FOSTERING INNOVATION FOR PRODUCTIVITY AND COMPETITIVENESS

EXECUTIVE SUMMARY

- **Message 1.** Mexico can exploit better the opportunities for technological progress and productivity offered by its proximity to the United States. Given the multisectoral nature of innovation, better coordination in policymaking, stronger mechanisms to define budgetary priorities, and greater synergies among public policy interventions is necessary. A holistic innovation strategy as used in highly innovative economies such as Finland could help guide such efforts. A policy of more systematic impact evaluations of programs related to innovation needs to be in place along with the development of the necessary capabilities to be able to implement it.

- **Message 2.** The research base needs to be strengthened through increased investments in public R&D, and much further collaboration needs to be encouraged between universities and the productive sector to better use existing technological capacities and deploy incremental R&D investments to move the productive sector up the value chain. Such collaborations could be encouraged through funding, more adequate rules on intellectual property rights and incentives at universities, and the development of specialized skills and intermediaries that facilitate technology transfer.

- **Message 3.** A policy on human resources for innovation should be defined that addresses challenges at various stages of human resources formation Efforts to increase the formation of advanced human resources need to be sustained, with attention to enhancing the quality of domestic graduate education programs along with greater students' participation in international programs.

OBJECTIVE

This note provides a medium-term agenda for supporting Mexico's competitiveness by fostering greater innovation. Globalization and the dynamism of economies that compete with Mexico, particularly those in East Asia, bring a renewed urgency to Mexico's innovation policy agenda. While the firm is at the center of innovation, empirical evidence shows that public policy can generate an external environment more conducive to innovation. The past decade has brought several policy changes and new programs, but further changes would help the country catch up with more innovative economies and move up the value chain. Given the multisectoral nature of innovation and multiplicity of programs, better coordination in policymaking, stronger mechanisms to define budgetary priorities for innovation, and greater coherence and synergies among public policy interventions are necessary. A comprehensive innovation strategy as used in highly innovative economies such as Finland could help guide such efforts.

KEY CHALLENGES

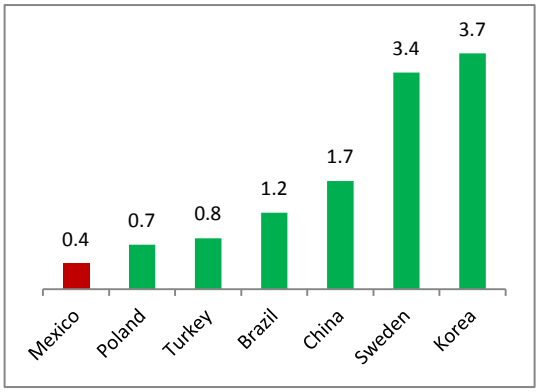
Boosting innovation is critical to Mexico's growth and competitiveness. Mexico's growth, low relative to the country's potential, has been driven mainly by accumulation in labor and capital. Over 2005–08 the contribution of total factor productivity was small and negative (–2 percent). This raises serious concerns because empirical research has shown that total factor productivity explains a substantial share of the difference in per capita income between developed and developing countries (Bosworth and Collins, 2003). According to the research, a substantial share of differences in total factor productivity are explained by technological progress or innovation broadly defined, meaning new combinations of existing resources (Romer 1990, and Aghion and Howitt, 2007), . Innovation can occur through organizational changes, changes in managerial practices, new methods of production, new sources of supply, development of new products, or upgrades to the quality of existing products. Technological progress can result from adopting knowledge that is globally available ("catching up") or developing new knowledge. Both are relevant to Mexico, depending on the sector's state of development. Information on Mexico's performance with regard to a variety of indicators follows. Some caution in their interpretation is important given the challenges faced in measuring innovation as the literature points out.

