

OECD Review of Innovation Policy: Colombia

Overall Assessment and Recommendations

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-manufacturing”, 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.

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.

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.

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.

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.

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.

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*. 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.
- *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, 2014) 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 interconnected 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 0.1. SWOT analysis

STRENGTHS	OPPORTUNITIES
<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • 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
<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • 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.

Reference

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