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Foreword

This review of Mexico's innovation policy is part of a series of OECD country reviews.[1] It was requested by the Mexican authorities, represented by the National Council for Science and Technology (CONACYT), and was carried out by the OECD Directorate for Science, Technology and Industry (DSTI) under the auspices of the Committee for Scientific and Technological Policy.[2] It took place concurrently with another study, *OECD Reviews of Regional Innovation: 15 Mexican States*; the two are complementary and provide Mexico with a coherent package of recommendations for both national and sub-national levels to work together effectively to support sustainable innovation-led economic growth throughout the country.

This study draws on a background report commissioned by the Mexican authorities,[3] and on the results of a series of interviews with major stakeholders in Mexico's innovation system. The review was drafted by Daniel Malkin (consultant to the OECD), and Gernot Hutschenreiter and Michael Keenan (Country Review Unit, DSTI, OECD), with contributions from and under the supervision of Jean Guinet (Head, Country Review Unit, DSTI, OECD).

The review owes much to officials from National Council on Science and Technology (CONACYT), particularly Leonardo Rios Guerrero and Victor Reyes Peniche, and members of the Mexican Association of Directors of Applied Research and Technological Development (ADIAT), particularly Leopoldo Rodríguez Sánchez, for providing guidance on the issues to be examined, organising interviews, presenting interim results in Mexico,[4] and feedback on early drafts of the review.

1. See *www.oecd.org/sti/innovation/reviews*.
2. The review has benefited from a peer review process within the OECD. The two examiners were Luis Sanz, Professor at CSIC (Spain) and Chair of the OECD Committee on Scientific and Technological Policy (CSTP), and Patrick Vock, Director of CEST (Switzerland) and Chair of the CSTP Working Party on Technology and Innovation Policy (TIP).
3. The background report was prepared by the National Council on Science and Technology (CONACYT) in collaboration with ADIAT. Fausto Alzati co-ordinated the work with the support of Leopoldo Rodríguez Sánchez, Leonardo Rios Guerrero, Efraín Aceves Piña and Fernando Guillén Guzmán, drawing on a draft prepared by Gabriela Dutrénit (coordinator), Mario Capdevielle, Juan Manuel Corona Alcantar, Martín Puchet Anyul, Fernando Santiago and Alexandre Vera-Cruz.
4. An interim version of the review's overall assessment and recommendations was presented at the "Forum on Innovation for the Competitiveness of Mexico" organised by CONACYT and NAFIN in Mexico City on 12 January 2009.

Table of Contents

Overall Assessment and Recommendations 7

Fostering innovation to boost Mexico's socio-economic development 7
Mexico's innovation system: main policy challenges 9
Recommendations 20
Concluding remarks 30
Notes 32

Évaluation générale et recommandations 33

Encourager l'innovation pour stimuler le développement socioéconomique du Mexique 33
Le système d'innovation mexicain : principaux défis pour les pouvoirs publics 35
Recommandations 48
Conclusions 60
Notes 62

Chapter 1. Economic Performance and Framework Conditions for Innovation 63

1.1. Economic performance 63
1.2. International trade and foreign direct investment 68
1.3. Economic structure and structural change 74
1.4. Framework conditions for innovation 78
1.5. The role of innovation in Mexico's economic development 90
1.6. Performance in science, technology and innovation in an international comparison 91
Notes 108

Chapter 2. Main Actors of Innovation 111

2.1. Business sector 111
2.2. Public research centres 129
2.3. Higher education institutes 139
2.4. Human resources 146
Notes 157

Chapter 3. The Role of Government 159

3.1. The evolution of Mexico's S&T and innovation policies 160
3.2. Institutional setting and governance 164
3.3. Financing, priority setting and policy mix 166
3.4. The portfolio of instruments and programmes: a critical assessment 174
3.5. Moving towards more efficient innovation policy 199
Notes 206

References 211

Overall Assessment and Recommendations

Fostering innovation to boost Mexico's socio-economic development

Over the past decade, Mexico has made significant progress towards macroeconomic stability and has launched important structural reforms to open the economy further to trade and investment and improve the functioning of markets for goods and services. However, potential GDP growth remains much too low to bridge the wide gap in living standards with wealthier OECD countries and reduce widespread poverty. Mexico increasingly struggles to compete with many other large emerging economies, which are building their capabilities to harness the benefits of globalisation at a much faster pace.

One important reason is that Mexico's public and private decision makers have been slow to realise the importance of investment in innovation as a driver of growth and competitiveness. Losing competitiveness in knowledge-based activities can become a self-reinforcing process that is increasingly hard to reverse because weak innovation capabilities limit the opportunities offered by international spillovers from competitors' rising investment in knowledge. To provide the Mexican economy with stronger, sustainable growth, renewed efforts at reform are needed on a broad front, motivated by a sense of urgency and vision and backed by strong political commitment and leadership.

The current global economic crisis should not preclude or weaken these efforts. "Strong innovation performance is more important than ever in the current context. Stimulus packages should be designed in a way that supports innovation" ("OECD Strategic Response to the Financial and Economic Crisis: Contributions to the Global Effort", OECD, 2009).

To create an innovative Mexico able to meet citizens' growing needs and aspirations (higher standard of living, improved health, better security and environment, enriched cultural life, etc.), the government should commit to setting its policies in line with this objective. It should back business strategies and civil society initiatives in order to stimulate all forms of individual and collective creativity and innovation. Boosting investment in human capital, particularly in education, and fostering innovation in the business sector will be crucial to achieving this goal. The recently approved Special Programme for Science, Technology and Innovation (PECITI) is a positive initial step in that direction. It needs to be consolidated, supported by adequate budgetary commitments and complemented by governance reforms in the institutional setup that shape the design, funding, implementation and evaluation of policies.

Recent economic performance and new challenges

Mexico has benefited significantly from reforms undertaken over the past two decades to liberalise its economy and improve macroeconomic management. It has made considerable progress in achieving macroeconomic stability. Since the 1995 peso crisis Mexico's GDP growth has averaged a reasonable 3.6% a year. Yet, in recent years growth has been weaker than that of Latin America's more dynamic economies, such as Brazil and Chile, and economic growth has not been sufficient to help move per capita output to the level of the more advanced OECD economies. In fact, Mexico's labour productivity growth has been one of the lowest among OECD countries since 2000. A key objective of Mexico's economic policy is therefore to foster productivity gains and put the economy on a sustainable path of higher growth.

One of the main drivers of economic growth has been Mexico's opening to international trade and investment. Largely owing to the opportunities provided by the North American Free Trade Agreement (NAFTA) and the Maquila/Pitex programmes, Mexico has recorded high growth in manufacturing exports, mainly to the United States. The share of trade in gross domestic product (GDP) has doubled over the last 20 years, with the share of manufacturing rising from 20% to about 85% and an increasing export specialisation in sectors or products integrated in global value chains. However, in spite of the sizeable initial positive effects induced by technology imports and factor reallocation within and across sectors related to trade integration and increased foreign direct investment (FDI), Mexico's recent trade performance can be attributed more to comparatively low labour costs than to high and rising productivity and innovative capacity.

At the sectoral and firm level, the preference for imported technology over the development of domestic innovation capacity – and a resulting lack of absorptive capacities in Mexican firms – has limited technology diffusion and transfer through increased intra-industry trade and FDI flows. In Mexico, industries classified as high-technology do not invest significantly more in research and development (R&D) and innovation (in relation to their value added) than those in lower technology categories. Accordingly, they do not play a driving role in the dissemination of knowledge and technology throughout the business sector or in the formation of technology-based value chains.

The absence of robust productivity growth and the low overall innovative performance of the business sector (as measured, for example, by innovation inputs and outputs as well as the creation of technology-based firms), along with the rise of Mexico's relative unit labour costs since the late 1990s, have tended to erode Mexico's international competitiveness, especially vis-à-vis emerging economies such as China which, as of 2003, overtook Mexico as the United States' second largest trading partner after Canada and has significantly boosted its investment in science, technology, innovation and human capital over the last decade.[1]

An increasing role for innovation and innovation-related policies in achieving sustainable high growth

Achieving higher growth of GDP per capita is the key policy challenge and a necessary basis for alleviating the high incidence of poverty. Innovation can play a leading role by boosting productivity growth. It is also necessary in order to maximise the benefits of Mexico's integration in the global economy by increasing Mexican firms' capacity to absorb and adapt technologies developed abroad and raise their international competitiveness.

OECD countries' experience shows that the performance of innovation systems does not rest only on dedicated policies aimed at fostering science, technology and innovation. It is predicated upon various factors or conditions that are far from being met effectively in Mexico:

- political recognition of the importance of knowledge-related investments along with appropriate budgetary allocations;
- sound governance arrangements that ensure the involvement of stakeholders in the definition of policy orientations and priorities as well as efficient management of policy implementation;
- a policy mix that fits the challenges faced by the innovation system and institutional flexibility that allows adaptive policy responses;
- existence of framework conditions for the business environment which affect positively firms' incentives and capacity to innovate (*e.g.* access to capital, competition and intellectual property regimes);
- physical and ICT infrastructure which facilitates the location and development of knowledge and innovation investment platforms;
- a well-educated workforce and sustained to develop skilled human capital.

Mexico has to advance on all these fronts to ensure that increased public and private investment in knowledge will actually contribute both to raising the innovative capacity of its economy and to meeting the main social challenges faced by its population.

Mexico's innovation system: main policy challenges

With the adoption of the 1999 and 2002 science and technology (S&T) laws, the new CONACYT Organic Law and the approval of the 2001-06 Special Programme for Science and Technology (PECYT), a number of initiatives were taken to improve the design and implementation of Mexico's science, technology and innovation (STI) policy. While some positive achievements must be recognised, overall the goals set have not been reached and structural weaknesses continue to affect the performance of the innovation system. Drawing upon past policy successes and failures the 2008-12 PECITI constitutes a welcome effort to address these structural weaknesses by taking advantage of untapped opportunities offered by Mexico's social and economic endowments (see the following table).

Summary table: SWOT analysis of the Mexican national innovation system

Strengths	Weaknesses
• A set of top-quality universities (both public and private) and public research centres • A sizeable pool of qualified scientists • A relatively large domestic market • A set of globalised, internationally competitive firms • Regional and sectoral clusters of excellence • Attractiveness for FDI inflows into specific sectors • The accumulated experience of some public agencies for the promotion of STI and economic development • Good natural resources endowment • Cultural diversity as a source of creativity	• Inefficient governance of the National Innovation System (NIS) • Unbalanced policy mix • Low budget allocation and weak political commitment to STI policy • Bureaucratic management of support programmes • A very low level of public/private co-operation; low mobility of human resources in S&T • Poor performance of the education system; low qualification of the labour force • Insufficient technological infrastructure • Low technological absorptive capacity of the vast majority of small and medium-sized enterprises (SMEs) • Weak IPR culture • Little competition in some sectors; barriers to enterprise creation; deficient corporate governance in the publicly owned industrial sector • Premium on imported technology • Financial markets ill-adapted to innovation-related investment
Opportunities	**Threats**
• A young population • Geographical proximity to the United States • Incipient development of a significant pool of engineers • Growing demand for knowledge-intensive social goods • Insertion in global knowledge networks and technological platforms • Diversification of production and trade towards goods and services with higher knowledge content • Engagement of SMEs in more innovation-driven strategies • Technology diffusion around multinational enterprises in line with the development of innovation-based global value chains • Biodiversity as a potential economic asset	• Growing competition from emerging economies • Accelerated expansion of the scientific and technological frontier • Intensifying global competition for talent • High economic and technological dependence on low-growth economies • Poor linkages with dynamic emerging regions experiencing rapid economic, scientific and technological development • Regional concentration of innovation capabilities

Institutional and structural weaknesses continue to affect the innovation system

Efficient governance practices have not developed as anticipated, and this has hindered a clear policy focus on the priority actions defined in the PECYT. The coordination authority formally entrusted to the National Council for Science and Technology (CONACYT) in the 2002 S&T Law could not be effectively exerted in the preparation of the S&T budget and the definition of policy orientation. The distinction between political bodies responsible for policy design and administrative bodies in charge of policy implementation has remained blurred. Moreover, the multiplication of poorly funded support instruments catering to various constituencies and burdened by bureaucratic management has diluted government action, so that a de facto policy mix has had limited impact on the performance of the Mexican innovation system.

Resources devoted to R&D activities have fallen short of stated objectives. In terms of innovation inputs and outputs, Mexico's STI system lags that of other OECD countries and some important emerging economies. The ratio of R&D expenditures to GDP is the second lowest among OECD countries and, despite growing R&D investment by industry, most R&D is still performed by the public sector. Patenting activity per capita or unit of R&D is among the lowest in the OECD area. The technological balance of payments shows a very large and persistent deficit, with exports covering less than 10% of imports, and technology licensing agreements among Mexican institutions are extremely rare.

Despite recent progress, the training of human resources for science and technology remains insufficient, and the low propensity of firms to hire such resources discourages their further development. This adversely affects the diffusion of knowledge and the innovative capacity of the business sector.

Notwithstanding valuable efforts to strengthen the technological infrastructure and improve access to technological services, the vast majority of Mexican small and medium-sized enterprises (SMEs) still lack the capacity to introduce and manage innovative activities, owing in part to the low level of qualifications of their workforce and their management.

Finally, industry-science relationships are very weak both in terms of knowledge flows – including those embodied in human capital – and of collaboration on innovation projects which draw on academic knowledge.

Positive but limited impact of some recent policy initiatives

In recent years, a number of policy initiatives have been developed or tested with some – albeit limited – success. Some have had a relatively positive impact on innovation performance and need to be pursued. The management and/or financing of those that have contributed to strengthening innovative capacities need to be reviewed with a view to increasing their impact.

A more proactive role for public research centres

In recent years two parallel changes in the governance and financing of public research centres (PRCs) have led them to take a more proactive approach to strategic decisions. The institution of "performance agreements" established a governance mechanism that includes appraisals and accountability to increase transparency and induce the centres to give priority to research and technological activities or programmes

with acknowledged social or economic relevance. Concomitant changes in funding allocations have driven most PRCs to increase the share of self-financing in their overall budget.[2]

These changes have led PRCs to change the orientation and organisation of their activities with a view to increasing their co-operation with the private sector and other entities to which they provide R&D and technological services. Another factor that has favoured this evolution has been the priority given to projects involving co-operation between PRCs and enterprises in submissions for financial support to CONACYT and other funding bodies such as the Ministry of Economy.

Fostering business investment in innovative activities

From 2000 to 2006, the period covered by the PECYT, several initiatives involving direct and indirect support measures helped to foster business investment in innovation-related activities. These initiatives have led to a significant increase of both the volume of business R&D and the shares of total R&D financed or performed by the productive sector which still remain low by OECD standards.

Among these support measures figures prominently the fiscal incentive put in place by CONACYT in 2002, which represented more than 75% of total support in 2006. However, beyond its noteworthy quantitative effect on innovation-related business investment, this measure raises questions relating to the efficiency of its management, the distortion effects linked to the concentration of beneficiaries, and the disproportionate role of fiscal incentives with respect to other, more direct, support measures.

With some exceptions, direct support measures implemented by the Mexican administration in order to enhance business investment in innovative activities have met with limited success. As in the case of sectoral funds, their efficiency has too often been hampered by a limited focus, a multiplicity of eligibility criteria, burdensome management and co-ordination problems. Among the exceptions are the programmes managed and funded by a single institution: the incipient CONACYT AVANCE programme for new technology-based firms, the PROSOFT programme, funded by the Ministry of Economy, for ICT applications, and the SME Fund of the Ministry of Economy's section on innovation and technological development which supports entrepreneurial initiatives backed by intermediary institutions acting as brokers.

In the most advanced states of the Federation local governments have also played a dynamic role in promoting the development of specialized clusters and strengthening their scientific and technological infrastructure. In most instances successful programmes have benefited not only from good co-ordination between federal and local governments and institutions, but also from strong participation by business associations and intermediary organisations, including provision of funding.

Supply of highly skilled human resources for science and technology

Mexico still lags most other OECD countries and emerging economies such as Brazil, Chile and China in the production of highly skilled human resources for S&T (HRST). However, in spite of Mexico's unstable STI policy over the last two decades, CONACYT has maintained its efforts to develop these, at least in terms of the share of its budget.