Intermediary indicators for technology-based innovation such as investments in research and development (R&D) and patents suggest that Mexico faces an innovation shortfall. The country's overall investment in R&D remains low compared with countries with similar GDP per capita: 0.4 percent of GDP in 2009 (figure 1), well below other emerging markets such as Brazil (1.2 percent) and China (1.7 percent) and even farther from top innovation countries such as the Republic of Korea (3.7 percent) and Sweden (3.4 percent). Over the past decade Mexico's private sector expenditure on R&D rose but remains low. Despite a recent increase, public expenditure on R&D as percent of GDP is barely above levels at the beginning of the last decade. In highly innovative economies R&D expenditure is driven primarily by the private sector, but the public sector is likely to play a greater role in emerging markets that are building core technological capabilities and that confront more acute market failures.[1] The number of patents granted to Mexican nationals by the U.S. Patent Office has not changed much since the late 1990s and remains low; by contrast, the number of patents granted to many Organisation for Economic Co-operation and Development (OECD) countries and select emerging markets has

surged.[2] Between 2000 and 2008, for example, the number of patents granted to China more than tripled, and the number granted to the Republic of Korea more than doubled. Mexico's stagnation in patenting occurred despite an increase in R&D, which could signal weak connectivity between research centers and the productive sector.

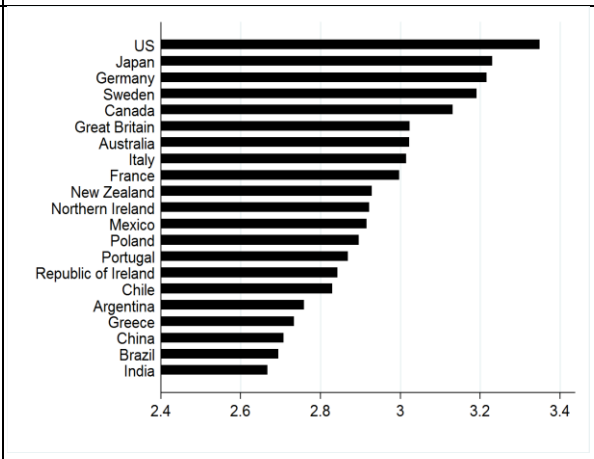
Technology licensing by firms--a mechanism to benefit from globally available technologies--also appears lower than in peer countries. According to World Bank Enterprise Surveys, the percentage of Mexican firms using foreign licensed technologies is close to 10 percent, compared with 13 percent in Brazil and 16 percent in Turkey.

Figure 1. Research and development expenditure
(percent of GDP, most recent year available)



Source: UNESCO, Science and Technology Data Tables.

Figure 2. Management skills
(most recent year available)



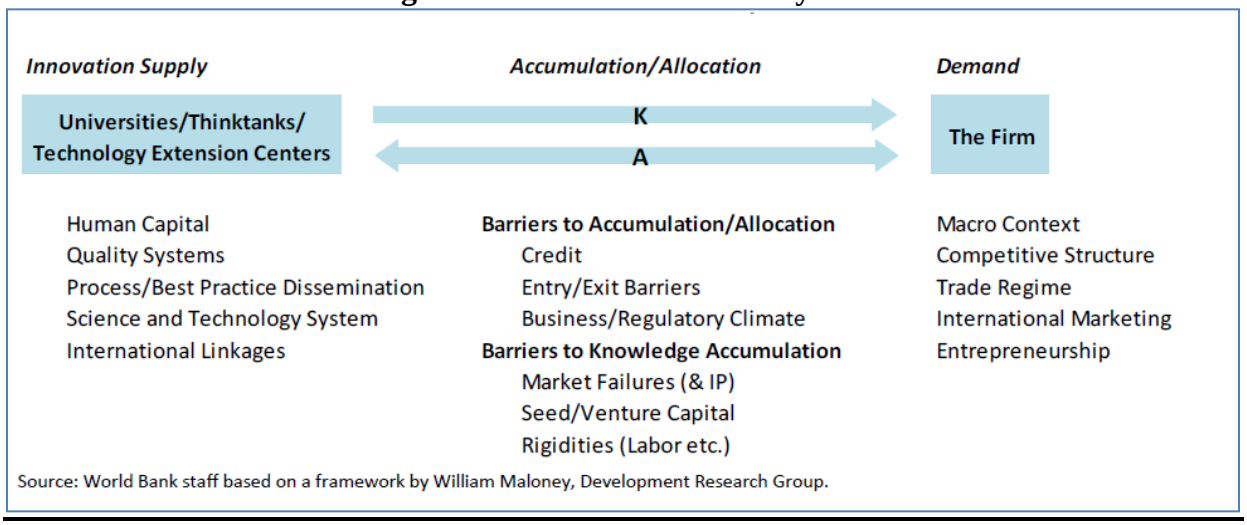
Source: World Bank and surveys by N. Bloom

