-American School of Thought of S&T for Development • 1968: Fusagasugá conference: basis for creation of Colciencias	• 1970: Creation of first master's programmes • 1983: IADB - ICFES credit programme • 1983: IADB - Colciencias first credit programme • 1986: First doctoral programme • 1987: International Forum on S&T policy • 1988: S&T mission
1989-2001	2001-08
• 1990: Law 29 - S&T law • 1990: Decree 1767, Colciencias was ascribed to DNP • 1991 IADB Colciencias second credit programme • 1991: Decrees 393, 585, 591: creation of the SNCyT, regulation of contract and association models in S&T • 1993: Mission of Science, Technology and Development • 1995: National innovation system launched • 1996: Law 344, SENA resources to S&T activities • 1999: Creation of the Colombian Observatory of Science and Technology	• 2000: Law 643 created the Health Research Fund • 2001: Publindex launched: index of Colombian scientific journals • 2002: ScienTI platform launched • 2002: World Bank-Colciencias credit for doctoral programme and scholarships • 2003: Law 812, Economic and Social Development Plan, that requires SENA to give money to Colciencias • 2005: Maloka forum: discussion of a new law for S&T started • 2006: Visión Colombia 2019: long-term plan for STI • 2008 Colombia Sienbra y Construye Futuro - National Research and Innovation Policy

Source: Salazar, M. (2010), *Communication Channels among the Actors of the Colombian System of Science, Technology and Innovation: A Test of the Sabáto's Triangle Model*, PhD Thesis, Simon Fraser University, Vancouver.

More recent times have seen a series of national-level strategies. The Colombian Vision for 2019 (DNP, 2006) (set to coincide with the 200th anniversary of independence from Spain) proposed a broad range of goals for the research and innovation system, in which Colciencias was to play a central and strengthened role. These included:

- Raising R&D intensity (GERD/GDP) from 0.21% to 1% by 2010 and 1.5% by 2015, of which half should be funded by business;
- Setting up better S&T indicators;
- Strengthening S&T culture in Colombia;
- Building human capital through bigger PhD programmes and raising the researcher population from 21 000 to 40 000 by 2010 and 55 000 by 2019.
- Funding the creation of laboratories, research teams and graduate schools in the universities.
- Encouraging industrial innovation by requiring companies to report their R&D expenditures, creating better academic-industry links, building technology centres, strengthening the intellectual property rights (IPR) system, funding innovation capacity in strategic parts of industry, and promoting the provision of venture capital.
- Getting three Colombian universities into the Top 500.
- Encouraging Colombian industry to become more innovative and competitive by using new technologies.

Two years later, Colciencias offered a research and innovation strategy (2008) that largely developed these ideas. It argued that:

- The National Council of Science and Technology (NCS&T) had not functioned effectively as a national STI decision-making body, as it had lacked the political mandate to accomplish the tasks for which it was created and the legal instruments to make its decisions sufficiently binding.
- The Council for National Science and Technology Programmes (CNS&TP) had created unequal relations between its members: a strong and highly participatory academic sector, a productive sector that is virtually non-existent or passive, and an uncommitted and sometimes inadequately represented state.
- Only some Departmental Councils for Science and Technology (DCS&T) were fully operational, so that their task is currently being undertaken as part of Colciencias' support for the development of departmental agendas for STI, the inclusion of these in departmental development plans, as well as their co-ordination with the regional competitiveness commissions.
- While Law 29 of 1990 provides mechanisms for the co-ordination of scientific and technological activity, its application had not been easy or satisfactory. For example, articles 4 and 7 of the law create the basis for co-ordinating national public investment in STI. However, the legal, procedural and logistical basis had not been finalised (National Council for Economic and Social Development, 2009).

This analysis prompted the preparation of CONPES 3582 of 2009 (National Council for Economic and Social Policy/CONPES, 2009). This policy document defined national strategy with respect to STI and set the basis for Law 1286 of 2009, which changed the status of Colciencias to a Department of State and extended the role of the National Council for Science and Technology to cover innovation.

That CONPES document represents a consensus among ten ministries, various agencies and the DNP. It set out a wide-ranging diagnosis of the performance of the research and innovation system that is largely consistent with the findings of the present report, but places less emphasis on issues related to in-firm innovation, middle-level skills and the need for a systemic approach to the innovation system that encompasses demand. It identifies poor co-ordination of the policies, programme and intentions of the actors in the (formal) National System for Science, Technology and Innovation (NSST&I) as a significant problem that helps explain why “many of the problems identified in past diagnostics persist [notably] ... low levels of innovation from companies, weak institutional structure in the system, lack of human resources for research and innovation, lack of policy focus on strategic areas, low social appropriation of knowledge and regional disparities in scientific and technological capabilities, which together generate a low capacity to generate and use knowledge”. A key reason for poor co-ordination is lack of political commitment, so that STI decisions are not necessarily binding, the resources available fluctuate, the division of labour among state entities is often unclear, and synergies among various actors are not exploited. There has been heavy reliance on international loans to fund STI activities. While this overcomes short-term resource fluctuations, it also means that individual efforts are not necessarily sustained.

The document offers a comprehensive set of strategies to address the problems identified:

- Encourage innovation through a comprehensive set of tools to support entrepreneurs and innovators.
- Strengthen the institutional structure of the NSST&I by making Colciencias an administrative department (of the state) and establishing the Francisco José de Caldas Fund, a vehicle to allow other administrative departments to use Colciencias as a research and innovation funding agency. This relates to setting up medium- and long-term investment plans for science, technology and innovation and strengthening the existing national research and innovation programmes.
- Strengthen human resources for research and innovation. The main thrust of this strategy is to increase PhD production.
- Promote the social appropriation of knowledge, through the mass media, training mediators and supporting organisations that promote science communication.
- Focus state action on the long-term development of strategic sectors characterised by high scientific and technological content and therefore high value added, in particular energy and natural resources, biotechnology, health, materials and electronics, ICT, logistics and design and the construction of citizenship and social inclusion.
- Strengthen STI capabilities through research co-operation by strengthening regional STI systems and building regional STI capacity.

Finally, the CONPES document calls for 31 planning and strategy exercises to be set in train and implemented, most of them within 6-12 months. This clearly represents a potentially massive administrative effort.

A separate line of policy development focused on competitiveness had been prepared under the Ministry of the Economy. It was explicitly extended to include innovation at the

time when innovation was added to S&T policy. A different CONPES document (No. 3527 of 2008) was prepared by the secretariat of the new National Council for Competitiveness and Innovation during 2007. It diagnosed key problems relating to competitiveness:

- Little sophistication and low added value in production processes
- Low productivity and employment generation in the formal sectors of the economy
- Particularly low productivity in agriculture
- High levels of business and labour informality
- Low levels of innovation and technology absorption
- Unsophisticated financial markets
- Deficiencies in transport and energy infrastructure
- Low quality and relevance of education
- Tax structure not adapted to competitiveness
- Backwardness in information technology penetration and connectivity
- Environmental degradation limiting competition
- Weak institutional framework for competitiveness.

It established a vision for 2032 in which Colombia would develop some world-class industrial clusters, make a great leap forward in productivity, and move most informal businesses and jobs into the formal sector. This would be achieved through better use of science and technology on the one hand and a range of strategies that cut across sectors on the other. It laid out 15 action plans to achieve this. The action plan for STI simply refers to CONPES 3582 on the system of science, technology and innovation. The plans are essentially transversal, in the sense that they address general issues (the need for public-private dialogue, better infrastructure and regulation, freer trade, improved education and a competency framework for education and training, improved financing systems, etc.) rather than set sector priorities.⁴

In principle, the National Development Plan should operate at a higher level than these more specific ones. The NDP for the period 2011-14 marked a major advance in the policy prominence given to science, technology and innovation as activities with a central role in achieving core objectives for sustainable growth and competitiveness. In particular, knowledge and innovation were seen as underpinning the five priority engines of growth and job creation.

In practice however, knowledge and innovation were grouped as one of the five development engines concerned with new innovation-based sectors. In the plans for this engine there was certainly a strong link between STI-related issues and enterprise development in a set of nine activities that were, for the most part, quite narrowly defined segments of several economic sectors: four service industry activities (e.g. the graphics communication industry and health and wellbeing tourism); four mainly manufacturing activities (e.g. cosmetics and toiletries and auto parts and vehicles) and one in agro-processing manufacturing (chocolate and confectionary). However, in the subsequent explanation of the plans for the other four development engines, policy and strategy for

associated STI capabilities and activities are less obvious. Their coverage of STI issues is confined to high-level aspirations such as a need to increase R&D. There is no treatment of the intermediate-level obstacles that need to be removed to achieve these goals. As a result the usefulness for STI policy appears diminished. It would seem necessary to better distinguish the various policy dimensions and challenges (e.g. human resources and specific skill components, support to business and agriculture, public R&D funding and performance, governance issues), and to be more explicit about innovation policy instruments.

It is not clear whether these disconnections are as deep and pervasive on the ground as in the planning document. Nor is it clear how much the conceptual framing of STI activities contributes to such disconnections. But a further set of conceptual issues may be relevant. They concern the kinds of STI-related activities and issues that are seen as within the scope of STI-related policy. For example, in connection with the plans for at least three of the major development engines (transport infrastructure, mining and energy, and housing and urban development) a number of specific features of innovation and innovation capability development seem likely to be especially significant:

- The intensity of design, engineering and related activities in innovation processes, and not just their R&D-intensity;
- The importance of accumulating human resources and other capabilities in those and related domains such as architecture and planning;
- The importance of accumulating those capabilities not primarily in central technological institutes but within business enterprises themselves, many of them in the services sector rather than manufacturing;
- The associated importance of creating the human capital components of those capabilities not only in education and training institutes but also by explicit expenditure on training and organised acquisition of experience within business enterprises;
- The central role of large investment projects as core stepping stones of development, and the associated importance of international suppliers of finance capital, engineering and other services, and often complex manufactured goods for such projects.
- The significance of such projects, and their links with international enterprises as potential vehicles not merely for investment in physical capital (new mines, roads, refineries, urban transport systems, water supply and sanitation facilities, and so forth), but also for investment in various forms of technological learning to develop and deepen the human capital and knowledge capital of local enterprises.

There are large gaps in the way the National Development Plan addresses the STI-related dimensions of development in these priority sectors. Apart from very brief remarks about training in operational and technical skills, there is no discussion of the scale and composition of the human resource base needed to implement the plans. In particular there is no indication of the strategies to be pursued to develop higher-level design, engineering, architectural and managerial capabilities. Innovation is not discussed and, apart from a brief comment on developing clusters of related industries around the petroleum industry, there is no discussion of whether or how strategies might be pursued to develop innovation-generating suppliers of firms around the core sectors at the heart of these priority development paths – though plans in this area were being explored by the INNpulsas programme for the mining industry in early 2013.

The impression is therefore that high-level aims for developing a much more knowledge-based and innovation-intensive economy were not clearly connected to the development of the rapidly growing sectors that are the priority paths for future social and economic development. Market failures, system failures and co-ordination failures seem to be pervasive for these kinds of innovation and especially the underlying processes of innovation capability development, yet they occupy a very small part of the current STI policy agenda in Colombia, which is preoccupied with PhD training. While such training is of course important, it covers only a small part of the spectrum of innovation capabilities and, as discussed in Chapter 3, seems a poor match for current needs.

Table 4.3 presents the thematic focus of four successive key innovation policy documents. It shows a degree of consistency across policies but also differences of level and articulation that reinforce the diagnosis in the CONPES 2009 document that co-ordination across different parts of the NSST&I is difficult.

Table 4.3. Thematic focus of successive innovation policy documents

Colombia Builds and Sows (2008)	National Council for Economic and Social Policy/CONPES (2009)	National Development Plan (2010)	Productive Transformation programme (2010-12)
		Civil applications from the defence sector	Energy and services
Electronics and materials	Electronics and materials	Electronics and materials	Car parts and cars
	ICT	ICT	Metal mechanical, iron and steel
Biofuels			Software and ICT
Water resources	Energy and natural resources	Energy and natural resources	BPO&O business
Biodiversity	Biotechnology	Biotechnology	Beef
	Logistics and design	Logistics	Shrimp
			Chocolate and confectionery
			Dairy
			Fruit and vegetables
			Oils and biofuels
			Cosmetics and cleaning
		Design	Fashion
		Creative and cultural industries	Printing and publishing
		Tourism	Nature tourism
Health sciences	Health	Health	Health and welfare tourism
Peace and social cohesion	Building citizenship and social inclusion		

The DNP (supported by Chilean consultants Eduardo Bitran, José-Miguel Benavente and Claudio Maggi⁵) orchestrated a national innovation strategy in 2011. It diagnosed national innovation performance as inadequate and indicated the need to intervene to improve companies' innovation performance, the production of human capital, and science and technology.⁶ Constructively, it allocates responsibilities for implementation of the improvements needed to specific ministries and agencies, including the regions. However, it does not address the issue of thematic priorities, which needs to be tackled at a national level while respecting the needs and autonomy of the regions. The strategy focuses on the three pillars of business innovation, human capital, and science and technology. It identifies a long list of needed reforms and actions and allocates

responsibility for them to various organisations. However, the strategy appears not to have been translated into law so the needed institutionalisation – a body that can serve as a co-ordinator or arena for the governance of the system – is absent and elements of the strategy that are not already part of policy may be hard to implement.

At the beginning of the last decade, efforts were centered on incentivising research and knowledge generation, by boosting dissemination strategies and publications. Policy has since emphasised research as a central axis of education (and higher education in particular) with Colciencias playing a central role in this process. For example, this is evident in elements of the design of instruments introduced during this time (such as research group accreditation) and the fact that linking research to education is a mandatory requirement for the accreditation of university programmes.

However, some of the parameters considered in those processes did not comply fully with international standards, which made international comparisons difficult and complicated impact assessment. For this reason, in 2013 Colciencias adjusted the standard measurement for scientific research production and productivity for research groups, considering international standards. Thus, the opportunity to assess national strengths, in comparison with peers worldwide, will promote the chances of being identified as potential members of networks and potentially as regional or global leaders in particular subject areas.

Sector structure, innovation and “industrial policy”

As noted earlier there has been significant change in recent decades in the sectoral composition of the Colombian economy. Among the major industries, agriculture and manufacturing in particular have grown relatively slowly and now account for smaller proportions of GDP. Others have grown relatively rapidly and increased their shares of GDP. They include the mining and petroleum sector, the utility industries (electricity, gas and water), the construction industry, and some segments of the services industry, in particular transport and communications. At the same time, within manufacturing there has been no sign of any shift towards high-technology or medium-high-technology sectors. Only the medium-low-technology sectors have increased their share of total manufacturing.

In other words, neither at the more aggregated major industry level nor within manufacturing has there been any noticeable movement in a direction that is increasingly important given Colombia’s rising concentration on commodity exports and exchange rate appreciation: the acceleration of diversification into higher value-adding tradable manufactures and services. These patterns of evolving sector structure raise three sets of questions about STI policy:

- The first is the wide difference between types of innovation process (different modes of innovation) both across broad industry categories and within them.
- The second is the widely held view that particular industries and manufacturing sectors are inherently more high-technological and R&D-intensive than others. Consequently, entry to such industries is presumed to have a particularly positive developmental role in middle-income countries like Colombia, and should therefore be targets for industrial policy.
- The third is the closely related issue of policy to encourage diversification in the structure of the economy. Commonly discussed over the years as an issue of industrial policy, it has increasingly been seen as a policy domain that calls for much greater integration of industrial policy and STI policy.

Diversity in the modes of innovation

It has long been clear that different segments of the economy undertake innovation in different ways: they use different kinds of knowledge and different sources of knowledge, and there are differences in the division of labour between technology-producing and technology-using firms. These are not better or worse modes of innovating. They are just different and appear to work in specific contexts.

However, most of the understanding about such differences has concerned the technologically advanced economies and is usually restricted to manufacturing industries. Moreover, most analytical and policy attention has focused heavily on the variations in science-intensive and research-based modes of innovation and has neglected other forms of innovation, also efficient in the contexts in which they are used, that are more dependent on various forms of experience-based learning and incremental forms of innovation.⁷

In Colombia, it is becoming clear that there are significant modes of innovation that differ sharply from those in manufacturing industries. They make intensive use of design and engineering competences; they generate innovative specifications for products, processes and systems by drawing heavily on existing stocks of knowledge and on accumulated experience of production operations. Hence, R&D supplements design and engineering rather than drives innovation. A large part of this type of innovative activity is centred on large but intermittent investment projects; it also involves a substantial stream of innovations in the form of incremental improvements to existing process facilities that typically have very long lives.

Large established firms play a central role in these modes of innovation, but they do so within an organisational structure of dense interactions with large numbers of suppliers of knowledge-intensive goods and various kinds of knowledge-intensive engineering services. Consequently, the primary competence of the large firms at the heart of these networks may be the capacity to integrate the innovative activities of other firms. Suppliers of knowledge-intensive and experience-intensive services, not only suppliers of manufactured goods, are important components of these innovation-intensive supplier systems. Experience plays a crucial role as a key input in this mode of innovation. It is not just experience in production, but experience in the process of innovation itself, and in the management of multi-actor innovation projects.

Variations on this mode of innovation appear to be particularly important in infrastructure industries and in large process-based industries such as mining, petroleum and their immediate downstream manufacturing activities, as well as in other energy industries such as most forms of electrical power generation. These are precisely the kinds of industry that have assumed rapidly growing importance in Colombia.

The types of innovation process that seem most important in these industries are not those that have attracted most policy attention in Colombia so far. Instead, current policy approaches seem to focus on a relatively narrow range of innovation modes. These match quite closely the science-intensive mode of manufacturing innovation described above: research-based product innovation; the implementation of innovation via new start-up enterprises that are often suited to science park or incubator facilities; and high reliance on access to high-risk, new venture funding. In addition, innovation modes in this narrow spectrum are often seen as PhD-intensive, as well as intensive in the use of knowledge links with universities and research institutes.

Types of innovation with such characteristics are obviously important. But even within manufacturing they occupy a relatively narrow (science-intensive) part of the spectrum of efficient modes of innovation. For non-manufacturing innovation, they probably occupy an even narrower part of the spectrum, which often overlaps very little with the predominant innovation modes. Given the current focus of innovation policy there is a high risk that the portfolio of support mechanisms will be poorly matched to the modes of innovation that are important in large parts of the Colombian economy.

Moreover, as shown earlier in Chapter 3, there appears to be little or no association between the innovativeness of Colombian firms and the sector's technological intensity in OECD countries. This is not surprising in itself as, even within the same sectors, Colombia is likely to specialise in substantially different types of economic activities compared to OECD countries. Firms in sectors classified as Low-technology do consistently have relatively low levels of innovative activity and innovative capability across a range of indicators. But firms in High-technology industries do not appear to have consistently higher levels of innovativeness than firms in the two Medium-technology categories. Moreover more than half Colombian firms in the High-technology group of industries appear not to have introduced any innovations in 2009-10. Even in the Medium-high-technology group, nearly 60% of the firms were non-innovators.

The key policy issue seems therefore to be not about targeting specific sectors for preferential treatment. Instead it seems more important to focus on raising the innovativeness across a broad range of firms. Of course, that is not to say that the specific types of economic activities firms engage in have no bearing on their propensity to innovate. The argument is rather that from a policy perspective, it may be more efficient and effective not to be prescriptive about the types of sectors that deserve innovation support and to approach the issue of structural change from the perspective of the internal capabilities of firms to diversify.

Innovation and diversification of the structure of industry

Over recent years in many developing countries policies to accelerate diversification of the structure of production towards more knowledge-intensive and higher value-added activities have involved three trends that have departed from merely trying to speed up entry to apparently higher-technology industries:

- The first has involved closer integration of industry-related and STI-related policy domains.
- The second has been the application of increasingly systematic methods for identifying potential new industries and activities on the basis of their proximity to existing areas of comparative advantage and the opportunities they offer for developing export markets.
- The third has been the growing use of associated methods of facilitation and co-ordination in which government actors seek to interact with business interests to identify new routes for diversification and implement action to open them up.

Colombia has been following these trends for at least a decade, and a considerable number of initiatives have been pursued under successive governments. The National Development Plan 2010-14 emphasised such initiatives by focusing the first of the five engines of growth and development on new innovation-based sectors. The Production Transformation Programme (PTP) developed by the Ministry of Commerce, Industry and Tourism (MCIT) currently plays a leading role in driving this engine.

A central feature of several of these initiatives has been the engagement of eminent international consultants to contribute to and legitimate the process of identifying diversification opportunities, notably Monitor, McKinsey and recently Ricardo Hausmann from Harvard University. Despite the broad similarities of these searches for diversification opportunities, a striking feature is that the outcomes have varied widely and there is now an extensive list of activities and industries that constitute apparent priorities for policy support.

Views differ on the extent to which these activities have been government-induced winner-picking, enterprise-based self-discovery of latent areas of comparative advantage, or rent-seeking business capture of the policy process. But that is not the issue addressed here. Instead, the question is whether these approaches to policy have addressed only the symptoms of the low and slow diversification of production in Colombia or have dealt with the chronic conditions that underlie those symptoms. In this respect, it is useful to consider three features of diversification in relatively dynamic firms and industries:

- It is undertaken primarily by firms;
- A very large part of the basis for doing so is firms' own innovative capabilities;
- R&D capabilities are only a very small part of those innovation capabilities.

The experience of Korea is instructive in these respects. The rapid diversification of Korean firms between the late 1960s and early 1990s was driven by the innovation capabilities of large business enterprises, and those capabilities were largely what Amsden (1989, 2001) described as project execution capabilities (or investment capabilities). While these differed from R&D-based innovation capabilities, they contributed to the diversification of production via types of innovation that would now be described as new-to-the-economy and new-to-the-firm innovation. In particular, the primary purpose of such project execution capabilities was: “to identify possible projects and ascertain prospects for viability under alternative design scenarios” (Amsden, 2001, p. 4). These activities are almost identical to the activities described by Hausmann and Rodrik as the self-discovery of diversification opportunities in areas of potential comparative advantage in the economy.

Whether in Korea or elsewhere, and regardless of the label attached to them, these capabilities for identifying (and for exploiting) diversification opportunities constitute stocks of knowledge assets accumulated by firms as a result of prior investment in various kinds of human resources and knowledge capital. In other words, their availability in firms for use in identification of opportunities, self-discovery or execution of diversification projects reflects the extent of prior investment in acquisition and accumulation, a form of investment in knowledge-capital and human capital that was especially high in the Korean context.

In Colombia, however, enterprise investment in knowledge capital and human capital has probably been very low over the last decade or so. This cannot be established directly because the relevant data are not available. However, it seems highly probable that, at least in manufacturing industry, the extremely low levels of expenditure on R&D and the high incidence of non-innovating firms are matched by correspondingly low levels of investment, first in the search for and development of opportunities for diversification, and second in the *knowledge assets* and *human capital* needed for identifying and achieving such diversification. For all of the reasons for market and co-ordination failure identified by Hausmann and Rodrik, this almost certainly means a socially inefficient rate of diversification.

Colombia's efforts to address the issue of diversification appear to have focused almost entirely on trying to reduce underinvestment in the identification of opportunities for diversification, and the STI policy portfolio has included very little that seeks to address the kind of underinvestment in knowledge assets and human capital for diversification. Policy should be more concerned with improving the ability of Colombian firms to diversify and with strengthening their ability to do so.

This does not mean that current approaches should be abandoned. They help to offset the social costs of the low rates of diversification by enterprises. However, much greater attention than at present should also be given to addressing the longer-term issue of low levels of investment in diversification capabilities. Much more pervasive and intensive measures are needed to strengthen these capabilities in enterprises so that Colombia can overcome this problem.

This issue of structural change in the economy is one thread in the broader need to re-balance the structure of innovative activity by massively raising the amount undertaken by enterprises. It links into a combination of policy areas: stimulating demand for innovation by enterprises, strengthening the development of human resources for enterprise-based (and other) innovation in a broader range of ways, and deploying a more intensive and diversified portfolio of measures that support business R&D and innovation. This entails coupling demand and market experimentation by firms to a process of making choices and setting priorities at the national and regional levels in terms of the location of societal investment in research, education and infrastructure.

Recent years have seen an array of impressive national innovation strategies in Colombia – for systems, STI, competitiveness, and agriculture and in the national plan. They call for radical transformations of many parts of the national research and innovation system and more broadly imply a massive implementation effort with many parts. As Bitran et al. (2011) point out, in practice it is difficult to do so much at once, the amount of money committed is not commensurate with the size of the task, and the organisations involved often lack the required capacity and experience.

This is partly a question of political commitment. For a number of reasons, it appears difficult for a country of Colombia's income per head to allocate sufficient resources to research and innovation, even though there are sound reasons to believe that such an investment is required to generate the economic development needed to alleviate poverty. The problem of commitment is exacerbated by a reluctance to set priorities. This means, first, that the strategies identify many needed reforms and improvements and then propose to tackle all of them at once. Second, this results in reluctance to set thematic or branch priorities, which are necessary to build critical mass in industry and in research and thus to guide the development and specialisation of the research and innovation system. In practice, there is no strong link from national strategies to the project level. Often the legal mechanisms (laws and regulations) to implement them are not enacted. In a highly legalistic system such as Colombia's, where administrators are at personal risk if they use public money in ways that the national audit office subsequently decides are incompatible with existing law, this tends to result in inaction (Gregson and Velasco, 2011).

The reluctance to define thematic priorities is understandable in any setting, given the mixed international experience with industrial policy. But even without a thematic concentration (or targeting) of public resources, the reluctance to define sectoral strategies can be problematic. Because innovation in specific sectors has specific needs and characteristics, generic STI policies alone cannot tackle the diversity of these

research and innovation systems. Branch or cluster policy needs to be specified at a much greater level of detail than seems to be the case in Colombia. Initiatives like the PTP may be useful in clearing away some regulatory obstacles to development and building team spirit but need to be articulated further in order to send steering signals to other parts of the system. For example, cluster road maps can usefully specify:

- The need for strategic intelligence;
- The structure and market dynamics of the cluster, including its actual and potential international linkages;
- Research, education and training needs, so that these can be connected to infrastructures and funding programmes;
- Communication needs with government;
- Actual and potential roles of FDI;
- The need for increased or reduced regulation.

As these needs are not permanent but evolving, there has to be a continuous channel for dialogue between the developing clusters and public policy makers.

4.3. Royalty funding for science, technology and innovation: scale, regional dimension and impact

The most substantial step in the recent evolution of STI policy in Colombia was the creation in 2011 of a new General Royalty System to administer the royalties accruing to the state from the exploitation of the country's mineral resources. In the past, just eight departments had received 80% of the royalties. Since 2012 royalty income is distributed to the regions using a formula based on a combination of population and relative wealth, so that poorer regions get more income per head than richer ones.⁸ Box 4.1 summarises the new royalty system. Figure 4.2 shows how the change has affected the allocation among regions.

From the perspective of STI policy, two aspects of the change in the royalty system were particularly important.

- First, within the revised set of uses for the royalties, 10% was to be allocated for science, technology and innovation.
- Second, there was to be a broader regional allocation of the funds (including the 10% for STI) across all 32 departments of the country.