The postgraduate scholarship programme started in the early 1980s is currently the most important source of funding for Mexicans interested in pursuing postgraduate studies either in Mexico or abroad. It has benefited more than 150 000 students to date.

While overall efforts to promote the supply of these resources need to be maintained, they need to be complemented by measures to support demand from the private sector, as envisaged by the PECITI's IDEA programme. Moreover, in light of the evolving structure of demand for highly skilled resources, more discipline-based criteria should be introduced for awarding scholarships.

Scientific and technological infrastructure

The development and maintenance of advanced scientific and technological infrastructure has long suffered from low priority and limited sources of funding, in part owing to severe budgetary restrictions. In comparison with more advanced OECD countries, Mexico under-invests in S&T equipment and infrastructure per unit of R&D expenditures or number of qualified researchers.

Only recently has this situation begun to be addressed, with a doubling of federal investment between 2002 and 2006. This investment has helped to facilitate the decentralisation of S&T capacities; in a number of instances, state governments have added their funding contribution to that of the federal investment effort.[3] Outstanding challenges

In spite of the positive results of some institutional reforms and other policy initiatives in the PECYT framework, only limited progress has been made in overcoming the chronic structural weaknesses of Mexico's innovation system. These continue to hinder the emergence of a virtuous dynamic in which the production of knowledge and its diffusion and use are mutually reinforcing and yield benefits in economic growth and social well-being. Overcoming them represents outstanding challenges for the design, governance, funding and implementation of Mexico's S&T and innovation policy in the coming years.

Raising public investment in S&T and R&D activities

No country has advanced decisively up the ladder of innovative economic performance without sustained public investment in tangible and intangible S&T assets. In Mexico increasing the volume of public resources devoted to R&D and developing the absorptive capacities to put them to use efficiently are a prerequisite for engaging in a virtuous dynamic in which public and private investment in innovation complement each other to ensure rising social returns to investment in knowledge.

In this regard, and in spite of the 1% objective of the R&D-to-GDP ratio for 2006 set by the 2002 S&T Law, Mexico's performance only reached 0.49% in 2007, the second lowest among OECD countries.[4] Worse, while this ratio increased moderately from 0.4%

in 2002 – mainly owing to the business sector – federal budget expenditure on S&T has remained practically unchanged in constant value over the past six years. This has meant a reduction in the share of the federal budget and of GDP. Indeed, by international standards, the government devotes very few resources to its public research system. Yet international comparisons show that in better-performing countries, the business sector's share in total R&D expenditures does not increase sustainably when absolute public R&D expenditures decline.

The evolution of private and public expenditures is certainly an impediment to the strengthening of Mexico's innovation system. More articulation and collaboration between the private and public sectors requires interaction between two dynamic partners. It cannot be achieved if the volume of resources allocated to one of them stagnates or decreases.

Against this rather gloomy background, the budget appropriations for S&T increased by 16.2% in 2008 over 2007. This is a welcome and encouraging signal.[5]

Consolidation of support programmes and policy co-ordination

Despite PECYT's well-meant efforts to better focus the objectives of STI policy and implement support measures more coherently, the management of direct support programmes has too often suffered from major governance weaknesses, notably problems of co-ordination, dilution of responsibilities and fragmentation. Indeed, during the period covered by the PECYT, support programmes were organised less according to policy objectives than as a result of compromises between CONACYT and sectoral ministries regarding management and funding responsibilities. This has resulted in the development of an unusually large number of poorly endowed support programmes, with many eligibility criteria and very cumbersome decision-making procedures. Alone or in co-ordination with other federal government or state bodies, CONACYT manages over 60 funds or support programmes. This leads to significant inefficiencies due to transaction costs, administrative rivalries and bureaucratic delays.

A striking example of these inefficiencies is the 17 sectoral funds jointly financed and operated by CONACYT and sectoral ministries to promote STI capabilities according to the "strategic needs" of the participating "sector". Their budgetary endowments are quite small, averaging less than USD 100 million a year. Moreover, the selection criteria often define granting priorities at a very detailed level;[6] this distorts the selection process.

Rejection rates are high. Possible reasons include strong demand for relatively limited available funding, poor qualifications of applicants, weak project relevance, bureaucratic conflicts, and/or unclear criteria. Given the amount of support these funds can offer individual proposals, high rejection rates are likely to mean very high administrative costs for project selection.

For the sake of efficiency, there may be a case for replacing sectoral funds focused on applied research[7] by sectoral priority programmes with increased *ex ante* contributions from S&T budgets of sectoral ministries funded on a competitive basis. This would be in line with practices increasingly observed in other OECD countries, in which the definition of priorities is accompanied by the setting of a budget of pooled resources allocated competitively by a "means agency" with oversight responsibility.

The 32 mixed funds, jointly administered by CONACYT and state government bodies and progressively developed since 2001, were meant to foster research and/or

innovation capacity at the regional level and to help articulate federal and regional STI policies and support programmes.

Although they constitute in principle a valuable means of federal/state co-ordination, the present record of mixed funds is not wholly satisfactory:

- In many cases they have suffered from a lack of well-defined demand on the part of the states owing in part to inefficient co-ordination among stakeholders, especially in less developed states. On the whole they have been of greater benefit to the narrowly defined S&T interests of locally established research centres and higher education institutions (HEIs).
- The amounts allocated have generally been quite small[8] and have supported a narrow base of projects with limited spillovers to regional innovative capacity[9].
- Their management and effectiveness have often suffered from lengthy selection and disbursement processes and from a number of states' weak capacity to develop and submit adequate R&D and innovation projects.

Countries that have implemented funds that are co-financed and managed by different government bodies have more often than not encountered implementation problems. Mexico is no exception and, apart from more substantial resource requirements, it needs clearer and more efficient rules for managing the schemes. Among beneficiaries there seems to be widespread consensus that, in addition to their limited endowment, sectoral and mixed funds suffer from inefficient management and delayed disbursement of funds to selected projects.

In contrast with these mixed outcomes, the Mexican administration has developed other instruments to support R&D, innovative activities or technological development which have proved more efficient in terms of management and co-ordination, and more successful in terms of outcomes. As noted above, prominent among these are the CONACYT AVANCE programme and the PROSOFT programme and the SME Fund financed and managed by the Ministry of Economy. With important nuances, there is also the R&D fiscal incentive system managed by CONACYT in co-ordination with the Ministries of Finance, of Economy and of Education.

Enhancing the performance of the academic research system and fostering public research linkages with industry

Over the last decade, in a context of nearly stagnant resources, the productivity of Mexico's science system, as measured by scientific performance and relevance, has improved notably. The volume of scientific production has increased significantly[10] and its quality has also improved to some extent.[11] This is largely due to the National System of Researchers (SNI). Since its inception in 1984, it has played a positive role in the development of a community of qualified researchers selected, promoted and rewarded (with non-taxable complements to their remuneration) according to criteria based on the volume and excellence of their scientific production.

However, public research in Mexico's higher education institutions continues to present weaknesses which limit their capacity to generate knowledge and train an adequate supply of highly skilled personnel able to contribute efficiently to addressing social challenges and strengthening the innovation capacity of the productive sector. Moreover, as academic research remains highly centralised, this hinders knowledge spillovers.

The SNI's reward system is biased towards the evaluation of individuals and published scientific results; it acts as a disincentive to undertake long-term projects and multidisciplinary research on challenging problems that offer potential benefits in terms of innovation. Technological achievements are not recognised on a par with published scientific results. This hinders co-operation with industry and institutional mobility of researchers between academia and industry. In addition, the combined effect of the SNI's remuneration and pension systems on retirement decisions is likely to be an ageing of the scientific community. This could dangerously affect its future productivity in terms of output, novelty and quality.

A major factor in the coherence and dynamism of an innovation system is the depth and breadth of knowledge exchanges between science and industry. In recent years, a number of PRCs and some HEIs have stepped up their co-operation with the enterprise sector via joint research activities on product and process development and the provision of technological services. Similarly, there are successful, albeit limited, initiatives by enterprises or social sectors to source knowledge in research institutions to strengthen their innovative activities. Yet, one of the major weaknesses of Mexico's innovation system remains the low level of knowledge exchange between science and industry. Various factors account for this:

- On the demand side, the scarcity of highly skilled labour in a large majority of firms and the weakness of technology transfer schemes lessen possibilities to absorb knowledge from, and effectively interact with, research institutions in the initial stages of product or process innovation. In this context the recently introduced IDEA programme to encourage the insertion of highly skilled S&T personnel in enterprises is certainly a valuable initiative. The programme should be extended and its implementation be made more flexible and decentralised.
- On the supply side, given the SNI's bias towards rewarding scientific publications, researchers lack incentives to engage in collaboration with firms and restrictions on inter-institutional mobility reinforce existing disincentives. At the institutional level co-operation is increasing slowly, as the move towards more self-financing by research centres drives them to seek opportunities for collaboration. The growing importance of science-based innovation is starting to define the research agendas of PRCs and advanced HEIs such as Cinvestav and to foster collaboration with enterprises with research capabilities. Strengthening public research institutions' capacity to develop, protect and manage intellectual property would also contribute to that objective.
- On the institutional side, despite initiatives by public or private intermediary institutions, such as Infotec, Cenam, Impi, Fumec or Produce, technology diffusion mechanisms remain weak and access to technological information and services poorly supported. The scarcity of private intermediary institutions and certification bodies also hinders technology diffusion and collaboration.

An apparent paradox is that most current policy instruments in support of R&D, innovation and technological development include collaboration by public and private institutions as one criterion of project selection. Unfortunately, this has not yielded the expected results, which suggests that a more direct approach or incentives specifically focused on strengthening science-industry linkages are in order.

Rather than being a secondary objective of support programmes with different primary objectives, industry-science relationships would be more efficiently fostered in the framework of well-funded dedicated programmes or instruments designed with the involvement of all relevant stakeholders. A prominent example is the public/private partnerships for research and innovation which have been set up in a number of OECD countries. Mexico has recently emulated this approach with the launch of the Strategic Alliances and Innovation Networks for Competitiveness (AERIs) which constitute an improvement over the Consorcio programme launched at the beginning of the decade.

Other types of actions, which do not necessarily require funding, are based on incentives provided by institutional reforms, such as those concerning the mobility of researchers and the development of technology transfer or licensing offices (TTOs and TLOs) in research institutions receiving public funding. In this respect the IMPI/ CONACYT Fund is a welcome initiative which should facilitate the development of such offices.

Policy mix and programme implementation

Against the general background of limited budgetary resources devoted to S&T, governance issues concerning the respective roles of CONACYT and various ministries and their co-ordination in the design and implementation of STI policy have strongly affected – and to a large extent distorted – the policy mix of programmes and instruments in support of STI. This is reflected in:

- the multiplicity of poorly funded programmes;
- a mismatch between the level of resources allocated to various instruments and the nature of the problems or type of market or systemic failures they are meant to address;
- the frequent multiplicity of eligibility criteria attached to funding instruments, which may hinder the attainment of their stated priority objective;
- the problems posed by the dilution or conflicts of funding and management responsibilities among co-ordinating agencies which often result in inadequate design and complexities in the implementation of some instruments.

Support to business R&D and innovation: an unbalanced policy mix in need of reform

Until very recently Mexico stood out among OECD countries in terms of the very high share of fiscal incentives in total support to business R&D and innovation (about 75%). This imbalance was compounded by the high level of tax relief provided through this incentive when compared with other countries with similar schemes. Moreover, in Mexico, fiscal incentives were poorly adapted to supporting the innovation projects of the vast majority of firms. Many do not engage in R&D activity in order to innovate and therefore cannot, in principle, benefit from this type of support. Instruments that should address the needs of such firms, such as matching grants or subsidised or conditional loans, were much less well endowed than fiscal incentives.

It is clear that a streamlining of support programmes, a rebalancing of their respective endowments, and a simplification of management structures was in order:

- *Fiscal incentives*. On the basis of the experience of the other 20 OECD countries that have implemented fiscal incentives, there still seems to be a rationale for this type of support instrument in Mexico, provided its design, management and eligibility criteria are revised in line with best practices in other countries. The changes should of course be envisaged in the light of the new corporate tax reform instituting the single rate corporate tax (IETU). They should reduce the budgetary costs of fiscal incentives, raise their efficiency and facilitate a transition to a more balanced policy mix.
- *Promoting innovation in SMEs*. The Economía-CONACYT Technological Innovation Fund is the main instrument for fostering innovation in SMEs. Beyond its relatively small endowment, its impact is limited by excessive eligibility criteria and co-ordination problems which complicate its management. In other OECD countries, as well as in advanced Latin American countries such as Brazil, Argentina and Chile, funds involving matching grants to SMEs are usually better endowed and managed by dedicated agencies, which are distinct from, but accountable to, financing ministries. In Mexico another factor that weakens the management efficiency of the Economía-CONACYT Fund's operation is its relatively weak capacity to assess the potential return on investment in R&D and innovation of the project proposals submitted for funding.
- *Stimulating innovation in strategic areas*. In spite of the explicit identification of strategic priority sectors and technology areas in the 2001-06 PECYT, no fully fledged dedicated programmes to foster relevant research and innovation were implemented. Projects supported by the sectoral funds do not really fill this gap. The 2007-12 PECITI also includes sectoral and technological priorities that should be pursued through specific dedicated programmes, notably in terms of support to public/private co-operation. It is to be hoped that the PECITI will be able to deliver what the PECYT did not.
- *Support to new technology-based firms*. This is another weak point in the Mexican policy mix. Only AVANCE and, to a lesser extent, the business accelerators initiative funded by the Ministry of Economy, support the development of research-based innovation activities in high-technology firms. These programmes fulfil an important mission but are underfunded and provide few opportunities for researchers from public research institutions to create high-technology firms or spin-offs. In this regard, more attention and support should be given to the development of financial and prudential products (*e.g.* seed and venture capital, guarantee schemes) adapted to the creation and growth of this category of firms.

Support to public research: improving funding modes, incentives and governance

Resources allocated to public research should increase, but allocation procedures and criteria should meet various criteria to ensure that funded activities contribute efficiently to the generation of knowledge, the training of highly skilled personnel, and the strengthening of the innovation capacity of the productive sector through a leveraging effect on private investment. The criteria should be reflected in the modes of financing research activities, the incentives provided to researchers and research teams, and evaluation mechanisms. They should be aligned with the evolution of the mix of funding mechanisms and the governance structure that support public research institutions.

A better balance should be struck between institutional funding, competitive funding and other sources of funding. A growing share and volume of resources should be devoted to competitive funding through the restructuring of sectoral funds that support basic and applied research. These are presently financed and managed by CONACYT in co-ordination with SEP and other sectoral ministries.

- *Institutional funding.* In line with recognised best practices in other countries, the volume and allocation of institutional funding should be based on the results of periodic evaluations, with emphasis on the quality of research according to academic standards. They should also be based on criteria pertaining to the contribution of researchers and other highly qualified S&T resources to innovation (*e.g.* patents and relations with industry). Moreover, increases in institutional funding should continue to be examined in light of the need to further decentralise academic research activities.
- *Competitive funding.* CONACYT should be solely responsible for this type of funding. One part should be devoted to research projects selected on the basis of criteria of research excellence irrespective of scientific discipline, with an emphasis on collaborative projects. The other part should fund research projects submitted in the framework of research and innovation priority programmes as defined in the PECITI. The source of finance for such projects could be a consolidated fund endowed with the resources previously available under the sectoral funds. In particular, this fund would finance medium-term research and innovation programmes based on public/private partnerships such as those launched in the framework of the AERIs.
- Other sources of finance for public research should be actively sought, in particular for international co-operation under CONACYT agreements. Public research institutions should also be encouraged to develop their own international collaboration networks, and regulatory obstacles that hinder such developments should be removed or lessened.

Another important aspect of policy relating to public research institutions is the training of highly skilled human resources. In this regard, the CONACYT scholarship programme and various recent initiatives to support doctoral programmes and post-doctoral activities seem to go in the right direction and should be maintained.

Finally, there is little doubt that allocations from the federal level should continue to seek a more balanced spatial distribution of the scientific and technological infrastructure. Here, the trend to link the granting of increased institutional resources to PRCs and HEIs at least in part to a regionalisation of their facilities should be maintained if not reinforced.

Reforming the SNI: a long-term challenge

Without the SNI, centrally managed by CONACYT and financed on its budget, the level of excellence of Mexico's research activities and the number and diversity of internationally recognised researchers would not be what they are presently.