The gap in non-technological inputs and forms of innovation appears less acute. A recent survey showed that management practices of Mexican firms—another important input to firm performance—were superior to those of Brazil and Chile but still below those of more advanced economies (figure 2). This could result from the country's greater connectivity with the United States. Further, the quality of exports, measured by the price that Mexican goods command in the United States, has been rising faster than the regional average, though it started at a below-average level.[3]

Several factors help explain gaps in Mexico's innovation performance. Innovation is a process of knowledge creation and accumulation by economic agents that depends heavily on the external environment and available resources. At the center of growth and innovation is the firm, and barriers to accumulation of either physical capital (K) or knowledge capital (A) can stimulate or stifle innovation. Figure 3 illustrates drivers of innovation, on both the demand and knowledge supply sides. In Mexico's case less than adequate competition, labor market rigidities, serious gaps in human resources, very limited financing for startups, and—critically important—weak links between the productive sector and knowledge institutions have all contributed to the

shortfall. While various market failures justify government intervention, little information is available on the impact of most government programs to foster innovation. These issues are further discussed below.

Figure 3. National innovation system



The demand for innovation: need to improve the investment climate

Mexico's investment climate does not favor the demand for innovation. Competition, which has a substantial impact on firm behavior, can be an important driver of innovation. Moreover, competition from innovative new firms can be particularly important in achieving productivity gains. Yet Mexico's competition environment is less than favorable in many sectors.[4] The World Economic Forum ranks the intensity of local competition at 84 out of 142 countries and the extent of market dominance at 124. Restrictions on foreign ownership in key network industries are not contributing to competition and innovation in those industries either. In addition, regulations constraining labor reallocation have also likely had an adverse impact on the density of startups and reduced existing companies' demand for investment in new technologies. Broadly speaking, universities' rules on intellectual property rights are not incentivizing researchers to transform their knowledge into innovations and collaborations with industry as further discussed below.

The supply side: need to enhance human resource development

Over the past decade Mexico has made very important progress in the development of its human resources, a critical pillar of an innovative economy, but further efforts will be necessary since it has not closed the gaps with its peers. Quality and quantity gaps remain at all stages of the education system. Mexico has seen impressive growth in the participation rate in secondary education but still lags rates in Brazil, Chile and the OECD. Graduation rates for students in secondary education are low, at just 45 percent. International learning tests also point to quality problems in the basic education system, creating a severe bottleneck to expanding the tertiary system.[5] Enrollment in tertiary education among the relevant age cohort was 27 percent in 2009, a good progress over the past decade, but still below the rate in Brazil (36 percent),

Turkey (46 percent), and Chile (59 percent). The tertiary system also confronts quality challenges, with many graduates often not meeting the skills demanded by the labor market, for example skills demanded by the software industry. To address this gap, Mexico First, part of a larger initiative to support the growth of the software industry (Prosoft 2.0), has facilitated the development of a public-private partnership that has helped overcome skills mismatch; similar partnerships could be replicated in other key industries.[6] In addition, few universities offer entrepreneurship training.

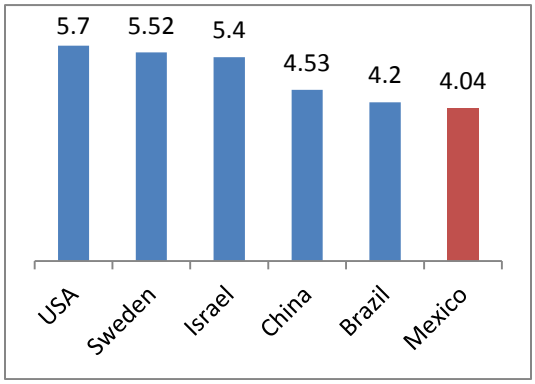
Despite Mexico's increased investment in advanced human capital, the number of researchers has not caught up with its peers. The number of researchers has increased about 80 percent over the last decade, a result of sustained government efforts to fund training and education in technical areas. However, Mexico's 1 researcher per 1,000 members of the labor force in 2009 is still below that of comparator countries (1.5 in China, 1.3 in Brazil, and 2.4 in Turkey) and substantially below advanced economies (10 in the Republic of Korea). Moreover, the share of researchers in the private sector in Mexico (less than 40 percent in 2009) is lower than in highly innovative economies (69 percent in the Republic of Korea). This limits the adoption of new technologies, solving of production issues, and development of new products.