Box 4.1. The new royalty system

The new General Royalty System implemented in 2012 allocates royalties across six main funds:

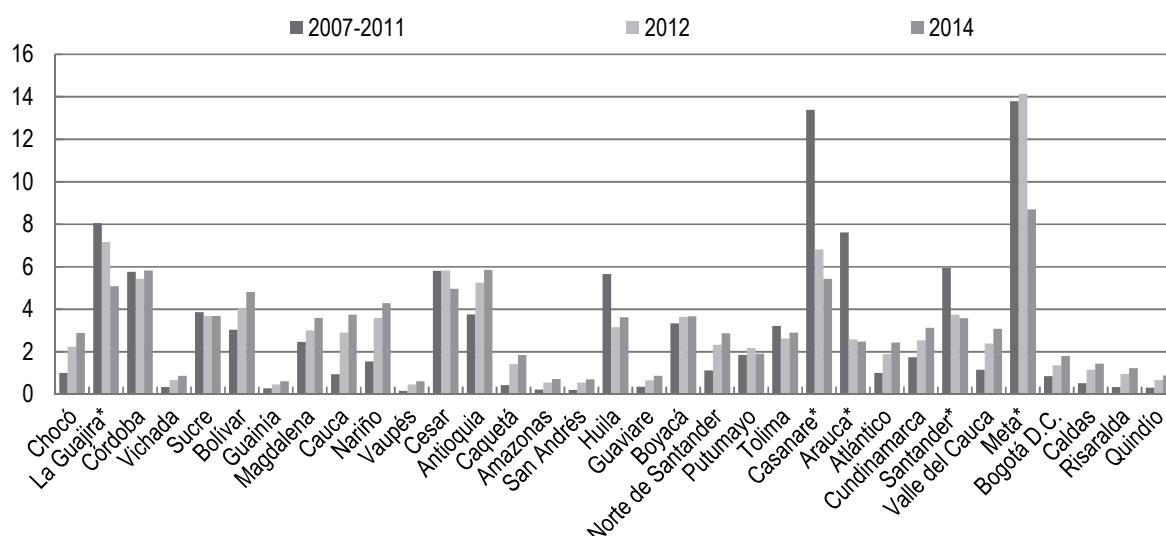
- 10% goes to the territorial pension savings fund (Fonpef), managed by the Ministry of Finance, which covers pensions for sub-national public employees.
- 10% is allocated to the science, technology and innovation fund managed by Colciencias (the Department of Science, Technology and Innovation). Projects are presented by local public or private bodies and should be validated by the relevant Governing Bodies of Administration and Decision (*Órganos Colegiados de Administración y Decisión*, OCAD). Regional universities are included in the selection process.
- Up to 30% is allocated to the sub-national Savings and Stabilisation Fund (managed by the central bank). In the first year, 25% is allocated to this fund and in subsequent years the amount saved grows at half of the increase in expected royalty revenues.

The remaining resources are divided into direct allocations to producing regions, the Regional Compensation Fund and the Regional Development Fund:

- Direct allocations to producing regions will decline from 25% in 2012 to 10% after 2014. The released funds will benefit the regional compensation and development funds.
- The Regional Compensation Fund, which will last for 30 years, will get 24% of the royalties after 2014, and will invest in local projects in the poorest regions and municipalities (more than two departments should be involved). At the end of the 30th year, the resources will migrate to the Regional Development Fund.
- The Regional Development Fund will receive 16% of the resources after 2014 and the money is not earmarked for specific spending items. The fund will operate indefinitely. The main purpose of the last two funds is to improve regional productivity, with most of the resources to be spent on infrastructure projects.

Source: OECD (2013a), *OECD Economic Surveys: Colombia 2013: Economic Assessment*, OECD Publishing.
http://dx.doi.org/10.1787/eco_surveys-col-2013-en.

Figure 4.2. Share of total royalties allocated to individual regions before and after the reform



Source: OECD (2013a), *OECD Economic Surveys: Colombia 2013: Economic Assessment*, OECD Publishing.
http://dx.doi.org/10.1787/eco_surveys-col-2013-en.

The total resources available for the first round of STI-related funding in 2012 was COP 869 000 million (approximately USD 460 million). However, projects were only approved for a total budgeted expenditure of COP 567 052 million (approximately USD 299 million).⁹ Colciencias was responsible for administering the funding, but the project ideas for funding were identified and formulated into proposals essentially bottom up from the department level.

Three aspects of this major change in policy are discussed further here: i) the scale of the new funding relative both to previous expenditure levels in Colombia and to expenditure levels in a leading Latin American comparator country, Brazil; ii) the regional dimension of the change; and iii) the impact and effective absorption of the funding.

The scale of the new royalty funding

The STI-related royalty funding is intended to cover four categories of scientific and technological activities (STA): research and development, innovation, training and scientific and technological capacity building, scientific and technological services.

Table 4.4. Royalty funding and previous expenditure on STI activities (STA)

<i>Actual STA expenditure – 2010 (without royalties)</i>		Million COP	
1	All public STA expenditure	1 253 800	
2	Total STA expenditure	2 727 453	
3.	Total STA expenditure/GDP (2010) (%)	0.50 %	
<i>Royalty-funded STA expenditure (2012)</i>		Available funding	Approved funding
4.	Royalty-funded STA	869.00	567 052
5	Royalty-funded STA/Public STA (Row 4/1 %)	69 %	45 %
6.	Royalty-funded STA/Total STA (Row 4/2 %)	32 %	21 %
<i>Combined actual 2010 STA and 2012 royalty-funded STA</i>			
7	Total combined expenditure	3 596 453	3 294 505
8	Total combined expenditure/GDP (2010) (%)	0.66 %	0.61 %

Note: One important simplification is the combination of two different kinds of data about STA funding and expenditure: data about 2012 royalty funding, typically for projects that will run about three years, and data about annual STA expenditure in Colombia from other, non-royalty sources in 2010. The assumption is that roughly similar allocations for expenditure over about three years will follow in 2013 and 2014, and consequently that the figures in the table provide a rough indication of the size of the additional royalty-derived expenditure in 2014 relative to the pre-royalty level of STA expenditure in 2010.

Source: OECD based on Colciencias (2013), “Regalías para la Ciencia, Tecnología e Innovación. Camino a la prosperidad regional”, presentation, 5 February, Bogota.

Unfortunately, there appears to be no publicly available information about the scale of funding for these separate components, even for R&D. Comparison of the new funding stream with previous levels of funding can therefore only be made with the broad overall STA category.¹⁰ This is attempted in a broadly indicative way in Table 4.4. Three main points are striking:

- The additional royalty funding is equivalent to a very large proportion of all public STA funding in 2010 – nearly 70% in the case of the initially available funding, and still about 45% in the case of the approved funding (Row 5).
- Even when compared with total national STA expenditure in 2010 (public and private), the additional injection of royalty funding constitutes a step jump of nearly one-third (available funding) and one-fifth (approved funding) (Row 6).

- The injection of additional funding has a significant effect on the economy's STA intensity (STA as a proportion of GDP). If the royalty funding for 2012 is added to the actual STA in 2010, it raises the ratio from about 0.5% to more than 0.6% even with only the approved funding.

It is important, however, to see this change in funding in two wider contexts: the longer-term development of funding for STI activities in Colombia, and the experience of other economies with which Colombia might be compared – in this case Brazil, the regional leader in terms of STA intensity. This is attempted in Table 4.5 and shows that:

- The highest recorded level of STA intensity in Colombia was achieved over several years in the mid-1990s (0.6% in 1995), but by 2000 it had collapsed, falling to half that level. It rose again through the 2000s, but by 2010 had not yet regained the mid-1990s level.
- The STA intensity of other Latin American and Caribbean (LAC) economies was also rising during the decade, especially during the second half, and in Brazil it reached more than 1.6% by 2000. Colombia did not reach that level during the late 2000s and its relative STA intensity had fallen to about half of the average level across all countries of the region, and to less than one-third of the level in Brazil.¹¹
- As noted above, adding the approved level of 2012 royalty funding to actual STA expenditure in 2010 would raise STA intensity to about 0.6%. This would merely bring it back by about 2014 to the level of the mid-1990s. Relative to Brazil, that level would obviously be higher than without the royalty funding. But at some 37% by around 2014, that is not substantially higher than the relative level of 33% achieved in 2005.

Table 4.5. Colombian STA royalty funding in a comparative context

STA intensity (STA expenditure/GDP %)		1995	2000	2005	2010
1.	Colombia	0.6 %	0.3 %	0.4 %	0.5 %
2.	Brazil		1.30 %	1.27 %	1.62 %
3.	Colombia relative to Brazil (row 1/2 %)		24 %	33 %	31 %
<i>Colombia actual 2010 STA plus 2012 approved royalty-funded STA</i>					
4.	Colombia: combined STA intensity (%)				0.6 %
5.	Combined STA intensity relative to Brazil (row 4/2 %)				37 %

Source: OECD based on RICyT and Colciencias (2013), “Regalías para la Ciencia, Tecnología e Innovación. Camino a la prosperidad regional”, presentation, 5 February, Bogota.

In other words, the impact of royalty funding so far might only seem to reverse negative trends in the scale of STA expenditure relative to the country's own experience over the last decade or so, and also relative to the experience of other regional economies.

The scale of future royalty funding is uncertain. However, to build an innovation system that is more commensurate with the scale of the Colombian economy, and to do so in a world in which other regional and OECD economies are likely to continue increasing their knowledge and innovation intensity, Colombia will almost certainly need to do more than absorb rising levels of funding via the new royalty stream. Core public funding for STI activities will also have to grow much faster than in the past.

Allocating the STI Fund

Applications to the STI Fund are invited in the strategic areas identified in the National Development Plan (Table 4.3) and assessed using a complex set of criteria (Table 4.6). The Fund can finance R&D projects, education and training in science and technology, scientific and technological services, and a range of activities related to innovation, such as acquiring external know-how, capital equipment, organisational change or the design of new machinery and equipment.

Table 4.6. Criteria for assessing STI Fund proposals

General criteria	Specific STI fund criteria
• Accordance with sectoral or territorial goals: NPD and territorial development plans, strategic departmental STI (40%) • Improvement of living conditions of the so-called special communities (10%) • Allocation of resources in public (physical) infrastructure to improve the quality of education (10%) • Projects on environmental recovery and stabilisation, reforestation and ecosystem restoration (10%) • To finish projects already started that are strategic for regional development (10%) • For extension, expansion and utilisation of non-conventional energy (10%) • To improve infrastructure along the Colombian borders (5%) • Improvement of infrastructure in areas where exploration and exploitation of non-renewable resources take place (5%)	• The programme or project takes into account the vocations and potential of the region (i.e. use of existing natural, human and productive resources in the region), to solve the problems or needs already identified (25%) • Programme or project could contribute to the formation or linking of highly qualified STI talent (20%) • Programme or project could contribute to STI capacity building (other than to human capital formation) (20%) • The results from the programme or innovation project could be applied in the short or medium term (15%) • Includes collaboration between actors from the following areas: scientific/technological, production, public and civil society (10%) • The project considers the use of additional sources of funding (5%) • The project could contribute to close gaps, through partnerships between regions with different levels of STI capabilities (5%).

Source: Colciencias (2013), “Regalías para la Ciencia, Tecnología e Innovación. Camino a la prosperidad regional”, presentation, 5 February, Bogotá.

While the STI Fund is administered by Colciencias, it is ultimately governed by the Governing Body of Administration and Decision (*Órgano Colegiado de Administración y Decisión*, OCAD) committee, which takes final responsibility for project funding decisions. Its members include:

- Three national ministries (one vote);
- A senior representative of the National Planning Department (DNP) (who shares the vote of the national ministries (which implies that the four of them have to reach a consensus);
- A representative from Colciencias (which also acts as the Technical Secretariat);
- Six governors from the departments (one vote);
- Representatives of six universities (one vote).

The High Level Commission of Ethnic Minorities (Comision Consultiva de Alto Nivel de las Comunidades Negras, Afrocolombianas, Raizales y Palanqueras) elects one representative from the public universities. Governors are renewed every year, while representatives of the universities are elected for a two-year period, renewable once. The universities' representatives are elected internally.

According to current legislation, the OCAD is in charge of:

- Defining, evaluating, approving and prioritising the usefulness and suitability of funding projects under the STI fund;
- Making decisions on the departments' and country's needs;
- Making decisions based on scientific and technical quality and relevance;
- Orienting the resources of the STI Fund towards projects with regional impact that stimulate regional capabilities;
- Putting together the comites consultivos (advisory committees);
- Designating a project executor for public projects.

Proposals are initially put to the regional authorities. The assessment and decision process is complex. In simple terms, the regions decide which projects they would like to see funded. Colciencias assesses them for quality and passes recommendations to the OCAD for final decision. A step-by-step description is given in the Appendix.

The regional dimension

Even before the establishment of the new General Royalty System in 2011, the 32 departments could establish and implement their own innovation and development policies. The new system has further strengthened their autonomy in this respect. Each department has its own advisory council for science, technology and innovation (CODECYT or CODETI), normally chaired by the governor, composed of regional industry, research and education institutions, and the regional representatives of Colciencias and SENA, which develops regional innovation and research strategies. (About half of the departments have developed such a strategy.) Each also has a regional competitiveness council, whose membership tends to overlap with that of the science, technology and innovation council, reducing the risk of incoherence.

Proposals to apply 10% of the overall departmental allocations to STI activities are developed at the departmental level. The state cannot impose either a division of labour or co-operation among the departments. In practice, there is limited co-ordination among them. The Private Competitiveness Council recently analysed regional innovation and industry priorities and found 80 different ones. At the national level, too, there is a proliferation of strategic priorities, and there do not appear to be any strongly prioritised national thematic priorities.

While Colciencias' Office of Regionalisation has run programmes to help develop STI planning and implementation capacity at the regional level, that capacity varies widely. Unsurprisingly, research-performing capacity is concentrated in the Bogotá region and in five other departments (Table 4.7). Over half of the development centres for new technologies are in Bogotá as are three-quarters of those working with services (CONPES, 2009).

Table 4.7. Distribution of research groups across regions, 2011

	A1	A	B	C	D	Not categorised, unranked	Total
Amazonas	0	1	2	5	0	2	10
Antioquia	45	59	100	128	193	213	738
Archipelago de San Andres, Providencia y Santa Catalina	0	0	2	0	0	0	2
Atlántico	11	14	41	53	66	60	245
Bogotá D.C.	94	98	272	385	795	615	2259
Bolívar	8	7	24	29	70	37	175
Boyacá	3	6	9	17	79	42	156
Caldas	9	9	26	28	39	36	147
Caquetá	0	1	2	8	9	14	34
Casanare	0	0	0	0	1	3	4
Cauca	2	2	9	25	49	39	126
Cesar	0	1	2	3	21	14	41
Chocó	0	1	4	3	16	7	31
Córdoba	1	1	7	11	23	26	69
Cundinamarca	3	3	9	16	34	17	82
Guaviare	0	0	0	1	0	0	1
Huila	1	3	6	11	27	12	60
La Guajira	0	0	1	2	10	7	20
Magdalena	3	2	11	17	37	30	100
Meta	1	0	3	4	26	16	50
Nariño	0	1	3	18	51	22	95
Norte de Santander	0	0	8	7	44	30	89
Quindío	2	4	4	7	20	16	53
Risaralda	1	12	13	42	42	31	141
Santander	9	11	34	43	100	68	265
Sucre	0	1	0	5	13	7	26
Tolima	0	2	9	7	26	33	77
Valle del Cauca	23	36	66	90	154	89	458
Total	216	275	667	965	1 945	1486	5 554

Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Initial experience with distributing the 10% of royalties dedicated to science, technology and innovation underscores some of the difficulties involved in co-ordinating the regional and national levels. The STI Fund through which the royalties are distributed involves a complex and multi-level approval procedure, which is mapped out in detail in the Appendix. Project proposals are developed and prioritised at the regional level before being passed to Colciencias, where they are assessed for conformity with the rules, quality and feasibility. The OCAD finally approves them at the national level.

Regional capacity for setting and implementing development plans varies greatly. Regions with limited STI capacity have difficulty formulating STI projects, and in many cases propose investment and other projects that fall outside the mission of the STI Fund. While the Fund encourages cross-regional co-operation, little is proposed. The regions optimise locally, aiming to spend all the available funds within their own boundaries. As a result, opportunities to develop capacity across regional boundaries are missed, projects are fragmented and opportunities to build critical mass and resources that follow the boundaries of natural resources or clusters of industry rather than administrative boundaries tend to be lost.

To facilitate the process, Colciencias has supported the drafting of 27 regional development plans for STI, some of which are being implemented and used as reference for project formulation. In addition, INNpalsa developed a roadmap instrument for improving region's capacities to plan on the areas of competitiveness, innovation and investment projects. It is called Competitive Routes Program (Programa Rutas Competitivas). INNpalsa has already funded and accompanied the development of several of these routes. Colciencias has a regional funding instrument whose main activity is to provide support to small and medium-sized enterprises (SMEs) and large businesses on what Colciencias calls "initiation into innovation" and to help companies to start engaging in innovation activities. The support includes access to academic courses in innovation management, training of consultants in innovation management, training of business managers with access to funding sources, organising missions to help businesses contact successful innovative companies.

Absorption and impact

Beyond the specific issue of disparities within and between departments in STI capabilities, especially capabilities to develop proposals and administer programmes, there is the more general question of the overall country-wide availability of scientific, technological and innovation capabilities to absorb effectively a large jump in funding. In Colombia, it seems especially important because of the small scale of the Colombian system: the substantial increase in funding from the royalty system should only be a first step in a long-term commitment to raising funding levels. Nothing is more likely to undermine that commitment than low outputs and poor impacts from this initial step, which critics could easily present as a waste of resources.

At the same time, Colombia needs to address the system's structural issues as well as its scale, in particular the need for a radical shift in the balance between innovation activities in enterprises and in public organisations. Making that shift requires not just more STI-related human resources, but specific capacities, many of which seem to be in short supply. There is an opportunity to respond to the absorptive capacity constraints by using the additional royalty funding to redress this imbalance. Table 4.8 shows the recent level of investment in R&D and in wider innovation activities by region, underscoring the need to develop innovation capacity as well as research.

Table 4.8. Investments in R&D and innovation activities, by department, 2010-12

Region	R&D	STA	Region	R&D	STA
Amazonas	0.95%	0.39%	Guainía	0.00%	0.00%
Antioquia	26.95%	21.41%	Huila	0.30%	0.22%
Arauca	0.01%	0.01%	La Guajira	0.04%	0.04%
Archipiélago de San Andrés, Providencia y Santa Catalina	0.12%	0.25%	Magdalena	1.23%	0.85%
Atlántico	1.33%	1.91%	Meta	0.11%	0.21%
Bogotá, D.C.	41.23%	52.57%	Nariño	0.86%	0.91%
Bolívar	2.44%	1.63%	Norte de Santander	0.50%	0.48%
Boyacá	1.41%	0.89%	Putumayo	0.00%	0.01%
Caldas	3.75%	2.45%	Quindío	0.52%	0.35%
Caquetá	0.05%	0.03%	Risaralda	0.84%	0.58%
Casanare	0.00%	0.03%	Santander	2.80%	2.10%
Cauca	1.14%	1.14%	Sucre	0.04%	0.04%
Cesar	0.07%	0.07%	Tolima	0.10%	0.39%
Chocó	0.13%	0.11%	Valle del Cauca	7.56%	6.42%
Córdoba	0.16%	0.24%	Vichada	0.00%	0.00%
Cundinamarca	5.40%	4.28%	Vaupés	0.00%	0.00%
Guaviare	0.00%	0.00%	Total	100.00%	100.00%

Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Information on the outputs and impacts of this funding is not yet available. However, it is not too soon to assess whether and where future outputs and impacts seem likely to be constrained by limitations on the availability of human resources and other capabilities for undertaking the planned scientific, technological and innovation activities. Quantitative and qualitative limitations need to be identified as early as possible and combined into assessments that can help to guide capacity development activity in connection with existing projects and programmes and more generally in connection with the evolving stream of new funding.

It has not been possible, for the purposes of this review, to obtain a summary of the scale and other characteristics of capacity development components of the approved royalty-funded projects and programmes. However, a superficial review of the projects provides two impressions. One is that a considerable proportion of the STI-related funding is allocated to explicit training and capacity-building projects, while other projects also include such elements. The second is that a large proportion of the more explicit training and capacity-building projects involve academic training and learning activities such as master's level training and activities under Colciencias' ONDAS programme aimed at promoting science and technology to young people. These observations again suggest too few of these activities are aimed at developing innovation-centred capabilities among the technological, professional and managerial employees of enterprises.

The absorptive capacity issue needs to be at the centre of policy attention and management activities concerned with the STI component of the new royalties system. This requires: i) an active, on-going review of areas in which planned outputs and impacts are likely to be constrained by limited capacities to undertake scientific, technological and innovation activities; ii) active reviews and summaries of the human resource development and capacity-building activities incorporated in royalty-funded projects; and iii) active links between them.

4.4. Main policy actors

The National Planning Department (DNP)

The President's Office (*Oficina de la Presidencia*), the National Council on Economic and Social Policy (*Consejo Nacional de Política Económica y Social*, CONPES) and the National Planning Department (*Departamento Nacional de Planeación*, DNP) play a central role in the strategic orientation and programming of public policy, including innovation and other aspects of industrial and development policy. Whereas CONPES is the central government's nerve-centre for overseeing and co-ordinating the implementation of the President's agenda, DNP's mission is to prepare the National Development Plan and act as secretariat to CONPES (OECD, 2013b).

DNP fulfils a range of policy functions defined in Decree 1832 of 2012 which include planning, monitoring, co-ordination and evaluation. Its typical policy cycle begins with the drafting of the National Development Plan. The Plan is the government's policy roadmap for the duration of the President's term in office and serves to legitimise strategic initiatives by the government (OECD, 2013c). Once the Plan is approved by Congress the DNP co-ordinates and supports the various parts of central and regional government in designing, monitoring and evaluating the implementation of policies in line with Plan. The DNP is among the better staffed and more reliable public-sector entities and is present across the country through its regional offices and local officials. Its Director is appointed by the President and holds a cabinet-level position (OECD, 2013b; OECD, 2013c).

Colciencias

Historically, Colciencias was an agency under the DNP. In 2009, Law 1286 altered its status so that it effectively took on the functions both of a ministry of science and a research and an innovation funding agency. This gave it the right to its own line in the state budget and to a seat on the CONPES. Previously, its budget was part of that of the DNP.

Colciencias thus encompasses the roles of science ministry, research council and innovation agency and is also the co-ordinator of innovation and research policy across government. This means that its performance is very important to the success of the research and innovation system. According to its strategic plan for 2011-14, Colciencias has three main activities:

- Co-ordinating, developing and implementing policy for the governance component of the national system of science, technology and innovation.
- Developing innovation and research capacities and programmes to support economic and social development in the higher education and research sector and in business.
- Developing human capital for research and innovation.

It operates a wide range of innovation and research funding instruments (see Appendix) and appears to be respected in the innovation and research communities. It makes heavy use of seconded academics as well as career civil servants in its operations. It runs 11 research councils, two-thirds populated by researchers. It is strongly networked in the academic community but much less in business.

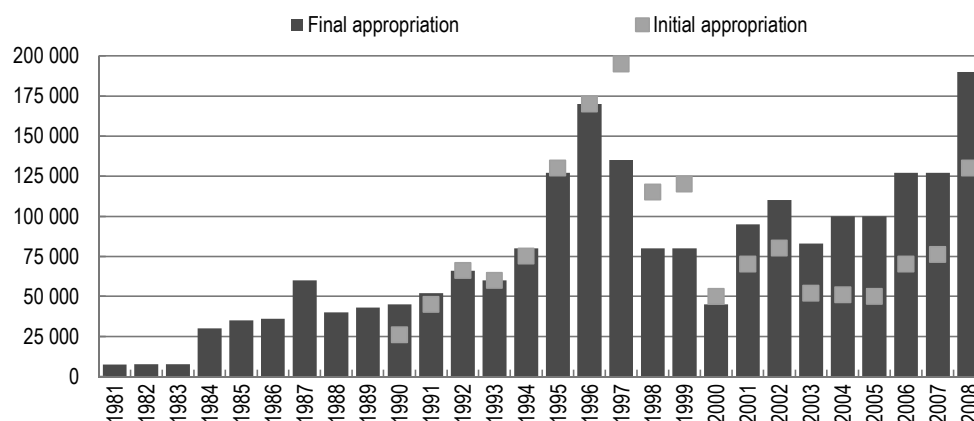
In addition to distributing its own budget, Colciencias uses its skills and experience in research funding to assess research and innovation projects funded from other sources via the Francisco José de Caldas Fund (which has been used to fund medical research on behalf of the Department of Health, research on behalf of the ministries of agriculture, mining and energy as well as ISA, Codensa and Ecopetrol) and the Regalias. In effect, Colciencias combines the functions of a research council (such as the US National Science Foundation) and an innovation agency (such as TEKES in Finland). It provides a natural place for co-ordination in the government system because it manages a substantial proportion of state funding for innovation and research. With the status of a ministry, Colciencias is more able than other countries' research councils or innovation agencies to set its own policies and can interact on equal terms with sector ministries. However, it also sets Colciencias up as a competitor in annual budget negotiations.

Colciencias provides the secretariat to the national Advisory Council on Science, Technology and Innovation as well as to the STI Fund, which distributes mineral royalties to STI projects in the regions.

As is the case with all funders, there are complaints from the beneficiary communities about excessive bureaucracy and paperwork and about assessment processes taking a long time. The success rate for research proposals from universities is very low (around 7-8%), as Colciencias' own budget has not grown: the dramatic growth in funding has been through the royalty system.

Figure 4.3 shows the development of Colciencias' budget in real terms. The growth from 1984 was enabled by the first Inter-American Development Bank (IDB) loan, which lasted until 1987. The peak around 1996 was driven by the third loan, while the subsequent dip resulted from the low priority given to S&T by the Pastrana administration (1998-2002). During this period, Colciencias was partly kept afloat by budget transfers from SENA; this led to protracted disagreement about the respective roles of SENA and Colciencias in innovation and to the two organisations' overlapping functions. The requirement for SENA to transfer budget to Colciencias ended in 2011. While the Colciencias budget appears to have been more dependable since 1985, the difficulty of pursuing long-term, consistent policies against a background of budget volatility is evident. Even since 2011, Colciencias' budget is substantially based upon a World Bank loan. The dependence on loan finance also implies dependence on the priorities of the lending organisations, since they negotiate the uses to which loans are put.

Figure 4.3. Colciencias' initial and final budget appropriations, 1981-2008



Source: OECD approximations based on Colciencias (2008), *Colombia Construye y Siembra Futuro: Política Nacional de Fomento a la Investigación y la Innovación*, Bogotá.

Colciencias' funding mechanisms fall broadly into three groups:

- Strengthening of STI capacities, by co-financing of basic and applied research carried out by universities and other public research organisations, provision of co-funding, direct credit lines and loan guarantees to companies, support for business on building capacity in innovation management, among others.
- S&T training through different PhD scholarship programmes. Currently this mechanism takes one-third of the total investment budget of Colciencias.
- Support to the STI system.