Today, this idiosyncratic system, which ensures against brain drain, also presents, as currently operated, both disincentives to increased collaboration with the private sector in innovative activities and longer-term risks relating to the evolution of the age structure of the Mexican research community. While the SNI's role in developing a quality research base and ensuring the attractiveness of research careers should be preserved, reforms should be undertaken to address these challenges. In the longer term, this could lead to the adoption by research institutions of remuneration patterns based on nationally defined standards, but increasingly managed internally, and to institutions' responsibility for the quality and relevance of their research platforms.

Recommendations

Strategic objectives

In an increasingly global competitive environment, in order to maintain productivity growth, alleviate poverty and better respond to pressing social needs, Mexico must pursue sound macroeconomic policies and deepen the structural reforms that have been engaged.

To close the gap in income per capita with the more developed countries and, in the shorter term, to avoid being overwhelmed by the most dynamic emerging economies, Mexico must harness the potential of science and technology. In addition to the urgent improvement of some key framework conditions for innovation (especially in education, competition and basic infrastructure), it needs to pursue political, economic and social objectives:

- Build a more powerful, firm-centred innovation system by significantly increasing public (financial and other) support to innovation which can then leverage private investment in market-pulled innovation.
- Ensure that basic and mission-oriented research is supported only in areas in which critical mass and excellence can be achieved, and use regulatory reform and competitive funding more effectively to strengthen public research on well-defined priority socio-economic needs.
- Pursue the decentralisation of innovation policy while reinforcing state-level management capabilities and carry out strict evaluations, based on a consistent national model, of programmes using federal resources.

Political commitment and social impact

Reaping the economic and social benefits of investment in science and technology takes time. Therefore, sustained political commitment and the visibility of the benefits to the economy and society as a whole are essential to a successful S&T and innovation policy. There are no examples of developed or emerging countries that have succeeded in putting knowledge and innovation at the core of their development strategy without such a long-term commitment.

In Mexico, this commitment has too often not been sustained. The objective of a ratio of R&D to GDP of 1%, to be achieved by the end of the previous administration, was not reached. It may have been unrealistic in the first place, but for the main stakeholders it was at best a missed opportunity, at worst a lack of political commitment. The present administration has made a similar commitment in the PECITI, and in 2008, the S&T budget was increased significantly. This commitment needs to be maintained over time by the executive and legislative branches of government, and the scientific, economic and social outcomes of increased public investment should be brought out in due course in the public arena.

Political commitment also involves consensus building when determining national priorities and setting oversight processes to ensure that these are effectively addressed in the design of innovation policies and reflected both in budgetary appropriations and institutional arrangements for policy implementation.

Policy efficiency

Efficient use of public funds to meet economic and social challenges is a principle of sound budgetary management. Public resources for scientific and technological development compete with other current or investment expenditures in areas which are often perceived as having higher or more immediate priority. Resources to alleviate poverty and develop social and economic infrastructure put strong pressure on the budget. While fiscal reform and additional revenues stemming from energy price increases can open new margins of manoeuvre, the opportunity costs of public resources devoted to S&T policies and the legitimacy of the use of these resources to address market and systemic failures must still be justified by appropriate accounting of expected economic and social returns and *ex post* evaluations.

Improving the overall level of skills while developing HRST

A qualified human resource base is a cornerstone of any innovation-based strategy for socio-economic development. Mexico has a pool of qualified scientists and engineers as a result of efforts over the past two decades, notably the scholarship programmes, .but it is insufficient in light of the country's size and economic potential. The bulk of the labour force is largely unskilled or low-skilled, and in a large majority of firms the lack of managerial skills hinders their capacity to absorb technology and makes them unwilling to take the risks associated with innovation. This is one source of the low demand for highly skilled human resources for S&T. Mexico thus faces both a supply and demand problem in this respect. Along with the issue of educational attainment, which raises concerns that go beyond innovation policy, addressing the mismatch relating to HRST should be high on the S&T policy agenda. In this regard, measures considered in the framework of the PECITI deserve to be financed at an appropriate level and in a sustained manner.

Linking science to innovation

One of the main challenges for Mexico's S&T policy is to foster synergies between curiosity-driven science and market-led innovation through favourable institutional settings and incentive structures. While curiosity-driven research should continue to be supported as a public good, more social accountability should be required, especially when the research aims to solve specific problems. Resource limitations encourage

entrenched behaviour by vested interests and hinder collaboration. An increase in resources for S&T should be made largely conditional on an increase in co-operative behaviour. With the development of consortia and AERIs, the emphasis on co-operation in a number of support programmes, the increased emphasis on competitive funding and self-financing of research institutions, Mexico is moving in that direction. This evolution needs to be pursued and strengthened.

As is increasingly the case in other OECD countries, STI policy should give more emphasis to well-endowed research and innovation programmes that support public/private partnerships for collective goods in priority areas such as health, environment, energy and communication as well as sectors in which Mexico enjoys comparative advantages based on its natural resources. In such programmes the scientific and business communities should share management responsibilities.

In co-operation with state or municipal governments which already have valuable initiatives in this direction, increased emphasis should be given to the promotion of technology or sectoral competitive advantages around clusters that pool scientific, infrastructure and managerial resources and foster innovation through knowledge spillovers and technology diffusion.

Engaging lagging SMEs in innovative activities

Beyond a set of globalised, high-performance domestic or foreign enterprises and a growing but still limited number of smaller innovative ones, Mexico has an overwhelming majority of firms, mostly SMEs, which lack the capacity to make knowledge management and technological development part of their competitive strategy. In many sectors, these firms constitute an untapped mine of productivity, growth and employment, and no lasting success can be expected from innovation policy if this structural duality is not overcome. Notwithstanding the valuable contribution of some existing programmes, essentially those of the Ministry of Economy, with the support of intermediary institutions, and, to a lesser extent, of CONACYT and its PRCs and sectoral ministries, the reinforcement of measures in favour of SMEs must be a strategic objective of Mexico's STI policy, notably in areas such as the development of human resources and the upgrading of technological infrastructures and services.

Guiding principles

The strategic orientations of the 2001-06 PECYT responded to a valid diagnosis of the main weaknesses of the Mexican STI system. However, its largely unfulfilled expectations point to failures, as well as partial successes, from which to draw lessons for guiding principles in the design, governance, funding and implementation of STI policies in the PECITI. These principles should be inspired by best practices in more advanced countries, taking into account the specificities of the Mexican situation.

- *Effective governance.* A prerequisite is political commitment at the highest executive levels of government regarding adequate budgetary appropriations in support of STI activities. This commitment should be reflected in the operation of the governance structure entrusted with the steering of STI policy and its co-ordination with major stakeholders, including ministerial departments whose actions impinge on the framework conditions that affect the performance of the innovation system.

- *Clear and transparent priority setting* should be achieved through the involvement of all major stakeholders, that is, the scientific and business communities and the civil sector. Outcomes should be reflected in planning and budget documents submitted by the government to the legislative branch and widely disseminated to the public upon approval.
- *Dynamic balance between public and private resources devoted to R&D and innovation.* A condition for improved innovation performance by the private sector is access to and collaboration with the public research system. Such collaboration should be funded on the basis of criteria of excellence and the relevance of research activities.
- *Clarification of functional responsibilities.* Following international best practices, the political bodies responsible for defining priorities and for policy design should be distinct from agencies in charge of policy implementation, with the latter accountable to the former.
- *Single agent management.* While co-ordination of various government bodies or different levels of government is necessary for policy design and/or programme funding, single body management of implementation is generally preferable to arrangements involving joint management and funding. These usually entail high transaction costs and complicated or even antagonistic decision-making processes.
- *Critical mass and lean procedures in the delivery of government support.* Multiplication of programmes should be avoided. This is often the result of opacity in policy design, response to vested interests and/or overlapping responsibilities among government agencies. Moreover it often involves high administrative costs, inefficiencies in delivery and it can lead to fragmentation and programmes of less than critical mass.
- *Balanced policy mix*. The policy mix should reflect the importance of various policy priorities and the critical mass necessary for effective programmes. For support to business R&D and innovation, the policy mix should strike an appropriate balance between direct (*e.g.* matching funds) and indirect support measures and sectoral support; it should also take account of the types of market or systemic failures these measures can address. In the case of support to public research institutions, it should strike an appropriate balance between institutional and competitive funding while encouraging access to external resources.
- *Balance between top-down and bottom-up approaches*. Stakeholders such as intermediary institutions and state bodies should contribute to the definition and implementation of programmes that benefit their constituencies. Good practices already adopted (*e.g.* technological infrastructure, technological clusters, AERIs) should be generalised when appropriate.
- *Evaluation and accountability.* Regular evaluation of support programmes and institutions receiving public support should become the norm, with practical consequences for further rounds of support. However, a balance must be struck between the need for periodic adjustments based on evaluations and the stability of support programmes in order to ensure their long-term impact on the behaviour of beneficiaries. Regular audits should also check that budgetary appropriations earmarked for S&T are effectively spent in that area.

Improving governance structures

Given Mexico's institutions and government structure, there is no silver bullet to improve the governance of the STI system.

The creation of a Ministry of Science and Technology (or of Higher Education, Science and Technology), a common practice in OECD countries, would in principle be worth considering. It would be in charge of policy design and entrusted with the power to co-ordinate the whole of the S&T budget and oversee government agencies responsible for policy implementation. CONACYT legitimately aspired to fulfil that function but has not been given the means, and has not been in an institutional position, to do so.

However, the creation of a new ministry seems unrealistic at the present time. Moreover it is politically unlikely that the power that was denied to CONACYT for implementing the PECYT would now be ensured by the granting of ministerial status, especially since it has recently been decided to make the Minister of Economy chairman of the CONACYT Board.

The creation of a new ministry remains nevertheless a valid option to be considered in the future. For the shorter term the most feasible option is an inter-ministerial council chaired by the president and including ministers with management and budgetary responsibility for S&T programmes or institutions.

An effective S&T inter-ministerial council

An S&T council at ministerial level could be entrusted with defining national priorities and ensuring interdepartmental co-ordination of S&T policy orientation and national support programmes. It would be involved in the preparation of the S&T budget. While such a council formally exists – the General Council of Scientific Research and Technology Development – in the framework of the S&T Law, it had fewer prerogatives and essentially did not function under the previous administration.[12]

The current revision of the S&T Law, which extends its scope to innovation, maintains the formal existence of the Council and contains provisions which may help to ensure its more effective functioning, notably the creation of an Intersectoral Committee on Innovation.

The Council should have real influence – or at least a consultative say – on resource appropriations (including all S&T resources beyond those of Chapter 38), and possibly on resource transfers between the federal and state levels. Its oversight responsibilities should also encompass regulatory policies that impinge upon the performance of the STI system, via legislative proposals or a consultative role regarding the impact on innovation of key framework conditions such as competition policy or labour regulations. In this respect it would seem important for the Council to be in a position to review the provisions of existing laws and regulations (*e.g.* the Law on Parapublic Entities, the Law on Public Procurement and the Labour Law) which may presently hinder the efficiency of public research institutions and, more generally, adversely affect the performance of the innovation system.

The Council could be assisted by a tripartite S&T Consultative Board composed of representatives of the scientific and business communities and intermediary institutions. The existing Advisory Forum for Science and Technology (FCCT) instituted by the S&T Law could in principle perform the functions of such as body, but its role and composition should be reconsidered. One the one hand, its membership should be better

balanced between representatives of the academic and the industrial sectors;[13] on the other, it should better manage its dual role of advocacy for S&T and innovation and consensus building among the stakeholders it represents.

The Council would be expected to meet at ministerial level at least once a year to address strategic issues concerning S&T policy and their consequences in terms of budgetary appropriations and legislative or regulatory action. More frequent meetings at lower levels would be devoted to inter-ministerial co-ordination and monitoring of policy implementation.

In addition, and in order to acknowledge and enhance the role of S&T and innovation in Mexico's social and economic development, CONACYT could also become a full member of the Government's Restricted Cabinet which deals with economic matters and competitiveness.

In this institutional setting, S&T planning and budgeting would be distinguished from financing and implementation of competitive programmes, with the latter performed by "means" or financing agencies. However, non-competitive forms of financing would continue to be the responsibility of sectoral ministries, for example mission-oriented STI programmes or projects carried out in the research institutions under their authority, or the institutional funding of basic research by the Ministry of Education.

CONACYT and the Ministry of Economy would have particular responsibilities as the main government bodies responsible for policy implementation and programme funding and because of the complementarity of their actions to support R&D and innovation. The question of their respective roles is therefore important for the governance of the STI system.

An evolving role for CONACYT

In order to ensure stability and avoid disruptions associated with the current practice of rotating chairmanships, the Minister of Economy should chair the CONACYT Board on a more permanent basis. In addition to CONACYT's role in the overall co-ordination of S&T policy, which could be strengthened if its director general reported directly to the president, CONACYT would evolve into a "means agency" with the following main responsibilities:

- Management of competitive funds to finance R&D-intensive projects or programmes including:
  - The *Basic Science Fund* for non-oriented research performed by public research institutions.
  - A limited number of *sectoral funds* in areas corresponding to national technological or sectoral STI priorities and devoted to the financing of medium-term applied R&D and innovation programmes submitted by public research institutions and/or industrial associations. While CONACYT would be responsible for managing these funds, ministries with administrative responsibilities for priority sectors would be involved in programme definition and evaluation of outcomes. Part of the resources allocated to these funds would be explicitly devoted to the medium-term financing of public/private research and innovation partnerships (consortia and AERIs). The effective management of these funds would require streamlining bureaucratic decision and disbursement procedures.

  - The *AVANCE institutional fund*, whenever projects are presented in collaboration with public research institutions.

- Management of the interface with sub-federal entities for the development of STI capacities:
  - Programming and co-financing of *mixed funds* according to national and regional priorities with particular attention to the development of S&T infrastructure for regional innovation systems and technological clusters and increased devolution of project selection and management to the states.

- Public research centres
  - CONACYT would continue to oversee and fund the institutional component of its research centres while encouraging the centres' greater management autonomy (including further progress towards self-financing), closer links with HEIs, or even possible partial or total privatisation for those that primarily provide services.

- Fiscal incentives
  - CONACYT should jointly manage the reformed fiscal incentives instrument with the Ministry of Finance, with particular responsibility for information dissemination, procedural support, ex post control and monitoring and evaluation.

Finally, CONACYT would also keep its oversight and financing responsibilities for the programmes aimed at enhancing international scientific co-operation (FONCICYT) and developing the supply of HRST (*e.g.* postgraduate scholarship and IDEA programmes).

The role of the Ministry of Economy in the promotion of innovation for competitiveness

The Ministry of Economy plays an important role in fostering competitiveness and, like ministries with similar responsibilities in most OECD countries, it should move towards greater emphasis on the promotion of enterprises' innovation capacity building and technological infrastructure. Its actions could be organised along the following lines.

Technological Innovation Trust Fund

This fund would cover the missions presently attributed to the Economía-CONACYT Technological Innovation Fund and support innovation projects submitted by firms, essentially SMEs. Support would be granted through matching funds or grants. Eligible investment expenditures would include R&D costs and technological infrastructure (*e.g.* ICT, logistics, metrology, certification, IPR). Projects should be assessed on the basis of expected returns and supported irrespective of sectors or technological area. Eligibility should be conditional on a market or systemic failure which hinders the development of economically viable innovative activities.[14] The only discriminating factor among projects would be preferential treatment for those carried out in co-operation with PRCs or HEIs.

The fund would develop links with the financial sector through its contribution to the development of venture and seed capital funds and guarantee funds in co-operation with NAFIN. Like innovation agencies in various OECD countries, it could also provide

special incentives for the creation of new technology-based firms. Possibly, this fund could become an autonomous innovation agency able to participate financially in firms it supports. In this case, it would have to receive endowments from the public sector and financial institutions.

Technological infrastructure and diffusion

In liaison with institutions such as INFOTEC, CENAM and IMPI, the Ministry of Economy should develop or strengthen its support for technological infrastructure and diffusion programmes submitted by intermediary institutions or industry associations, notably with a view to the development of innovation clusters and productive networks. This important area of promotion of regional innovation capacities will require strong co-ordination with CONACYT.

Finally, the Ministry of Economy should be endowed with adequate resources for emulating the PROSOFT programme in other priority technology areas, provided that the support is complemented by funding from other sources, including firms, intermediary institutions and local governments, and contributes to the development of sectoral and regional clusters.