The low share of international graduate students limits knowledge transfer from abroad and international integration of the Mexican innovation system. Despite higher cultural and linguistic obstacles, data from UNESCO indicates that the Republic of Korea, Malaysia, and Thailand have more students studying in the United States than does Mexico. The country's share has hovered around 2.1-2.4 of the total. Even Vietnam, with a much lower GDP per capita than Mexico, has nearly caught up. International students bring new ideas and knowledge to Mexico's innovation system and are a critical bridge to the global scientific and economic community once in the labor force.

Weak links and missing agents in Mexico's innovation ecosystem

Collaborations between industry and research centers have increased modestly in recent years but remain far and few compared with the active knowledge exchanges in dynamic innovation ecosystems (figure 4). Cooperation between industry and academia has been minimal due to different incentives and cultures. Public funding of science and technology programs have traditionally not favored such collaborations, as discussed below; initiatives to foster technology transfer have emerged only since the mid-2000s. In addition, regulations on intellectual property management (that is, regulations on how to share the monetary benefits derived from technology transfer with researchers) of many research centers and universities has not encouraged the transfer of knowhow, and capacity for managing intellectual property at these institutions has been very low. At the same time, skills gaps and lack of capacity to absorb knowledge in the productive sector have constrained demand for such exchanges.

Figure 4. University-industry collaboration, 2011



Source: World Economic Forum, 2011.

In addition to investment climate issues, inadequate financing and other missing links are holding back the entry of higher value firms with the potential to contribute to Mexico's structural transformation. The number of newly registered firms is very low in Mexico at 0.6 per 1,000 workers compared with 2.4 in Brazil and 4.4 for the OECD according to the World Bank Entrepreneurship snapshots and 6.3 in China according to the Global Entrepreneurship Monitor (2010). Forming higher value firms (whether technology-based or not) is notoriously challenging worldwide and more so in emerging markets, which have few angel investors and inadequate venture capital funding. New entrepreneurs also face a steep learning curve, making support structures that facilitate mentoring and networking to markets and financiers very valuable. A few initiatives are trying to address these gaps; Nacional Financiera is fostering a venture capital industry through a "fund of funds"; the Ministry of Economy is supporting incubators and business accelerators; and Consejo Nacional de Ciencia y Tecnología (CONACYT) has piloted some initiatives to support the creation of new technology-based firms.

Diversity of science, technology, and innovation programs but incomplete information on outcomes

Over the past decade several policy changes have been implemented to address key market failures and build the capabilities needed for innovation, but little information is available on the impact of these initiatives. Policy changes started with the Law on Science and Technology in 2002, and subsequent amendments in 2009 emphasized the importance of innovation and incorporated better incentives for technology transfer by CONACYT's public research centers, which has led to several new programs. Many other institutions (most prominently the Ministry of Economy) also support innovation-related activities. But not enough information is available on the performance and impact of these programs.

Adopting existing knowledge is as important as developing new knowledge, and to address this gap, the Mexican government has deployed multiple programs for small and medium-size enterprises. Nelson and Winter (1982) point out that firms face a "bounded rationality" and often find difficulty adopting new knowledge because they do not know where the frontier is. In most cases firms develop the knowledge of how to do things incrementally, and such knowledge then becomes routines. Routines contribute to the day-to-day operation of the firm but constrain

the adoption of new knowledge. Enhancing management ability to adopt and manage best practices and new technologies through well targeted support can increase firm productivity dramatically, as the rigorous randomized experiment conducted Bloom et al. (2011) in the textile sector illustrates.[7] Aware of these difficulties, the Mexican government has several programs (for example, Fondo de Apoyo para la Micro, Pequeña y Mediana Empresa) that help small and medium-size enterprises enhance absorptive capacity through new forms of work organization, improved business practices, modern manufacturing processes, and investment in worker training.