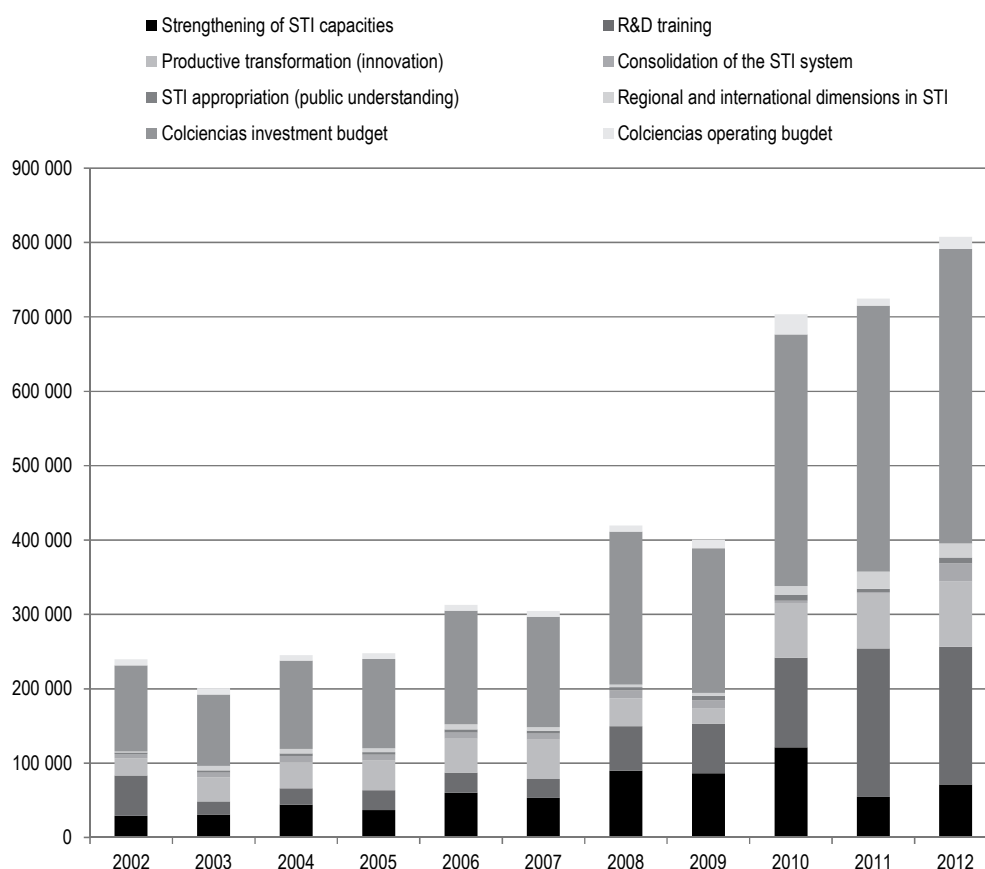
Like its overall budget, the budgets of Colciencias' programmes can be volatile. For instance, the Young Researchers Programme went from COP 2 000 million in 2008 to COP 11 341 million the following year and down to COP 4 751 million in 2010. In parallel, the relative importance of each funding mechanism changes from year to year, as in the case of support for research and innovation projects.

Table 4.9. Colciencias funding, per funding mechanisms (in millions of COP, constant prices, 2008)

Instrument	2007	2008	2009	2010	2011
1. Strengthening of STI capabilities	65%	88%	45%	56%	54%
Programme: ONDAS	1 346	2 000	0	0	0
Support to centres of excellence	8 366	0	0	0	0
Funding to research and innovation projects	74 961	90 179	51 315	71 274	46 056
Programme: Young researchers	1 561	2 000	11 341	4 751	733
Internationalisation	2 808	2 266	1 169	1 425	4 409
Regionalisation activities	1 561	1 500	0	30 369	64 127
Support to innovation (not included in projects)	0	0	19 402	67 219	67 916
2. S&T training	16%	0%	27%	31%	35%
Support to pursue PhD degree	21 696	0	50 083	96 413	118 273
3. Institutional support	18%	10%	26%	11%	9%
Support to technological centres	14 643	0	0	0	0
Strengthening of the STI national system	3 503	3 920	36 453	23 506	9 122
Administrative costs - STI national system	6 220	6 846	11 358	11 378	22 816
Other	2%	2%	3%	2%	1%
Other	2 153	2 000	5 403	7 608	4 677
Total	138 818	110 711	186 524	313 943	338 129

Source: Colciencias.

Colciencias does not provide institutional funding to public universities. Its support comes only in the form of funding research projects submitted through the different programmes/calls available. As Figure 4.4 shows, Colciencias devotes a small absolute amount and share of its budget to innovation. The major opportunity to fund innovation projects is through the STI Fund.

Figure 4.4. Colciencias' budget by type of expenditure, 2002-12 (in constant 2011 COP)

Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

The Ministry of Commerce, Industry and Tourism

There have been successive plans and committees to strengthen a changing list of industries in Colombia. The Samper administration set up a National Council for Competitiveness in 1994, with advisory committees for: firm management, productivity and quality; technology; human resources; infrastructure; and regulatory and legal frameworks. Eleven agreements between the state and industry were put in place, with undertakings from the state on regulation and from industry on performance. Policy from this period does not appear to have been monitored or evaluated, so its effects are unknown. The two following administrations continued this tradition of agreements between the government (by the Ministry of Commerce, Industry and Tourism). This resulted in a cumulative total of 41 agreements. However, the fact that these were developed by a single ministry meant that their ability to bind government as a whole was very limited.

The Pastrana administration (1998-2002) reorganised the previous committees into ten new ones, co-ordinated by the Red Colombia Compite. The next administration (Uribe 1, 2002-06) established the so-called Domestic Agenda, a competing set of nationwide consultation exercises aiming to strengthen the export industries (Meléndez and Perry, 2010). A review by external consultants of the period 1998-2006 concluded (in part based on an opinion survey in industry) that it had suffered from: duplication of

effort; little horizontal activity or co-ordination; insufficient formal linkage to government-level decision-making bodies, notably the CONPES; weak participation by industry, especially SMEs; major process weaknesses; weak execution; weak monitoring of activities and commitments; and inadequate impact evaluation (B.O.T. Concesiones de Gerencia, 2006).

As currently structured, the Ministry of Commerce, Industry and Tourism has vice-ministers responsible for international trade, tourism and business development. The ministry and its agencies run a number of innovation-related activities. In the past, the ministry funded work by Hausmann and Klinger (2008) which sought to identify the sectors on which Colombia should focus its development efforts. A follow-up project by McKinsey was intended to build the basis for implementation and led to the Productive Transformation Programme (PTP).

The PTP programme co-ordinates development activities in 18 strategic branches, though it is not itself a major funder of innovation projects. It carries out competitions among sectors or branches, which then write and implement a development plan, with a combination of actions to be performed by the sector and by government, such as simplifying regulation, removing administrative obstacles and so on. It does not give direct subsidies to the sector involved, but the sector can request important inputs from the state, such as increased education and training. Plans are expected to address, for example, needs for human capital development, legal framework and regulation, strengthening innovation in the sector, and infrastructure and sustainability.

The first sectors to enter the programme were outsourcing and off-shoring, software, cosmetics and personal-care products, health tourism, textiles and clothing, electricity, auto parts, printing and graphic arts. In effect, the PTP has the potential to be a cluster policy. It can support the development of specific clusters to improve internal communications and organisation and connect to opportunities for improving performance via instruments such as innovation support, linkage with the research, education and training systems, international market research and marketing, and so on. The PTP takes little advantage of these possibilities.

In current terminology, cluster policy has become smart specialisation. The difference is fundamentally that a smart specialisation strategy covers multiple clusters identified on the basis of existing success or resources. Like Hausmann and Klinger, who argue that it is preferable to diversify from positions of strength, policy makers who adopt the smart specialisation variant of cluster policy abstain from creating new clusters from scratch. Of course, any kind of selectivity (including the choice not to be selective) involves a degree of risk and may lead to actual or perceived government failure. The current thinking on smart specialisation sees this risk as acceptable and, ultimately, as less risky than not setting priorities. However, the corollary is that the organisational, institutional and programmatic aspects of the strategy need to be worked out in some detail to ensure that the areas of specialisation have a viable place in the cluster/sector innovation system.

The ministry also funds the INNpulsas unit within the Bancoldex state development bank. INNpulsas seeks to foster innovation in companies and to develop a funding ecosystem for innovative entrepreneurship. Despite its small budget, INNpulsas has become an important player in innovation policy, by taking on some innovation agency functions and supporting entrepreneurship and regional growth based on innovation. INNpulsas has been structured into two branches: The first branch is iNNpulsas Colombia, focused on three main areas of action: i) Mentality and Culture of Innovation; ii) Regional Growth; and iii) Extraordinary Business Growth. The second branch is

iNNpalsa SME Modernization Fund, focused on SME modernization and innovation. iNNpalsa promotes innovation through meetings, conferences, media exposure and competitions. In 2012, the ministry provided non-reimbursable co-funding to 25 companies to support innovation projects. It also established a line of credit of COP 60 billion for innovation projects and disbursed COP 44 billion to 41 firms. It maintains network relationships with innovation and research organisations in Colombia and abroad. It also funded 12 regions to develop innovation roadmaps, with the aim of increasing their capacity to plan and implement innovation measures.

Ministry of Labour

The Ministry of Labour runs SENA, established in 1957, whose task is primarily to provide vocational education and training (VET) through standard courses and training customised to the needs of individual companies. While SENA was seen as effective during its early years, attempts to create a market in private training services funded by the SENA levy during the 1990s were not very successful. Meléndez and Perry found rather negative industry views of SENA's efficiency and effectiveness in the early 2000s. They suggest that at that point SENA covered about 20% of the national training needs, with 38% supplied by private providers, 17% by other public institutions and 25% by the companies themselves (Meléndez and Perry, 2010).

In 2003, 70% of firms used the SENA apprenticeship scheme and 60% benefited from SENA training. A more recent survey suggests that firms have maintained their in-house training efforts but make less use of outside sources (Table 4.10).

Table 4.10. Percentage of companies using training programmes, 2008

Policy instrument	Total	Large	Medium	Small
Basic training through SENA	34	33	35	36
Specific training through SENA	33	36	23	45
Training through other government-owned institute	37	36	42	33
Training through private institute	30	30	33	25
Training within the firm	34	36	30	40

Source: EOS Fedesarrollo Survey, October 2008, quoted in Meléndez and Perry (2010), "Industrial Policies in Colombia", IDB-WP-126, IDB, Washington, DC.

Industry surveys of SENA indicate that industry satisfaction with its performance was very low a decade ago but that it has improved substantially over time (Table 4.11).

Table 4.11. Percentage of firms rating training instruments as inadequate

Policy instrument	Before 1990	1990-2000	2000-present
Basic training through SENA	38	24	24
Specific training through SENA	45	28	27
Training through other government-owned institute	58	54	54
Training through private institute	29	27	18
Training within the firm	27	16	15

Source: EOS Fedesarrollo Survey, October 2008, quoted in Meléndez and Perry (2010), "Industrial Policies in Colombia", IDB-WP-126, IDB, Washington, DC.

SENA currently has 33 regional centres, 116 training centres and 287 mobile classrooms. It maintains 15 technology parks, two dedicated technology development facilities, a small industrial extension service and funds training-related R&D projects. SENA also runs the Fondo Emprender, which provides start-up capital to new firms. Until 2011, it operated the Invitations to Technological Innovation and Development, a programme that funded innovations and technological developments intended to improve productivity and foster world-class industry. The “invitations” go primarily to the sectors that participate in the PTP.

SENA is funded by a 2% payroll levy, which makes it less dependent upon the state budget than other agencies. Vocational education and training makes up 89% of the training delivered. A further 7% is technical. The remaining 4% is technological. While this is a small proportion of SENA’s total effort, it accounts for over half of the national effort in the area.

According to OECD (2012), SENA is poorly integrated into national strategies for data collection on tertiary and higher education, academic programme planning, strategic planning and quality assurance mechanisms. Important efforts are under way, guided by the Ministries of Labour and Education, to develop and implement a national competency framework to integrate the national training effort. Signals about the quality of SENA training are mixed. There seems to be scope for improving the ability of the training system to evolve in a timely way with industry needs as well as its quality and practices, when compared with standards in countries with which Colombia would like to compete. There is evidence that the CERES part of the training system has problems of scale, quality and relevance. The OECD tertiary education review suggested that an evaluation is needed in this area.

Table 4.12. SENA enrolment by year and skill category

Programme type	2003	2004	2005	2006	2007	2008	2009	2010	2011
T&T and above	48 123	93 029	97 468	141 765	197 486	249 654	255 422	296 686	353 104
Labour technician	144 408	172 965	258 145	292 120	283 544	322 999	509 463	667 544	666 389
Complementary	2 070 851	2 698 805	3 497 739	3 714 924	4 675 158	5 470 775	7 155 388	7 251 686	7 910 207
Total	2 263 382	2 964 799	3 853 352	4 148 809	5 153 188	6 043 428	7 920 273	8 215 916	8 929 700

Note: Disaggregation of tertiary figures (T&T and above) is from additional background data provided by MEN and SENA to the OECD.

Source: SENA Sofia Plus quoted in OECD et al., (2012), *Reviews of National Policies for Education: Tertiary Education in Colombia 2012*, OECD Publishing. doi: [10.1787/9789264180697-en](https://doi.org/10.1787/9789264180697-en).

Law 344 of 1996 required SENA to devote 20% of its levy income to programmes for competitiveness and innovation, which it did through a mix of internal course delivery and funding of external organisations. About one-quarter of the 20% went to Colciencias (Arbaláez and Torrado, 2011). The obligation to transfer resources to Colciencias ceased in 2012.

SENA’s position in the research and innovation system is problematic. Its basis is a levy/grant system for vocational education and training, yet it also has substantial innovation support functions. As a result, its technology centres, science parks and technology development centres overlap with the roles of the university and research institute sectors. It thus fragments the national effort and hinders the development of critical mass in these areas. Its role in supplying start-up capital or playing some of the roles of a development bank also

appear misplaced, since they again fragment the effort and the capacity to offer such services as part of a bigger portfolio at Bancoldex. It would be better to:

- Refocus SENA on its core training role, which it should increasingly exercise in co-operation with the universities and colleges;
- Transfer the science parks and technology centre activities to the colleges and universities, possibly retaining ownership in a national company in the style of Norway's Industrial Development Corporation (SIVA), which is responsible for developing such activities and collocating them with institutions in the research and higher education system;
- Move the funding function to Bancoldex or an agency built around the development banking function, as Norway has done (see Box 4.2).

Box 4.2. Innovation funding in Norway

Innovation Norway plays a central role in innovation funding. It:

- Has the state's regional business development bank at its core and offers a range of funding instruments to support the development of entrepreneurship and of existing companies.
- Runs a range of business development and innovation support programmes (which mostly involve little or no research. For more R&D-based innovation support, the Research Council of Norway (RCN) or one of the joint RCN-Innovation Norway programmes is the operative partner.
- Incorporates the export/trade promotion function.
- Maintains a regional presence across Norway, providing a one-stop-shop for business and innovation support.

Ministry of Information Technology and Communications

The Ministry of Information Technology and Communications (*Ministerio de Tecnologías de la Información y las Comunicaciones*, MinTIC) is the government ministry in charge of designing, adopting and promoting policies, plans, programmes and projects in the ICT sector. MinTIC has the main responsibility for overseeing the ICT industries. Its role is not limited to policy, however. It has a number of other bodies under its tutelage, such as the Communications Regulation Commission (*Comisión de Regulación de Comunicaciones*, CRC) and the National Spectrum Agency (*Agencia Nacional del Espectro*, ANE), as well as powers over key areas, such as spectrum assignment or enforcement of regulation, that go beyond setting policy objectives and measuring progress (OECD, 2014a, forthcoming).

Its strategic objectives include the facilitation of access to ICTs and to their benefits, the development of a nationally-relevant and globally competitive ICT sector and the promotion of ICTs within and by the government. Its portfolio of policies and instruments mobilised to achieve these objectives is quite broad, in recognition of the systemic nature of the task it faces. It includes financial facilitation and infrastructure investment for the wider adoption of ICTs by households and businesses, support for the development of indigenous technological and content solutions, support for sector-specific research and innovation and international co-operation.

MinTIC's flagship initiative is the plan "*Vive Digital*" (Live Digitally), a comprehensive collection of both ICT demand and supply side initiatives that target the main pillars of the Internet ecosystem from infrastructure deployment and the provision of affordable access, to developing content and applications, increasing adoption and use and developing skills. Within the Vive Digital plan, MinTIC co-ordinates and supports the implementation of Government online (*Gobierno en Línea*), the programme that introduces ICT solutions to support administrative simplification (OECD, 2013b).

Most of the funding for the programmes of the Vive Digital strategy comes from the telecommunications fund FONTIC (*Fondo para las Tecnologías de Información y las Comunicaciones*) that was created in 1976. The fund depends on MinTIC but has a separate legal status (Article 35 of the 2009 ICT law). Market participants in the telecommunications market that provide telecommunication networks and services have to contribute 2.2% of their gross revenues to the fund (see also OECD 2014a, forthcoming). Rates used to be higher before 2009. The funds need to be executed within a year which might not be the most efficient way of using resources.

In 2012, the total budget of the fund amounted to a significant USD 399 million (COP 782.1 billion). A multitude of different ICT programmes are funded by FONTIC which makes it challenging to identify the funding of every single initiative. Table 4.13 shows an overview of the distribution of funds by broader categories for the year 2012. In this year, a significant part of the fund went either to infrastructure projects or to other programmes granting access to the Internet. While the current focus on access and connecting individuals and businesses to the Internet is justified, as a next step, it would seem worthwhile to shift focus on developing IT services and applications as a promising sector for economic development, building on existing initiatives. In 2012, the share of funding that was spent on initiatives targeting the demand side was relatively low.

Table 4.13. Overview of allocated funds for selected Vive Digital programmes in 2012

Vive Digital Programme	Allocated funds in 2012 (in COP)	Allocated funds in 2012 (in USD)	% of total budget
Connectivity Programme (Infrastructure)	245 016 313 502	124 958 320	31.33%
Computers for Education Programme	119 632 150 960	61 012 397	15.30%
Establishment of technocenters in the country	92 000 000 000	46 920 000	11.76%
Regional Vive Digital programme	90 000 000 000	45 900 000	11.51%
E-government programme	48 000 000 000	24 480 000	6.14%
Funding of CIFANTIC (research centre for sectorial ICT innovation nodes)	14 347 600 000	7 317 276	1.83%
Program to strengthen the IT industry in the country (FITI)	12 000 000 000	6 120 000	1.53%
ICT adoption programmes (training and services)	17 050 000 000	8 695 500	2.18%
Institutional strengthening of national IT sector	10 200 000 000	5 202 000	1.30%
Digital content programme	6 499 500 000	3 314 745	0.83%
IT Viceministry programme	3 000 000 000	1 530 000	0.38%
Innovation and development programme (I+D+i)	2 500 000 000	1 275 000	0.32%
SME programme	500 000 000	255 000	0.06%

Source: OECD based on MinTIC.

Given the significant amount of public resources spent on developing the Internet economy, a crucial next step is to undertake a thorough impact assessment of all ICT policies of the Vive Digital programme. While this has been done for some programmes such as *Computers for Education*, it is lacking for most other initiatives. The risk is not only that public funding may not be spent in the most efficient way and but also in the potential to crowd out private initiatives.

4.5. Public governance: Agenda setting, co-ordination and evaluation

The organisation of the state part of Colombia's system is one that is fairly unusual in OECD countries. Generally, these countries allocate major responsibility for research in the universities and for basic research to the education ministry and the task of funding innovation and more obviously industrially relevant research to the industry ministry. The other 'sector' or 'mission' ministries have to organise the research they need in order to regulate and legislate for their sector – sometimes also playing a role in building and maintaining the national capacity needed to do such research. For the last 30 years or so, most have done this through agencies. The education and industry ministries delegate innovation and research funding to research councils and innovation agencies, which run competitions and award funding for the best projects. Sector ministries vary in the degree to which they operate funding agencies related to their mission, but the great majority run government laboratories or public research institutes to supply the research they need (and often also to provide them with other technical services).

In Colombia, the National Planning Department DNP co-ordinates government policy for economic and social development at national level, currently through Prosperity for All (2011-14). The planning process appears to be inclusive; individual organisations contribute and it is not wholly top-down. Unusually, Colciencias functions both as a ministry and as an agent that largely does the work of a combined innovation agency and research council. Like a government minister, its president answers directly to the President of the Republic, it has its own line in the national budget, and it co-ordinates innovation and research policy across the whole of the national government.

In effect, there are two parallel governance systems for innovation, one from the perspective of research and the other of competitiveness. CONPES, the economic and social policy council (to which the DNP is the technical secretariat), oversees both systems. CONPES is composed of the President and some government ministers; it meets every two to three weeks and handles a wide range of social and economic issues. (Research and innovation are a small part of the CONPES agenda.) Apparently, many people sit on committees in both governance systems; this reduces the scope for the emergence of contradictory policies. While the sector ministries are involved in the National Commission of Competitiveness and Innovation, they also maintain separate, individual strategies. The process of co-ordinating horizontally across Colciencias and the sector ministries to tackle issues such as climate change and other problems increasingly being discussed as grand challenges appears to be at a fairly early stage. There is no appropriate arena at present and no referee (Salazar, 2010).

Figure 4.5 outlines the committee structure of the two systems, which are discussed in more detail below (see Chapter 3 for a discussion of the agricultural system).

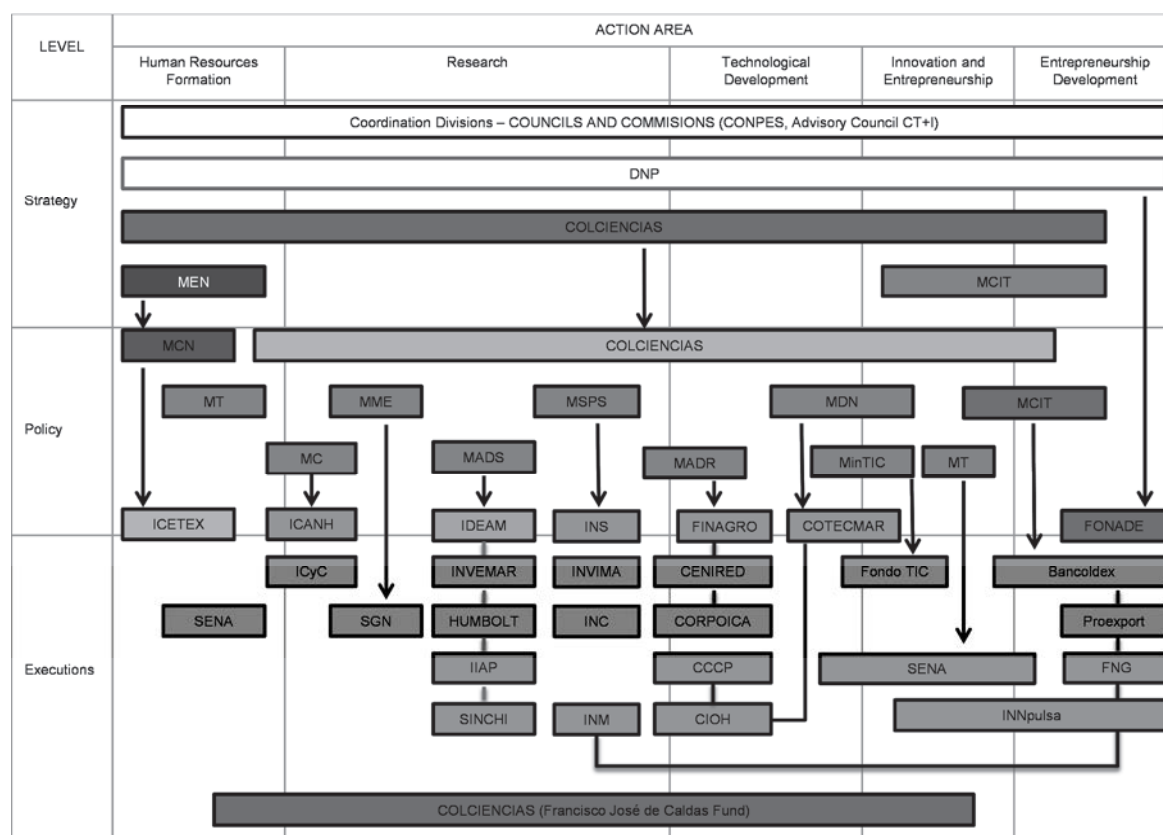
Figure 4.5. Committee structures of the state National System of Science, Technology and Innovation and the state National System of Competitiveness and Innovation

Dimension	National System of Science, Technology and Innovation	National System of Competitiveness and Innovation
National	National Council on Economic and Social Policy (CONPES) [Technical Secretariat DNP] Central Government Advisory Council CT+I [Technical Secretariat, Colciencias] Advisory Central Government Entrepreneurs Regions	National Commission of Competitiveness and Innovation [Technical Secretariat, Mixed] Entrepreneurs Workers Academy Civil Society Regions Local Government Central Government
Sectorial	CT+I National Programs Council [Technical Secretariat, Colciencias] Advisory Central Government Entrepreneurs	Mixed Technical Committees [Technical Secretariat, DN Ministries] Advisory Entrepreneurs Civil Society Central Government
Regional	Departmental Councils of STI (CODECTI) [Technical Secretariat: Governors Offices] Academy Local Government Entrepreneurs Regions Central Government	Competitiveness Regional Commissions (CRC) [Technical Secretariat: Governors Office, Chambers of Commerce] Entrepreneurs Workers Academy Civil Society Regions Local Government Central Government

Source: Fog et al. (2012), *National System for Science, Technology and Innovation in Colombia*, Background Report for the OECD Review of Innovation Policy, Bogotá, based on DNP – DDE.

The state ‘National System of Science, Technology and Innovation’

The ‘System’ of Science and Technology was established by law in 1991; innovation was added in 2006. Figure 4.6 shows the roles of various state organisations in strategy development, policy making and the execution of science, technology and innovation policy. While the execution category primarily covers research performers, it also includes funders such as Bancoldex, Icetex and the Francisco José de Caldas Fund managed by Colciencias.

Figure 4.6. Roles of state entities in the state National System of Science, Technology and Innovation

Source: Adapted from Fog et al. (2012), *National System for Science, Technology and Innovation in Colombia*, Background Report for the OECD Review of Innovation Policy, Bogotá based on DNP – DDE.

The national Advisory Council for Science, Technology and Innovation comprises ministers, academics and representatives of the private sector. Before Colciencias became a department of state, it had considerable influence, among other things because it approved the actions of Colciencias. Since that time, it has lost its authority not only over Colciencias but also over the tax incentive scheme, which has passed to the Tax Benefit Council. While it discusses policy, it has little real power. Its remaining function is to generate strategic intelligence, but it has few resources and there appears to be little output.

The councils for national science, technology and innovation programmes typically have seven to ten members appointed by the Director of Colciencias, of whom three to five are researchers, at least two are from the business sector (their attendance is said to be sporadic) and two to three are from government, typically the DNP and ministries with an interest in the thematic area addressed. In practice, two-thirds of the council members are researchers. With government taking up many of the remaining positions, there is little input from industry. The councils' role is to:

- Approve the policies for research, promotion, information, communication, regionalisation and training and the funding of the programme.
- Co-ordinate the development of the S&T programme strategic plan, after an extensive process of national and regional consultation. (These plans are normally drawn up by academics.)
- Promote government and private fund raising.
- Allocate financial resources for different projects, after a peer review co-ordinated by Colciencias.

Salazar's survey indicates that council members do not see their role as initiating new research directions or co-ordinating within the innovation system (Salazar, 2011). Nor do they contribute much to policy making. The ministry representatives in the councils tend to be low-level and reluctant to involve the councils in policy discussions (Salazar, 2010). Of the councils in place seven cover branches of science and four relate to innovation.¹²

Each region has its own advisory council for science, technology and innovation (CODECTI), normally chaired by the governor. It includes regional industry, research and education institutions, and the regional representatives of Colciencias and SENA.

Despite the appearance of cohesion suggested by Figure 4.5 the committees do not have mutual reporting relationships. Colciencias is the primary channel for co-ordination. As its budget covers only a small sub-set of the activities of the System for Science, Technology and Innovation, its ability to co-ordinate is limited.

The state 'National System of Competitiveness and Innovation'

The National System for Competitiveness and Innovation is the set of guidelines, rules, activities, resources, programmes, and public and private institutions that provide and promote the implementation of a policy of productivity and competitiveness. It was set up by Decree 3439 CONPES 2828 of 2006. Its mission is to co-ordinate the efforts of institutions involved in the formulation, implementation and monitoring of policies that affect the country's competitiveness. It is headed by the National Commission for Competitiveness and Innovation, which is chaired by the President of the Republic and has a mix of ministers and representatives of state agencies, universities, regions, employers and labour.

In practice, the Commission only meets once a year; its Executive Committee does the main work. This is composed of the High Council for Public and Private Management (ACGPP – in effect, an advisor to the president), DNP, Colciencias, the Ministry of the Economy, the Confederation of Chambers of Commerce and the Private Council for Competitiveness. The Private Council for Competitiveness was set up in 2007 and provides a public-private arena for policy discussion and a focus for the regular production of indicators of competitiveness. It is supported by a secretariat comprised of the head of DNP and a representative of the private sector.