Improving the articulation between the federal and state levels

Governance reforms should also concern the design, management and financing of policies and programmes that aim at strengthening STI capacities at state and local levels. This raises several questions.

Co-ordination mechanisms between the federal and state levels that involve CONACYT and state S&T councils should be reinforced with a view to identifying projects that correspond to national priorities, and therefore call for a larger share of federal funding, and those that correspond to state priorities, and therefore imply differentiated funding shares, especially in light of the fiscal reform that increases resource transfers. The more strategic approach currently adopted by CONACYT in the definition and design of projects selected for funding is a good step in that direction which deserves to be developed further.

As noted above, the management and effectiveness of mixed funds have quite often been impaired by lengthy selection and disbursement processes, and, in a number of states, by weak capacity to develop and submit adequate R&D and innovation proposals. The supply/demand balance of mixed funds should be modified to give states more management responsibility for funds allocated to institutions located in their territorial jurisdiction. Decentralisation of policy should be accompanied by decentralisation of management[15] and, to a larger extent than is now the case, by decentralisation of resources. This would greatly reduce the administrative burden borne by CONACYT, as mixed funds would eventually merge with, or contribute to, the state S&T budget for financing projects presented or led by local institutions. The shifting balance of management and financing responsibilities between the federal and state levels would obviously not be the same for all states.

As concerns the strengthening of S&T capacities of less developed states, a mechanism similar to the European Union's Structural Funds for overcoming regional disparities in terms of infrastructure would deserve consideration by the Congress.

Evaluation

Finally, good governance implies regular evaluation exercises with feedback on policy design and financing. In Mexico an embryonic culture of evaluating outcomes has to be further developed, as too many policy assessments tend to be simply a description of resource allocation, a check that procedures have been respected, and sometimes consideration of the quality of management. Too often issues of the effectiveness of the policy instrument *vis-à-vis* its stated objectives and its cost effectiveness are not addressed. Following practices increasingly implemented in other countries, CONACYT and other ministries responsible for the funding of S&T and innovation programmes or projects should develop monitoring and assessment systems based on qualitative and quantitative information and indicators. The rationale of support programmes as well as the expected outputs and outcomes should be highlighted at the outset. Monitoring and *ex post* assessments should provide feedback on policy design and funding.

Specific recommendations

Improve the policy mix in support of business R&D and innovation

- *Reduce the ceiling on budgetary resources devoted to the fiscal incentive system*, shift granting decisions from discretionary to automatic procedures and institute a cap per beneficiary enterprise. Eliminate the multiplicity of selection and eligibility criteria by restricting them to R&D and innovation-related activities without discrimination among sectors or firms. Consider a dual volume/increment system to provide better incentives to innovative SMEs, and a preferential tax credit rate for SMEs. Reduce compliance costs so as not to deter smaller firms. Establish a joint CONACYT/Ministry of Finance Commission entrusted with the definition and implementation of new operating rules for the reformed fiscal incentive system. This should reduce the budgetary cost in terms of foregone revenues.
- In parallel with the reduction of indirect support provided by fiscal incentives, *increase the volume of direct support* to firms through existing (or reformed) competitive support schemes by providing resources in the form of matching funds, subsidised loans or, in certain cases, grants. Give a bonus to collaborative projects. Streamline eligibility criteria. Increase support for developing new technology-based firms, reduce obstacles to their creation and facilitate their access to capital markets. Part of this increase should be financed by the savings incurred by the reform of the fiscal incentive system.[16]
- Link the management of direct support schemes to the strengthening of *contributions from the financial sector* (guarantees, venture and seed capital), notably its public component (NAFIN). Strengthen *project assessment capacity* in support programme management structures.
- Increase the leverage of public research on private investment in R&D in national priority areas through *public/private partnerships for research and innovation* (AERIs).
- Consider *sectoral support programmes* that require matching resources from firms, intermediary institutions and regional governments; use this instrument to

support the development of clusters. Emulate the PROSOFT programme in other priority areas.

- Develop an innovation-friendly *public procurement policy*, based on international good practices and compatible with international agreements, to support innovation in sectors with high social demand (health, energy, transport, environment, education). This would probably require a modification of the public procurement law (*Ley de adquisiciones*).
- Support SMEs' demand for, and access to, *technological services* (metrology, certification) and information, and encourage the development of a competitive public and private supply of these services. Strengthen *technology diffusion* programmes by encouraging collaboration between public institutions and industry associations.
- Strengthen the mission of IMPI with respect to the *diffusion of technological information through easier access to its patent information base* and the provision of services to facilitate patent application and filing procedures.

Strengthen public research and encourage its contribution to innovation

- Consolidate non-competitive *institutional funding of HEIs,* expanding it to cover infrastructure costs. Evaluate outcomes of institutional funding regularly. Use institutional funding to advance the decentralisation of research capacities.
- *Increase the volume and share of competitive funding*, in both basic research and applied R&D and innovation programmes in national priority areas. Give preferential treatment to collaborative research.
- Use the planned IMPI/CONACYT Fund to foster the systematic creation of, or affiliation with, *technology licensing and transfer offices* in public research institutions, including HEIs, in order to promote the diffusion of research results.
- Streamline rules and procedures for *contractual agreements* between public research organisations and the private sector.
- *Consolidate the evaluation criteria used by the SNI* to better account for researchers' innovation-related output.
- Initiate a consultative process involving the administration and the scientific community *on the long-term future of the SNI.*
- *Adopt common governance structures and accountability requirements* in all public research centres; in particular *extend performance agreement* schemes to research centres overseen by sectoral ministries. Review the established performance agreements in the light of other OECD countries' experiences and draw lessons for Mexico.
- Strengthen the move towards *greater management autonomy of PRCs* in terms of investment and personnel. Remove management constraints stemming from the Law on Parapublic Entities that hinder the pursuit of S&T activities, in particular those conducted in collaboration with the private sector. Consider increasing levels of self-financing or even the possibility of privatisation of those more involved in technology development and transfer.

- Entrust the Science Consultative Council and/or the Mexican Academy of Science with the preparation of annual reports on ways in which the scientific community can best address Mexico's social and economic challenges.

Foster the development, insertion and mobility of highly skilled human resources

- Adopt a more strategic approach in the Postgraduate Scholarship Programme by introducing some degree of selectivity in awards.
- Facilitate temporary hiring of postgraduates in PRCs for secondment in industry.
- Strengthen existing programmes that facilitate the *insertion of highly skilled personnel in the business sector* and remove obstacles to the institutional mobility of researchers.[17]

Strengthen regional STI capacity

- In consultation with state S&T councils, develop *a medium- to long-term master plan for federal/state co-operation* on the development of S&T infrastructure.
- Strengthen *regional S&T infrastructures* through institutional funding of HEIs and PRCs.
- Consider the establishment of a "structural fund" specifically dedicated to the *development of S&T infrastructure in less developed states*.
- Use sectoral funds to foster the development of *regional innovation clusters* with matching resources from the states, local governments and industry associations.
- Increase *states' management autonomy* for deciding allocation and disbursement of joint federal/state funds for research and innovation projects.

Concluding remarks

This report argues that Mexico has moved too slowly towards an innovation-fuelled growth path, which, in the short term, would enhance the country's knowledge-based competitiveness and allow it to reap benefits from globalisation similar to those reaped by dynamic emerging economies. In the longer term, such a path would allow Mexico to bridge the wide gap in living standards with wealthier OECD countries.

The report suggests that, as part of a wide and ambitious "national innovation agenda", the Mexican government should urgently increase the priority given to reforms and policies that can enhance capabilities throughout the economy and drive innovation.

It first reiterates the call of other recent OECD reports for reforms in policies that shape framework conditions for innovation, with emphasis on education and competition policies (OECD, 2006a, 2007a, 2007b, 2009a).

Focusing on the role of science, technology and innovation policy *stricto sensu*, whose primary and explicit objective is to enhance innovation capabilities in the public and private sectors, it proposes the following prioritisation and sequencing of government initiatives.

In the short term, the government's increased commitment to fostering innovation should result in:

- Improved governance structures to ensure more effective leadership and coherence in the formulation, implementation and evaluation of relevant policies at federal and state level.
- Sustained budgetary spending in support of R&D and innovation through better designed and managed programmes. In particular, the overall budgetary effort in support of business innovation (defined as the sum of foregone tax revenues and the cost of direct support) should be at least maintained, but a new balance should be found between tax incentives and grants, to the benefit of the latter.

In a longer term perspective, the government should initiate or contemplate other changes in the infrastructure and incentive structures of the Mexican innovation system. As well as the future of the SNI, the position of public research centres and universities in an increasingly firm-centred Mexican innovation system should be re-examined.

Notes

1. See *OECD Reviews of Innovation Policy: China* (OECD, 2008a).
2. The share of self-financing by CONACYT centres reached 35% in 2006.
3. As in the case of the National Laboratory of Genomics for Biodiversity (LANGEBIO) in Guanajuato.
4. And behind countries such as China (1.43), Brazil (1.0), South Africa (0.9) and Chile (0.7).
5. With 20% growth for CONACYT appropriations.
6. 15 sectoral priorities for the Economía-CONACYT Fund.
7. All sectoral funds except SEP-CONACYT and Economía-CONACYT.
8. 4.2% of the CONACYT budget for 2002-06.
9. However, funding increased in 2008 with MXN 350 million allocated to so-called "strategic projects", with MXN 30 million minimum per project.
10. Between 1997 and 2006 Mexico's share in the world total scientific production grew from 0.52% to 0.75%.
11. As measured by the number of citations per scientific article.
12. It met only three times in six years.
13. Presently the Forum is composed of 14 representatives of the academic sector and three members of industry.
14. These constraints can be diverse: access to finance, access to proprietary technology, availability of qualified personnel, etc.
15. This, as well as federal/state co-ordination, would be facilitated by more homogeneous state administrative structures regarding the administrations responsible for S&T policy and programmes.
16. The calculation of these savings should take into account the residual costs of tax credits.
17. This may involve a reform of the labour law as it applies to the statute of public research institute personnel.

Évaluation générale et recommandations

Encourager l'innovation pour stimuler le développement socioéconomique du Mexique

Ces dix dernières années, le Mexique a beaucoup progressé vers la stabilité macroéconomique et a lancé d'importantes réformes structurelles pour ouvrir davantage son économie aux échanges et à l'investissement, et pour améliorer le fonctionnement des marchés de biens et de services. Cela étant, le potentiel de croissance du PIB est bien trop faible pour combler le large écart de niveau de vie qui existe entre le Mexique et les pays de l'OCDE les plus riches, et pour remédier à une pauvreté encore largement répandue. Le pays est confronté à une concurrence accrue de la part d'autres grandes économies émergentes qui sont en train de renforcer plus rapidement que lui leurs capacités pour tirer parti de la mondialisation.

L'une des principales causes de cette situation est que les décideurs mexicains – publics et privés – ont mis du temps à prendre pleinement conscience que l'investissement dans l'innovation était un important moteur de la croissance et de la compétitivité. Or, la perte de compétitivité dans les activités fondées sur le savoir peut être à l'origine d'un cercle vicieux de plus en plus difficile à enrayer, car la faiblesse des capacités d'innovation limite les retombées internationales de la hausse des investissements des concurrents dans le savoir. Pour obtenir une croissance économique plus forte et plus durable, le gouvernement mexicain doit montrer une volonté sans faille dans la poursuite de son travail de réforme sur un large front, motivé par un sentiment d'urgence et inspiré par une vision mobilisatrice.

La crise économique mondiale ne doit pas décourager ou amoindrir ces efforts. "Une forte performance en matière d'innovation est plus importante que jamais dans le contexte actuel. Les plans de relance doivent être conçus de façon à stimuler l'innovation". (« Réponse stratégique de l'OCDE à la crise financière et économique : Contributions à l'effort global », OCDE, 2009).

Pour permettre au pays de s'engager plus résolument sur la voie de l'innovation et ainsi de mieux répondre aux besoins et aspirations croissants de sa population (hausse du niveau de vie, amélioration de la santé, renforcement de la sécurité et préservation de l'environnement, enrichissement de la vie culturelle, etc.), il doit orienter l'ensemble de ses politiques dans ce sens et apporter son soutien aux initiatives des entreprises privées et de la société civile afin d'encourager toutes les formes de créativité et d'innovation, tant individuelles que collectives. Augmenter l'investissement dans le capital humain – en particulier dans l'éducation – et favoriser l'innovation dans le secteur privé seront indispensable pour atteindre cet objectif. Le programme spécial pour la science, la technologie et l'innovation (PECITI), qui a été approuvé récemment, est une étape positive dans cette direction. Il devra toutefois bénéficier de moyens budgétaires adaptés et être complété par des réformes de gouvernance portant sur la structure institutionnelle

chargée de la conception, du financement, de la mise en œuvre et de l'évaluation des politiques.

Performances économiques récentes et nouveaux défis

La situation du Mexique a considérablement évolué depuis les réformes entreprises au cours des vingt dernières années pour libéraliser l'économie et améliorer la gestion macroéconomique. Le pays a beaucoup progressé vers la stabilité macroéconomique : depuis la crise du peso en 1995, son PIB a enregistré une croissance raisonnable, de l'ordre de 3.6 % par an en moyenne. Ces dernières années, en revanche, la croissance mexicaine a été plus faible que celle des économies les plus dynamiques d'Amérique latine (le Brésil et le Chili), et elle n'a pas été suffisante pour amener le PIB par habitant au même niveau que celui des économies de l'OCDE les plus avancées. En fait, depuis 2000, la hausse de la productivité du travail mexicaine est l'une des plus faibles de tous les pays de l'OCDE. C'est pourquoi une priorité vitale de la politique économique du Mexique doit être de favoriser les gains de productivité et de créer les conditions d'une croissance accrue et durable de l'économie.

L'un des principaux moteurs de la croissance économique du Mexique a été l'ouverture du pays au commerce international et à l'investissement étranger. C'est en grande partie grâce aux débouchés créés par l'Accord de libre-échange nord-américain (ALENA) et les programmes Maquila/Pitex que le Mexique a pu enregistrer une forte augmentation de ses exportations de produits manufacturés, principalement à destination des États-Unis. La proportion des échanges dans le PIB (produit intérieur brut) a doublé en 20 ans, avec une hausse de la part du secteur manufacturier (qui est passée de 20 à près de 85 %) et une spécialisation accrue des activités d'exportation dans les secteurs (ou les produits) qui sont intégrés dans les chaînes de valeur mondiales. Toutefois, malgré les effets positifs initiaux des importations de technologies et de la réallocation des facteurs de production parmi et entre les secteurs concernés par l'intégration commerciale et l'augmentation des investissements directs étrangers (IDE), les récentes performances commerciales du Mexique s'expliquent davantage par des coûts de main-d'œuvre relativement faibles que par une productivité et une capacité d'innovation élevées et croissantes.

La préférence pour les technologies importées au détriment des innovations nationales – qui s'est traduite par une capacité d'absorption insuffisante de la part des sociétés mexicaines – a limité la diffusion et le transfert de technologie via les échanges intrabranches et les IDE. Au Mexique, les secteurs dits de pointe n'investissent pas beaucoup plus (en proportion de leur valeur ajoutée) dans la R-D et l'innovation que les secteurs à faible intensité technologique. Ils n'ont, par conséquent, pas de rôle moteur dans la propagation du savoir et des technologies dans l'ensemble des entreprises, ou la constitution de chaînes de valeur fondées sur la technologie.

La croissance fragile de la productivité et la faible performance globale du secteur des entreprises en matière d'innovation (mesurée, par exemple, par les indicateurs d'investissement dans l'innovation, ainsi que par la création de sociétés tournées vers la technologie), mais aussi la hausse des coûts unitaires relatifs de la main-d'œuvre mexicaine depuis la fin des années 90, ont eu tendance à éroder la compétitivité internationale du Mexique, en particulier par rapport aux économies émergentes telles que la Chine : celle-ci a, dès 2003, remplacé le Mexique en tant que deuxième partenaire commercial des États-Unis derrière le Canada, et a considérablement accru ses

investissements dans la science, la technologie, l'innovation et le capital humain au cours des dix dernières années[1].