Program effectiveness is unclear, and the large number of existing programs suggests pulverization and overlaps. A 2011 World Bank study identified 151 small and medium-size enterprise programs administered by government agencies.[8] Impact evaluations of the programs are rare in Mexico—and are mostly qualitative and narrow in scope, measuring either beneficiary satisfaction with support services or easily quantified program coverage indicators. The World Bank study found positive and significant impact for firms participating in a few of the programs (a 5 percent increase in value added in one case and a 6 percent increase in employment, among other outcomes).

Technology extension programs for the agricultural sector appear to face similar challenges. These programs, largely sponsored by SAGARPA, present gaps in monitoring and evaluation, which weaken the focus on results and accountability. In addition, they could make a more efficient use of state based agricultural foundations that have successfully taken off during the last decade.

Along with these basic innovation programs for small and medium-size enterprises, the Mexican government has supported R&D, though funding has been low and needs to be reoriented to better respond to Mexico's development needs. CONACYT has been the primary institution financing advanced human capital and research and, since the mid-2000s, technology transfer (that is, commercialization of research). Other public institutions, most importantly Pemex, also have research funds. Overall public funding for R&D has been low compared with countries with similar GDP per capita. A substantial share of funding is allocated to the Sistema Nacional de Investigadores, which prevented brain drain in the 1980s but rewards researchers on an individual basis for publications, which does not facilitate today's needs for multidisciplinary research or favor collaboration with industry or commercialization of research. CONACYT's public research centers, a valuable pillar of Mexico's technological infrastructure, could also work more closely with industry, and more of their resources could come from competitive funding, rather than direct budgetary transfers. More than 15 sectoral funds were jointly created by CONACYT and other federal institutions. Most resources were thinly spread among funds, and little information is available on outcomes.

A few initiatives encourage technology transfer and R&D-related innovation by private firms. For example, CONACYT established Proinnova and several other programs to encourage public-private collaborative research. The 2009 amendments to the Law of Science and Technology seek to improve intellectual property rights of researchers at CONACYT's public research centers. The current challenge is to create the capabilities and a culture within CONACYT's centers for greater technology transfer activities to take root.

Federal initiatives to promote innovation at the subnational level have not yielded all the desired results due to lack of capacity. Recognizing that opportunities and needs differ across states, CONACYT has developed initiatives (such as mixed funds and regional funds) to foster science and technology at the subnational level. Jalisco and Nuevo Leon, for example, have actively used these funds to support their innovation strategies. Government officials in Jalisco have involved multiple statekholders in the design of the strategy and committed public resources to it. Among others, the strategy seeks to encourage greater industry-university collaboration, and supports pre-competitive research funding, investments in research infrastructure and human capital. Many of the interventions are targeted at addressing gaps that are specific to key local clusters (e.g., skills in the rapidly growing software sectors, quality gaps in traditional industries). Many other states have yet to formulate a clear vision of how science and technology can contribute to their development agenda and have not been able to use the mixed funds as effectively. Similarly, proposals submitted to the regional funds have been suboptimal.

POLICY OPTIONS

Enhancing policymaking coordination and governance

Given the multisectoral nature of innovation and multiplicity of programs, better coordination in policymaking, stronger mechanisms to define budgetary priorities for innovation, and greater coherence and synergies among public policy interventions are necessary. A comprehensive strategy developed by a high-level council could be a useful tool to help coordinate policymaking and guide budgetary decisions as many other countries committed to innovation (e.g. Finland since the early 1990s) have shown.

Several options are available to formulate such a strategy. The General Council of Scientific Research and Technology, headed by the president and entrusted with developing the six-year Science, Technology and Innovation Program, could be responsible for it. Previous programs emphasized building Mexico's scientific and technological capacities but overlooked broader innovation challenges. The council requires a broader mandate and nongovernmental members who are innovation experts. Another option is the Innovation Committee, headed by the Ministry of Economy, but it might not have enough seniority to lead a national policy. Alternatively, the president could form and lead a new high-level council with representatives from relevant ministries.

The National Innovation Strategy will be effective only if the council remains an active policymaking body as other international experiences such as Finland have shown. It would need to define budgetary priorities for innovation annually and ensure that rigorous impact evaluations inform its decision making. A secretariat (for example, in the Ministry of Economy) would also be needed.