The Ministry of the Economy and the Confederation of Chambers of Commerce are to co-ordinate the links to the 32 regional competitiveness commissions composed of regional stakeholders. Their task is to orchestrate competitiveness strategies at the regional level and to co-ordinate with the national level. They are supported by technical secretariats provided by the regional chamber of commerce and the regional government. In practice, the effectiveness of these regional bodies varies. A few are very sophisticated; many are said not to function well.

Nine mixed technical committees, public-private organisations whose task is to make policy proposals, support the work of the Council at the national level. An additional five committees exist but are inactive. The active ones cover logistics and transport (Comifal), biodiversity, business formalisation, cultural industries, identification of improvement opportunities for investment attractiveness, sanitary and phytosanitary, stock market - financial deepening, biofuels and rationalisation of procedures.

In some countries the national budget-setting process provides an opportunity to co-ordinate STI policy. The Norwegian Ministry of Education and Research, for example, collates information about ministries' plans relevant to STI during the budget cycle, so as to present an overall view. In the Colombian budget process, individual ministries submit large project ideas to DNP early in the year. On one occasion, Colciencias and DNP were able to develop a consolidated picture during the budget process and created an opportunity for co-ordination, but Colciencias has reverted to submitting its own proposals alongside those of the ministries. CONPES sets the budget without an overview of the STI element.

The half dozen or so ministries with historic responsibility for research have internal science directorates. Recent reforms require all ministries to spend at least 1% of their budget on R&D. Experience elsewhere suggests that this will put pressure on them to develop clearer strategies and to give more priority to research and innovation.

Lessons from abroad

In the past 20 years or so, an increasing number of countries have established national advisory committees or councils for research and innovation or STI. The Finnish Research and Innovation Council has served as an inspiration for many. Their growth appears partly due to the increasing degree to which research and innovation policy issues affect various sectors of society and partly to the spread of the innovation systems perspective, which recognises the systemic nature of innovation and the need for a co-ordinated approach by government.

The councils almost always include both industry and academia as advisors. The Finnish council is somewhat unusual in involving the research institute sector, despite its inherent closeness to innovation processes. A review of these councils revealed a number of apparently desirable characteristics (see Box 4.3). The councils considered tended not to suffer from policy capture. They engaged with a sufficiently wide set of stakeholders and provided a neutral forum for discussion, so that attempts by special interests to pursue their own objectives quickly became visible.

From the government perspective, the councils reviewed provide three possible choices:

- A *joint planning model* (Japan), in which the government uses the council as a virtual horizontal ministry of innovation, much as engineering companies build project teams by bringing together people across different disciplines.
- A *co-ordination model* (Finland, Netherlands Innovation Platform, Austria), in which the council is expected to communicate horizontally across ministry responsibilities so as to align policies in support of innovation, although the alignment may not be binding. The Czech council is in this category.

- An *advice model* (Canada, Ireland, Netherlands AWT, Switzerland, United Kingdom), in which the government is happy to be advised on research and innovation policy but does not wish to be restricted by that advice.

Box 4.3 Desiderata for research and innovation councils

- An innovation policy council should serve as a open public arena where stakeholders and decision makers debate and influence the direction of long-term research and innovation policy. This role should be complemented by active consultation of stakeholders.
- Its composition and status should be such that it is socially and politically legitimate and therefore largely robust to changes in government. It should include scientific and technological expertise.
- The council may sometimes need to act as referee and take decisions with which not everyone agrees, but an important goal is to create consensus about policy, so that it is natural for stakeholders to do things that are consistent with policy.
- Part of the council's function is to create and collate the strategic intelligence it needs in order to analyse deficiencies in the innovation system and propose improvements. This should be part of a wider pattern of distributed strategic intelligence, in which others also gather and analyse data and exploit them in support of policy analysis and deployment. The information produced and exchanged should be open so that it can be debated.
- The council should produce a long-term strategy for the innovation system that not only tackles systemic and market failures but also sets thematic priorities, is holistic, suggests an appropriate policy mix and serves to reduce the "dynamic inconsistency" between the longer-term perspective of the research and innovation system and the shorter-term perspectives of the world of politics.
- Co-ordination is a key role of the council vertically, horizontally and over time. In many countries, it also needs to have a regional dimension. Co-ordination serves to reduce inconsistencies and conflicts among policies and actors, to make the division of labour in the support system efficient and to reduce fragmentation of effort while empowering the actors involved to do their jobs effectively.
- The council needs to maintain a high profile with the public and opinion formers by promoting the importance of research and innovation and demonstrating its own impact.
- It should be sufficiently independent to be able to act as a agent of change. This means it should have no agendas or operational functions other than its brief to promote R&D and innovation and it should not have an interest in acquiring or spending significant resources of its own.
- The council should have a clear interface with government, at least at the level of ministers, so that someone is responsible for accepting (or rejecting) and implementing its advice. This often means that some ministers should be members of the council.

Source: Arnold and Hutschenreiter (2009), "Chile's National Innovation Council for Competitiveness: Interim Assessment and Outlook", www.cincel.cl/documentos/Recursos/CHILE_COUNCIL_FINAL.pdf.

The planning and co-ordination models require significant commitments of ministers' time as well as the willingness of political parties to see research and innovation as permanent, central aspects of government policy. The councils examined are all a part of systems with considerable distributed strategic intelligence in the state's part of the innovation system. This means that a great deal of instrument and even policy design takes place in ministries, agencies and other levels below that of the advisory council. This allows for exploiting the superior knowledge of needs and implementation found at lower levels of the system and requires good communication between the council and these lower levels. Making good use of the intelligence distributed through the system appears to depend to a fair extent on developing what might be called social networking capital.

This central co-ordinating function appears to be missing in Colombia. By definition, it cannot be replaced by the many councils and committees of the various systems of innovation, since these require co-ordination. CONPES can only fulfil this role partially, if at all, as its mandate is much wider than innovation policy, so that it may lack the necessary institutional reach and knowledge of specific needs.

Strategic intelligence

To intervene intelligently, selectively and effectively requires a broad knowledge base to support STI policy making and its implementation. At least three types of knowledge are involved:

- Statistics and indicators that describe the innovation and research system;
- Evaluations and evaluative studies that systematically use experience with interventions for accountability, to test whether interventions make a difference, and to learn how to develop and improve policies and interventions.
- Prospective studies that explore alternative future opportunities and policies.

The first consists of compilations and analyses of internationally comparable statistical indicators on key characteristics of STI systems. They can help both to identify the broad outlines of problems that need to be on the policy agenda and to benchmark progress against local aims and international experience in relevant comparator contexts. Colombia seems to have fairly good information about the national system but only a limited amount of international comparison. The Observatory of Science and Technology (*Observatorio Colombiano de Ciencia y Tecnología*, OCyT) was set up in 1999 as a public-private partnership involving 25 organisations. About 80% of its core funding comes from Colciencias. It collects a wide range of STI-related statistics, and provides syntheses in the form of a comprehensive set of indicators that are made available via various media. In addition, the National Administrative Department of Statistics (DANE) undertakes regular innovation surveys covering manufacturing industry and compiles accessible data sets, which are used by OCyT, by Colombian researchers, and in international studies undertaken by bodies such as the IDB.

However, the scope of the available information is very narrow. It focuses heavily on innovation in the manufacturing sector and a growing body of analytical work draws on that information to deepen understanding of manufacturing innovation. In contrast, apart from a certain amount of data and analysis relating to agricultural innovation, there appears to be very little information about innovation in other areas of the economy, and almost none that is in a form that might usefully inform policy.

The gap in the understanding of science, technology and innovation beyond the manufacturing and agricultural sectors thus concerns the greater part of the economy. Two domains seem particularly important. One is knowledge-intensive and innovation-related services, activities that may now play the knowledge-generating and innovation-diffusing role that the capital goods sectors played in the past century. The second, and much larger domain, is science, technology and innovation in the non-manufacturing components of industry that account for about one-quarter of the economy: the extractive industries, the energy and utility sectors, and the construction industry, which have grown very rapidly over the last two or three decades.

The gaps in policy-related understanding in these domains are not unique to Colombia. There is very little understanding in these areas in other countries, too. Yet the fragments that are available suggest that there appear to be substantial differences in key features of innovation between these sectors and manufacturing (see section 3.2 above). In particular, compared with the role of R&D in manufacturing, that of design, engineering and architectural capabilities and activities seems especially important. This has only recently begun to be recognised in some OECD countries, and little is known about its place within innovation processes.

The understanding of important aspects of science, technology and innovation in the area of social innovation is also limited. In particular, while participatory approaches to innovation have appeared in many countries over many years, especially in agriculture, there has been little systematic monitoring of the processes and outcomes. In Colombia, also, there is little even basic understanding of ways to achieve desired outcomes in different contexts. Given the significance currently attached to these modes of innovation, a better understanding of their organisational and process-related characteristics is needed.

The second category – evaluative studies – is poorly developed in Colombia. There is a tradition of economic evaluation of interventions that affect companies, normally based on surveys and econometric techniques. These are typically done by international funders, especially the IDB, and are valuable in terms of accountability. However, they give little insight into the mechanisms and processes of intervention, alternative means to reach the desired ends, or further needs for intervention. They should be supplemented by qualitative approaches that facilitate learning. The lack of a local evaluation culture and the fact that evaluations are only done to satisfy international sponsors is a major problem. The types of quantitative process indicators being incorporated in national plans can help to know whether interventions exist but do not address their effectiveness and provide no basis for policy learning. If one does not know whether interventions make a difference, one cannot make sensible policy. Evaluation needs to be better incorporated in national practice than is the case today.

The third category, prospective studies, has been addressed over the past decade via a range of foresight studies and a national foresight programme (Vasquez, 2006). These do not appear to have been well integrated into national planning processes in recent years. In international practice, the use of indicators and performance contracts as a way to steer research performers and agencies generally appears to be linked to a broader process of dialogue-based soft steering and the use of distributed strategic intelligence. In this respect, stakeholder involvement is an increasingly important component of the policy-making process. Analytical capacity and the ability to generate strategic intelligence and design programmes and other interventions also need to be distributed throughout the various levels of the system. International experience shows that the effectiveness of a policy-making process relies on good linkages between the different levels of the governance structure.

Policy makers and other stakeholders need continuous strategic intelligence about the innovation system in order to develop open systems able both to reflect on performance and to consider future policy opportunities. Some of this comes via the normal activities of actors such as innovation agencies, which collect information and experience as they work. Other intelligence comes from dedicated studies and special exercises such as foresight and planning. Evaluation provides a significant feedback loop from present and past actions. These elements, taken together, provide the basis for policy learning, while the ability of the system and its actors to make use of the information to adapt and improve policies over

time depends not only on the availability of information but, crucially, on institutions and governance arrangements that effectively connect knowledge to policy practice.

There appear to be strong arguments for some balance in strategic intelligence capabilities between the ministry and agency levels:

- To connect the implementation of research and innovation policy with the political sphere;
- To generate tension between the levels of policy and programmes, so that policies and interventions are mutually questioned;
- To ensure that ministries have buyer competence when setting up performance contracts with their agents;
- By delegating aspects of policy implementation to agencies, to reduce the need for ministries to be all-knowing. This balance generates a source of operational intelligence that is close to the eventual beneficiaries of research and innovation policy and that can provide kinds of knowledge not readily available at ministry level.

In Colombia's research and innovation system, however, agencies are at an early stage. Separating policy making from implementation allows for a system of checks and balances, tends to prevent the policy-making level from being involved in project selection and the distribution of funds, and helps to build strategic intelligence in the agency without allowing the interests of beneficiaries to affect policy-making directly.

The transformation of Colciencias into a state department has created a voice for innovation and research at the government level, but it has not solved the co-ordination problem or created the distance between policy making and implementation that is desirable in the STI system. While INNpulsA has taken on some business innovation support functions, it is still too small to play the role of a fully-fledged innovation agency. It is unfortunate that a ministry implements the PTP rather than an agency. A conventional ministry-agency model would not only provide better governance but also enable high-level co-ordination by a research and innovation council (if this is possible in the Colombian system) and, by removing the element of budget competition between Colciencias and other ministries, make it possible for an agency to implement and co-ordinate STI policies on behalf of and across many ministries, in the style of the RCN.

4.6. Supporting business R&D and innovation

While Colombia has a considerable repertoire of funding instruments to support innovation, their availability varies and only small amounts of funds are available or taken up. Instruments to support business innovation in Colombia are listed in the Appendix.

The Third Innovation Survey of manufacturing companies found that only 369 firms (5.3%) used government innovation policy instruments to fund intramural research in 2005 and 292 (0.3%) in 2006. Some 72% of respondents were unaware of any government instruments to support company innovation. The best-known instrument was Bancoldex's Proexport export finance loan scheme (15% of respondents). Small firms were the worst informed, and companies with more than 200 employees were better informed. In 2006, 81% of the money from these instruments went to larger firms and was concentrated in 2% of them (Sánchez and Lucio-Anas, 2011). This confirms the

earlier observation that the support system is sub-scale and that it needs to reach out to many more firms than at present.

Internationally, interventions to increase the rate and effectiveness of company innovation are generally of five types:

- Those aiming to sensitise companies to the importance of innovation and help them establish the ability to undertake it;
- Measures that support companies' in-house innovation efforts, such as grants and fiscal incentives;
- Programmes and activities that create or strengthen links between the research and higher education sector and companies;
- Schemes that use business-to-business links to induce innovation and improve quality and productivity;
- Ways to strengthen the innovation skills available within firms (discussed further below).

Understanding opportunities to innovate

If companies are to innovate, they need to understand the importance of innovation for a successful business. The INNpulsas projects that generate publicity for the idea of innovation are therefore important, as is Colciencias' ONDAS programme to promote public understanding of research. Other kinds of interventions can also help companies to understand improvement opportunities; they can be technology-related or more conventionally business-related:

- In terms of pure business opportunities, Norway has for some decades run a programme called FRAM, in which groups of entrepreneurs in different businesses undertake a mixture of classroom training and project work with the aim of achieving a 10% increase in their company's profits. The persistence of the programme reflects confidence that this improves companies' strategies and ability to exploit markets. Such an initiative could be a very useful complement to necessity-driven entrepreneurship.
- Many countries have run technology audit programmes in which an experienced engineer manager reviews the company's activities and technologies and proposes improvements and a programme for implementing them, again with the aim of increasing profitability.
- Wider publicity campaigns showing examples of how successful innovation turns into money have also been run in many countries; innovation prizes are a variant of this idea. There are no examples of publicity focused on the costs of not innovating, but this might be a useful ingredient in a publicity campaign.

The most important source of innovation is firms' own efforts. Even if some of the knowledge used is externally produced it is barely possible to innovate without internalising and developing that knowledge. The logical first step in supporting business innovation and R&D is therefore to take action to develop companies' absorptive capacity. Cohen and Levinthal (1990) introduced the idea of absorptive capacity to the R&D and innovation literature. They define it as "the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends". They

– and most other observers – treat R&D workers as a proxy for absorptive capacity. In reality, an engineer, a scientist or even a good technician can provide the first step in building absorptive capacity.

Other interventions that can kick-start the innovation process involve injecting new or additional human resources into companies.

- One of the longest-standing examples is the Teaching Company Scheme (currently called the Technology Transfer Partnership, operated in the United Kingdom and several Commonwealth countries under various names). It involves placing a fresh graduate (typically an engineer or hard scientist) in a company with some subsidy and a link to her or his college for supervision of an innovation project. Some schemes do not specify this link, but the use of fresh graduates tends to mean that they are likely to exploit their academic networks. After the subsidy ends, these people tend to remain in the company, raising technological capabilities, triggering innovation and eventually encouraging the recruitment of further graduates without subsidy.
- Some years ago Denmark created an industry doctoral scheme that has been widely copied, including by Colciencias. In these schemes the state and the company share the cost of a PhD student working on a problem that is of relevance to the company, with the expectation that they will join the firm on a full-time basis once they complete their degree, giving the company access to higher-level skills and an improved ability to exploit the international knowledge base for innovation.

Supporting in-house innovation by companies

Grants

Historically, Colciencias has been reluctant to provide direct subsidies to industry. In the mid-1990s, it introduced a co-funding instrument through which the state and a company shared the costs of work done in the research sector. The co-funding (*Cofinanciación*) programme grants up to 50% of the innovation project costs for large enterprises and up to 70% for SMEs and micro-enterprises. After fiscal incentives, it is the main mechanism for supporting business innovation and university-industry collaboration in Colombia. Companies apply for the grants, nominating the technology service provider (either a university or a centre for technological development). If approved, Colciencias funds a share of the total cost of the project. Public resources are transferred directly to the technology provider. According to Colciencias, this minimises the likelihood of inappropriate use of the resources (or crowding out) by the private sector. The second programme is a soft loan scheme (*Reembolso Obligado*) that provides partial funding for in-firm innovation projects. An IDB evaluation of these schemes shows that they had significant and positive effects on beneficiaries' labour productivity, product diversification and product innovation (Crespi et al., 2011).

These funding instruments represented a departure from previous practice in that, for the first time, they supported companies' innovation activities directly instead of funding universities and technology research centres. They shifted control of the subsidised activities from state research institutions to the users. Much of the activity they prompted was engineering and development. In the first three years (1995-97), projects were large-scale (on average worth just over a million COP) and represented strategic choices to develop areas with high potential spillovers, for example by supporting innovation in a

major steel company and developing a project to build a Colombian aeroplane. After 1997, projects were much smaller and less concerned with picking winners. Based primarily on credits and guarantees, the new instruments refrained from subsidising companies' intra-mural R&D activities. Colciencias only started to provide grants directly to private firms to strengthen their innovation capacity in 2011 through knowledge management, strategic innovation management, rethinking business models and other innovation-related practices via the Innovation Management Support Programme. Even here, the primary support is to build companies' capacities rather than support specific innovation projects.

Box 4.4. Understanding competence centres

Competence centres are a type of research and innovation funding instrument that has been used since the 1980s. The centres are typically located on a university campus and are a consortium of companies working together with people from more than one academic department on R&D, usually jointly. Sometimes research institutes are also involved. They are distinct from the usual academic-industry R&D collaborations in that they normally have structural objectives; they not only produce knowledge for innovation but have an effect on how research is done in the universities and in the companies and also aim to change aspects of university education:

- Three partners normally fund them: industry, university and a state agency.
- They involve an unusually high degree of subsidy compared with other academic-industry co-operations, often around 60%.
- They involve long-term contractual arrangements and a much bigger commitment than traditional project funding of collaborative R&D.
- They create new on-campus structures and therefore make new organisational and structural demands on the universities.
- Their research is interdisciplinary and generally problem-focused and requires horizontal networking across traditional university structures.
- Their long-term presence on campus and their engagement with postgraduate education draws them into closer contact and co-operation with universities' core business of education and research than is generally the case with linkage actions, which tend to focus more directly on research.
- By drawing industry personnel to campus to join in research, they also extend academics' networks into the industrial research community.

It is central to the idea of competence centres that they aim to do more basic types of research than is normally possible in industry, or even in conventional academic/industrial collaborations. The extent to which the research is fundamental in an absolute sense will vary with the stage of technological development of the innovation system in which the centres operate.

The competence centres themselves produce (or contribute to the production of) public goods of various kinds – most obviously knowledge in publications and in other forms but also a supply of people and wider contributions to things like standards, norms, practices.

Their presence affects the universities. First, they change education, because the universities' education is affected by their research activities. Second, they change the way the universities organise, govern and carry out research; this normally leads to more flexibility and interdisciplinarity. Third, they influence the direction of research – they act as focusing devices that signal where interesting (fundable) research questions are to be found, the solution of which will lead to industrial effects.

Participating companies get benefits in terms of knowledge, networks and people; this leads over time to innovations and income. There are also spillovers to other companies – both from the changes in the universities and from the participating companies: people and knowledge move about in ways that cannot be prevented.

Source: Stern et al. (2013), "Long Term Industrial Impacts of the Swedish Competence Centres", VA 2013:10, VINNOVA, Stockholm.

Other countries have much more active interventions to support in-company innovation. Grants and loans to firms for R&D are a common mechanism, though there are generally limits to the proportion of the cost of a project that can be subsidised. (In Europe, these limits are set by the so-called state-aid rules). There is a long tradition of subsidising joint work between companies and universities or institutes. While many of these programmes have fostered bilateral relationships between individual companies and research-performing institutions, the last two or three decades have seen growing efforts to fund networks of organisations, as in the European Framework Programme, which has had a major and sustained impact on the structure and performance of European research and industry. An increasingly common form of intervention is to establish competence centres, academic-industrial consortia that conduct R&D over a long period (see Box 4.4). The international evaluation literature on competence centres shows that they have a range of important impacts:

- On the amount of industrial innovation undertaken by partner firms;
- On the generation of significant economic benefits (typically well in excess of the costs of the programmes to the state);
- On industrial innovation behaviour;
- On universities' willingness and ability to work with industry on R&D and higher education;
- On the direction of university research and education, which tend to align with industrial needs;

Benefits from competence centres to the university generally dwarf any income they receive from technology transfer office functions (Stern et al., 2013).

Fiscal incentives for R&D

Colombia allows companies to set 175% of their investment in R&D against corporation tax (subject to a limit of 20% of net income). During 2004-08, 83 organisations a year were granted access to the R&D tax incentive, although the proportion actually using the incentive is not known (Salazar, 2010). Data for 2002-11 suggest that the rate is unchanged, for a potential cost of some COP 132 billion a year (USD 69 million). The actual cost in 2012 was COP 335 million, spread across 139 projects. Of these, 22 were in hydrocarbons, 21 in food, 14 in energy, with the balance spread across many other sectors.

An evaluation of the scheme (Mercer-Blackman, 2008) suggested that it was rather inefficient. At that time it offered a 125% write-off of eligible costs against corporate tax. Eligible costs did not include researchers' wages, so most of the incentive was used for various kinds of investment. Projects have to be approved by Colciencias, which uses external experts to judge whether the work is R&D of appropriate seriousness and quality. Public bodies and others not liable to corporate tax often applied for the incentive, in order to get a seal of approval for internal projects. In the period to 2008, 48% of applications came from public organisations and 8% from universities. The money was mostly spent internally – only 6% of applications related to investing in an external R&D project, for example in an institute or university.

Applicant companies were generally large and export-oriented. The incentive was more additional for small organisations than for large ones, and 84% of beneficiaries said that they would have done the project irrespective of whether their application was

approved. The sums of money involved were small and averaged 0.1% of the R&D expenditure of beneficiary organisations. In short, the findings of the evaluation were that it generated less R&D than it cost the exchequer to run, the degree of free riding was high, and in absolute terms it made little difference. Now, five years later, it would be important to do another evaluation to find out whether subsequent changes to the scheme have improved the situation. If not, there is a strong case for abolishing it or, at a minimum, using international experience to retune it towards small firms that are new to R&D.

Business-to-business linkage

Initiatives that exploit producer-user relations to spur innovation are rare in Colombia. This is a problem, because many supply chains seem to be poorly developed and because international customers and competitors strongly influence companies' decisions to innovate. Typical interventions to promote business-to-business linkages include:

- cluster and network policies, which build relationships among companies;
- encouragement of FDI and support for the efforts of the foreign multinationals to quality assure, certify, and encourage innovation in domestic supply chains;
- application of similar measures to large domestic companies;
- promotion of the use of key ISO standards (notably 9 000 on quality and 14 000 on environment) to raise the quality and sustainability of production and increase confidence in Colombian suppliers among domestic and international buyers.

The PTP has a small number of programmatic measures, such as training, kaizen workshops and productivity diagnosis, that may encourage companies to innovate, especially in terms of process. One would expect the kind of platform building and agenda setting done through the programme to cement relations among firms in clusters and to improve their links with external sources of knowledge and human capital as well as market signals. However, given the small size of the effort to support in-firm innovation, these effects may be limited. More broadly, the promotion of business-to-business innovation linkages is a significant gap in the Colombian policy repertoire.

Science-industry links

Science-industry linkage mechanisms receive considerable policy attention in Colombia. One reason is the state-centred focus of policy. Another is reluctance to fund private companies, as corruption has been a significant problem. A third is the tendency to import ideas from leading institutions in highly developed countries that are not necessarily effective or urgently needed in a developing country where much of the innovation system is weak. These include focus on PhD education (at the cost of wider skills) and measures such as technology transfer offices to promote innovations from universities.

External sources of knowledge complement companies' internal innovation efforts. Even when external knowledge is a significant input, innovation is co-produced. Interviews with a handful of local companies and research institutes confirmed that in Colombia, as elsewhere, advanced companies access world science directly, for example by contacting universities and research institutes abroad. Less capable firms only do so through the mediation of partners in the Colombian university and research sectors. Existing evidence confirms that, in Colombia as elsewhere, university links and human capital with higher qualifications are associated with higher rates of company innovation (Marotta et al., 2007).

In addition to producing human capital, therefore, universities and research institutes need to engage with world science in order to access knowledge. This requires them to operate at relatively high levels of scientific and technological quality. However, despite the introduction of an element of performance measurement in determining university core funding, Colombia is still a long way from what other countries in the region have achieved in this respect.

Research institutes and universities can play important roles not only in supporting individual innovations but also in helping companies increase their capabilities over time. The analysis of non-university research institutes earlier suggested that they tend to have rather narrow specialisations. A combination of lock-in by the interests of stakeholders who govern (and sometimes fund) such institutes is likely to make it difficult for the system to respond to the changing needs of industry and to tackle the increasingly horizontal and interdisciplinary nature of problems. There seems to be scope to consider merging a number of research institutes and government laboratories, as several European countries have done. This would involve not only reorganisations and mergers but also reconsideration of the institutes' funding mechanisms. The Swedish model of grouping research institutes and government labs in thematically focused clusters may be attractive, because it copes with funding diversity. More centralised solutions, in the Dutch or Finnish style, are also possible.

Despite improvements, the quantity and quality of academic-industry links remain limited in Colombia. It is important to enable such relationships to develop and to remove bureaucratic obstacles to them as well as to the commercialisation of research results. Because faculty in the public universities cannot draw more than one salary, they are in effect unable to set up spin-off companies, or they must make complex arrangements to circumvent the rules.

Many academic-industry links are small-scale and informal and their number is not known. There is nonetheless evidence (especially in the major cities outside the capital) that more formal and substantial links are emerging, although their innovation potential – and the potential for industry to signal its needs to universities – is clearly under-exploited.

Some of the major universities have established such linkages. The (private) University of the Andes has achieved increasing contract research income over the last decade (Table 4.14). The low level of co-operation with externals – as opposed to projects done for externals – nonetheless suggests that such linkage are at an early stage and reinforces the impression that industrial absorptive capacity is limited.

Table 4.14. Contract research income of the University of the Andes, 2001-11 (real 2011 COP)

Category	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Funding for research projects	622	2 936	5 375	5 419	3 299	6 771	9 682	13 186	14 723	5 340	2 351	69 705
Co-operation agreement	330	17	1 327	25 260	2 508	2 759	15 688	1 426	4 978	3 940	740	58 972
Contingent recovery	0	1 664	1 444	4 552	2 789	11 705	4 048	2 652	3 662	1 231	3 288	37 035
Co-research projects	0	0	24	14	420	951	1 602	4 323	236	442	517	8 530
Total	952	4 618	8 170	35 245	9 017	22 187	31 019	21 587	23 599	10 952	6 896	174 242

Source: Villaveces et al. (2012), *La investigación en Uniandes 2011: perspectivas de la internacionalización*, Universidad de los Andes, Vicerrectoría de Investigaciones, Ediciones Uniandes, Bogotá.

Over the period considered, almost three-quarters of the external research income has come from Colombia. Whatever the source, however, the income is lumpy and hard to manage. Table 4.15 shows that the amount and proportion of research income from Colombian companies is modest.