L'importance croissante de l'innovation et des politiques de promotion de l'innovation pour une croissance élevée et durable

La hausse du PIB par habitant est le plus gros défi stratégique car il est la condition indispensable pour réduire l'ampleur de la pauvreté. L'innovation peut, à cet égard, jouer un rôle très important en favorisant l'amélioration de la productivité. Elle est également une condition essentielle pour retirer le maximum d'avantages de l'intégration du Mexique dans l'économie mondiale, car elle augmente la capacité des entreprises mexicaines à absorber et à adapter les technologies provenant de l'étranger, ainsi qu'à affirmer leur compétitivité sur le marché mondial.

L'expérience des pays de l'OCDE montre que les performances des systèmes d'innovation ne dépendent pas uniquement de la mise en œuvre de politiques spécifiques axées sur la promotion de la science, de la technologie et de l'innovation (STI), mais qu'elles dépendent aussi de conditions plus générales qui sont loin d'être réunies au Mexique :

- reconnaissance politique de l'importance des investissements dans le savoir, et affectation d'enveloppes budgétaires en conséquence ;
- dispositifs de gouvernance qui permettent la participation des parties prenantes à la définition des orientations et des priorités, ainsi qu'une mise en œuvre efficace des politiques correspondantes ;
- assortiment de mesures permettant de relever les défis du système d'innovation, et flexibilité institutionnelle assurant l'adaptabilité de cet assortiment ;
- existence de conditions-cadres définissant l'environnement des entreprises et influant de manière positive sur les incitations et les capacités de ces dernières à innover (par exemple, accès aux capitaux, réglementation de la concurrence et régime de propriété intellectuelle) ;
- infrastructure physique et des TIC facilitant l'implantation et le développement de plateformes d'investissement dans l'innovation et le savoir ;
- dernier aspect, mais non le moindre, disponibilité d'une main-d'œuvre bien formée, et efforts continus pour accroître le stock de capital humain qualifié.

Le Mexique doit progresser sur tous ces points pour qu'une augmentation de l'investissement (public et privé) dans le savoir contribue réellement à la fois à améliorer la capacité d'innovation de son économie, et aussi à résoudre les principales difficultés sociales de la population mexicaine.

Le système d'innovation mexicain : principaux défis pour les pouvoirs publics

Comme l'attestent l'adoption des lois de 1999 et 2002 sur la science et la technologie (S-T) et de la nouvelle loi organique du CONACYT (Conseil national de la science et de la technologie), ainsi que l'approbation du Programme spécial 2001-06 pour la science et la technologie (PECYT), un certain nombre d'initiatives ont été prises pour améliorer la conception et la mise en œuvre de la politique mexicaine de STI. Bien que quelques

résultats positifs soient à noter, les objectifs n'ont dans l'ensemble pas été atteints, et des lacunes structurelles continuent d'altérer le fonctionnement du système d'innovation. Tenant compte des précédents échecs et succès de la politique, le PECITI de 2008-12 est le signe encourageant d'une volonté de résoudre ces faiblesses structurelles en mettant à profit les atouts inexploités dont dispose le Mexique sur le plan social et économique (voir le tableau récapitulatif ci-contre).

Des lacunes structurelles et institutionnelles continuent de nuire au système d'innovation

L'amélioration des pratiques de gouvernance n'a pas été suffisante pour permettre une mise en œuvre efficace des actions prioritaires définies dans le PECYT. Le pouvoir de coordination conféré officiellement au CONACYT dans la loi sur la science et la technologie de 2002 n'a pas pu être exercé effectivement, que ce soit dans le cadre de la préparation du budget de la science et de la technologie ou dans celui de la définition des orientations. La distinction entre les organes politiques chargés de l'élaboration de la politique et les organes administratifs chargés de sa mise en œuvre est restée floue. La multiplication d'instruments de soutien mal financés, au service de communautés divisées et gérés de façon trop bureaucratique, ont dilué l'action gouvernementale, qui n'a donc pu avoir qu'un effet positif limité sur les performances du système d'innovation mexicain.

Les ressources consacrées aux activités de R-D sont restées en deçà des objectifs déclarés. Selon les indicateurs d'innovation disponibles, le système scientifique, technologique et d'innovation du Mexique est en retard par rapport aux autres pays de l'OCDE et certaines des économies émergentes importantes. Le Mexique se situe à l'avant-dernier rang des pays de l'OCDE pour le pourcentage des dépenses de R-D par rapport au PIB. Malgré l'augmentation des investissements de R-D par le secteur industriel, la R&D est restée pour l'essentiel l'apanage du secteur public. Le nombre de dépôts de brevets par habitant ou par unité de R-D figure parmi les plus faibles de la zone OCDE. La balance des paiements technologiques affiche un déficit énorme et persistant – les exportations représentent moins de 10 % des importations – et les accords de licences technologiques entre les institutions mexicaines sont extrêmement rares.

Malgré de récents progrès, la formation des ressources humaines dans le domaine des sciences et des technologies demeure insuffisante, et la faible propension des entreprises à recruter ce type de personnel dissuade d'en former davantage. Cela constitue un obstacle sérieux à la diffusion du savoir et à la capacité d'innovation du secteur des entreprises.

En dépit des efforts méritoires qui ont été déployés pour renforcer l'infrastructure technologique et améliorer l'accès aux services correspondants, la grande majorité des petites et moyennes entreprises (PME) mexicaines n'ont toujours pas les moyens de mettre en place et de gérer des activités novatrices, en partie à cause du faible niveau de qualification de leur main-d'œuvre et de leur personnel d'encadrement.

Enfin et surtout, les relations entre l'industrie et la communauté scientifique demeurent très peu développées, à la fois en termes de flux de savoir – y compris lorsqu'ils se matérialisent dans le capital humain – et de collaboration concernant les projets d'innovation fondés sur des connaissances universitaires.

Tableau récapitulatif : Analyse SWOT du système d'innovation mexicain

Points forts	Points faibles
• Ensemble d'universités (à la fois publiques et privées) et de centres de recherche publics de première qualité • Réserve importante de scientifiques qualifiés • Marché intérieur relativement vaste • Ensemble d'entreprises mondialisées et faisant preuve de compétitivité internationale • Pôles d'excellence régionaux et sectoriels • Attraits de certains secteurs pour les IDE • Vaste expérience de certains organismes publics en ce qui concerne la promotion de la STI et le développement économique • Ressources naturelles importantes • Diversité culturelle source de créativité	• Gestion peu efficiente du système d'innovation national • Ensemble de mesures déséquilibré • Faiblesse de l'enveloppe budgétaire et de l'engagement politique à l'égard de la STI • Gestion bureaucratique des programmes de soutien • Très faible coopération entre les secteurs public et privé ; faible mobilité des ressources humaines dans le domaine des sciences et technologies • Mauvaises performances du système éducatif ; main-d'œuvre peu qualifiée • Infrastructure technologique insuffisante • Faible capacité d'absorption technologique pour la grande majorité des petites et moyennes entreprises (PME) • Mauvaise connaissance des droits de propriété intellectuelle • Concurrence peu développée dans certains secteurs ; obstacles à la création d'entreprises ; mauvaise gestion des entreprises du secteur industriel public • Priorité aux technologies importées • Marchés financiers inadaptés à l'investissement axé sur l'innovation
Possibilités	**Risques**
• Jeunesse de la population • Proximité géographique avec les États-Unis • Développement naissant d'une importante réserve d'ingénieurs • Demande croissante de biens sociaux à forte technicité • Participation à des réseaux de connaissances et des plateformes technologiques d'envergure mondiale • Diversification de la production et du commerce vers les biens et les services présentant une plus grande technicité • Stratégies des PME davantage axées sur l'innovation • Diffusion technologique autour des entreprises multinationales, conformément aux chaînes de valeur mondiales de l'innovation • La biodiversité comme possible atout économique	• Concurrence accrue de la part des économies émergentes • Expansion de plus en plus rapide de nouveaux horizons scientifiques et technologiques • Intensification de la concurrence mondiale des cerveaux • Grande dépendance économique et technologique à l'égard des pays à faible croissance • Rareté des liens avec les régions émergentes dynamiques connaissant un développement économique, scientifique et technologique rapide • Concentration des capacités d'innovation au niveau régional

Effets positifs mais limités de certaines initiatives récentes

Au cours des dernières années, un certain nombre d'initiatives ont été prises ou expérimentées avec un certain degré de succès, quoique limité. Certaines ont eu des effets relativement positifs sur les performances en matière d'innovation, et doivent à ce titre être poursuivies. D'autres ont contribué à renforcer les capacités d'innovation mais doivent être repensées au niveau de la gestion et/ou du financement afin de gagner en efficacité.

Un rôle plus proactif pour les centres de recherche publics

Ces dernières années, les réformes simultanées de la gouvernance et du financement des centres de recherche publics a conduit ces derniers à adopter une approche plus proactive en ce qui concerne les décisions stratégiques. La mise en œuvre « d'accords de performances » a institué un système de gouvernance qui est fondé sur l'évaluation et l'obligation d'accroître la transparence, et qui oblige les centres à accorder la priorité à la recherche et aux activités technologiques, ou aux programmes présentant une utilité sociale ou économique reconnue. Dans le même temps, la réforme du financement a obligé la plupart des centres de recherche publics à accroître leur part d'autofinancement dans leur budget global[2].

Ces aménagements ont conduit les centres de recherche publics à modifier l'orientation et l'organisation de leurs activités en intensifiant leur coopération avec le secteur privé et avec d'autres entités auxquelles ils fournissent des services technologiques et de R-D. Un autre facteur ayant contribué à cette évolution a été le fait que les projets supposant une coopération entre les centres de recherche publics et les entreprises se sont vus souvent accorder la priorité pour l'octroi d'aide financière par la CONACYT et d'autres organismes publics tels que le ministère de l'Économie, dans le cadre de programmes ayant un autre objectif premier.

Encourager les entreprises à investir dans les activités d'innovation

Pendant la période de mise en œuvre du PECYT (2001-06), plusieurs initiatives incluant des mesures de soutien directes et indirectes ont contribué à encourager l'investissement du secteur privé dans les activités d'innovation. Ces initiatives ont entraîné une forte augmentation à la fois du volume des activités de R-D des entreprises ainsi que du pourcentage de la R-D totale financé ou assuré par le secteur productif, pourcentage qui reste toutefois toujours inférieur à la moyenne de l'OCDE.

Parmi ces mesures de soutien, la plus importante a été l'incitation fiscale mise en place par le CONACYT en 2002, qui a représenté plus de 75 % de l'aide totale en 2006. Toutefois, au-delà de ses effets positifs significatifs sur l'investissement privé dans l'innovation, l'efficience de cette mesure a été discutable, notamment en ce qui concerne sa gestion, la concentration de ses bénéfices, ou encore son poids disproportionné par rapport à d'autres mesures de soutien plus directes.

Malgré quelques exceptions, les mesures de soutien directes mises en œuvre par l'administration mexicaine pour stimuler l'investissement privé dans les activités d'innovation ont eu un succès limité. Dans un trop grand nombre de cas, comme par exemple celui des fonds d'investissement sectoriel, l'efficacité des mesures a été réduite par leur ciblage restreint, la multiplicité des critères d'obtention, les lourdeurs de gestion et les problèmes de coordination. Au titre des exceptions, il convient de mentionner les

programmes qui ont été gérés et financés par une seule institution, comme le récent programme AVANCE du CONACYT – qui s'intéresse aux nouvelles entreprises à vocation technologique – le programme PROSOFT qui, financé par le ministère de l'Économie, concerne les applications des TIC, et enfin le fonds pour les PME du ministère de l'Économie qui, via son volet sur l'innovation et le développement technologique, finance les initiatives entrepreneuriales soutenues par des institutions intermédiaires intervenant comme négociateurs.

Dans les États les plus avancés économiquement de la République fédérale mexicaine, les autorités locales ont également joué un rôle actif en promouvant le développement des pôles d'activités spécialisés et en renforçant l'infrastructure scientifique et technologique devant servir à les soutenir. Dans la plupart des cas, les programmes qui ont été couronnés de succès sont ceux qui ont bénéficié non seulement d'une approche bien coordonnée entre les autorités et les institutions locales et fédérales, mais aussi d'une forte participation des associations professionnelles et des organisations intermédiaires, y compris dans l'apport d'un financement.

Disponibilité de ressources humaines très qualifiées dans le domaine des sciences et des technologies

Le Mexique n'a toujours pas rattrapé son retard par rapport à la plupart des pays de l'OCDE et des économies émergentes comme le Brésil, le Chili et la Chine en ce qui concerne la disponibilité de ressources humaines très qualifiées dans le domaine des sciences et des technologies. Il faut toutefois reconnaître que, malgré l'instabilité de la politique en matière de science, de technologie et d'innovation menée par le Mexique au cours des vingt dernières années, le CONACYT a eu le mérite de ne pas relâcher ses efforts, tout au moins au plan budgétaire, pour développer ces ressources.

Le programme de bourses de l'enseignement supérieur qui a été lancé au début des années 80 est aujourd'hui la principale source de financement pour les Mexicains souhaitant suivre des études de troisième cycle dans leur pays ou à l'étranger. Ce programme a bénéficié à ce jour à plus de 150 000 étudiants.

Bien que l'ensemble des efforts doivent être poursuivis, les initiatives mettant l'accent sur l'offre doivent être complétées par des mesures visant à intensifier la demande du secteur privé, comme cela est actuellement prévu par le programme IDEA du PECITI. Il conviendrait par ailleurs, compte tenu de l'évolution de la structure de la demande de ressources hautement qualifiées, de prévoir pour l'attribution des bourses des critères de sélection davantage fondés sur les disciplines.

Infrastructure scientifique et technologique

La mise en place et l'entretien d'une infrastructure scientifique et technologique élaborée ont longtemps été relégués au dernier rang des priorités, y compris en termes de financement, en raison notamment de sévères restrictions budgétaires. Contrairement aux pays de l'OCDE plus avancés, le Mexique n'investit pas suffisamment dans l'équipement et l'infrastructure des sciences et technologies, que ce soit en proportion des dépenses de R-D ou du nombre de chercheurs qualifiés.

Cette situation n'a commencé à se débloquer que récemment, avec la multiplication par deux des investissements fédéraux entre 2002 et 2006, qui a permis d'amorcer la décentralisation des capacités scientifiques et technologiques. Dans un certain nombre de

cas, les administrations des États ont ajouté leur contribution à celle de l'administration fédérale[3].

Défis à relever

Malgré les quelques résultats positifs des réformes institutionnelles et autres initiatives engagées dans le cadre du PECYT, la correction des lacunes structurelles chroniques du système d'innovation mexicain n'a guère progressé. Ces lacunes continuent de faire obstacle à la création d'un cercle vertueux dans lequel la production de savoir ainsi que sa diffusion et son utilisation se renforcent mutuellement et génèrent des effets positifs en termes de croissance économique et de bien-être social. L'élimination de ces lacunes représente le défi essentiel à relever en ce qui concerne la conception, la gouvernance, le financement et la mise en œuvre de la politique future du Mexique en matière de S-T et d'innovation.

Augmenter l'investissement public dans la science, la technologie et les activités de R-D

Aucun pays n'a réussi à améliorer de façon décisive ses performances économiques en matière d'innovation sans un investissement public constant dans les actifs scientifiques et technologiques corporels et incorporels. Au Mexique, l'augmentation du volume des ressources publiques consacrées à la R-D et le développement des capacités d'absorption (pour permettre une utilisation efficace de ces ressources) sont deux conditions indispensables pour enclencher un cercle vertueux dans lequel les investissements publics et privés en faveur de l'innovation se complètent et garantissent une meilleure rentabilité sociale des investissements dans le savoir.

À cet égard, et malgré l'objectif fixé par la loi sur la science et la technologie de 2002 – à savoir, que les dépenses de R-D représentent 1 % du PIB en 2006 –, les performances du Mexique demeurent extrêmement faibles, avec un ratio de 0.49 % en 2007, ce qui place le pays à l'avant-dernier rang du classement OCDE[4]. Bien que ce taux traduise un léger progrès par rapport à 2002 (0.4 %) – principalement grâce au secteur des entreprises – les dépenses fédérales consacrées à la science et à la technologie sont restées pratiquement inchangées en valeur constante depuis les six dernières années, ce qui signifie que leur part dans le budget fédéral et le PIB a baissé. En fait, par rapport aux autres pays, le gouvernement mexicain affecte très peu de ressources à son système de recherche public. Pourtant, une comparaison internationale montre que dans les pays les plus performants, la part du secteur privé dans les dépenses totales de R-D n'augmente pas de façon durable quand les dépenses publiques de R-D diminuent en valeur absolue.