Enhancing firms' absorptive capacity and linking them to Mexico's technological base

Consolidating small and medium-size enterprise support programs and greater efforts at evaluation should be priorities. Effectively implementing well targeted technology extension services is crucial for Mexican firms, particularly small and medium-size ones, to move into

higher value added activities. The country's huge array of programs suggests that Mexico needs a more coherent framework to orient resources more strategically and avoid program overlap. The lack of information on budgets, activities, and beneficiaries points to a need for better consolidation of information on support for small and medium-size enterprises. Technology extension programs targeted at small producers in the agricultural sector are equally critical. Such programs could also benefit from stronger monitoring and evaluation mechanisms that would inform program design. State-based agricultural foundations could be more actively involved as intermediaries in these programs.

Much more collaboration between Mexico's research base and productive sector is needed. Such collaborations are pervasive in all dynamic innovation systems, whether in Israel, Sweden, or Taiwan (China). Technology transfer needs to become a higher priority, supported with appropriate financing. Funding would have a market-enhancing purpose that develops missing capacities (such as technology transfer offices) and addresses other market failures (such as coordination). However, there is scope for integrating similar programs—such as Innovatec, Innovapyme, and the Innovation Technology Fund—to reduce costs and confusion to users. Programs such as Magnet in Israel and similar ones sponsored by Tekes in Finland could be good reference points for collaborative programs.

Stronger incentives for technology transfer at public research centers and universities are also needed. A culture of collaboration with the private sector—as is prevalent in universities in Israel, Taiwan (China), and the United States—needs to be developed. Many universities in Europe, such as Cambridge and Oxford, have successfully made such cultural transitions. To this end, CONACYT's core funding allocation to its public research centers could incorporate technology transfer activities as a performance parameter, career promotion for its researchers could recognize patenting and other technology transfer activities. Such changes together with the new rules on intellectual property management noted above could set an example for universities in Mexico to follow. Similar changes in funding and incentives by public technology institutes in Finland (e.g., VTT) and other OECD countries could be a model for Mexico to consider.

Mexico's research base can be further expanded and strengthened. Every innovative economy has benefited from a strong science and technology base. The objectives and impact of the programs developed to foster research must be assessed. For example, little is known of the impact of the more than 15 sectoral funds created during the last decade. Changes to programs should encourage larger scale, collaborative, and multidisciplinary research that can resolve more complex problems and should forge more international collaboration. CONACYT's research centers could use more competitive funding to continuously foster excellence. Institutional funding of 25–35 percent is a common practice in OECD countries. The revised funding model would pave the way for further collaboration with other research centers and the private sector. A transition plan could make this possible. Finally, the *Sistema Nacional de Investigadores* system could benefit from more participation of international evaluators, bringing greater objectivity to the evaluation, as well as a study on potential system reforms.

Greater efforts should be made to enhance the states' capacities to formulate their own innovation strategies so they can make better use of their resources and benefit from programs at the federal level.

Enhancing human resource management for innovation

A policy on human resources for innovation should be defined to address challenges faced at each stage of human resources formation. The policy needs to improve the relevance and quality of curriculum and teaching methods. Further efforts are needed to address the causes of secondary school dropout and to enhance teaching quality. (For further discussion, see Mexico Policy Note 4 on labor markets for inclusive growth). And mechanisms and standards for evaluating the quality of universities need to be strengthened.

Efforts to increase the formation of advanced human resources need to be sustained, with attention to increasing the innovation system's absorptive capacity. On the public sector side this means increasing support for research centers, and on the private sector side it implies boosting demand for innovation. For example, Finland and Israel show that university and industry research consortia are effective in forming industry-connected human capital.

Enhancing the quality of graduate education in Mexico needs to go hand in hand with graduate students' participation in international programs. Mexican students' participation in international programs will bring global knowledge to Mexico's industry and public research base. Greater exposure of domestic graduate programs to external assessments is also needed. The certification process of these programs should be changed to allow for more international participation. Moreover, the overall system would benefit from an external evaluation of its own evaluation processes by an international independent panel formed ad hoc or through a formal structure such as the European Association for Quality Assurance in Higher Education.