Table 4.15. University of the Andes: Colombian sources of research income, 2001-11, in constant 2011 COP millions

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Colciencias	0	1 347	2 671	3 801	3 414	8 462	4 140	3 643	2 718	1 818	2 964	34 979
UniAndes	46	993	853	11 988	1 440	4 859	4 249	2 831	5 311	1 099	1 284	34 953
Government	49	1 845	1 040	3 168	979	2 592	3 164	2 929	10 752	3 278	538	30 336
Business	0	4	3 040	1 189	757	2 031	1 871	1 181	1 372	1 167	410	13 021
Academic institutions	0	0	109	428	363	1 034	932	2 714	291	24	18	5 913
Non-profit organisations	330	17	16	680	489	663	656	1 443	537	300	616	5 748
Total	425	4 206	7 729	21 254	7 442	19 641	15 012	14 741	20 981	7 686	5 830	124 949

Source: Villaveces et al. (2012), *La investigación en Uniandes 2011: perspectivas de la internacionalización*, Universidad de los Andes, Vicerrectoría de Investigaciones, Ediciones Uniandes, Bogotá.

Table 4.16. Top 20 external research funders at the University of the Andes

Position	Entity	Country
1	Colciencias	Colombia
2	Universidad de los Andes	Colombia
3	European Commission	European Union
4	Inter-American Development Bank	Multilateral
5	Industria Militar INDUMIL	Colombia
6	Secretaria Distrital de Ambiente	Colombia
7	Empresa de Acueducto y Alcantarillado de Bogota ESP	Colombia
8	Ecopetrol SA	Colombia
9	Universidad Nacional de Colombia	Colombia
10	Financial Fund for Development Projects FONADE	Colombia
11	International Center for Tropical Agriculture	Multilateral
12	Compania Avina Stiftung	Switzerland
13	The Ford Foundation	United States
14	International Development Research Centre	Canada
15	Fondo para la Accion Ambiental y la Ninez	Colombia
16	Ministerio de Educacion Nacional	Colombia
17	Condensa SA ESP	Colombia
18	Instituto de Desarrollo Urbano IDU	Colombia
19	Fondacion Cardio Infantil	Colombia
20	Ministerio de Agricultura y Desarrollo Rural	Colombia

Source: Villaveces et al. (2012), *La investigación en Uniandes 2011: perspectivas de la internacionalización*, Universidad de los Andes, Vicerrectoría de Investigaciones, Ediciones Uniandes, Bogotá.

Table 4.16 shows that there are four companies among the university's top 20 external research funders: Industria Militar (Colombia); the Bogotá water company (Empresa de Acueducto y Alcantarillado de Bogotá ESP); Ecopetrol, the national oil and gas company; and Codensa, the Spanish-owned Bogotá electricity company. The

importance of the European Commission as a funder suggests that the university is well integrated in the EU Framework Programme.

The University of Antioch has a significant list of industrial research partners (Table 4.17), indicating that it has quite good links with local industry.

Table 4.17. Industrial partners of the University of Antioch

Firms		Firms	
AASCVA y Faes Pharma	Foreign	Humax Pharmaceutical	Private
Asociación Colombiana de Criadores de Búfalos	Private	IMAX	Foreign
Asosenepol	Private	Imusa S.A.	Private
Cadena Láctea de Antioquia	Private	Industrias Médicas Sampedro	Private
Cedimed S.A.	Private	INNOPAN	Private
Cementos Argos	Private	Instituto del Tórax S.A.	Private
Colgate	Private	Interquim S.A	Private
Compañía Nacional de Chocolates S.A.	Private	Inversiones Mi Vaquita	Private
CONDENSA/ EMGESA	Private	ISA	Mixed
Cooperativa Lechera de Antioquia Colanta	Private	ISAGEN	Mixed
CORNARE	Public	La colmena	Private
Corpoayapel	Private	Laboratorios Laproff	Private
Dentauro	Private	Manitoba	Private
Dimaq	Private	NEURORG Ltda.	Private
Dime Colombia	Private	Newfttis	Foreign
Ecopetrol	Mixed	ORMCO	Foreign
Electrocontrol S.A.	Private	Praexo Ltda	Private
Empresas Públicas de Medellín (EPM)	Mixed	Premex	Private
Fábrica de Licores de Antioquia (FLA)	Public	Servicentro JM	Private
FRA	Foreign	Setas colombianas S.A.	Private
Gimnasio Forma	Private	Sumicol S.A.	Private
Glocosme Ltda	Private	Tecnofarma	Private
Gyneco LTDA	Private	Uniban	Private

Source: University of Antioch.

On the industry side, Ecopetrol appears to be the company with the most university and institute links in Colombia. It has 28 co-operation agreements with universities and other research-performing organisations around the country.

The system will benefit from increased interest in, and incentives for, building many more such links. Colciencias already funds some joint projects but there is scope for more and for schemes that place bachelor's and master's graduates in industry, in addition to the programme that funds industrial PhDs. International experience shows that exploiting teacher-student relationships as students move into industry is a powerful way to increase companies' absorptive capacity and exchange knowledge.

A considerable number of technology transfer offices¹³ are associated with higher education institutions. Génesis (2009) surveyed 39 such organisations in the Medellín area and found that while three of the 35 responding organisations used good practices in international terms, such activities were generally unfocused, lacked clear business models and had practices that were mostly out-of-date and primitive. The overall effort was fragmented and overlapping. Another study found that this type of organisation was generally weak, with few links to external services, out-dated knowledge and working methods, and without services for design, market research or innovation (CONFECAMARAS & P3 Ventures, 2012).

The first business incubator in Colombia was set up in 1994 in Bogotá and another half dozen were set up in the major cities during the latter 1990s. SENA established a National Business Creation and Incubation System in 2002, which provides support both to universities and to others establishing incubators. Currently there are 31 incubators across the country. They mainly provide office space, services to support the writing of business plans, specialised consultancy, and assistance in finding funding. They are criticised as having little contact with investors, markets or customers outside the incubators and for weak and intermittent funding (Fog et al., 2012).

SENA offers training for innovation management and entrepreneurship. Its technology extension and technology centre activities provide important opportunities to support business innovation. They appear not to have been evaluated, so their practical value is unclear. Given the importance of developing a stronger, nationwide set of research, tertiary and university institutions, these functions would be better integrated in the research and higher education infrastructure, where they could share labour, knowledge and scale.

Skills for innovation

The greater part of Colciencias' efforts involve developing human capital, notably at the PhD level, and research. While these are important building blocks of the innovation system, they should be complemented by a focus on business. Skills interventions are discussed below.

4.7. Facilitating access to risk financing

The major ratings agencies started to grade Colombia again in 2011, having not done so for more than a decade, and thus encouraged international investment. While private equity funds operate in Colombia, they invest primarily in large established companies and sectors, notably infrastructure, hydrocarbons and energy. They are not a significant force in promoting innovation.

There are two sources of state venture capital. One is the Emprender Fund operated by SENA. It provides seed and start-up capital to those who have recently completed SENA courses or graduated from university. The second results from competitions run by Colciencias and FONTIC for ventures in information and communication technologies (ICT). In this case, advice is also provided to the companies. However, there is apparently no local private venture capital available for the early phases of company development. INNpursa aims to foster a funding ecosystem for start-ups, including the encouragement of business angels, but so far little has been accomplished. While an objective of the Competitiveness Strategy (CONPES 3527) is for Bancoldex to set up a more comprehensive development unit to improve the availability of early-stage funding, this has not yet happened (Colombian Private Council on Competitiveness, 2012).

Overall, there is no means of co-ordination that would ensure the availability of external financing through the various stages of the company life cycle.]

4.8. Promoting skills for innovation

Skills for innovation can be fostered directly in industry or indirectly by affecting the amount and characteristics of human resources emerging from the education and research system.

Promoting innovation skills via the education and research system

The balance of subjects and levels in tertiary education as a whole is problematic in Colombia (for a discussion of the tertiary and higher education system, see Chapter 3). First, university education has expanded much faster than other parts of tertiary education; this risks creating an imbalance in the workforce. Second, much university expansion has been in non-technical subjects rather than in the disciplines mainly needed to support innovation. In its next stage of development, Colombia will need technically oriented courses in both the university sector and in other parts of tertiary education, rather than a continuation of what appears to be an expansion driven by student demand or by the universities.

Colciencias is orienting its PhD grants towards the sectors prioritised in national strategy (though as Table 4.3 suggests, these priorities are wide-ranging and change quickly over time). It intends to give about half of its PhD grants to the exact and biological sciences. Some thematic orientation of grants and loans at lower levels may also be necessary to make the system coherent.

These measures need to be accompanied by others, such as bilateral academic-industry R&D projects and competence centres that focus research and educational efforts on areas of industrial need and feed back into increased industrial innovation capacity and form highly skilled manpower for areas of need. Signals from the PTP and other cluster activities can indicate skill needs at a wide range of levels, from vocational skills to PhDs. They also need to be complemented by the kind of schemes described earlier that help develop companies' absorptive capacity.

At present, almost no PhDs are employed in industry. The rising supply of PhDs cannot fully be absorbed by the tertiary and research sectors, nor is it desirable that it should be. Colciencias is already operating a doctoral scheme that co-sponsors doctoral candidates with industry. Many countries use competence centre programmes to improve research-industry links and to orient PhD education (and university research) towards fields of industrial interest. This will become easier as Colombia's industrial absorptive capacity increases – such programmes depend upon fairly high levels of R&D capability in universities' business partners. As PhD education increases, an increasing share of PhDs should find their way into business, and PhD education can be tuned to this end.

The importance of spin-off entrepreneurship from universities and research institutes can be exaggerated. The major effects of the universities and institutes tend to be on established companies. Often the most effective university-related entrepreneurs are new graduates rather than researchers or professors. Incorporating some entrepreneurship training into degrees at all levels is therefore useful. Box 4.5 describes a successful model that has operated in Stockholm for the past 20 years.

Box 4.5. Stockholm School of Entrepreneurship

The Stockholm School of Entrepreneurship (SSES) was founded by the Royal Institute of Technology (KTH), the Stockholm School of Economics (SSE) and the Karolinska Institutet to develop an integrated teaching curriculum to meet the demands of students, faculty and industry. A generous donation from the Erling-Persson Family Foundation allowed the school to establish itself firmly as an independent organisation in August 1999. A further donation from the foundation in 2002 made it possible for Konstfack to become the fourth member institution. In 2009 Stockholm University was invited to join as the fifth member institution.

SSES is recognised as a leading academic facility in the area of innovation and entrepreneurship. Its origin can be traced back to several courses taught at KTH and SSE in the 1990s. Its mission is to increase interest in and knowledge about practical and interdisciplinary entrepreneurship throughout the SSES's member schools. It was established to provide member schools' students with inspiration, education and training in applied entrepreneurship. As interest grew, so did the need to recognise how important entrepreneurship is in a modern economy, and to structure the teaching of relevant skills accordingly. The school draws on the different academic environments of its five member institutions and gathers their innovative and entrepreneurial competencies under one roof in a joint education programme. This academic programme in practical entrepreneurship education and training has already offered over 130 academic courses, over 185 extracurricular activities, examined over 7 000 students and led to over 350 companies operated by alumni students. It works as a brand, an operating platform for marketing, management and co-ordination, as well as an international network of entrepreneurs and researchers.

SSES is structured as a non-profit association with the acting rectors of the member universities as eligible members. The board of SSES represents the member universities and industry representatives. This structure creates strong regional and personal commitment to SSES. It also provides a sustainable and effective platform for high-level academic decision making. SSES is also represented by a dedicated team of some 60 faculty and staff. Around 200 guest speakers, mentors and coaches take part in the education programme every year.

Promoting innovation skills in industry

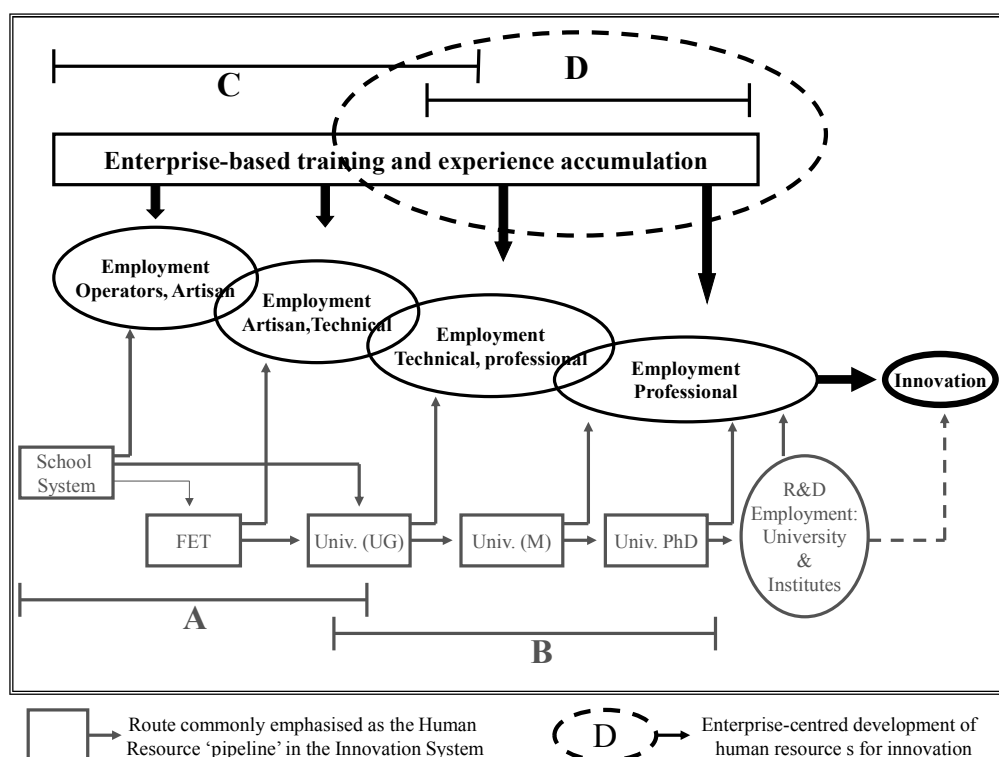
An important aspect of human resource development for innovation is the role played by firms, especially large ones. However, this is not usually considered in policy concerned with human resource development in STI systems in developing economies. Instead, attention concentrates on the areas covered above, or on areas A, B and C in Figure 4.7.

This leaves a considerable gap in D, the area of enterprise-based training and accumulation of experience that complements professional education and training provided by formal institutions, primarily in the higher education sector. This complementarity is especially important in areas such as design, engineering and project management for which formal education and training usually provide only an initial base of relevant skills and knowledge, generally a relatively small proportion of what is needed to contribute effectively to innovation. It needs to be extended and deepened by further training and learning that only take place where the innovation-related competence is to be used, i.e. in business enterprises, as in D (upper part of the figure).

Moreover, there may be an important gap in the system of incentives and support for investment by enterprises in strengthening their human resources in the technical/professional fields (area B). These resources are not just components of the private innovation systems of the individual firms that invest in their creation. They typically

diffuse as externalities to other firms, especially to smaller ones, and they can contribute to the dynamic evolution of the structure of the economy in socially desirable directions. It may be important to consider whether new mechanisms are needed to induce higher levels of corporate investment in these capabilities. It will be increasingly important to consider how to exploit more fully the full potential of inward technology flows, since much innovation draws primarily on imported technology, often in conjunction with innovation-cum-investment projects to set up new production or infrastructure facilities or to introduce new products. Experience elsewhere indicates that it is possible to organise such projects in ways that include knowledge transfer components that substantially strengthen domestic innovative capabilities.

Figure 4.7. Enterprise-based training and learning in the innovation system



Enterprise-based human resource development seems to be particularly strong in the kinds of industry that are important in Colombia. These include not only higher-value-added manufacturing and services, but also non-manufacturing industries that are central to several of the priority engines of development highlighted in the National Development Plan: the mineral, petroleum and other energy industries and their customers and suppliers, as well as the various infrastructure industries at the heart of the plans to develop transport, communications, and the urban environment.

Thanks to SENA, many aspects of vocational education and training are handled well in Colombia. However, there is no national competencies framework and no system that allows credits from tertiary education to be transferred into the university system. This limits educational mobility. These need to be established, with mechanisms for constant updating, to make the education system more effective.

Colciencias' new Innovation Management Support Programme, started in 2010, provides for the first time direct grant support to private firms for innovation purposes. Earlier, support was only provided in the form of co-funding, credit lines and loan guarantees. It:

- supports capacity building in innovation management, including the design, adoption and improvement of routines and practices for innovation management;
- facilitates learning opportunities for the creation of portfolios of innovation projects with varying degrees of complexity and impact on the productive structure of the organisation;
- encourages the formation of links between businesses, technology managers, and national and international centres of research and technological development with experience in supporting continuous innovation activities in enterprises;
- promotes the value and benefits of systematic innovation management through case studies that showcase the experience of each project funded through this mechanism.

A key aspect of the development of innovation skills not normally considered in the policy process is the role of firms, especially large ones. Large firms have been particularly effective in creating and accumulating knowledge resources in a wide range of industrial development contexts: the United States in the nineteenth century, Germany during the same period and into the twentieth century, Japan in the mid-twentieth century (Chandler et al., 1997), and more recently Korea, Singapore and Chinese Taipei (Amsden and Chu, 2003).

Large firms are better placed than smaller ones to invest in training and to achieve scale in using it. They typically capture a large fraction of the benefits. For example, returns to investment in training design engineers depends on the frequency of future design projects. This was strikingly illustrated, for instance, in the intensive efforts of large Korean firms in the 1960s and 1970s to acquire and accumulate engineering capabilities for use in a rapid succession of investment projects.

In most economies, large firms account for a large share of business investment in R&D (BERD). They develop knowledge across a wider range of technologies than those directly involved in their core production activities, primarily to support the management of their supply chains. This extended knowledge base is associated with the technologies of related industries, from which they buy inputs of materials, components, assemblies, engineering and other knowledge-intensive services, and capital equipment, and to which they sell their products (Patel and Pavitt, 1997; Granstrand, et al., 1997; Brusoni et al., 2001). This forms part of the basis for user-producer interactions and networked innovation activities. It underpins the diversification of the firm's activities. Large firms are typically effective accumulators of experience because they can afford to invest explicitly in it, e.g. by secondment of engineering and management personnel to other organisations and by rotating personnel through different activities and projects.

However, large firms rarely appropriate the full returns from their investments in accumulating knowledge. Much of it leaks or spills over to suppliers and customers and the rest of the economy, especially through the movement of skilled people. Large firms frequently act as sources of knowledge for the smaller firms that are their suppliers and customers, and as sources of knowledge assets for the establishment of new small firms

(spin-outs). Indeed, spin-offs from large firms are probably much more important economically than spin-offs from universities.

Knowledge dispersion by large firms occurs in two ways: more or less steady trickles over time and phases of major change in the economic environment of enterprises. The highly organised accumulation and sharing of knowledge in the Norwegian oil and gas industry is a textbook example. Colombia has opportunities to do the same in relation to its own hydrocarbons sector and in response to the need to improve physical infrastructures ranging from roads to telecommunications.

However, large firms do not automatically play this role in the development of national innovation systems. It may require particular types of social contract between the state and private business or state-facilitated collaboration among firms, and specific relationships between public and private technological organisations.

Strong engineering, design and project management capabilities will also be required. For example, much diversification into new kinds of production is likely to be based on existing bodies of knowledge that have to be engineered into particular products, processes and organisational procedures. Procuring goods and services from new local suppliers will frequently have a strong technological dimension and may involve the reverse engineering and technological upgrading of potential supply capability. The scope of public funding mechanisms to support such forms of innovation needs to be much wider than for those that focus on conventional R&D projects in which global technological novelty is a core requirement.

It follows that, as well as stimulating R&D, policy should strengthen firms' design, engineering and related capabilities. These can provide a stream of incremental innovation during the operation of existing facilities. They provide the basis for continuous streams of process improvement that have a major impact on productivity and costs and require in-house capabilities that are deeply embedded in the details of the specific markets and technologies of individual firms.

Even for larger and more intermittent investment projects, efficiency is not necessarily achieved by outsourcing the whole process to specialised supplier firms. Evidence from the global chemical industry suggests that project implementation is typically more efficient when it is based on partnerships that draw on substantial in-house engineering and project management capabilities in the facility-operating firms.

These design, engineering and related capabilities have an independent economic life of their own. Firms providing these services constitute a specialised sector of knowledge-intensive economic activity, often with the potential to expand into export markets in their own right. However, a key constituent of these capabilities is detailed experience in the relevant user industries.

A striking feature of the global knowledge economy is not just greater demand from business enterprises for higher skills supplied by the education and training system. It is also the extent to which business enterprises have increasingly strengthened their internal knowledge resources. Their investment in creating human capital takes a wide variety of forms that complement and build upon the education and training provided by school and further/higher education and span the spectrum of skill levels from operator/artisan skills to higher professional capabilities.

The mechanisms vary widely: in-house training, commissioning special training programmes from external suppliers, seconding personnel to other organisations, and intensive knowledge-management operations to capture explicit information and to exchange wider forms of experience. Particularly striking have been the creation of various kinds of corporate university to support these efforts: the Pohang University of Science and Technology set up in 1986 by POSCO (a steel company) in Korea, or VALER, the corporate university established in 2003 by CVRD (a mining company) in Brazil.

This was a common feature of the development of heavy process industries in Japan and later Korea, where intensive efforts were made to build into investment projects opportunities for training and experience acquisition in design, engineering and even technology development activities. These typically relied heavily on the organisation of R&D projects in local firms; the projects were designed to generate knowledge about the technology that was imported, not to generate knowledge for globally novel innovations (Ozawa, 1974; Amsden, 1989 and 2001; Enos and Park, 1988; Kim, 1997). In some cases, the use of technology-importing investment projects as vehicles to create new innovative capabilities has been organised into distinct technological learning projects that are treated as bank-funded investments to create human and organisational capital – as illustrated in a Brazilian case in Box 4.6. A common feature of these initiatives was a form of government support for firms (not necessarily funding) to make the necessary investments, and government-backed development banks have also played important roles.

This suggests that current approaches to supporting the development of the Colombian innovation system leave a gap concerned with exploiting the potential of major technology-importing investment projects in order to augment domestic innovation capacity, and not just production capacity.

Box 4.6. Bank-funded investment in innovation capabilities

Investing in engineering capabilities: Petroquisa's Copesul Project in Brazil

In the late 1970s, Petroquisa, a subsidiary of Petrobras, the Brazilian petroleum company, planned to construct a new petrochemical plant – the Copesul plant. This was a standard industrial investment project: Petroquisa put up most of the equity capital, and debt financing was provided by the Brazilian National Economic Development Bank, the World Bank and the IDB. The core project involved the normal components of procurement and construction (with substantial elements of local sourcing), plus training in plant operation and start-up.

More unusual was the component concerned with the engineering for the plant. Petroquisa sought to organise this component in a way that would augment the country's engineering capabilities in this area of technology. The development of these capabilities had come to a point where a step-change was needed to create competence in qualitatively different kinds of capability from those that had already been developed. The planned change was from extensive capabilities for detailed engineering of chemical plants, where local sourcing was already nearly 100%, to capabilities for basic engineering and technology development for which there was no existing Brazilian supply capability. This new platform of capabilities could not be created in an academic environment or by any amount of accumulation of experience in the qualitatively different activities of detailed engineering.

Petroquisa therefore built into the engineering component of the project a specific technological learning sub-project to achieve this step-change in capabilities. It had the following features.

- It was designed as a training and experience acquisition sub-project to be implemented with the international company supplying engineering services for the plant. It was built into the invitations to bid for the engineering contract, and the sub-project was an explicit element in negotiations with potential suppliers.

.../...

Box 4.6. Bank-funded investment in innovation capabilities (*continued*)

- The arrangements for training and experience acquisition were designed in a way that did not impose risks (e.g. of delay or higher costs) on the main plant project.
- To provide a nucleus for the training and experience acquisition project, Petroquisa assembled a team of 20 experienced engineering staff in the basic engineering department of its R&D facility, CENPES. This group spent four months and 10 000 man-hours strengthening its engineering competence in order to create a core of absorptive capacity *before* the start of the training and experience acquisition part of the sub-project.
- Staff from two Brazilian engineering firms were included in the core team to ensure that the augmented capabilities would be acquired by a small network of organisations – not only by the plant operator (Petroquisa) but also specialised engineering service suppliers.
- The core of the training activity involved the 20 engineering staff who undertook training courses for a total of ten months in the European offices of the engineering suppliers. This involved parallel engineering of parts of the process plant being constructed. The subsequent experience acquisition involved a simulation of the whole design process for a similar plant.
- Further elements of the package were designed to ensure that the Brazilian organisations acquired not just a one-off injection of capability to design an existing state-of-the art plant, but a basis for further development of the core technology. This required further training in the development of experimental units in CENPES, the provision of the relevant design and data programmes, plus rights to subsequent upgrades and improvements over ten years.

Perhaps the most striking feature of this sub-project was that it was treated as an investment project in its own right – an investment in creating knowledge and capabilities alongside the investment in the overall plant. Feasibility studies of the returns that would accrue from the subsequent application of these capabilities were conducted and the expected returns were deemed adequate to secure additional project funding from two of the development banks that were funding the main plant project. In effect, bank finance was used alongside one project to invest in generating spillovers for subsequent projects undertaken both by Petroquisa and by the specialised engineering service suppliers.

Sources: Sercovich (1980), “State-owned enterprises and dynamic comparative advantages in the world petrochemical industry: The case of commodity olefins in Brazil”, *Development Discussion Paper* No. 96, Harvard Institute for International Development, Cambridge, MA; and bank project appraisal documents.

However, it is clear from experience in other countries that the technological activities of subsidiaries of multinationals (MNEs) change over time, and in some contexts they become substantial performers of R&D. A particularly illuminating case is the development of subsidiary behaviour in the Brazilian automobile industry. In the early 1990s, as the Brazilian economy was opened to the international market, most of the auto industry subsidiaries ran down the R&D and engineering activities that had been built up during the import-substituting era. This prompted widespread comment about the inevitable demise of innovative activity in the MNE-dominated Brazilian industry. However, by the later 1990s most of the assemblers and some of the MNEs’ first-tier suppliers began to change their strategies, gradually increasing the depth of the design and engineering activity they undertook in Brazil. Today, several of the Brazilian subsidiaries have become significant actors in the global engineering and technology development networks of their corporate parents and affiliates. Key factors in this transition appear to have been a mixture of the regional scale of the markets served by Brazil and the high quality of locally available design and engineering expertise, and support from education and research organisations.

The host country can significantly influence such paths of change. Singapore used various forms of facilitation, support, inducement and development of the host country context for FDI at different stages to influence the behaviour of subsidiaries that now undertake significant innovative activities locally. In Ireland, MNE subsidiaries play a large R&D-performing role in the national innovation system. Ireland has used a battery of measures to increase the innovation capabilities of MNE subsidiaries and their suppliers in Ireland. These include supplier development schemes and the involvement of small, university-based centres in supporting MNEs and their supply chains with training, innovation projects and human capital. In recent years, production-focused instruments have been strengthened by the creation of Science Foundation Ireland, which invests in creating centres of research excellence in niches of ICT and biotechnology and which, together with other parts of the state system, targets inward investment in research and innovation. Client executives at the Industrial Development Authority are explicitly tasked with meeting the continuing needs of MNE subsidiaries for development support, as are their equivalents in Enterprise Ireland, who look after indigenous companies. This strengthens the position of the Irish subsidiaries in international competition.

These experiences illustrate the need to take a strategic perspective on the technological behaviour of MNE subsidiaries (Mytelka and Barclay, 2004). This involves going beyond policy efforts intended merely to attract FDI to measures that will induce changing patterns of technological behaviour by subsidiaries and thus contribute positively to the development of the host country innovation system.