Cette évolution des dépenses publiques et privées constitue certainement un obstacle à la consolidation du système d'innovation mexicain. Le renforcement des liens et de la collaboration entre les secteurs public et privé suppose la mise en place d'interactions entre deux partenaires dynamiques. Or, cela n'est pas possible si le volume des ressources attribuées à l'un des deux stagne ou diminue.

Dans ce contexte relativement morose, l'on ne peut que se réjouir du signal encourageant que représentent les enveloppes budgétaires allouées récemment à la science et à la technologie, dont le montant a augmenté de 16.2 % entre 2007 et 2008[5].

Renforcer les programmes de soutien et la coordination des politiques

Malgré les bonnes intentions du PECYT – dont le but était de faire en sorte que la politique scientifique, technologique et d'innovation soit plus clairement orientées dans ses objectifs et plus cohérente dans la mise en œuvre des mesures de soutien – la gestion des programmes d'aide directe a trop souvent pâti de sérieuses défaillances de la gouvernance, notamment le manque de coordination, la dispersion des responsabilités et la fragmentation. En fait, au cours de la période de mise en œuvre du PECYT, les programmes de soutien ont été organisés moins en fonction des objectifs d'action que des compromis qui avaient été conclus entre le CONACYT et les ministères des différents secteurs au sujet des responsabilités en termes de gestion et de financement. Le résultat a été un nombre anormalement élevé de programmes de soutien insuffisamment financés, avec des critères d'obtention trop nombreux et des procédures décisionnelles extrêmement lourdes. Que ce soit seul ou en collaboration avec d'autres organismes (de l'administration fédérale ou des États), le CONACYT s'est retrouvé à gérer plus de 60 fonds ou programmes de soutien. Cette situation est à l'origine d'un important manque d'efficacité dû aux coûts de transaction, aux rivalités administratives et aux retards causés par l'excès de bureaucratie.

L'exemple le plus flagrant de ce manque d'efficacité est l'existence de 17 fonds d'investissement sectoriel qui sont financés et gérés conjointement par le CONACYT et les ministères des différents secteurs afin de développer les capacités scientifiques, technologiques et innovantes en fonction des « besoins stratégiques » du « secteur » participant. Les crédits qui leur sont affectés sont relativement faibles, avec une moyenne de moins de 100 millions USD par an au total. Par ailleurs, les priorités de financement sont souvent définies avec un très grand niveau de détail[6], ce qui fausse le processus de sélection.

Le taux de rejet est élevé, ce qui peut s'expliquer par le nombre de demandes trop élevé par rapport aux fonds disponibles, le peu de qualification des candidats, la faible pertinence des projets, les conflits administratifs et/ou le manque de clarté des critères. Compte tenu des sommes restreintes que ces fonds peuvent allouer à chacun projet individuel, le taux élevé de refus semble impliquer que la sélection des projets est extrêmement coûteuse sur le plan administratif.

Pour des besoins d'efficience, on pourrait légitimement remplacer les fonds d'investissement sectoriel dédiés à la recherche appliquée[7] par des programmes prioritaires par secteur, financés sur une base concurrentielle à l'aide de crédits d'un montant plus élevé prélevés sur les budgets de science et de technologie des ministères correspondants. Cela se rapprocherait des pratiques qui sont de plus en plus observées dans les autres pays de l'OCDE, où la définition des priorités s'accompagne de la constitution d'un budget dont les ressources provenant de plusieurs sources sont allouées aux propositions les plus intéressantes par une « agence de moyens » ayant une mission de gestion.

Les 32 fonds mixtes, qui sont gérés conjointement par le CONACYT et les organismes publics des États et qui se sont développés progressivement depuis 2001, ont été conçus pour aider à dynamiser la recherche et/ou l'innovation au niveau régional, ainsi qu'à créer un lien entre les politiques scientifiques, technologiques et d'innovation et les programmes de soutien fédéraux et régionaux.

Bien que ces fonds représentent en principe un bon moyen de coordination entre le gouvernement fédéral et les États, leur bilan n'est à ce jour pas très satisfaisant :

- Ils ont souvent pâti de l'absence d'une demande clairement articulée de la part des États, en raison en partie d'une coordination inefficace entre les parties prenantes, en particulier dans les États moins développés. Ils ont dans l'ensemble été plus utiles pour les centres de recherche et les établissements d'enseignement supérieur installés au niveau local, dont les intérêts scientifiques et technologiques sont bien ciblés.
- Les sommes allouées étaient généralement assez faibles[8] et ont servi à financer un nombre réduit de projets ayant peu d'effets sur la capacité d'innovation régionale.[9]
- Leur gestion et leur efficacité ont souvent été compromises par la lenteur des processus de sélection et de décaissement des crédits, ainsi que par l'incapacité d'un certain nombre d'États à concevoir et proposer des projets de R-D et d'innovation intéressants.

La plupart des pays qui ont mis en place des fonds cofinancés et gérés par des organismes publics différents se sont le plus souvent heurtés à des problèmes de mise en œuvre. Le Mexique ne fait pas exception à la règle, et outre des ressources plus abondantes, ce sont des règles de gestion plus claires et plus efficaces qui sont requises. Les bénéficiaires sont généralement d'accord sur le fait qu'en plus de leurs finances restreintes, les fonds mixtes et les fonds d'investissement sectoriel ont pour inconvénients une gestion peu efficiente et une lenteur dans le versement des sommes aux projets sélectionnés.

Contrairement aux résultats mitigés des fonds mixtes et des fonds d'investissement sectoriel, les autres instruments mis en place par l'administration mexicaine pour encourager la R-D, l'innovation ou le développement technologique se sont avérés plus efficients sur le plan de la gestion et de la coordination, et plus efficaces en termes de résultats. Comme cela a été indiqué plus haut, les exemples les plus représentatifs sont notamment le programme AVANCE du CONACYT, le programme PROSOFT et le fonds pour les PME – qui sont tous les deux financés et gérés par le ministère de l'Économie – et, avec certaines réserves toutefois, le système d'incitation fiscale à la R-D, qui est géré par le CONACYT en collaboration avec les ministères des Finances, de l'Économie et de l'Éducation.

Améliorer les performances de la recherche universitaire et favoriser les liens entre les centres de recherche publics et l'industrie

Au cours des dix dernières années, dans un contexte de quasi-stagnation des ressources, la productivité du système scientifique mexicain – mesurée par les performances et la pertinence des activités scientifiques – s'est nettement améliorée. La production scientifique a considérablement gagné en volume[10] ainsi que, dans une moindre mesure, en qualité[11]. Cela est dû en grande partie au SNI qui, depuis sa création en 1984, a joué un grand rôle dans la création d'une forte communauté de chercheurs qualifiés dont la sélection, la promotion et les récompenses (sommes non imposables s'ajoutant à leur rémunération) dépendent de critères fondés sur la quantité et la qualité de leurs travaux scientifiques.

Cela étant, la recherche publique menée dans les établissements d'enseignement supérieur mexicains présente toujours d'importantes lacunes qui limitent sa capacité à

générer du savoir et à former un nombre suffisant de professionnels hautement qualifiés pouvant contribuer efficacement à la résolution des problèmes sociaux et au renforcement de la capacité d'innovation du secteur productif. De surcroît, la recherche universitaire est encore très centralisée, ce qui empêche les transferts de connaissances.

Le système d'incitations pécuniaires instauré par le SNI s'appuie sur l'évaluation des personnes et le décompte des publications de travaux scientifiques. Il n'incite pas à mener des projets à long terme ou des travaux de recherche pluridisciplinaires sur des questions difficiles qui peuvent s'avérer bénéfiques en termes d'innovation. Les réalisations technologiques ne bénéficient pas de la même reconnaissance que les résultats scientifiques publiés, ce qui n'encourage pas la coopération avec l'industrie et fait obstacle à la mobilité des chercheurs entre l'université et le secteur industriel. Par ailleurs, l'effet combiné des systèmes de rémunération du SNI et de pension sur les décisions de départ à la retraite sera probablement un vieillissement de la communauté scientifique, qui pourrait s'avérer extrêmement nuisible à sa productivité future en termes de rendement, d'originalité et de qualité.

Dans un système d'innovation, l'un des principaux facteurs de cohérence et de dynamisme est l'intensité et l'ampleur des échanges de connaissances entre le monde scientifique et l'industrie. Ces dernières années, de nombreux centres de recherche publics et quelques établissements d'enseignement supérieur ont renforcé leur coopération avec le secteur des entreprises via des travaux de recherche conjoints consacrés au développement de produits et de processus, et via la prestation de services technologiques. D'un autre côté, des initiatives concluantes, quoique d'ampleur limitée, ont été lancées par des entreprises ou des secteurs sociaux pour se procurer du savoir auprès des organismes de recherche dans le but de renforcer leurs activités d'innovation. Il n'en demeure pas moins que le faible niveau d'échange de connaissances entre le monde scientifique et l'industrie est l'une des principales lacunes du système d'innovation mexicain. Cette situation peut s'expliquer par un certain nombre de facteurs :

- Du côté de la demande, le manque de personnel hautement qualifié dans une grande majorité d'entreprises, ainsi que la fragilité des dispositifs de transfert de technologies constituent des obstacles à l'absorption du savoir des organismes de recherche – et à une interaction efficace avec eux – pendant les premières étapes de développement des produits ou des processus. À cet égard, le programme IDEA, qui a été lancé récemment pour encourager l'insertion dans les entreprises de professionnels des S-T très qualifiés, est une initiative très utile. Le programme mérite d'être étendu en prévoyant un assouplissement et une décentralisation de sa mise en œuvre.

- Du côté de l'offre, le fait que le SNI récompense essentiellement les publications scientifiques n'incite pas les chercheurs à instaurer une collaboration avec les entreprises, et les obstacles à la mobilité de ces chercheurs d'une institution à une aggrave les conséquences. Au niveau institutionnel, la coopération se met progressivement en place, encouragée par exemple dans le cas des centres de recherche publics par la tendance à l'autofinancement croissant. L'importance prise par l'innovation fondée sur la science commence à influencer les programmes de recherche des centres publics et des établissements d'enseignement supérieur avancés tels que le Cinvestav, et à encourager la collaboration avec les entreprises dotées de moyens de recherche. Le renforcement de la capacité des organismes de recherche publics à développer, protéger et gérer la propriété intellectuelle permettrait également accélérer cette évolution.

- Sur le plan institutionnel, malgré les initiatives des institutions intermédiaires publiques ou privées telles qu'Infotec, Cenam, Impi, Fumec ou Produce, les mécanismes de diffusion de la technologie restent peu développés, et l'accès aux informations et aux services technologiques est trop rarement facilité. Le manque d'institutions intermédiaires et d'organismes de certification privés constitue un autre frein à la diffusion de la technologie et à la collaboration.

Pourtant, la plupart des instruments d'action qui encouragent aujourd'hui au Mexique la R-D, l'innovation et le développement technologique prévoient notamment comme critère de sélection des projets celui de la collaboration entre les secteurs public et privé. Malheureusement, le traitement préférentiel réservé aux projets de collaboration n'a pas donné les résultats escomptés, ce qui laisse à penser que des approches plus directes ou des mesures d'incitation conçues spécifiquement pour renforcer les liens entre le monde scientifique et l'industrie sont nécessaires.

Au lieu de faire des relations entre la science et l'industrie un objectif secondaire commun de programmes de soutien aux objectifs principaux différents, un moyen plus efficace de les promouvoir serait de les inclure dans des programmes ou des instruments spécialisés bénéficiant d'un financement adéquat et conçus en collaboration avec les parties prenantes. Les exemples les plus représentatifs de ces types de programmes sont les partenariats public-privé qui se sont mis en place dans le domaine de la recherche et de l'innovation dans un certain nombre de pays de l'OCDE. Cette approche a été récemment imitée au Mexique, avec la création des Alliances stratégiques et Réseaux d'Innovation pour la Compétitivité (AERI), qui représentent un progrès par rapport au programme *Consorcio* lancé au début de la décennie.

D'autres types d'actions, qui ne nécessitent pas nécessairement de mise financière, consistent en des réformes institutionnelles, notamment celles relatives à la mobilité des chercheurs et à la mise en place de bureaux de transfert de technologie ou de délivrance de licences dans les organismes de recherche bénéficiant de fonds publics. À cet égard, le fonds IMPI-CONACYT est une excellente initiative qui devrait faciliter l'instauration de ces bureaux.

Assortiment de mesures et mise en œuvre des programmes

Dans un contexte général marqué par la faiblesse des budgets affectés à la science et à la technologie, les problèmes de gouvernance concernant le rôle respectif du CONACYT et de divers ministères ainsi que la coordination de leurs actions respectives ont affecté défavorablement l'assortiment et la qualité individuelle des mesures prises en faveur de la STI, comme en témoignent :

- le très grand nombre de programmes dotés d'un financement insuffisant ;
- l'inadéquation entre le volume de ressources affecté à certains instruments et la nature des problèmes ou des défaillances systémiques ou du marché auxquels ils sont sensés remédier ;
- la multiplicité des critères d'éligibilité qui peuvent nuire à la réalisation des objectifs prioritaires déclarés de nombreux programmes ;
- la dilution ou l'antagonisme des responsabilités en matière de gestion et de financement entre les organismes de coordination qui ne peuvent qu'aboutir à des instruments mal conçus et difficiles à mettre en œuvre.

Soutien à la R-D et à l'innovation dans le secteur privé : une panoplie de mesures déséquilibrée qui a besoin d'être réformée

Jusqu'à une date récente, le Mexique se distinguait des autres pays de l'OCDE par le pourcentage très élevé des incitations fiscales (environ 75 %) dans le coût budgétaire de l'ensemble des mesures visant à encourager la R-D et l'innovation dans les entreprises. Ce déséquilibre était dû au fait que ces allégements fiscaux en faveur de la R-D étaient nettement plus généreux que ceux observés dans les autres pays ayant instauré des dispositifs similaires. Par ailleurs, les mesures d'incitation fiscale instaurées par le Mexique étaient peu adaptées à la situation de la plupart des entreprises. Un grand nombre d'entre elles n'investissent en effet pas dans la R-D pour innover et ne peuvent donc pas, en principe, bénéficier de ce type de soutien. En revanche, les instruments qui permettraient de mieux répondre à leurs besoins – par exemple, les subventions, ou encore les prêts conditionnels ou subventionnés – étaient en fait beaucoup moins bien financés que les incitations fiscales.

De toute évidence, une rationalisation des programmes de soutien, un rééquilibrage de leur financement et une simplification des structures de gestion était nécessaire :

- *Incitations fiscales*. Au vu de l'expérience des 20 autres pays de l'OCDE qui ont mis en place des mesures d'incitation fiscale, l'utilisation de ce type d'instrument au Mexique semble toujours pertinente, à condition que sa conception, sa gestion et les critères d'obtention soient modifiés en tenant compte des pratiques exemplaires internationales. Les changements nécessaires devront évidemment être envisagés dans le cadre de la nouvelle réforme sur la fiscalité des entreprises, qui a institué l'impôt à taux unique (IETU). Ils devront permettre de réduire le coût budgétaire des incitations fiscales, d'accroître leur efficience et de faciliter la transition vers un assortiment de mesures plus équilibré.

- *Promouvoir l'innovation dans les PME.* Le fonds pour l'innovation technologique Economía-CONACYT est le principal instrument de soutien utilisé pour stimuler l'innovation dans les PME. Outre ses ressources relativement faibles, ce fonds pèche par manque d'efficacité en raison des trop nombreux critères d'obtention et des problèmes de coordination qui compliquent sa gestion. Dans les autres pays de l'OCDE, de même que dans les pays d'Amérique latine les plus avancés (Brésil, Argentine et Chili), les fonds versant des subventions aux PME sont généralement mieux dotés en ressources et sont gérés non pas par les ministères financeurs mais par des organismes spécialisés travaillant sous leur responsabilité. Au Mexique, l'autre facteur qui empêche actuellement une gestion efficiente du fonds Economía-CONACYT est la capacité relativement faible de ce dernier à évaluer la possible rentabilité des investissements en matière de R-D et d'innovation qui sont prévus dans les projets pour lesquels un financement est sollicité.