Integrating Mexico's innovation system globally and removing barriers to the demand for innovation

The rapidly growing body of international knowledge makes it imperative to connect Mexico globally. This includes attracting international students to Mexico; encouraging international research collaborations; and incorporating more international evaluators in large-scale research programs, the Sistema Nacional de Investigadores, and Mexico's system of graduate programs.

Enhancing the investment climate

A stronger investment climate—and in particular a more competitive business environment and more flexible employment regulations—would increase firms' demand for innovation. A more competitive telecommunications sector would favor expanded Internet services and lower connectivity costs, facilitating smaller business integration into more productive activities.

Matrix of short and medium-term policy reform options*

Reform option	Short-term options	Medium-term options
Enhance policymaking coordination and governance	• Develop an innovation strategy to help coordinate policymaking and guide budgetary decisions. (AR) • Develop medium-term plans to conduct impact evaluations of innovation-related programs and initiate implementation of plans. (AR) • Enhance states' capacities to formulate their own innovation strategies. (AR)	• Have the Innovation Council monitor strategy performance and advise on budgetary allocations and programs (AR) • Regularly implement and dislose to the council and the public impact evaluations of innovation-related programs. (AR) • Conduct independent evaluations of large-scale programs and reviews of the overall performance of key institutions related to innovation (such as CONACYT and the broad innovation portfolio under the Ministry of Economy, including its small and medium-size enterprise programs). (AR)
Enhancing absorptive capacity for firms and a link between Mexico's technological base and the productive sector	• Improve monitoring and evaluation of existing and new support initiatives for small and medium-size enterprises by improving information on program budgets, activities, and beneficiaries and on assessment of program effectiveness. (AR) • Improving monitoring and evaluation of technology extension services programs for small farmers (AR) • Improve monitoring and evaluation of various programs supporting research and examine options for integration (AR) • Increase university-industry collaboration through (AR): ○ Targeted programs to support research consortia, contract research, licensing of technologies, and technology spinoffs. ○ Development of technology transfer offices with	• Consolidate support programs for small and medium-size enterprises based on evaluation results. (AR) • Enhance programs on technology extension services for small farmers based on evaluation results. (AR) • Increase percentage of CONACYT's research centers' funding that comes from competitive funding rather than direct allocations. (AR) • Encourage larger scale, collaborative, and multidisciplinary research that can resolve more complex problems, including greater international collaborations. (AR) • Continue stimulating university-industry collaboration *inter alia* by providing funding for such research consortia, and improved incentives for researchers. (AR) • Conduct a study to explore reform options of the (SNI). (AR)

Reform option	Short-term options	Medium-term options
	administrative independence, a clear commercialization focus. ○ Greater participation of international evaluators in the *Sistema Nacional de Investigadores* (SNI) (AR)	
Enhancing human resources at all levels	• Improve the relevance and quality of curriculum and teaching methods (see Mexico Policy Note 4 on labor markets for more detail). (AR) • Increase the formation of advanced human capital, including the participation of Mexican students in overseas graduate and postdoctoral programs. (AR) • Change the certification process of domestic graduate programs to allow for more international participation in the evaluation process. (AR) • Conduct an external evaluation of the certification process of domestic graduate programs. (AR)	• Further increase the formation of advanced human capital, including the participation of Mexican students in overseas graduate and post-doctoral programs.(AR)
*LR=Legal Reform; AR= Administrative Reform. Preliminary classification.		

NOTES

[1] The percentage of R&D expenditure that comes from the private sector is close to 72 percent in 2010 for the Republic of Korea and 60 percent in 2009 for Sweden.

[2] Although an imperfect proxy for innovation outcomes, patents are one indicator of potential to commercialize R&D activities.

[3] Lederman and Maloney forthcoming.

[4] For further information, see Mexico Policy Note 1 on a more competitive business environment.

[5] See Mexico Policy Note 4 on Labor Markets for further detail.

[6] The program provides practical training in a variety of technical and managerial topics as well as English. The curricula are jointly developed between universities and the software industry.

[7] Bloom and others 2011.

[8] Lopez and Tan 2011. These also included programs other than technology extension services, such as programs to encourage training and conservation and improve earnings and safe working conditions for the workforce in small and medium-size enterprises.

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