Efforts to use MNEs as vehicles to broaden local capabilities can be construed as a matter of finding and then exploiting areas in which MNEs' private interests overlap with local developmental interests. It may be productive to envisage cost-sharing schemes to cover the costs of extending MNE activities beyond what they would undertake in their own interest, as the government of Singapore did for the costs subsidiaries incurred in providing technical support to local supplier companies.

Colombian policy does not seem to take advantage of the opportunity to use large firms as motors of development and innovation. Interventions could be extended to facilitate:

- The accumulation of knowledge and capabilities by large firms, both domestic and foreign-owned;
- The development of local capacity and experience, for example by supporting partnerships to learn how to carry out projects and to unpack technologies rather than outsourcing them or insisting on joint development projects as the price of granting firms access to national resources;
- The improvement of supply chains upstream and downstream of the large companies;
- The use of large companies' needs as key inputs in the planning and development of the research system in universities and institutes.

Along these lines, policy initiatives might consist of variations on the following:

- Subsidised support for firms to undertake projects centred on creating human resources for innovation. Such projects might be associated with firms' investment projects involving substantial technology imports.¹⁴
- Subsidised bank finance for investment in innovation-focused human capital.

- Funding and “facilitation” of projects involving collaboration in human resource development by R&D institutes and enterprises, perhaps along the lines of activities at ITRI in Chinese Taipei.

A more exploratory initiative might connect such initiatives with a reinvigoration of Colciencias’ schemes to mobilise the Colombian diaspora of professionals (Red Caldas and associated activities). They would need to be substantially shifted from the earlier, primarily academic, orientation. The initiative would need to strengthen enterprise-centred innovation and enterprise-centred human resource development components, for example, by exploring the potential for mobilising diaspora resources to gain access to enterprise-based training and experience overseas for high-potential middle-level engineers, managers and scientists employed in Colombia.

4.9. Spurring market demand for innovation

Analysis of innovation policy and innovation systems in all countries focuses heavily on supply-side issues: issues concerned with the development, allocation, organisation and management of the resources required to perform scientific, technological and innovation activities. Policy follows this orientation, concentrating heavily on the allocation of funding to develop and apply those innovation resources and on aspects of their organisation.

This is also the case in Colombia, at least at Colciencias. This orientation remains important for many reasons. Some are concerned with addressing the supply-side limitations in the innovation system that have been emphasised above: inadequacies in the scale of resources for innovation activities and for developing human capital. In addition there are no doubt limitations on the effectiveness with which those resources are allocated and managed.

But it is also important to address the demand-side processes that create pressures for innovation on supply-side actors. In broad terms they fall into two categories. Some originate in market contexts and are mediated through market mechanisms. Others may not be. In particular, some groups in society have too little income to exert strong pressure on the innovation system via the market. Instead their needs, or their social demands, for innovation may (or often may not) be channelled towards suppliers of innovation via non-market organisational structures or socio-political mechanisms. Both these processes seem important in the Colombian context and are discussed below.

An initial clarification may be useful because, contrary to some discussions of innovation policy issues in Colombia, the interface between the demand and supply sides of the innovation process is not located at the boundary between business enterprises (considered in that perspective to be the demand side) and innovation generated in public institutions (considered in that perspective to be the supply side).¹⁵ Instead, demands for innovation originating in market contexts impinge most immediately on production enterprises themselves, the innovation system actors that are on the front line in responding to most market demands for innovation. Consequently market-driven demands impinge on the supply side of the innovation process in production enterprises, where market signals can influence the decisions of entrepreneurs and managers to invest in innovation activities or to invest in strengthening their capabilities to innovate.

Thereafter, the pressures for innovation may percolate through the system as the front-line respondents create derived demand to secure complementary inputs to their own innovation responses from their suppliers. Some fraction of this derived demand may

feed back to other kinds of supplier: providers of knowledge and related inputs in universities or public research and technology organisations. In technologically dynamic innovation systems, knowledge inputs from research, development or design activities in such organisations complement the innovation activities of enterprises themselves. Rarely are they substitutes for enterprise innovation, though the provision of more routine technical advice or testing services may substitute for their in-house provision by firms, for example if specialised instrumentation or equipment is required.

The market influences that impinge on enterprises may be negative threats, such as pressures arising from competition, declining sales and falling prices for existing products. Or they may be positive opportunities, such as rising demand and prices of existing outputs, or signals about new opportunities generated by the emergence and growth of demand for products not currently produced. The impact of such influences at the intra-enterprise interface of demand and supply may vary. It may be high (or low) if the intensity of the stimuli generated by market contexts is high (or low). For example it is often argued that negative pressures from market competition are more influential than positive signals about opportunities. Similarly, firms' reaction may be very dynamic if managers and others are able to envisage potentially profitable innovation responses; or they may be sluggish if those capabilities are weak.

There do not appear to be any systematic analyses of these issues for Colombia, but anecdotal evidence prompts the somewhat speculative comment that demand-side market pressures for innovation by enterprises may be weak in the first place, even if the supply-side response capacity of firms is also weak.

- For example, a relatively large proportion of manufacturing firms reported in EDIT innovation surveys that they undertook no innovation in the preceding two years – 57% in the EDIT III survey (2005-06) and again in the EDIT IV survey (2007- 08). Moreover, a significant proportion of the enterprises reporting that they had undertaken no innovation in the second survey had also undertaken none in the first (OCyT, 2011). In other words, a considerable number of firms survived for four years without undertaking any innovation. This suggests that enterprises face limited pressures for change, and that competitive forces are weak.
- Another piece of information concerns a particular feature of the productivity patterns in Colombian industry. It is not the relatively slow changes in productivity but the unusually wide dispersion of productivity in Colombian firms, which is substantially wider than in other LAC economies. Again, the survival of a relatively large tail of low-productivity firms suggests that competitive pressures are more limited in Colombia than in several other regional economies.

These patterns suggest that measures to increase competitive pressures (such as new international trade agreements or the implementation of internal market reforms) should be considered important dimensions of innovation policy. They are likely to have positive effects on innovation in enterprises, but only if firms have the capabilities to envisage and implement innovation in response to competitive pressures.

Also, although there is little evidence, it seems likely that demand-side influences from front-line firms to other actors in the system may be significantly attenuated as they percolate through the system. This is suggested, at least in manufacturing, by such things as the high proportion of firms that do not innovate and the very low level of R&D

performed by firms. A manufacturing sector with these characteristics is not likely to generate much demand for complementary R&D in universities and research institutes.

The policy implications of the discussion of demand for innovation are the need for trade and industry policies that expose national and regional firms to competitive pressures to innovate. These can include using and supporting FDI as a way to stretch domestic suppliers and enforce increases in capacity along supply chains and cluster and smart specialisation policies that support business-to-business linkages, and especially supplier-user relations.

4.10. Defining the Internet and ICT sector as a platform for innovation

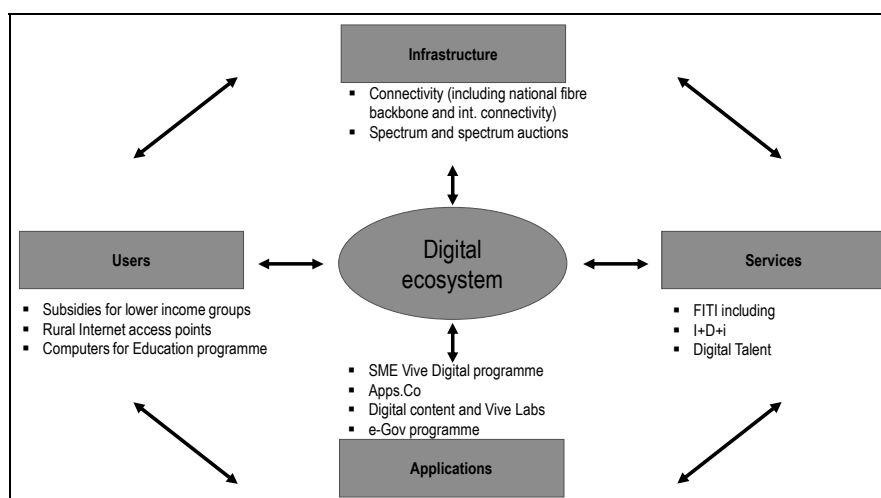
The Colombian government is aware of the importance of the Internet and ICTs for the economy and understands that policy measures can help address current shortcomings and further develop the Internet economy. As mentioned, the Vive Digital strategy contains proactive Internet and ICT policies that target the main pillars of the Internet ecosystem from infrastructure deployment and the provision of affordable access, to developing content and applications, increasing adoption and use and developing skills. It includes both ICT demand and supply side policies. The strategy has been aligned with the National Development Plan (2010-2014) where information and communication technologies are conceived as a horizontal pillar for the *locomotores* priority sectors.

Colombia's Digital Strategy

Programmes of the Vive Digital strategy

Overall, the Vive Digital Strategy comprises a large number of different policy programmes. Figure 4.8 provides an overview of the main programmes in terms of funding and as indicated by MinTIC that are discussed in this section. Since programmes and policies related to the expansion of infrastructure have already been discussed in Chapter 2 under the heading of framework conditions, this part will focus on the other three remaining pillars.

Figure 4.8. Overview of the main Vive Digital programmes

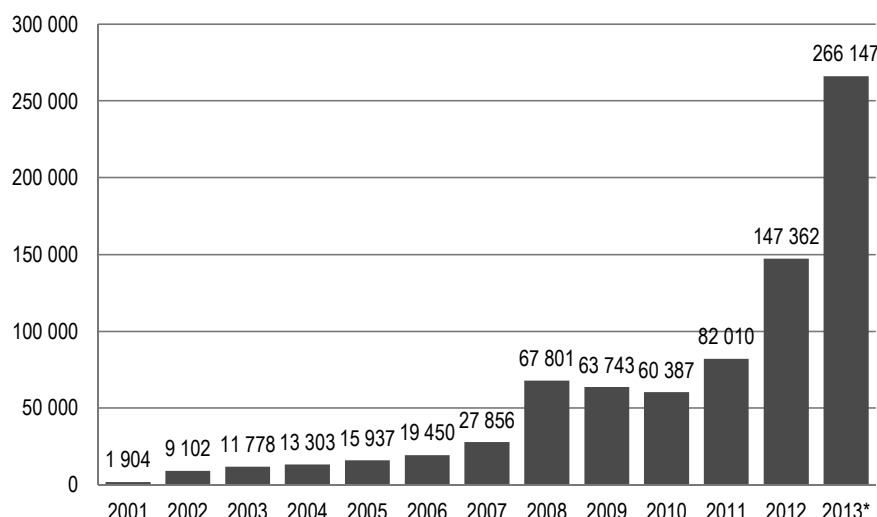


Source: OECD based on MinTIC (2014), "Estadísticas del sector TIC", <http://colombiatic.mintic.gov.co/602/w3-article-616.html>, and Molano Vega (2013), "Colombia's Digital Agenda: Successes and the Challenges Ahead", in: WEF (2013), *The Global Information Technology Outlook 2013*.

Users – Expanding the use of the Internet and ICT adoption

Policy programmes under this pillar are targeted at promoting the adoption and use of the Internet across all population groups and expanding the use of the Internet to rural areas. Since usage rates in rural areas and within lower income groups are significantly lower than in big cities and within higher income groups, this is an important step to develop the digital ecosystem in the country in an inclusive way. The ICT law 1341 (2009) put universal access for rural and remote areas at the forefront as well as the expansion of the Internet to lower income groups. As a consequence, the Vive Digital strategy contains several programmes directed at this aim. Besides subsidies for lower income groups, policy programmes in this pillar include initiatives to build-up Internet centres in villages (*Puntos Vive Digital and smaller Kioscos Vive Digital*) to foster the use of the Internet in rural and remote areas. So far, 101 Puntos Vive Digital have been built and 341 are currently under construction and a total of further 1144 Kioscos have been deployed and 6 477 are under construction. As previous experiences in other countries have shown, Internet access point were often only successful when regional commitment was behind their establishment and when those points took a holistic approach that went beyond just establishing an Internet connection with computers and included training facilities for the population. In this respect, the Colombian access points appear well designed. A challenge for the coming years, though, will be the maintenance costs for these locations.

An important programme in this pillar, both in terms of funding and in digitalisation of the country and training digital skills sets is the Computers for Education programme (*Computadores Para Educar*, CPE) which aims at improving the quality of education by bringing ICTs and ICT education to schools in rural and remote zones. Municipalities and public institutions can apply for the programme but have to co-fund it in order to ensure local buy-in. Depending on the income levels of the entities, the amounts of co-funding varies. While richer areas fund more than 50% of the programme, poorer areas fund less. The programme aims at (i) equipping all public education institutions with terminals (PCs, laptops, tablets) in order to achieve a ratio of 12 students per computer, (ii) training teachers on how to integrate ICTs in their course work and pedagogics, (iii) training parents and (iv) recycling old terminals. Figure 4.9 provides an overview of the number of delivered terminals during the last 12 years which shows increased efforts since 2001 on. In terms of terminals per students, the programme reached an average of 20 students per computer in 2010 and 15 students per computer at the end of 2012.

Figure 4.9. Delivered terminals (PCs, laptops, tablets), Computers for Education Programme

Note: * Planned delivery for 2013.

Source: OECD based on Computadores para Educar (2012, 2011), MinTIC (2014), “Estadísticas del sector TIC”, <http://colombiatic.mintic.gov.co/602/w3-article-616.html>, and Molano Vega (2013), “Colombia’s Digital Agenda: Successes and the Challenges Ahead”, in: WEF (2013), *The Global Information Technology Outlook 2013*.

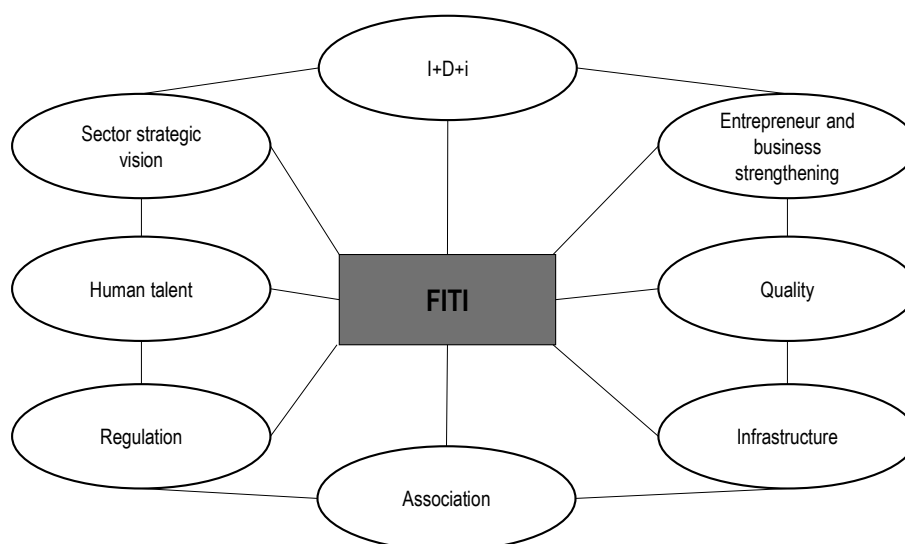
Funds allocated to this programme are significant. In 2012, for example, the programme spent USD 61 million. Impact studies of such programmes around the world have shown mixed results. For the Colombian CPE Programme, two impact studies have been conducted. The first was conducted by the World Bank in 2009 (Barrera-Osorio and Linden, 2009) and the second by the University of the Andes (Rodríguez Rosales et al., 2011). The first assessment suggested that the programme had “little effect on students’ test scores and other outcomes” (Barrera-Osoria and Linden 2009, p. 16). They assumed that the main reason for this finding lay in the concrete programme implementation since the computers were mainly used to learn how to use such a terminal rather than, for instance, for the purpose of language training. Another reason why no significant effects were observed could be the fact that the time span between the baseline survey and the follow-up survey (less than two years) might have been too short given that the programme set-up time amounted to 1 year and 8 months. Rodríguez Rosales et al. (2011) found that overall “the CPE program reduces dropout rates, raises standardized test scores and increases the probability of entering higher education” (Rodríguez Rosales et al. 2011, p. 2). In addition, the longer the schools were participating in the programme, the higher were the positive effects. Overall, results of the two studies seem to indicate that schools need to run the programme for a longer period of time to obtain significant benefits at the CPE schools typically located in poorer areas. Positive effects at these schools have the important potential to narrow inequality in the country. However, it seems sensible to continue monitoring the implementation of the programme.

Creation of services and fostering the national IT industry

The FITI programme (*Fortalecimiento de la Industria de las Tecnologías de la Información*, FITI) that has recently been established aims to develop the IT industry in Colombia. In this aim, a systemic model has been developed which consists of eight

modules and is shown in Figure 4.10. The module *Sector strategic vision* establishes a vision for the sector based on existing studies and aims at guiding the different stakeholders involved in the sector. The “regulatory dimension” aims to establish a regulatory framework that helps achieving the goals of the strategic vision. The “association dimension” seeks to connect all stakeholders of the sector to make use of synergies but to also strengthen sector coherence and ensure the representation of the IT sector both at the national and international level. The *Infrastructure* module was set up to undertake research to determine the sector specific infrastructure needs. An important element which is also supposed to facilitate exports of IT services is the *Quality* module, conceived to help Colombian firms adhere to international quality standards. The *Entrepreneurship and business strengthening* module aims at stimulating the creation of IT businesses¹⁶. The two remaining pillars, *Research, Development and innovation* (*Investigación, Desarrollo e innovación*, I+D+i) as well as *Human talent*, are treated below in some detail.

Figure 4.10. Modules of the FITI Framework



Source: OECD based on MinTIC

R&D and Innovation in ICTs

I+D+i (*Investigación, Desarrollo e Innovación*; Research, Development and Innovation) deserves special mention as MinTIC’s innovation programme, although it should be noted that innovation is also a component of other parts of the Vive Digital strategy. The programme is jointly developed with DNP and Colciencias with the aim of developing a national I+D+i agenda to develop the IT sector, strengthen the e-governance programme (see also the following section) and to improve the use of ICTs in other sectors of the economy. Its rationale derives from the National Development Programme and envisages impacts, in terms of productivity and competitiveness, not just in the ICT producing sector but in light of the in the economy as a whole.

The I+D+i programme runs over 2011-16, and is divided in three phases: The first phase (2011-mid 2012) consisted of developing the strategic framework and creating five innovation nodes as well as a prioritising the work. The nodes that were defined are IT

services for citizens, IT architecture for the government, Cybersecurity, Health and Justice. Criteria for the selection of the nodes were, amongst others, horizontality (i.e. that topics would be interesting for a large number of stakeholders), usefulness for the government and alignment with the Vive Digital and the e-government strategy. The second phase (mid-2012 to end-2014) is conceived to strengthen the functioning of the innovation nodes which are composed of representatives of the public sector, academia, research institutes and businesses (both ICT providers and users). By the third phase (2015-2016), the different innovation nodes are expected to be self-sustaining and ideally able to develop innovation projects without depending on public funding, and thus these projects will be driven by market demand.

Since the I+D+i programme was launched recently and is currently in the implementation phase, it is too early to observe its outcomes. In terms of the focus of the programme, it was certainly meaningful to try to increase the productivity levels of the public sector through the use of ICTs as a first step since the use of ICTs has been relatively low. However, since this innovation programme is intended to increase productivity and competitiveness at the level of the entire economy, it will be important to extend and complement it with other innovation nodes since increasing the productivity and competitiveness level of the private sector is at least as important. Consequently, in the future the focus could shift on the development of general ICT tools based on open standards that help firms across all sectors improve efficiency. A special focus could be placed on innovative tools that are particularly suited for SMEs. Some OECD countries, such as Germany, Finland and Korea have already developed policies in this area. Cloud computing, the Internet of things and the industrial Internet (including machine-to-machine communication) and guide entities in the public and private sector on how to make the best use of these new developments and innovations.

Human talent

This module of FITI addresses the skill shortage when it comes to ICT skills in the country. The overall module (i) aims to build the bridge between academia and the business sector to develop curricula that are tailored to the needs of the IT industry and it (ii) promotes IT curricula by providing scholarships through the Digital Talent (*Talento Digital*) programme established in 2013. Funding for this programme amounts to USD 18.4 million, used to support about 4 660 persons in 2014. It supports different types of IT-related education which includes apprenticeships, on-the-job training and university curricula. As such, it covers the whole breath of different types of education and does not solely focus on university curricula.

Persons who are selected have an obligation to contribute to the e-government programme “gobierno en línea”, for example, through helping roll out the strategy at the local level or developing a web application. Selection criteria are based on the results of the high-school state exam (weight: 50%), the social stratum (weight: 40%), and the quality level of the chosen IT-education programme (weight: 10%) whereby all curricula need to have the accreditation of the Ministry of Education. The weights show, as for other programmes of the Vive Digital strategy, that there is a particular commitment to support low-income groups. As indicated earlier on, the implementation of the stratum approach may not be sufficiently precise and a real income-based solution would be preferable. Besides this, the programme is a good step towards fostering ICT skills in the country at different skill levels.

So far, projects have been launched, for instance, in the agricultural sector, tourism, construction, telecommunication and the energy sector. Projects must benefit a large

number of micro-companies and SMEs in order to be selected. By the end of 2012, 20% of the micro-companies and SMEs have been connected to the Internet and use ICTs, and recently published data by MinTIC indicates that by the end of 2013, 60% of micro-companies and SMEs have been connected to the Internet. The objective has thus been achieved.

Given the high number of micro-companies and SMEs in the country, efforts should be continued. In addition, attention should carefully be paid that solutions developed by the buyer firms rely on open standards so that SMEs can also make use of these for business relationships with other buyers in order to avoid increasing the dependency of small companies from these larger buyers. An additional focus should be put on developing ICT skills in micro-companies and SMEs so that these companies are capacitated to use ICTs but also have the potential to actively work on an innovative use of ICTs in their organisations in other areas than seller-buyer relationships. Moreover, a policy focus should be put on further fostering the development of local content that serves the needs of these companies with a view to a content and services sector that would serve the entire Latin American market and would encourage businesses to use the Internet and ICTs systematically. Efforts could be linked to the initiative Apps.co.

Developing applications and local content in a digital entrepreneurship environment

As discussed in Chapter 3, a large number of companies, particularly SMEs, and households with lower income levels stated that they did not form part of the Internet economy because they did not consider ICTs as useful tools for their businesses and lives.

One important aim of the Vive Digital strategy is thus to incentivise the Colombian ICT sector to develop more applications locally as well as local content that serve the needs of businesses and citizens and that also contribute to increasing productivity levels in the country. In addition, this pillar of the Vive Digital strategy aims to develop IT entrepreneurship in Colombia. In the following, the main programmes of this pillar are discussed: the MiPyme (SME) Vive Digital Programme, Apps.co, Vive labs and digital content, and the Vive Digital Government online programme “Gobierno en línea”. Overall, this pillar of the Vive Digital strategy takes a very comprehensive approach since policy programmes address the needs of the private sector, the public sector, the needs of citizens and, in addition, work on fostering IT-entrepreneurship in the country.

The Apps.co programme

The Apps.co programme supports entrepreneurs in different phases of the business creation process. Depending of the maturity of the idea and the development state the start-up is in, people can apply to the different phases. The first phase of the programme provides software development training. Several courses for different platforms and different knowledge levels are offered. So far, 16 558 developers have been trained. The second phase consists of guiding entrepreneurs through the refinement of their business cases, prototypes and the validation of the business model. This phase is undertaken with the help of incubators, universities and chambers of commerce. A total of 738 business plans have been selected and supported so far in this phase. The third phase which is called the “consolidation phase” of the programme is directed to entrepreneurs who want to scale up the start-up. The programme provides support to these companies to reach new markets and customers. Initiatives include establishing contacts with investors and other companies and sending them to national and international events as well as to leading start-up hubs such as Silicon Valley where they present their businesses to

investors and other companies. The final phase called “acceleration” aims at growing start-ups steadily to reach bigger size and become sustainable. MinTIC works with Ruta N and the Israeli company Penza Group to connect the start-ups with venture capitalists who are willing to provide a second or third round of VC financing. To this date, 25 companies have been supported.

Although the programme is very recent, both start-ups and incubators reported that it has significantly helped to grow the IT-entrepreneurship ecosystem in the country and that it has increased awareness among younger people that there are possibilities to become an entrepreneur in Colombia which is something that has not been very culturally embedded in the society. A number of very successful applications have been placed on the market. One of them which is supported by Apps.co is the application Tappsi.co which significantly changed the taxi market in the country and highly increased the efficiency of taxis which are an important means of transportation in Colombia. This application is currently one of the safest ways to order a taxi in a country where taxi rides can be very dangerous. While similar applications have been launched in other markets worldwide (e.g. mytaxi in Germany, see also OECD, 2012), this start-up has a very strong focus on security and spends a lot of effort screening taxis and offering security services to customers like location-based data of the taxi and the provision of the information of the plates and drivers name which can be automatically shared via different means (SMS, social networks etc.).

When asked what could be improved, entrepreneurs and incubators reported that the Ministry has so far no legal means to provide seed capital and that it is especially difficult to get this kind of financial support when starting the business. It would thus be recommended to revise the legal framework and check for possibilities to support start-ups in this phase via other methods such as crowdfunding.

In addition, start-ups and incubators reported that although regulatory improvements have been made, it is still difficult to create a company in Colombia and that from a regulatory perspective once you failed with one business idea it is nearly impossible to obtain another loan from a bank for the next ten years.

Finally, it was noted that several agencies of the government have set-up programmes to foster entrepreneurship in the country but that there was no holistic governmental strategy connecting the different initiatives. This makes it hard for entrepreneurs to find out where and how they can get support, also because calls for proposals are typically published on the websites of different entities. It is thus recommended that MinTIC play a leading role in aggregating the information of all different programmes on one centralized platform so that entrepreneurs would have one central access-point. This would increase the efficiency of entrepreneurship programmes across public agencies.

Vive labs and digital content

The programme was established to foster the development of digital content across the country. The funding of the policy programme amounts to USD 10.2 million for a total of 17 Vive Labs that are planned to be established by the end of 2014. By end-2013, Vive labs have been launched in the departments of Atlántico, Armenia, Popayán, Cali, Manizales, Cauca, Cartagena, Medellín, Pereira, Bucaramanga, Bogotá y Montería. Those centres provide free training courses in the areas of content development, animation, mobile applications and video games. While putting a focus on content development is important to further develop the demand side of the ICT industry, it will be important to monitor and evaluate these initiatives. It currently seems that the various

Vive Labs work independently from each other and do not seem to have concrete output targets. It also seems that there is no clear established plan on how to carefully monitor the outcomes. This, however, would be essential to ensure that public funding is used in an effective way. In addition, it would be good to connect this initiative to the Apps.co programme and to the Tecnoparques that also provide ICT trainings and that are run by SENA.

Government Online

Government Online (*Gobierno en línea*) is the e-government strategy of the Vive Digital Plan. The main objectives are to (i) foster good governance through the Internet and ICTs (including the promotion of transparency, capacity building, increasing the efficiency of the public sector and broadening access to information held by the public sector) and to (ii) ensure an effective interaction of the citizens with the public sector. The first aims at mainstreaming the use of e-government processes within the public administration and to deploy it especially in legislative and judicial entities. The second provides e-government services to citizens and businesses in the aim to render more efficient the interaction with the state. So far, many services have been made available and mechanisms have been developed to foster participation of citizens in government activities, for example, via the platform crystal urn (*urna de cristal*)¹⁷. In addition, an agreement for an e-government innovation centre has recently been signed between the Ministry and the United Nations Department of Economic and Social Affairs (UNDESA). A detailed evaluation of the Government online programme can be found in OECD (2013c).