- *Stimuler l'innovation dans les domaines stratégiques*. Bien que les secteurs stratégiques et les domaines technologiques prioritaires aient été indiqués explicitement par le PECYT de 2001-06, aucun programme ciblé de grande envergure n'a été mis en œuvre pour favoriser la recherche et l'innovation dans les secteurs en question. Les projets financés par les fonds d'investissement sectoriel ne compensent pas vraiment ce manque. Le PECITI de 2007-12 recense lui aussi les priorités sectorielles et technologiques qui devront faire l'objet de programmes spécifiques et ciblés, notamment en ce qui concerne la coopération

entre les secteurs public et privé. Il faut espérer que le PECTI réussira là où le PECYT a échoué.

- *Aider les nouvelles entreprises tournées vers la technologie*. C'est là un autre point faible de la panoplie d'instruments. Seuls le programme AVANCE et, dans une moindre mesure, l'initiative de pépinières d'entreprises financée par le ministère de l'Économie, contribuent au développement des activités d'innovation et de recherche dans les entreprises de haute technologie. Ces dispositifs jouent un rôle important mais ils ne sont pas suffisamment financés et ne permettent pas vraiment aux chercheurs des organismes de recherche publics de créer des entreprises de haute technologie ou des sociétés-rejetons (*spin-offs*). Il convient, à cet égard, de consacrer plus d'attention et de ressources au développement de produits financiers et d'outils de gestion des risques (par exemple, fonds d'amorçage, capital risque, systèmes de garantie) qui soient adaptés à la création et à la croissance de ce type de société.

Soutien à la recherche dans le secteur public : amélioration des modes de financement, des incitations et de la gouvernance

Les ressources allouées à la recherche publique doivent certes être augmentées, mais il faut aussi que les procédures et les critères d'attribution satisfassent à plusieurs conditions pour que les activités financées puissent, grâce à un effet de levier sur l'investissement privé, contribuer efficacement à l'accroissement du capital de connaissances socialement utiles, à la formation d'un personnel hautement qualifié et au renforcement de la capacité d'innovation du secteur productif. Ces conditions ont trait notamment aux modes de financement des activités de recherche, aux incitations fournis aux chercheurs et aux équipes de recherche, ainsi qu'aux systèmes d'évaluation. Elles doivent évoluer de pair avec l'assortiment des dispositifs de financement ainsi qu'avec la structure de gouvernance des organismes de recherche publics.

Un meilleur équilibre doit être trouvé entre les différents modes de financement : institutionnel, concurrentiel et autres. Un pourcentage et un volume de ressources croissants devraient être consacrés au financement concurrentiel grâce à la restructuration des fonds d'investissement sectoriel (finançant la recherche fondamentale et appliquée), qui sont actuellement financés et gérés par le CONACYT en collaboration avec le SEP (Secrétariat pour l'enseignement public) et d'autres ministères sectoriels.

- *Financement institutionnel.* Conformément aux pratiques exemplaires mises en œuvre dans d'autres pays , le volume et l'attribution du financement institutionnel devraient dépendre des résultats des évaluations périodiques, en privilégiant les travaux de recherche de qualité (selon les normes universitaires en vigueur) et en tenant compte de critères tels que la contribution des chercheurs et des autres professionnels hautement qualifiés aux performances en matière d'innovation (par exemple, brevets déposés et relations avec l'industrie). D'autre part, l'augmentation du financement institutionnel doit continuer d'être envisagée en gardant à l'esprit la nécessité de décentraliser davantage les activités de recherche universitaires.

- *Financement concurrentiel.* Ce type de financement devrait être placé sous la seule responsabilité du CONACYT. Une partie serait consacrée aux projets de recherche satisfaisant au critère de l'excellence des travaux – quelle que soit la discipline scientifique concernée – la priorité étant accordée aux projets menés en

collaboration. L'autre partie financerait des projets de recherche rentrant dans le cadre des programmes de recherche et d'innovation prioritaires, tels que définis par le PECITI. La source de financement utilisée pour ces projets pourrait être un fonds consolidé doté des ressources qui servaient auparavant à alimenter les fonds d'investissement sectoriel. Ce fonds financerait en particulier les programmes de recherche et d'innovation à moyen terme, et plus spécialement les partenariats public-privé tels que ceux mis sur pied dans le cadre des AERI.

- D'autres sources de financement de la recherche publique devraient également être recherchées activement, en particulier du côté de la coopération internationale instituée par les accords du CONACYT. Les organismes de recherche publics devraient en outre être encouragés à créer leurs propres réseaux de collaboration internationale, et les réglementations qui font obstacle à de telles initiatives devraient être supprimées ou assouplies.

Un autre aspect important de la politique relative aux organismes de recherche publics est la formation de ressources humaines hautement qualifiées. À cet égard, le programme de bourses du CONACYT et les diverses initiatives qui ont été prises récemment pour encourager les études aux niveaux doctorat et post-doctorat semblent aller dans la bonne direction et doivent être maintenus.

Enfin, il est clair que les aides fédérales doivent continuer à favoriser une distribution géographique plus équilibrée de l'infrastructure scientifique et technologique. En l'occurrence, la tendance à conditionner – tout au moins en partie – l'augmentation du financement institutionnel des centres de recherche publics et des établissements d'enseignement supérieur à la régionalisation de leurs installations devra être confirmée, voire renforcée.

Réforme du SNI : un défi à long terme

Sans le SNI, géré et financé par le CONACYT, la qualité des travaux de recherche menés au Mexique ainsi que le nombre et la variété des chercheurs mexicains jouissant d'une reconnaissance internationale ne seraient pas ce qu'ils sont aujourd'hui.

À ce jour, ce système si particulier qui offre une protection contre la fuite des cerveaux comporte aussi, dans son fonctionnement actuel, à la fois des obstacles au renforcement de la collaboration avec le secteur privé pour les activités de recherche, et des risques à long terme liés à l'évolution de la pyramide des âges des chercheurs mexicains. Si le rôle du SNI – constitution d'un réservoir de chercheurs de premier ordre et préservation de l'attractivité des métiers de la recherche – doit être maintenu, un processus de réforme doit toutefois être engagé pour relever les deux défis précités. À longue échéance, cette réforme pourrait conduire à l'adoption de recherche de barèmes de rémunération fixés selon des normes nationales mais administrés de plus en plus par les organismes eux-mêmes, qui il incombe *in fine* la responsabilité de veiller à la qualité et la pertinence de leurs plates-formes de recherche.

Recommandations

Objectifs stratégiques

Dans un environnement concurrentiel de plus en plus mondialisé, s'il veut continuer d'accroître sa productivité économique, de réduire la pauvreté et d'apporter de meilleures réponses aux besoins urgents de la société, le Mexique n'a d'autre choix que de mener des politiques macroéconomiques responsables et d'approfondir les réformes structurelles qui ont été amorcées.

Pour aligner son revenu par habitant sur celui des pays plus développés et, à plus court terme, pour éviter d'être distancé par les économies émergentes les plus dynamiques, le Mexique doit mettre à profit le potentiel de la science et de la technologie. Outre les améliorations urgentes qu'il doit apporter à certaines conditions-cadres essentielles pour l'innovation (en particulier dans le domaine de l'éducation, de la concurrence et de l'infrastructure de base), le pays doit s'efforcer d'atteindre plusieurs objectifs politiques, économiques et sociaux :

- mettre en place un système d'innovation plus puissant et centré sur les entreprises en augmentant sensiblement l'aide publique (financière et autre) en faveur de l'innovation, d'une façon qui stimule l'investissement privé dans l'innovation répondant aux signaux du marché.
- s'assurer que le soutien à la recherche fondamentale et d'intérêt public n'a lieu que dans les domaines où l'on peut atteindre à la fois la masse critique et l'excellence, et faire un usage plus effectif de la réforme de la réglementation et du financement concurrentiel pour renforcer la recherche publique axée sur des besoins socioéconomiques prioritaires bien définis.
- poursuivre la décentralisation de la politique STI tout en consolidant les capacités de gestion au niveau des États, et soumettre les programmes bénéficiant de ressources fédérales à des évaluations strictes, suivant une méthodologie unifiée au plan national.

Volonté politique et impact social

Les bienfaits socioéconomiques de l'investissement dans la science et la technologie sont longs à concrétiser. C'est pourquoi le succès d'une politique scientifique, technologique et d'innovation dépend d'une volonté politique durable et de la visibilité des avantages pour l'économie et la société dans son ensemble. Il n'existe aucun exemple de pays développé ou émergent qui ait réussi à placer le savoir et l'innovation au cœur de sa stratégie de développement sans un tel engagement à long terme.

Au Mexique, la volonté politique a trop souvent fait défaut. L'objectif que s'était fixé la précédente administration pour la fin de son mandat – à savoir des dépenses de R-D représentant 1 % du PIB – n'a pas été atteint. Cet objectif était peut-être au départ irréaliste, mais pour les principales parties prenantes, ce fut au mieux une occasion manquée, au pire le signe d'un manque d'engagement. L'administration actuelle a affirmé une volonté similaire au travers du PECITI et en 2008 le budget consacré à la science et à la technologie a été considérablement augmenté. Cet engagement doit être maintenu sans relâche par les organes exécutifs et législatifs, et les répercussions scientifiques,

économiques et sociales d'une augmentation de l'investissement public doivent être portées à la connaissance du public en temps voulu.

La volonté politique s'incarne également dans la recherche d'un consensus lorsqu'il s'agit de définir les priorités nationales et d'instaurer des processus de contrôle pour vérifier que ces priorités sont effectivement respectées dans l'élaboration des politiques d'innovation, et qu'elles se reflètent à la fois dans l'affectation des crédits et dans les dispositifs institutionnels de mise en œuvre de la politique.

Efficience de la politique

L'usage efficient des fonds publics pour résoudre les problèmes sociaux et économiques est un principe de bonne gestion budgétaire. En matière de finances publiques, les dépenses pour la promotion du développement scientifique et technologique est en concurrence avec d'autres dépenses de fonctionnement ou d'investissement dans des domaines qui sont souvent considérés comme également prioritaires mais plus urgents. Les actions de lutte contre la pauvreté et le développement de l'infrastructure socioéconomique pèsent lourdement sur le budget. Bien que la réforme budgétaire et les revenus supplémentaires provenant de la hausse tendancielle du prix de l'énergie puissent donner une plus grande marge de manœuvre, le coût d'opportunité des ressources publiques consacrées à la politique d'innovation ainsi que leur utilité pour remédier aux défaillances systémiques et du marché doivent être justifiés par une estimation plausible des avantages socioéconomiques attendus, ainsi que par des évaluations *a posteriori*.

Améliorer le niveau global de compétences tout en développant les ressources humaines pour la science et la technologie (RHST)

L'existence d'un capital humain de qualité constitue la pierre angulaire de toute stratégie de développement socioéconomique reposant sur l'innovation. Le Mexique possède certes un réservoir important de scientifiques et d'ingénieurs qualifiés – grâce aux efforts déployés au cours des vingt dernières années, notamment aux programmes de bourses d'études – mais il n'est pas suffisant au regard de la taille et du potentiel économique du pays. L'essentiel de la main-d'œuvre n'a que très peu de qualifications, et pour une grande majorité d'entreprises, l'absence de compétences en matière de gestion constitue une entrave à leur capacité d'absorption de la technologie et à la prise des risques de l'innovation. C'est là l'une des raisons pour lesquelles la demande de ressources humaines hautement qualifiées dans les domaines scientifique et technologique est faible. Le Mexique est donc confronté à la fois à un problème d'offre et de demande en matière de RHST. Outre l'élévation du niveau de scolarité de la main d'œuvre en général, qui n'est pas nécessaire seulement du point de vue de la politique de l'innovation, la correction du déséquilibre affectant le marché des RHST devrait figurer parmi les priorités du programme d'action pour la science et la technologie. C'est pourquoi les mesures pertinentes envisagées dans le cadre du PECITI méritent un financement suffisant et continu.

Resserrer les liens entre la science et l'innovation

L'un des principaux défis qui se pose au Mexique est de favoriser les synergies entre la science – dont le moteur est la curiosité – et l'innovation – qui est motivée par la demande du marché – grâce à des cadres institutionnels et des structures d'incitation favorables. Si la recherche mue par la curiosité doit continuer de bénéficier d'un soutien en sa qualité de bien public, une plus grande responsabilisation sociale devrait cependant lui être imposée, en particulier lorsque son objectif est de résoudre des problèmes spécifiques. L'existence de ressources limitées encourage les comportements défensifs de groupes d'intérêts et fait obstacle à la collaboration. L'augmentation des ressources consacrées à la science et à la technologie devrait, dans une large mesure, être conditionnelle à un renforcement de l'esprit de coopération. Avec la mise sur pied de consortiums et des AERI, l'accent qui est mis sur la coopération dans un certain nombre de programmes de soutien, la place accrue qui est accordée au financement concurrentiel et à l'autofinancement des organismes de recherche publics, le Mexique s'oriente dans la bonne direction. Reste à maintenir le cap et à aller encore plus loin.

Dans ce contexte, à l'instar de ce que l'on constate de plus en plus dans les autres pays de l'OCDE, la politique STI doit mettre davantage l'accent sur les programmes, richement dotés, qui soutiennent des partenariats public-privé dans des domaines d'utilité public prioritaires tels que la santé, l'environnement, l'énergie et les communications, ainsi que dans des secteurs où le Mexique jouit d'un avantage concurrentiel en raison de ses importantes ressources naturelles. Il est important que les responsabilités de gestion de ces programmes soient partagées par la communauté scientifique et les milieux d'affaires.

En coopération avec les autorités des États ou des municipalités qui ont déjà pris des initiatives très utiles dans ce sens, des efforts supplémentaires devront être déployés pour promouvoir les avantages concurrentiels technologiques ou sectoriels dans des pôles d'activité qui mettent en commun des ressources scientifiques, des infrastructures et des moyens de gestion, et qui stimulent l'innovation par le transfert du savoir et la diffusion de la technologie.

Faire participer les PME retardataires aux activités d'innovation

Hormis un ensemble d'entreprises – nationales ou étrangères – présentes au niveau mondial et très performantes, ainsi qu'un groupe restreint mais croissant de sociétés innovantes de plus petite taille, le Mexique compte une écrasante majorité d'entreprises, des PME pour la plupart, qui n'ont pas les moyens d'inclure la gestion du savoir et le développement technologique dans leur stratégie concurrentielle. Dans de nombreux secteurs, ces entreprises représentent des gisements d'emploi, de productivité et de croissance encore largement inexploités. Aucun succès durable de la politique de l'innovation ne peut être attendu si l'on ne met pas fin à ce dualisme structurel. Sans ignorer l'apport de quelques programmes existants – essentiellement ceux mis en œuvre par le ministère de l'Économie avec l'aide des institutions intermédiaires et, dans une moindre mesure, du CONACYT, des organismes de recherche publics et des ministères sectoriels – le renforcement des actions en faveur des PME doit être un objectif stratégique de la politique du Mexique en matière de science, de technologie et d'innovation, notamment pour ce qui concerne le développement des ressources humaines et de l'infrastructure technologique ainsi que la promotion et la prestation de services technologiques.

Principes directeurs

Les orientations stratégiques du PECYT pour 2001-06 correspondaient à une évaluation lucide des principales lacunes du système scientifique, technologique et d'innovation mexicain. Les raisons pour lesquelles la mise en œuvre du programme n'a pas répondu aux attentes, comme ses réussites partielles – comportent des enseignements pour énoncer les principes directeurs devant guider la conception, la gouvernance, le financement et la mise en œuvre de la politique STI dans le cadre du PECITI. Ces principes devront s'inspirer des pratiques exemplaires relevées dans les pays plus avancés, en tenant compte des spécificités de la situation mexicaine.