With respect to the first programme, it is recommended to further increase public-sector efficiency through the consequent use of ICTs on national and regional levels and to further promote innovation in this area. The coordination function of MinTIC should be strengthened and enlarged. The appointment of a second vice minister to co-ordinate the use of ICTs across the public sector and oversee all e-government initiatives, is a promising step. With respect to the second programme, it is crucial to carefully monitor the *service quality* of the existing e-government services. Testing some selected services has shown that service quality should be improved since sometimes it is not possible to fill-out the forms online and online assistance is not provided. Also, care should be taken to avoid that citizens and businesses fill-in their forms online but then still have to present themselves at state entities physically. In addition, it is important to train public servants in order to create a “digital mindset” in public entities which is currently lacking in some entities.

Finally, an area for future work is *public sector information (PSI)*. PSI includes “information products and services generated, created, collected, processed, preserved, maintained, disseminated, or funded by or for the Government or public institution” (OECD Recommendation C(2008)36) of the Council for Enhanced Access and more Effective Use of Public Information). Public entities are important producers and repositories of data which, being valuable knowledge, are a source of competitive advantage in economies. The OECD PSI market was estimated to amount to USD 97 billion in 2008 and “aggregate OECD economic impacts of PSI-related applications and use were estimated to be around USD 500 billion” (OECD, 2013d). Given the important economic potential of PSI, it is thus recommended to develop a *national public-sector information platform* to make public content available to businesses and households in a machine-readable format in order to improve access. The platform could also serve as a driver for innovative applications.

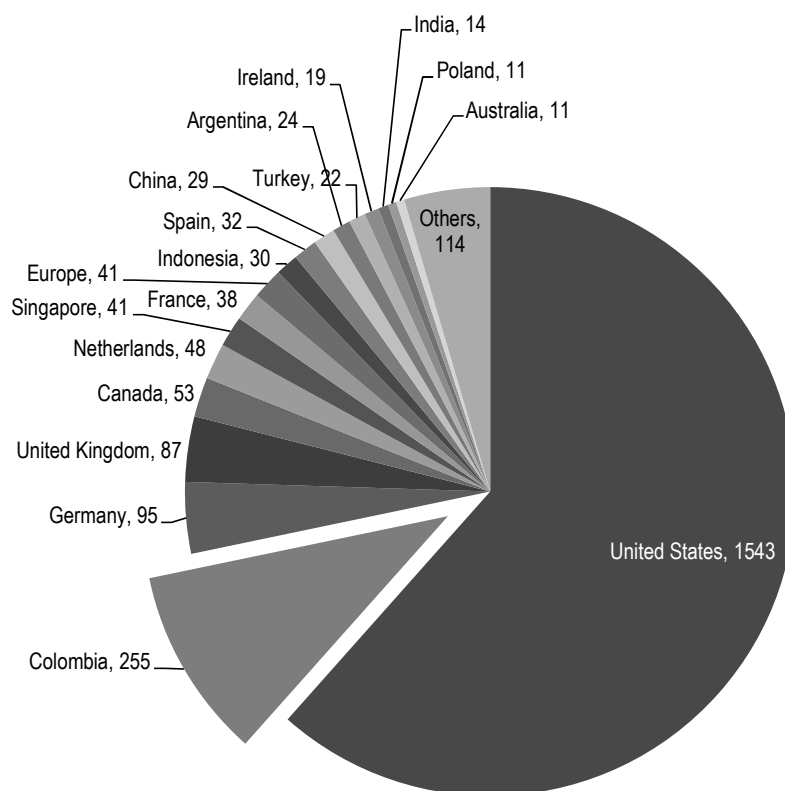
Hosting, IXPs and the Internet of Things as areas for future work

The Vive Digital strategy takes a holistic approach and covers both the supply and demand side of the Internet economy. While existing policy programmes should be maintained, it may be worthwhile to expand into areas that are likely to be important for the development of the Internet economy in Colombia. Besides the proposed area of PSI that has been discussed in the context of the e-governance strategy, important areas of work on the supply side are hosting, Internet Exchange Points (IXPs) and the Internet of Things.

The Colombian Internet economy needs a functioning Internet infrastructure which includes an efficient Internet traffic exchange that facilitates the transfer of data *domestically* and hosting of content within the country. Routing data via another country is not only expensive and slows down the speed at which Internet traffic is exchanged but is also a sign that the local Internet economy is not well developed. When looking at the current state of traffic exchange and hosting, there are strong indications that there might be several problems including competition problems.

When having a closer look at hosting in the country, there are indications that most content is hosted outside the country which means that Colombia has to massively rely on submarine fibre cables and that latency becomes an issue. While it is difficult to obtain precise statistics on the volume of hosting in Colombia, information on where the Alexa top million websites are hosted serves as a good proxy. Pingdom, a Swedish analytics company, analyses the hosting market worldwide and studies where the top 1 million websites of the world (Alexa one million) are co-located. For the purpose of this report, Pingdom retrieved data on where the websites with the country code top-level domain (ccTld) “.co” for Colombia are hosted. Out of the Alexa one million, there are about 2500 .co websites. Only about 10% of these are hosted in Colombia (see Figure 4.11). Although there are some caveats with these figures because the .co is used as a substitute for the .com domain, the general trend still holds true that websites with Colombia content directed at Colombians are rather hosted outside the country. It is thus recommended to carefully analyse why firms and citizens opt to host the content outside the country to then be able to set appropriate conditions for hosting content and applications in Colombia.

A topic linked to hosting is the topic of Internet Exchange Points (IXPs) which are an important means of interchanging data traffic locally which is much cheaper and faster than to exchange traffic internationally and which has been advised in several OECD studies (OECD 2014a forthcoming, OECD 2014b, Weller and Woodcock 2013). Colombia has, so far, only one IXP in Bogotá. The amount of traffic exchanged at this IXP is surprisingly low and most of the traffic is routed to the United States which adds latency problems and is more costly than exchanging the traffic locally. In addition, there is only a small set of companies (mainly ISPs) that interchanges traffic in Bogotá which points to potential competition and access problems. Fees to participate in the IXP seem to be very high at the moment with USD 25 000 to connect to the IXP and further variable costs.¹⁸ It is thus advisable that Colombia assesses barriers to local traffic exchange and that it considers implementing additional IXPs in bigger cities since experiences have shown that connectivity costs could be reduced by increasing the number of IXPs.

Figure 4.11. Overview of hosting countries of .co sites

Source: OECD based on Pingdom data (July 2013).

A further important topic not treated so far is *the Internet of things*. In the coming years, billions of devices will be connected to the Internet and many of them through mobile networks. As a result, energy companies, automobile manufacturers and consumer electronics companies will manage millions of mobile subscriptions and SIM-cards. Currently, these companies are required to use the SIM-cards of the mobile network they have chosen locking them into the networks and roaming agreements of these companies. The OECD has advised countries to liberalise access to the relevant numbers¹⁹ so that large scale users can competitively buy access to multiple mobile networks at the same time and are able to switch networks. This would greatly lower costs and increase flexibility and innovation in this area.

4.11. Stimulating social innovation and re-balancing innovation policy

A large proportion of a society's innovation is not mediated by mechanisms centred on markets and business enterprises. Innovation is also required to meet the needs of low-income groups for adequate health care, to meet the needs of disadvantaged rural communities for inputs to improve agricultural production, or to meet the needs of excluded urban communities for access to adequate water and sanitation services. In such cases, non-market organisational and institutional arrangements may be used wholly or in part to achieve the needed innovation, with widely varying degrees of success.

Social innovation in Colombia: an emerging focus for policy

Colombian organisations obviously engaged in this kind of innovation long before it was labelled social innovation. This is illustrated by the examples in Box 4.7, several of which were initiated in the 1980s and 1990s by a variety of actors who would probably have been surprised to learn that what they were doing fell into the category of social innovation.

Another feature of these innovations is that they emerged primarily from sources that are not usually thought of as sources of local innovation in Colombia: community groups, business associations and non-governmental organisations (NGOs) rather than R&D in companies, universities and research institutes. However, the more conventional kinds of innovation actor have also been engaged in what would now be recognised as social innovation. The participatory innovation in smallholder agriculture noted earlier is a case in point. But there are others in different socio-technological domains. For example the Cinara Institute in the Faculty of Engineering of the Universidad del Valle in Cali undertakes significant social innovation activities in its programme of technology development concerned with sustainable water and sanitation systems. The institute includes meaningful forms of participation by disadvantaged communities in the region in its research and technology development projects; and it combines such participation with explicit activities to enhance those communities' capacities to manage the new facilities, to negotiate with local authorities and to pursue other lines of innovation in their communities.

However, until very recently social innovation was not explicitly identified in Colombia's STI policy documents. The social role of innovation was obviously not ignored: significant areas of R&D were seen as oriented towards broad social purposes and objectives, and key policy documents included references to the importance of providing solutions for society in general. However, rather than being directly linked to specific programmes and policy initiatives, the social dimension of innovation policy appears essentially to have been implicit, often associated with broad ideas about promoting the social appropriation of knowledge or the consolidation of a scientific and technological culture.²⁰

It is therefore striking that Colombia's National Development Plan 2010-14 explicitly recognised the importance of social demand for innovation on the part of low-income, disadvantaged and excluded groups in society. This focus on social innovation is found in the section of the Plan concerned with achieving equality of opportunity for social prosperity, and more specifically in the section concerned with overcoming extreme poverty (pp. 415-26). The issue is discussed as an explicit component of the first of the five engines of development (concerned with creating new innovation-based sectors) in which proposals to promote social innovation are put forward (pp. 226-27). At this early stage the proposals are primarily about undertaking studies rather than operational activities – studies of market failures and the adaptation and scaling up of models of social innovation developed elsewhere.

Box 4.7. Examples of social innovation in Colombia

Selected finalists in a multi-year award competition for social innovation projects in the LAC region¹

- A large programme, closely associated with the Ministry of Commerce, Industry and Tourism, designed to raise artisan incomes by strengthening design, organisation and marketing in 11 types of artisanal production chains across 70 municipalities.
- A small community-led project to save traditional seed types and reinforce the indigenous knowledge bases of a community in Sotará community. It focused on crops that could replace illicit narcotics-related crops.
- A programme associated with local government in Antioquia designed to assist in developing new lifestyles for young people at risk from the drug cartel conflicts in Medellín.
- An NGO-led project to provide education and health services to improve the quality of life of children with HIV/Aids in Cali.
- An NGO-led project to support the social inclusion and guarantee the fundamental rights of children and youths at risk of homelessness in Bogotá.
- A project developed by the Bogotá Chamber of Commerce and supported by the IDB to train teachers and students to manage and reduce conflict among youths in schools.

Note: 1. A five-cycle annual competition initiated jointly by CEPAL and the Kellogg Foundation in 2004.

Sources: Rodríguez and Alvarado (2008), *Claves de la innovación social en América Latina y el Caribe*, CEPAL, Santiago de Chile; Marulanda and Tancredi (2010), *De la Innovación Social a la Política Pública: Historia de éxito en América Latina y el Caribe*, CEPAL, Santiago de Chile; Rodríguez et al. (2011), *Innovación social y desarrollo económico local*, CEPAL, Santiago de Chile.

In 2012 a collaborative study involving Colciencias, DNP and the National Agency for Overcoming Extreme Poverty (ANSPE) followed up the proposals in the National Plan. This study was mainly concerned with what social innovation actually consists of in practice, a challenging question also being addressed in many other countries. It sketched out future steps towards action: further studies of the social innovation domain – a complete mapping of the whole social innovation ecosystem, along with its actors and their interactions, and a conceptual model of the value chain of social innovation. The mapping is intended to provide a coherent and comprehensive policy framework that is consistent with the legally defined policy framework referred to as the National System For Science, Technology and Innovation. In turn, this comprehensive map is to provide a basis for identifying policy instruments and modalities and lead to the development of a manual for operational activities.

This emerging line of policy development for social innovation seems to be extremely important in Colombia, where substantial and pervasive developmental costs over many decades can be traced to the country's high levels of economic inequality and social exclusion. Consequently there are strong grounds for moving rapidly towards action that, in an explicit policy framework, would orient more substantial components of the country's overall innovation activity towards more effective ways of meeting social demands.

But the idea of social innovation as a distinct domain of STI policy is relatively novel everywhere, and there is a wide gap between the existence of social innovation activities and the use of specific policy frameworks to support innovation in this domain.²¹ By moving towards developing such a framework, Colombia is among a growing number of countries that are trying to move into a policy area that is immature and under-explored.

One feature of this situation is that, despite a great deal of literature about innumerable types of social innovation, there is little by way of systematic experience that can guide policy, or well-tested models of practice that can be used in developing a policy approach. The extent to which Colombia can draw on existing frameworks and models and adapt them to needs and conditions in the Colombian context is therefore limited. Colombia will have to depend much more on learning from policy experimentation and innovation in Colombia. This raises two difficulties.

- The scope of this emerging policy domain is very poorly defined. Its outer bounds are very fuzzy and elastic and it is difficult to identify particular fields within the overall domain. Therefore, it is difficult to identify either the overall scope for the implementation of policy or areas that are readily understood and on which practice might focus.
- Despite the huge body of case material on various kinds of social innovation around the world, there appears to be very little systematic evaluation of this experience.²² So, even if the scope for policy practice could be adequately defined, there are few, if any, answers to questions about which kinds of practice are likely to work and generate relatively high returns.

These two issues merit closer consideration because they raise questions about how policy development in this area might proceed in Colombia.

The problem of scope

Considerable efforts have been made around the world in recent years to define the idea of social innovation. As in the definition adopted by the OECD Forum on Social Innovation (Box 4.8), these have usually sought to distinguish between social and economic innovation.

Box 4.8. What is social innovation? – An OECD perspective

Social innovation implies conceptual, process or product change, organisational change and changes in financing, and can deal with new relationships with stakeholders and territories:

- “Social innovation seeks new answers to social problems by: identifying and delivering new services that improve the quality of life of individuals and communities; identifying and implementing new labour market integration processes, new competencies, new jobs, and new forms of participation, as diverse elements that each contribute to improving the position of individuals in the workforce.
- “Social innovations can therefore be seen as dealing with the welfare of individuals and communities, both as consumers and producers. The elements of this welfare are linked with their quality of life and activity. Wherever social innovations appear, they always bring about new references or processes.
- “*Social innovation is distinct from economic innovation* because it is not about introducing new types of production or exploiting new markets in themselves but is about satisfying new needs not provided for by the market (even if markets intervene later) or creating new, more satisfactory ways of insertion in terms of giving people a place and a role in production.
- “*The key distinction is* that social innovation deals with improving the welfare of individuals and communities through employment, consumption and/or participation, its expressed purpose being to provide solutions for individual and community problems.”

Source: Adopted by the Forum on Social Innovations of the OECD Local Economic and Employment Development Committee (LEED). OECD (2010, p. 196), *SMEs, Entrepreneurship and Innovation*, OECD Studies on SMEs and Entrepreneurship, OECD Publishing. Doi: [10.1787/9789264080355-en](https://doi.org/10.1787/9789264080355-en).

Subsequent versions of this definition²³ have played down the distinction between social and economic innovation, and other approaches (e.g. Phills et al., 2008) have emphasised similarities between the two. Other perspectives have inflated the idea to cover almost any kind of innovation for almost any kind of purpose. For example the Bureau of European Policy Advisers (BEPA) identified social innovation as “necessary to address poverty, create employment, develop capabilities and participation, and promote changes in production and consumption habits”, all as part of a broad aim to “uphold sustainable, smart and inclusive growth” (BEPA, 2011).

The authors did however recognise that this all-embracing perspective, along with other similarly broad approaches (e.g. European Commission, 2013), leave the door wide open to a variety of interpretations and to the inclusion of innumerable types of innovation actors, processes and outcomes – an opportunity to rename and re-label as social innovations a host of existing initiatives and practices. Consequently, they argued, attempts to develop comprehensive definitions as a basis for policy development run the risk of being excessively flexible, with large parts of the social innovation domain coming to be seen “simply as a re-branding of current programmes” (p. 40).

Following such an all-embracing approach would present obvious difficulties for Colombia. There is a risk that policy development would become bogged down in endless debate about the scope of the social innovation policy domain. There is also a risk that, reinforced by re-branding, policy initiatives would become fragmented across a diversity of inadequately resourced activities. There might also be more practical difficulties about the domain boundary itself – for example, whether it falls inside or extends beyond the legally defined scope of policy for the science, technology and innovation system.

However, the BEPA study also pointed implicitly towards what might be a less problem-ridden approach to follow in the Colombian context. Rather than trying to elaborate a single all-encompassing definition of the outer bounds of the policy domain, it gave greater emphasis to distinguishing different types of innovation within it. In particular, like others, it distinguished between different dimensions of social innovation. Among these it focused in particular on the dimension concerned with the social outputs (or aims and ends) of innovation activity, and distinguished between three different types of output.

Type 1: Social innovation as innovative responses to unmet social demands

This type of output relates to the needs of groups, communities or segments of society that are more vulnerable and less able to be involved in the market economy or to benefit from the value it generates. It therefore consists of innovation that meets social needs that are neglected by traditional forms of private market provision and are poorly served by public services. This is similar to the idea of inclusive innovation, and seems very close to the concept of social innovation discussed in the National Development Plan.

Type 2: Social innovation as innovative responses to societal challenges

This broader way of identifying the output of social innovation encompasses both the social and economic domains of innovation. It usually integrates these with the environmental/sustainability domain. It seeks to bring this integrated approach to innovation to bear on challenges facing society as a whole.

Type 3: Social innovation as innovation to achieve systemic transformation of society

This approach stretches the scope of social innovation yet wider. It identifies the aim or output of social innovation as contributing to the re-shaping of society itself, involving

changes in fundamental attitudes and values, strategies and policies, organisational structures and processes, delivery systems and services, methods and ways of working, responsibilities and tasks of institutions and linkages between them and other types of social actor. In other words social innovation outputs contribute to the reform of society in the direction of a more widely participative arena.

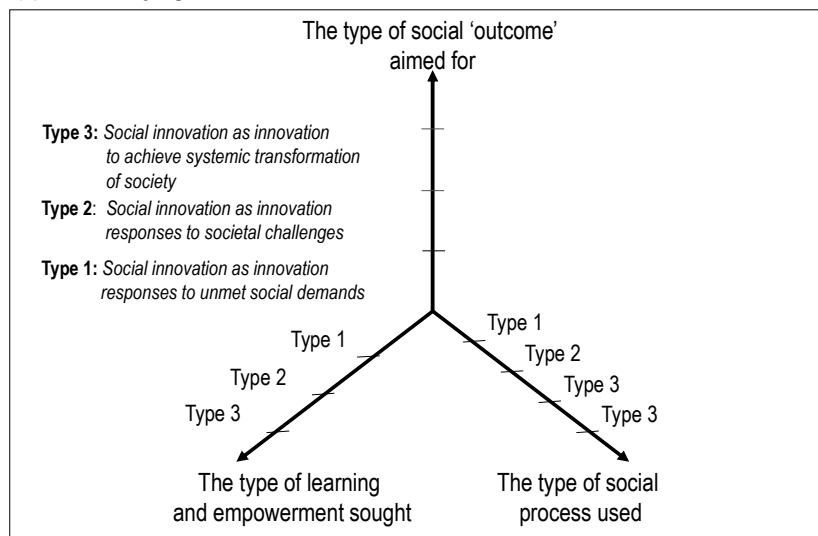
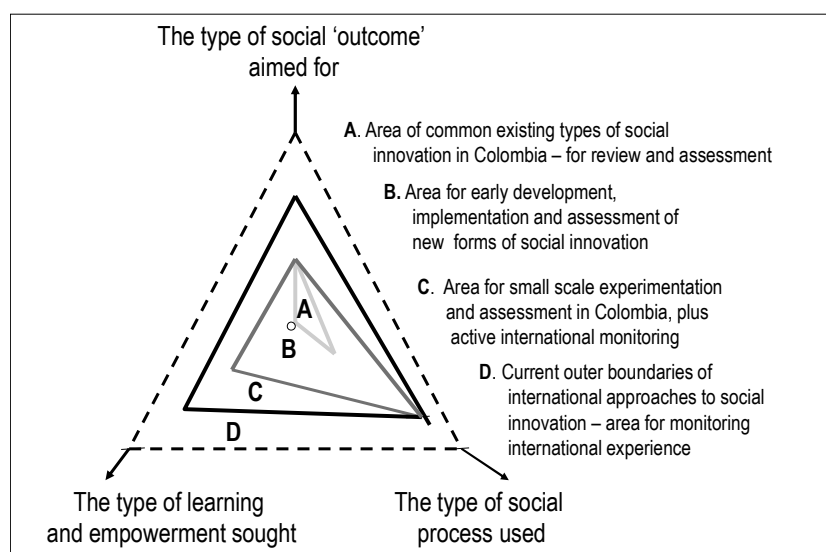
In addition to variations along the output dimension of social innovation, the BEPA study and others have identified variations along other dimensions. Two of these are perhaps the most commonly emphasised.

- One is often referred to as the process dimension of social innovation, and gives particular attention to the use of new forms of organisation and interaction among stakeholders in undertaking innovation. In particular, considerable emphasis is given to participation in the innovation process by the users and intended beneficiaries of its outputs, and a number of studies have highlighted the importance of significantly different types of user participation, especially in connection with innovation in smallholder agriculture (Johnson et al., 2003; Ashby, 2009; Letty et al., 2012).
- The other, commonly referred to as the learning or empowerment dimension, is concerned with ways in which social innovation not only delivers innovation outcomes, but also enhances the capabilities of users to engage more effectively in the subsequent use and further development of the innovation initially introduced, or to participate in further rounds of social innovation. Again, significant variations along this empowerment dimension have been distinguished.

Identification of such different dimensions of social innovation, together with important differences along them, opens up an approach to policy development in this area that does not require an immediate jump to a single all-encompassing framing of the policy domain or ecosystem. Instead, it concentrates on developing a set of more easily defined domains lying well within that boundary, each of which could be the focus of different approaches to policy for social innovation in Colombia.

A stylised basis for this approach is illustrated in Figure 4.12. Variations on each of the output, process and learning/empowerment dimensions of social innovation are indicated in (a), and these can be used to identify different areas of social innovation inside outer boundaries that are left open and flexible, as in (b). In effect a variable geometry approach, rather than one that may lose sight of important differences by pursuing a search for an overall framework, can be taken to policy development.

As illustrated in (b), the variable geometry of the policy domain might include a policy space like (B). This would lie well inside the outer boundaries of the overall social innovation domain, but would seek to reinforce types of social innovation that were close to Colombian experience on some dimensions but extend beyond it on others, such as types of social innovation in which: i) the intended outputs consist of innovation responses to unmet social needs, as in the apparent emphasis of the National Development Plan; ii) the social innovation process involves forms of participatory organisation that are significantly different from those most commonly employed in attempting to meet such social needs; and iii) types of learning and empowerment activity are also significantly different from those commonly used.

Figure 4.12. A stylised variable geometry for social innovation policy development**(a) An underlying framework to differentiate modes of social innovation****(b) Different areas of social innovation and different kinds of policy**

While policy development in such an area might move quite quickly to well-defined programmes of action, one can envisage also a wider policy space (like C) where the appropriate form of policy would be much more exploratory, involving support for small-scale experiments to map out and learn about areas of social innovation in which more active policy might be developed in future. One might also envisage a yet wider policy space (like D) in which policy action is limited to providing support for active monitoring of the evolution of international experience in the fuzzy outer boundaries of the social innovation domain.

But even within a reasonably well-defined policy space like (B), two points seem obvious: the number of distinctly different potential areas for active policy are likely to far exceed available funding, and the worst possible approach to policy development

would be to spread resources so thin over disparate areas that effectiveness in any of them would be seriously compromised. Hard choices would have to be made to concentrate resources in selected areas, and this is where difficulties arise from the limited availability of guidance from previous assessments and evaluations.

Limited guidance from previous experience

The poverty of sound data derived from systematic assessment and evaluation in this area applies not only to information about practical aspects of organising non-conventional innovation processes, i.e. what approaches seem to work effectively for similar innovation aims in roughly comparable circumstances. It also applies to evidence about the results and impacts one might expect from such innovation activities, i.e. what types and levels of return have been achieved in practice. One consequence is that debate about developing policies for social innovation can get bogged down in unhelpful contests between poorly substantiated claims for large positive impacts and fragments of evidence about the merits (e.g. lower costs) of conventional approaches.

This is understandable because quite complex impact pathways typically link innovation activities to the desired longer-term impacts, such as improved research efficiency, higher overall benefit streams, a more equitable distribution of those benefits and greater social inclusion of disadvantaged people. It is difficult to track causes and effects through these pathways, and the timescales involved are often much longer than the budgetary and management timescales of innovation projects and their internal evaluation requirements. It is therefore rare to find well-managed efforts to assess the outcomes of such projects and their causes even for individual projects, and it is even more unusual to find arrangements that integrate that kind of learning over multiple projects.

One conclusion to draw from this situation might be that, despite the socio-political importance of the issues to be addressed by various forms of social innovation, it is premature in Colombia to follow from the outline ideas in the National Development Plan to implement an expansion and re-shaping of existing policy initiatives in this area. Instead, caution should prevail, and initiatives beyond existing activities should be deferred until more adequate data become available and permit meaningful policy debate and development. However, two issues suggest that a more active phase of policy development should be considered.

First, the limitations of existing impact assessment data are sometimes a little less constraining than appears at first sight. For example, one synthesis of case-study data on social innovation in smallholder agriculture, although uneven, permits a broadly positive perspective on impacts. The evidence (summarised in Box 4.9) seems strong on some aspects (e.g. innovation adoption rates) and encouraging on others (e.g. costs and research efficiency), but tentative and qualified on yet others (e.g. empowerment effects and inclusion impacts). Similar syntheses may be available in other sectoral or technological areas.

Box 4.9. Possible impacts of social innovation in agriculture: impact pathways from participatory and empowerment/learning modes of innovation

Among the limited efforts to assess the benefits and costs of social innovation, probably the most systematic have been made in connection with participatory and empowerment modes of agricultural innovation. Drawing on the evidence of 50 case studies of plant breeding projects, Jacqueline Ashby, formerly at CIAT in Colombia, synthesised the evidence on this experience and reached the following conclusions about impacts.

Higher rates of adoption

Significantly participative modes of plant breeding can influence research objectives, priorities and practices in ways that contribute to the development of technologies better adapted to user contexts. Farmer adoption rates are therefore higher. This has enabled some breeding programmes to break through adoption bottlenecks involving prolonged periods of non-adoption of technologies developed by conventional modes of innovation.

“This experience, by now so diverse with respect to crops, cultures and production environments, demonstrates the efficacy of participatory selection in producing varieties for poor farmers who are otherwise excluded by conventional crop improvement programmes.”

Faster varietal release

They also enable breeding and selection to move more rapidly through successive stages, so leading to faster varietal release, for example within 6-7 years rather than 9-10 in conventional modes. This leads to earlier, not just faster, adoption by farmers with earlier benefits for them and also substantial increases in the discounted values of those benefits.

Increased research efficiency

Better adapted varieties, earlier varietal release and faster adoption rates can reduce the scope, scale and duration of activities needed in research projects, so increasing the efficiency of research. Thus, although participatory modes may increase expenditure outlays somewhat, total costs over the breeding and promotion cycle can be significantly reduced.

Enhanced skills, knowledge and social capital

With significant empowerment/learning dimensions, participatory modes of breeding can enhance farmers' skills, knowledge and other capacities to contribute to future innovation, enable them to undertake a greater range of tasks in future research projects, reduce research costs and stimulate their wider involvement in innovation and change at the local level.

Greater inclusion of the poor and disadvantaged in the benefits from innovation

Building empowerment/learning dimensions into participatory projects can also increase the inclusion of the poor and disadvantaged, especially women, thereby shifting the distribution of benefits from innovation. However, while this can be demonstrated in some instances, the evidence is limited and these kinds of impact may depend much more on local socio-political contexts than on the organisation of innovation *per se*.

Source: Ashby (2009), “The impact of participatory plant breeding”, Chapter 25 in S. Ceccarelli, E.P. Guimarães and E. Weltzien (eds.) (2009), *Plant breeding and farmer participation*, UN Food and Agriculture Organization, Rome.

Moving forward to policy implementation

The limitations of available data about innovation processes and their impacts means that analytical policy development can lead policy practice only to a certain extent before it adds little further value. But the two can then proceed in parallel via well-planned programmes that incorporate significant elements of experimental design, systematic monitoring and rapid feedback from practice to further development.

Experiments might include different means of project funding, including variants that enable user groups and communities to contract with specialists to support their innovation activities; or they may include different ways of organising participatory components of projects, or different ways of incorporating explicit elements of learning and empowerment. On-going monitoring can reinforce emerging success, correct inadequate approaches and close down projects if there are financial irregularities; and periodic policy re-development can learn from the experimentation. Such activities must be seen as important programme elements, not just as perfunctory add-ons to meet bureaucratic requirements for terminating projects. Indeed, they must be designed from the start to include follow-on monitoring to identify long-term impact pathways beyond the completion of specific projects.

It seems possible to move ahead with active policy development and implementation to follow up on the ideas about social innovation in the National Development Plan in ways that avoid the difficulties of defining and addressing an all-embracing social innovation policy space and ecosystem. Instead, a variable geometry view of that space can be used to identify areas in which policy development can proceed in different ways at different speeds. Within a well-bounded area, along the lines of (B), there seem to be specific domains in which there is already adequate understanding for designing programmes in which policy practice can move hand in hand with policy learning and development.

Social innovation in smallholder agriculture offers one such domain. Available evidence on processes and impacts in this area, combined with existing experience in Colombia, seems to suggest that activities could be expanded towards modes of innovation that encompass more significant and experimental forms of user involvement and user-learning and empowerment. Meeting social needs in the area of water and sanitation might be another domain. Meeting other social needs in the urban environment might also be an area consistent with the priorities of the main engines of development in the National Development Plan.

Programmes in two such domains seem entirely adequate for an initial policy initiative designed along experimental and learning-intensive lines; attempting more than three might overstretch capacities. Perhaps the most important element of innovation in moving forward in this area is not the characteristics of projects and programmes but the overall management and governance of policy action. The requirement seems to be for an arrangement that does the following:

- Integrates overall responsibility and management for social innovation policy so that core strategies are consistent and learning is accumulated across programmes in different sectoral and technological areas;
- Secures and sustains buy-in and active collaboration with organisations with sectoral responsibilities across central and local government (e.g. agriculture, rural development, and water and sanitation in both urban and rural contexts);

- Ensures that the essential demand-driven dimension of social innovation is concretely reflected in organisational arrangements for bottom-up direction of funding and contracting for technical and research services.

4.12. Fostering excellence, relevance and critical mass in public-sector research

Colciencias is the principal source of competitive project funding for the universities. It has a number of instruments to support research excellence as well as innovation. However there are important gaps in funding for research careers and the overall scale of research funding is too low. Bitran et al. (2011) point out that funding per active researcher in Colombian research programmes amounts to USD 1 300 compared with USD 13 000 in Mexico and USD 40 000 in Chile. A major increase in the amount of funding made available for competitively funded research is an absolute precondition for improving the performance of the research system.

With over 13 000 research groups registered, the research landscape in Colombia is extremely fragmented. In 2011, 5 554 of the groups were recognised. Table 4.18 shows their distribution by discipline and Colciencias' ranking, with the A1 category the best-performing.

Table 4.18. Recognised research groups by discipline, 2011

Disciplines	A1	A	A1+A %	B	C	D	Unranked	Total	%
Social sciences and humanities	65	91	8.0%	242	334	697	516	1945	35.0%
Health sciences	39	55	12.2%	106	130	226	213	769	13.8%
Basic sciences	32	36	10.6%	92	119	194	169	642	11.6%
Environmental sciences	10	20	7.4%	45	69	159	103	406	7.3%
Education	12	13	6.4%	26	67	161	110	389	7.0%
Electronics, telecoms and informatics	8	11	5.0%	47	70	147	95	378	6.8%
Industrial technology	16	13	8.2%	37	54	150	84	354	6.4%
Agricultural sciences	18	15	11.6%	29	60	90	73	285	5.1%
Biotechnology	4	8	10.3%	9	19	44	32	116	2.1%
Energy and mining	8	7	13.3%	16	20	33	29	113	2.0%
Marine sciences	3	4	11.9%	16	10	10	16	59	1.1%
Not classified	1	2	3.1%	2	13	34	46	98	1.8%
Total	216	275	8.8%	667	965	1945	1486	5554	100.0%

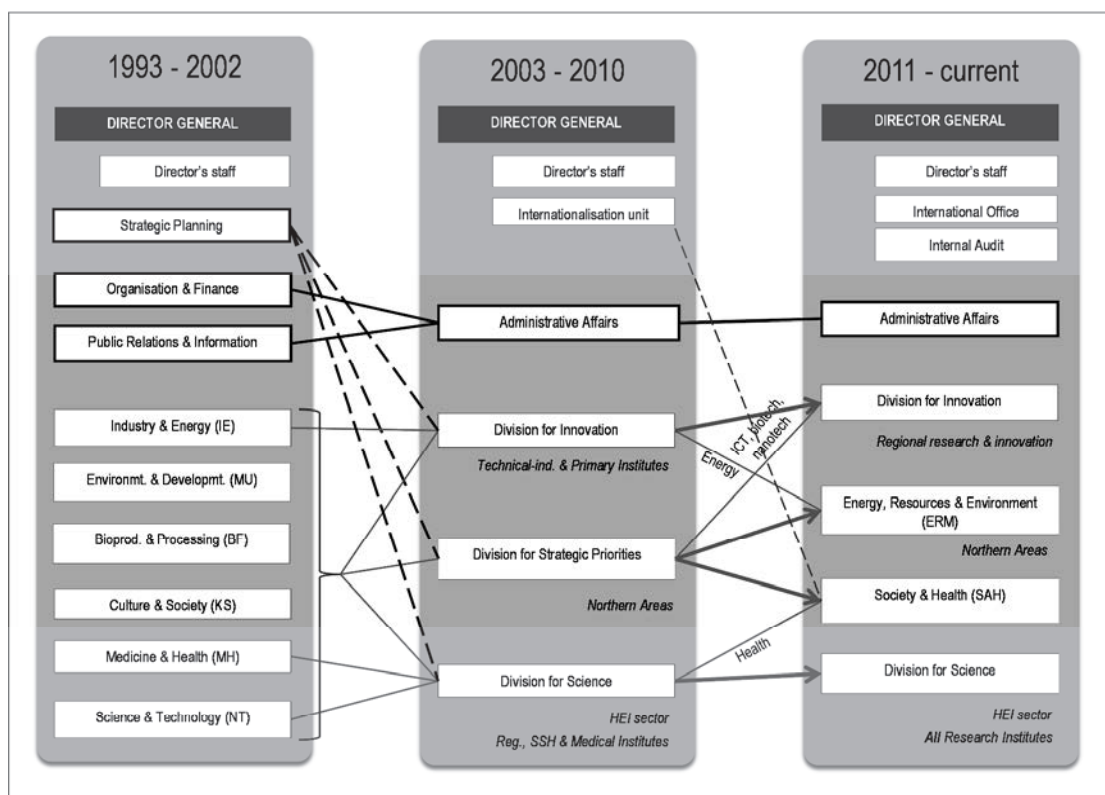
Source: OCyT (2012), *Indicadores de ciencia y tecnología, Colombia 2012*, Observatorio Colombiano de Ciencia y Tecnología, Bogotá.

Since Colciencias' classification is unique to Colombia, it cannot be benchmarked internationally. However, the proportion of A1/A groups by discipline may give a useful approximation of Colombia's areas of strength and weakness. Disciplines in which the proportion of these groups is above the mean are shaded in Table 4.18. These appear broadly consistent with the economy's areas of importance. It is noteworthy that they do not include electronics or (by a small margin) industrial technology, which would be important for developing high-technology industry. Education (41%) and industrial technology (42%) have a particularly large share of groups in category D (where the overall mean is 35%).

In 2007, Colciencias set up a programme to support so-called centres of excellence. In practice, these are networks rather than physical centres and do not enjoy some of the benefits of agglomeration normally arising from such centres. Though welcome, this is a very small effort given the size and fragmentation of the research landscape. To make a substantial difference to research performance, a larger and more sustained effort is needed – ideally spanning both centres of excellence and competence centres.

Colciencias does not appear to have a separate funding line for the bottom-up, researcher-initiated projects that are normally funded by research councils. These can be funded under Colciencias' 11 research programmes, which also handle innovation. One of the main reasons why most funding systems allocate part of universities' research income through competitive projects awarded by research councils is to create pressure for quality research. In principle, it is possible to operate a system that funds research irrespective of whether or not it aims to support innovation. However, the almost universal separation elsewhere of basic research funding from innovation funding suggests that, in practice, this is difficult. In any case, having one part of the funding system operate solely on quality criteria is a powerful way to raise the quality of university research. Colciencias should handle increased funding for researcher-initiated research by setting up a dedicated unit, of the research council type, based on international good practice.²⁴ This would involve moving the system towards the two-pillar model used in many OECD countries, with separate research and innovation funding agencies. For example, Finland maintains four research councils within the Academy of Finland and a separate innovation agency in the form of TEKES. Sweden has three research councils and the Swedish Governmental Agency for Innovation Systems (VINNOVA) as an innovation agency. The United Kingdom maintains research councils and the technology strategy board.

An alternative would be to build on the fact that Colciencias already has both research council and innovation responsibilities. The Research Council of Norway was created in 1993 in order to combine these functions. Originally, it simply placed the elements of its predecessor organisations under a single roof but this had little effect on its performance. Following an evaluation (Arnold et al., 2001), it was radically reorganised (Figure 4.13) into one division for innovation, one for science (which functioned like a research council) and one for strategic priorities that deliberately mixed the two funding styles in response to national needs. Recently, as strategic priorities became a very large part of the council's activity, it was reorganised again, splitting the strategic priorities into divisions for energy, resources and the environment on the one hand and society and health on the other, in order to make the priorities more manageable and to make it easier to access internal and external knowledge relevant to specific themes.

Figure 4.13. Developments in the Research Council of Norway's organisational structure

Source: Technopolis (2012), "Evaluation of the Research Council of Norway", <http://www.regjeringen.no/upload/KD/Vedlegg/Forskning/rapporter/RCN-Evaluation-Background-Report-No-2.pdf>.

Colciencias operates two programmes that encourage young people to take up science and technology. The ONDAS programme provides co-funding for research and innovation projects submitted by children and young people in eligible schools. A share of the budget is also allocated to train teachers in the use of research as a pedagogical tool. The young researchers and innovators programme (on-going) offers internships for young researchers and innovators in a research centre accredited by Colciencias. It has annual calls and applicants can apply to three different modalities with different objectives:

- Traditional: to link young people with research centres accredited by Colciencias.
- Regional: directed to young people living in regions with less developed STI capabilities, so they can build relationships with research centres and businesses located in other, more developed regions.
- Inter-institutional: to foster links between academia and the private sector. A young innovator is presented by a company to do an internship in a research centre accredited by Colciencias.

Colciencias' strengthened national STI system budget is mainly used to purchase licences to access specialised bibliographic and full-text scientific databases including Science Direct, Elsevier and Scopus. Currently 38 research centres and 26 public and private universities have access to these resources and it is intended to make them

nationally available. This budget can also support assessment of capabilities across the different actors of the STI system and impact evaluation studies of programmes.

A major missing element in the funding system is support for research careers. In particular, while the supply of PhDs is increasing, there is no provision for post-doctoral research. This is a major gap, since the opportunities to move directly from a PhD to a university post tend to be limited. Post-doctoral research experience – preferably in more than one location – is important for professional development as a researcher. For research universities, post-docs are also important not only for potential recruitment but because, in the hard sciences at least, they tend to be the middle managers of research teams, often managing PhD students and multiplying the effectiveness of professors who can therefore run larger teams. Creating a post-doctoral research scheme is necessary both to develop research capacity and to improve the performance of the research system. Making good use of post-docs depends upon reducing the fragmentation of the research community.

Many research councils not only support post-doctoral research but also have specific grants for young researchers. Conventionally, young researcher schemes target those below a certain age. Since people start their research careers at different ages, it can be more rational to limit the grants to people within a certain number of years of completing their PhD.

Overall, to improve quality and build the capacity needed in the research system it is necessary to increase significantly the amount available to fund research. A significant part of the increase should be awarded competitively through a unit that operates like a research council. A renewed effort is needed to build centres of excellence and competence centres in order to reduce the fragmentation of the research system. Specific funding should be provided to address the early steps of the research career: the post-doctoral and young researcher stages.

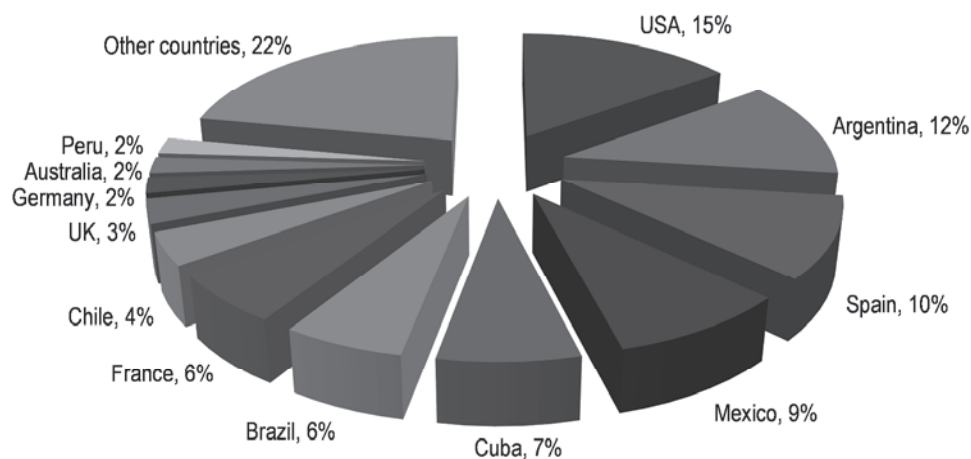
4.13. Building and exploiting international knowledge linkages

Internationalisation of research and innovation links is important for a number of reasons:

- Bibliometric analysis shows that international co-publications have a significantly higher impact than publications only with national authors (Narin and Whitlow, 1990; Academy of Finland, 2012). Despite the methodological shortcomings of bibliometrics as a tool to measure the quality of science, this suggests that international collaboration is related to the quality and visibility of science, as collaboration enhances quality, but possibly also through the selection of better-performing researchers for international collaboration (Luukkonen et al., 1992).
- Today, important agenda-setting research is conducted through international (European, global) initiatives. Involvement allows Colombia to keep up with developments, particularly in research domains connected to broader societal challenges and industry-oriented strategic research.
- Even after it has built further research capacity and quality, Colombia cannot be world-class in all domains of science and technology. International co-operation can provide the opportunity to work with the best in the field and/or to work with scientists with the complementary knowledge needed to make progress.

The national science, technology and innovation policy recognises the importance of maintaining strong international links in research and innovation. Colciencias therefore has an internationalisation strategy based on searching for and harnessing co-operation mechanisms, international mobility, developing scientific co-operation and harnessing the scientific diaspora. It operates mobility schemes that fund short visits abroad for researchers and supports engineering students to undertake periods of study in Germany or France. As discussed earlier, outward mobility of Colombians has been quite high, especially at the PhD stage, and this helps build external networks. The United States is the leading destination of Colombian higher education students studying abroad (Figure 4.14).

Figure 4.14. Distribution of Colombian higher education students studying abroad



Source: OECD et al., (2012), *Reviews of National Policies for Education: Tertiary Education in Colombia 2012*, OECD Publishing. doi: [10.1787/9789264180697-en](https://doi.org/10.1787/9789264180697-en).

Few of the faculty in Colombian universities are foreign nationals. The share of students in tertiary education who are non-nationals is even lower, only 0.08% in 2010 (OECD et al., 2013).

Colombia maintains a number of bilateral research agreements with other OECD countries, notably the United States, the United Kingdom, Spain, France, Germany and Switzerland. Among the middle-income countries with which it maintains links are China, India, Mexico, Chile and Argentina as well as a range of smaller Latin American countries. The IBEROEKA network, in place since 1991, supports business-sector co-operation within Latin America. However, the value of the 18 international co-operation projects conducted between 2002 and 2010 was only some USD 10 million; the volume of activity is not very large (Fog et al., 2012).

Up to June 2011, Colombian partners had been involved in 254 applications to the Seventh Framework Programme of the EU. Some 36 (14%) were successful – somewhat below the average, which tends to hover around 20%. Since these are consortium projects not led by the Colombian partner, these statistics do not say anything about the quality of the Colombian contribution. They do suggest, first, that Colombian partners have fairly good international networks – it is often difficult to get into a Framework Programme proposal, and doing so depends largely upon established relationships and the trust of the leading partners. Second, however, the comparatively low success rate implies that

Colombian partners are not so well connected with the most successful applicants. Greater effort could be devoted to understanding existing research networks and identifying the most successful ones with the aim of implanting Colombian partners. Since the Framework Programme is largely concerned with innovation, participating is an important way to build business as well as research relationships.

Colciencias uses internationalisation as an instrument to strengthen Colombian institutions. It provides support for the construction of international thematic networks through international mobility of researchers and innovators. This support includes financial resources to cover the costs of researchers' visits to international institutions. There are also initiatives to increase participation in multilateral and bilateral co-operation funds. Colciencias is Colombia's national contact point for the EU 7th Framework Programme (since 2007) but also nurtures relationships with Colombia's scientific diaspora. It is important for this possibility to be provided to Colombian industry as well as to the research sector. Colciencias has run a programme to help 40 universities develop their internationalisation strategies. At the individual level, Colombian academics are said to have good personal international networks. However, the Red Caldas network of expatriate Colombian researchers has withered. Reviving it could be a useful and relatively inexpensive way to strengthen international links.

4.14. A summary note on government institutions

This section brings together observations from various parts of this review about how to develop Colombia's government institutions in charge of STI. As in other countries government has to ensure that the institutions it contributes to the national research and innovation system are effective, efficient and tuned to the specific needs of the country. These needs are manifold, reflecting the varied requirements in different parts of society, different sectors or clusters, and regions. This diversity is one reason why a well-functioning innovation system needs a balance of distributed strategic intelligence with a degree of coordination, allowing overall priorities to be set and minimising fragmentation while connecting policy and its implementation to the varying realities of different parts of the innovation system.

A first observation is about the volatility of funding for research and innovation in Colombia. Building stronger and more capable institutions for innovation and research policy requires greater dependability in the budget. A second, and related, observation is that the STI governance system is in many respects overly fragmented. At the level of the formal "systems" of innovation (Science, Technology and Innovation; Competitiveness and Innovation; Agriculture and Innovation, etc.) the efforts and overview of the state are fragmented, creating a high-level co-ordination problem that is only partially solved by the fact that some key people sit on multiple committees. International experience indicates that if there is to be an effective national arena that co-ordinates, there should only be one. It should not tackle much detail (as it cannot have the detailed understanding to do that better than those who are closer to the problems), but it should set overall directions and priorities and act as the overall "referee". The ability to establish such an arena and the willingness to make it work depend strongly upon political commitment at the very top. The evidence to date is that political commitment to the idea of innovation has been, at best, variable in recent decades. One of the characteristics of countries that have successful research and innovation systems is that the importance of these systems is understood so well that it stops being a political issue.

There is no perfect model for such a high-level arena. The Research and Innovation Council (RIC) in Finland is often taken as the archetype. It works in some places and not in others. It does not even work all the time in Finland. But it is considerably better than no coordination at all. It cannot be replaced by a periodically written national plan because it is in permanent interaction with the evolution of the national research and innovation system.

The experience of other OECD countries is highly relevant in this context. One example to be considered is the Research Council of Norway (RCN). It has had a strong role in the governance of the Norwegian research and innovation system in part because the high-level arena (the cabinet's research committee) works intermittently and not very well. Spanning (like Colciencias) the role of a research council and an innovation agency, it has become a way to fund individual interventions that are sometimes relevant to one ministry and sometimes relevant to several. Rather than coordinating top down, RCN negotiates bottom up with the ministries to find the synergies among their needs and constructs R&D programmes that address these, for example in nanotechnology or climate change. Colciencias has the potential to do something similar through the mechanism of the Caldas Fund.

A key need is to achieve a separation between the role of Colciencias in policymaking as a Department of State and its role as an executive (or implementing) agency. This should be done for three reasons. Mixing the policymaking and implementation roles leads to poor governance, a confusion of roles (for example through the political level having the opportunity to influence project-level funding decisions) and difficulties in establishing and enforcing a performance contract between the policy and implementation levels. By contrast, a clearer separation may facilitate greater specialisation in the implementation function and enhance its effectiveness. This may allow also for a widening of the range of instruments deployed to address the manifold needs of business innovation – a key policy task identified by the review.

For these reasons many OECD countries have created operationally independent implementation agencies. It may be possible for Colciencias to achieve a sharper division of labour internally. However, a separate agency operating at arm's length could have additional advantages. In its combined role Colciencias is currently a competitor for budget and priority of all the other ministries not only in its Department role but also in its role as an agency. An operationally independent, implementation-focused agency, including the Caldas Fund, could take on a bottom-up co-ordination role, acting as the agency for multiple ministries and thus help achieve critical mass by aggregating what are currently distinct budget items. MICT, too, faces a similar if less obvious issue: Instead of running programmes itself it should also allocate this role to an agency.

Given the importance of linking research and innovation activities and the existing basis provided by Colciencias, an alternative option would be to strengthen its ability to handle innovation (since its roots are in research) and develop into an integrated research and innovation agency. As discussed, the Research Council of Norway (RCN) could provide an example. However, no matter where such an innovation agency function would be located it will need a wider and deeper skill set in relation to funding R&D and innovation.

The development banking, business and innovation support function needs a sufficiently different set of skills that a separate organisation is needed. Bancoldex and INNpalsa provide a stub here, which needs to be reinforced with both skills and programmes that support a wider range of innovation and company types. This function

needs to have a national spine (doing instrument design, quality control and maintaining accountability) but should be regionally delivered. Co-governance of the regional offices between the central agency and the regions is a potentially useful way to co-ordinate across the regions through linking to national strategies.

A decision on the location for the promotion of social innovation would have to await a closer specification of the definition of, and therefore priorities for, social innovation (section 4.11).

A reorganisation of the institutional landscape should take account of SENA's uncomfortable mix of functions. Entrepreneurship funding belongs in a business and innovation support agency, with which it shares skills. Some of the more technical activities of SENA might be better placed in or with the bigger set of incubators, science parks and incubators that already exist. But the available evidence is that these are fragmented and perform poorly – so a prelude would have to be a thorough review of that system as a whole. On the face of it, there seem to be very many such initiatives compared with the levels of capabilities and apparent market opportunities available. The experience of OECD countries provides useful examples.

Underpinning Colombia's move towards a strengthening research and innovation, strategic intelligence needs to be reinforced. At present, much of the strategic intelligence effort is focused in OCyT which produces statistics and indicators that are of great value in understanding the research and innovation system and making policy and should clearly continue to be developed. On the other hand, the system is weaker at producing intervention-specific studies, cluster or sector studies, foresights and – not least – evaluation studies that not only consider impacts but also provide feedback to the policy and programme design processes. These functions need to be distributed across relevant agencies, stakeholder groups and – as appropriate – additional external partners.

Notes

1. In the public management literature, it “is a perspective within which the conventional boundaries between politics and administration are perhaps less significant, and which enables large social questions to be approached more directly than from within the narrower perspective of traditional public administration”. Governance is a systemic activity, where “the boundaries between individual institutions become less significant than the question of how the whole ensemble dances (or fails to dance) together.” (Pollitt and Bouckaert, 2000).
2. This was not the case some years ago when direct support for innovation activities in enterprises was a more significant part of the policy portfolio.
3. The historical account in this section owes a great deal to a note prepared for the OECD team by Dr. Fernando Chaparro, former Director of Colciencias.
4. The one exception is the promotion of tourism.
5. Bitran, Benavente and Maggi bring useful experience from the Chilean National Council for Innovation for Competitiveness CNIC), where they did a similar but more detailed exercise.
6. An early stage of the strategy is documented (DNP, 2011) and various PowerPoint presentations exist, but a final document was not available at the time of the review.
7. For an examination of these differences and their policy implication in the context of manufacturing and services industries in Denmark, see Jensen et al. (2007).
8. At the same time, as the national plan points out, income disparities within individual regions are themselves very large.
9. This is a best estimate for the total approved in the 2012 round. However, it is difficult to provide an accurate figure for how much had been approved and by which date, to be spent over what period specifically for STA activities.
10. This seriously limits the possible comparative analysis in two ways: the STA category includes a highly heterogeneous collection of activities, and there are significant inconsistencies among and within countries about interpretation; only a few Latin American countries systematically report STA data.
11. This lag through the late 2000s was more pronounced for expenditure on R&D as a proportion of GDP (R&D intensity). Already in the middle of the decade the gap between Colombia’s R&D intensity and the expected level on the basis of national per capita income was larger in Colombia than in 11 other LAC countries. By 2010 it was only about one-quarter of the overall level in the region, and only about 16% of the level in Brazil.
12. These are: Marine, Basic research, Education, Social sciences and humanities, Health, Environment and habitat, Biotechnology, Energy and mining, Industrial development, Electronics, Telecommunications and informatics, Agriculture.

13. In the sense of units associated with higher education that aim to establish new businesses.
14. Defining and describing such projects in ways that permit the administration of funding mechanisms would present a novel challenge, but it should be no more difficult in principle than defining fundable R&D projects. For example, in the case of the Petroquisa project in Box 3.6, it was possible to define such a project in a way that permitted its financing by banks, as well as its *ex post* evaluation in terms of impacts that were tangibly achieved or realistically probable.
15. Such views are linked to perspectives on the national innovation system that identify it in narrow terms focused primarily, or even exclusively, on government bodies and public institutes.
16. The programme Apps.co that is supporting Colombian entrepreneurs is discussed in the application section below.
17. The aim of the platform to increase the transparency of government activities and to serve as a communication channel between citizens and the government.
18. Experiences in other OECD countries have shown that not peering domestically can be a strategic decision of larger ISPs to incur transit costs on smaller competing operators.
19. International Mobile Subscriber Identity.
20. This rather loose and implicit association between the idea of social innovation and even broader ideas about science, technology and innovation in society were later evident in the National Strategy for the Social Appropriation of Science, Technology and Innovation (Colciencias, 2010). It emphasised the importance of the idea that science, technology and innovation are social activities in a multi-dimensional sense, and that society as a whole should be able to understand, shape and participate in those activities. However, it did not explicitly address the concept of social innovation.
21. This gap is highlighted in a recent CEPAL study on developing policy frameworks and mechanisms to build on the experience of social innovation in the LAC region that was demonstrated in the competition referred to above in Box 3.7: “The region still faces the challenge of transforming these successful initiatives into public policy to fight against poverty and to affirm respect for economic, social and cultural rights”. This is evidently no place for quick-fix solutions: “...we still have a long road ahead until the gap between this great social wealth and public policy is bridged” (Marulanda and Tancredi, 2010, p. 5 and 8).
22. Some of the difficulties in this area were outlined in a recent European study (European Commission, 2012), along with measures to strengthen assessment and more general metrics concerned with social innovation. Also, focusing more specifically on developing countries, a review of studies of participatory modes of social innovation in agriculture (Letty et al., 2012) indicates how 30 years of case studies of practice have provided little systematic assessment, a gap that has only recently begun to be filled.
23. See www.oecd.org/cfe/leed/forum/socialinnovations.
24. Models include the US National Science Foundation, the German DFG and the European Research Council. The European Science Foundation has benchmarked and documented key research council processes (European Science Foundation, 2011).

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