- *Gouvernance efficace.* Elle doit s'ancrer au plus haut niveau du pouvoir exécutif qui doit s'engager à consentir les efforts budgétaires appropriés pour financer les activités scientifiques, technologiques et d'innovation. Cette volonté politique doit aussi se refléter dans le fonctionnement de la structure de gouvernance chargée d'orienter la politique en s'assurant de la participation des principales parties prenantes, y compris les services ministériels responsables des conditions-cadres conditionnant les performances du système d'innovation.
- *Définition claire et transparente des priorités.* Il faut pour cela solliciter la contribution des principales parties prenantes, dont la communauté scientifique, les milieux d'affaires et la société civile. Ce travail doit aboutir à la rédaction de documents de planification et de prévision budgétaire qui sont ensuite soumis par le gouvernement aux organes législatifs, puis largement diffusés auprès du grand public une fois qu'ils ont été approuvés.
- *Équilibre dynamique entre les ressources publiques et privées allouées à la R-D et à l'innovation.* L'une des conditions pour que le secteur privé puisse améliorer ses performances en matière d'innovation est d'avoir accès au système de recherche publique et de collaborer avec lui. Cette collaboration doit être financée en fonction de la qualité et de la pertinence des travaux de recherche.
- *Clarification des responsabilités opérationnelles.* Conformément aux pratiques exemplaires qui sont relevées au niveau mondial, les organes chargés de définir les priorités et d'élaborer la politique doivent être différents de ceux s'occupant de la mise en œuvre de la politique, les seconds étant placés sous la responsabilité des premiers.
- *Organe de gestion unique.* Si une coordination entre les différents organismes publics ou les différents échelons du gouvernement est nécessaire en ce qui concerne la conception de la politique et/ou le financement des programmes, un organe de gestion unique de la mise en œuvre est généralement préférable car les arrangements prévoyant une gestion et un financement conjoints entraînent habituellement des coûts de fonctionnement élevés et compliquent – voire bloquent – les processus décisionnels.
- *Masse critique et rationalisation des procédures de fourniture de l'aide publique.* La multiplication des programmes doit être évitée. Elle est souvent le reflet de l'opacité de la politique, de la préservation d'intérêts acquis de longue date et/ou d'un chevauchement de responsabilités entre les organismes publics. De surcroît, elle entraîne souvent des coûts administratifs élevés et un manque d'efficacité dans les prestations, et peut donner lieu à une fragmentation de l'action au détriment de la masse critique.

- *Assortiment de mesures équilibré*. L'assortiment de mesures doit exprimer les priorités en assurant que chaque mesure atteint la masse critique nécessaire à son efficacité. Pour favoriser la R-D et l'innovation dans le secteur privé, l'assortiment doit refléter un juste équilibre entre les aides directes (par exemple, les subventions), les aides indirectes et le soutien sectoriel, en tenant compte des types de défaillances systémiques ou du marché auxquelles ces mesures peuvent remédier. S'agissant du soutien aux organismes de recherche publics, l'équilibre à rechercher est entre le financement institutionnel et le financement concurrentiel, de sorte à encourager le recours aux ressources extérieures.
- *Équilibre entre les approches descendantes et ascendantes*. Les parties prenantes telles que les institutions intermédiaires et les sous l'autorité des États doivent contribuer pleinement à la définition et à la mise en œuvre des programmes qui bénéficient à leurs administrés. Les bonnes pratiques qui ont déjà été adoptées (infrastructure technologique, pôles d'activités technologiques et AERI) doivent, lorsque les circonstances s'y prêtent, être généralisées.
- *Évaluation et transparence.* L'évaluation régulière des programmes de soutien et des institutions bénéficiant d'aides publiques doit devenir la norme et avoir des conséquences concrètes sur l'avenir du soutien public. Il faut toutefois trouver un équilibre entre la nécessité de procéder à des ajustements périodiques sur la base des évaluations, et celle d'assurer la stabilité des programmes de façon à garantir leur effet à long terme sur le comportement des bénéficiaires. Des contrôles doivent également être organisés régulièrement pour vérifier que les enveloppes budgétaires allouées à la science et à la technologie sont effectivement dépensées dans ce domaine.

Amélioration des structures de gouvernance

Compte tenu de la structure du gouvernement et des institutions qui prévaut au Mexique, il n'existe pas de remède miracle pour améliorer la gouvernance du système scientifique, technologique et d'innovation.

La création d'un ministère de la Science et de la technologie (ou de l'Enseignement supérieur, de la science et de la technologie), qui est une pratique courante dans les pays de l'OCDE, serait en principe une bonne idée. Ce ministère serait chargé d'élaborer la politique et il aurait la capacité de coordonner l'ensemble du budget affecté à la science et à la technologie et de superviser les organismes publics responsables de la mise en œuvre de la politique. Le CONACYT aspirait légitimement à cette fonction, mais il n'en a pas reçu les moyens et n'avait pas le statut institutionnel pour le faire.

Cela étant, la création d'un nouveau ministère semble pour l'heure irréaliste. Il est en outre peu vraisemblable, politiquement parlant, que le pouvoir qui a été refusé au CONACYT pour la mise en œuvre du PECYT lui soit aujourd'hui accordé, avec en plus un statut ministériel, d'autant qu'il a récemment été décidé de nommer le ministre de l'Économie à la présidence du conseil d'administration du CONACYT.

La création d'un nouveau ministère reste néanmoins une possibilité à envisager pour l'avenir. Dans l'immédiat, l'option la plus réalisable est la mise en place d'un conseil interministériel chapeauté par le président et composé des ministres responsables de la gestion et du financement des programmes ou institutions scientifiques et technologiques.

Un Conseil interministériel chargé de la science et de la technologie vraiment opérationnel

Un Conseil de la science et de la technologie pourrait être créé au niveau ministériel, avec pour tâche de définir les priorités nationales et d'assurer la coordination interservices de l'orientation de la politique et des programmes de soutien nationaux à la science et à la technologie. Il participerait également à la préparation du budget correspondant. Bien qu'un tel conseil (jouissant toutefois de prérogatives moins étendues) existe officiellement – sous le nom de Conseil général pour le développement de la technologie et de la recherche scientifique – dans le cadre de la loi sur la science et la technologie, il n'a pas véritablement rempli ses fonctions dans la précédente administration[12].

La version amendée de la loi sur la science et la technologie, qui inclut désormais le domaine de l'innovation, confirme l'existence officielle de ce Conseil et contient des dispositions pouvant contribuer à une plus grande efficacité de son fonctionnement, notamment la création d'un Comité intersectoriel pour l'innovation.

Le Conseil interministériel devrait avoir une réelle influence – ou tout au moins jouer un rôle consultatif – dans le domaine de l'affectation des ressources (toutes celles allouées à la science et à la technologie, y compris celles qui ne font pas l'objet du chapitre 38), et éventuellement des transferts de ressources entre le gouvernement fédéral et les États. Il devrait par ailleurs, dans sa mission de supervision, s'intéresser aux politiques réglementaires qui influent sur les performances du système scientifique, technologique et d'innovation, en soumettant des propositions de loi ou en prodiguant des conseils sur l'amélioration souhaitable des principales conditions-cadres qui conditionnent l'innovation, telles que la politique en matière de concurrence ou la réglementation du travail. À cet égard, il serait important que le Conseil interministériel ait la possibilité d'examiner les dispositions législatives et réglementaires existantes (par exemple, la loi sur les entités parapubliques, la loi sur les marchés publics et la loi sur l'emploi) pour vérifier qu'elles ne nuisent pas à l'efficience des organismes de recherche publics et, plus généralement, ne pèsent pas négativement sur les performances du système d'innovation.

Le Conseil interministériel pourrait être secondé par un conseil consultatif tripartite sur la science et la technologie, composé de représentants de la communauté scientifique, des milieux d'affaires et des institutions intermédiaires. Le Forum consultatif pour la science et la technologie (FCCT), qui a été créé par la loi sur la science et la technologie, pourrait en principe remplir ces fonctions, mais son rôle et sa composition devraient alors être reconsidérés. D'une part, le nombre de ses membres devrait être réparti plus équitablement entre les représentants du monde universitaire et de l'industrie[13] ; d'autre part, il lui faudrait mieux réconcilier ses deux rôles – défense de la STI, d'une part, et recherche d'un consensus entre les parties prenantes qu'il représente, d'autre part.

Le Conseil se réunirait au niveau ministériel au moins une fois par an pour discuter des aspects stratégiques de la politique STI et de ce qu'ils induisent sur le plan budgétaire, mais aussi législatif ou réglementaire. D'autres réunions auraient lieu plus fréquemment à un niveau moins élevé pour aborder les questions de la coordination interministérielle et du suivi de la mise en œuvre de la politique.

Par ailleurs, en signe de reconnaissance du rôle de la science, de la technologie de l'innovation dans le développement socioéconomique du Mexique – et pour renforcer ce rôle – le CONACYT pourrait devenir un membre à part entière du Cabinet restreint du gouvernement, qui s'occupe des questions économiques et de la compétitivité.

Dans cette configuration institutionnelle, la planification et la budgétisation des programmes scientifiques et technologiques seraient séparées du financement et de la mise en œuvre des programmes concurrentiels, ces deux dernières fonctions étant remplies par des organismes financeurs. En revanche, le financement non concurrentiel continuerait d'être assuré par les ministères sectoriels : par exemple, par les organismes de recherche pour les programmes ou les projets scientifiques, technologiques ou d'innovation axés sur une mission spécifique, ou par le ministère de l'Éducation pour le financement institutionnel de la recherche fondamentale.

Le CONACYT et le ministère de l'Économie se verraient confier des responsabilités particulières, non seulement en tant que principaux organes gouvernementaux chargés de la mise en œuvre de la politique et du financement des programmes, mais aussi en raison de la complémentarité des actions qu'ils mènent en faveur de la R-D et de l'innovation à la charnière du développement scientifique et technologique. La question de leurs rôles respectifs est donc très importante.

Un rôle en évolution pour le CONACYT

Pour assurer la stabilité et éviter les perturbations causées par la pratique actuelle de la présidence tournante, le ministre de l'Économie devrait présider le conseil d'administration du CONACYT d'une manière plus permanente. Outre son rôle dans la coordination globale de la politique STI – qui pourrait être renforcé si son directeur général était placé sous l'autorité directe du président – le CONACYT évoluerait vers un rôle de bailleur de fonds dont les principales responsabilités seraient les suivantes :

- Gestion des fonds concurrentiels servant à financer les projets ou les programmes à forte intensité de R-D, à savoir :
  - Le *fonds pour les sciences pures,* qui s'adresse aux recherches non orientées menées par les organismes de recherche publics.
  - Un nombre limité de *fonds sectoriels*, qui concernent des domaines correspondant aux priorités technologiques ou sectorielles au niveau national, et qui servent à financer les programmes de R-D appliquée et d'innovation à moyen terme proposés par des institutions de recherche publiques et/ou des associations industrielles. Tandis que le CONACYT serait chargé de la gestion de ces fonds, les ministères ayant des responsabilités administratives dans les secteurs prioritaires interviendraient dans la définition des programmes et l'évaluation des résultats. Une partie des ressources allouées à ces fonds serait clairement destinée au financement à moyen terme des partenariats public-privé dans la recherche et l'innovation (consortiums et AERI). La gestion de ces fonds a besoin d'être améliorée par la rationalisation des procédures administratives de prise de décision et de décaissement.
  - Le *fonds institutionnel AVANCE*, qui finance les projets soumis en collaboration avec les organismes de recherche publics.
- Gestion de l'interface avec les entités infra fédérales pour développer les capacités de STI
  - Programmation et cofinancement des *fonds mixtes* en fonction des priorités nationales et régionales, en accordant une attention particulière au développement de l'infrastructure scientifique et technologique des systèmes

d'innovation et des pôles d'activités régionaux, et en confiant aux États une responsabilité accrue en matière de sélection et de gestion des projets.

- Centres de recherche publics
  - Le CONACYT continuerait à superviser et à financer le volet administratif de ses centres de recherche tout en encourageant leur autonomisation en matière de gestion (y compris en continuant d'accroître leurs taux d'autofinancement), le renforcement des liens avec les établissements d'enseignement supérieur, voire une éventuelle privatisation partielle ou totale de ceux qui fournissent principalement des services.
- Incitations fiscales
  - Le CONACYT devrait gérer la version réformée de l'incitation fiscale à la R-D industrielle en collaboration avec le ministère des Finances, et assumer des responsabilités particulières en ce qui concerne la diffusion des informations, le soutien sur le plan procédural, le suivi, le contrôle a posteriori, et l'évaluation.

Le CONACYT conserverait également ses attributions en matière de supervision et de financement des programmes qui visent à renforcer la coopération scientifique internationale (FONCICYT) et à développer les RHST (par exemple, via les bourses de l'enseignement supérieur et le programme IDEA).

Rôle du ministère de l'Économie dans la promotion de l'innovation au service de la compétitivité

Le ministère de l'Économie joue un rôle central dans la politique de renforcement de la compétitivité de l'économie mexicaine. Toutefois, à l'instar des ministères ayant des responsabilités similaires dans la plupart des pays de l'OCDE, il doit faire évoluer son action en mettant davantage l'accent sur le développement de l'infrastructure technologique et de la capacité d'innovation des entreprises. Son action dans ces domaines pourrait s'articuler comme suit :

Fonds spécial pour l'innovation technologique

Ce fonds prendrait en charge les missions actuellement dévolues au fonds pour l'innovation technologique Economía-CONACYT et financerait les projets d'innovation proposés par les entreprises (essentiellement les PME). Le financement serait assuré par des fonds de contrepartie ou des subventions. Les dépenses d'investissement couvertes par ce dispositif seraient celles associées à la R-D et à l'infrastructure technologique (par exemple les TIC, la logistique, la métrologie, la certification et les droits de propriété intellectuelle). Les projets devraient être évalués selon le critère des bénéfices attendus, sans discrimination en fonction du secteur ou du domaine technologique concerné. L'existence et la nature des défaillances systémiques ou du marché empêchant le développement d'activités d'innovation économiquement viables devraient déterminer les critères d'éligibilité[14]. Le seul aspect discriminatoire pourrait être le traitement de faveur accordé aux projets menés en collaboration avec les centres de recherche publics ou les établissements d'enseignement supérieur.

Ce fonds établirait des liens avec le secteur financier via sa contribution au développement de fonds de capital-risque, de fonds d'amorçage et de fonds de garantie, en collaboration avec la NAFIN. À l'instar de ce que font les organismes chargés de l'innovation dans plusieurs pays de l'OCDE, ce fonds pourrait aussi fournir des incitations particulières à la création d'entreprises à vocation technologique. Éventuellement, il pourrait devenir une agence pour l'innovation autonome, capable de prendre des participations financières dans les entreprises qu'il soutient. Dans ce cas, il devrait recevoir des dotations en capital de la part du secteur public et des institutions financières.

Infrastructure et diffusion technologiques

En liaison avec des institutions telles que INFOTEC, CENAM et IMPI, le ministère de l'Économie devrait mettre en place un soutien – ou renforcer celui qu'il fournit déjà – en faveur de l'infrastructure technologique et des programmes de diffusion de la technologie proposés par des institutions intermédiaires ou des associations industrielles, notamment pour créer des pôles d'activités d'innovation et des réseaux de production. Dans ce domaine important qu'est la revalorisation des capacités d'innovation régionales, une solide coordination avec le CONACYT sera nécessaire.

Enfin, le ministère de l'Économie devrait être doté de ressources suffisantes pour reproduire le programme PROSOFT dans d'autres domaines technologiques prioritaires, à condition que son aide soit complétée par d'autres sources de financement (notamment des entreprises, des institutions intermédiaires et des autorités locales) et qu'elle contribue au développement de pôles d'activités sectoriels et régionaux.

Amélioration de l'articulation entre politique fédérale et politique des États

Les réformes de la gouvernance devront également concerner la conception, la gestion et le financement des politiques et des programmes dont l'objectif est de renforcer les capacités STI aux niveaux national et local. Cela soulève plusieurs questions.

Les mécanismes de coordination entre le CONACYT (fédéral) et les conseils scientifiques et technologiques des États devront être renforcés de façon à ce qu'il soit possible de répertorier les projets qui correspondent le mieux aux priorités nationales – et nécessitent donc une plus grande part du budget fédéral. Ceux qui correspondent avant tout aux priorités des États devraient être soutenus par des enveloppes budgétaires différentes, surtout dans le contexte de la réforme budgétaire qui accroît les transferts de ressources. L'approche plus stratégique qui est actuellement mise en œuvre par le CONACYT pour la sélection des projets à soutenir est un bon pas dans cette direction, mais il convient d'aller encore plus loin.

Comme cela a été indiqué plus haut, la gestion et l'efficacité des fonds mixtes ont régulièrement pâti de la lenteur des processus de sélection et de décaissement des sommes allouées et de la faible capacité d'un certain nombre d'États à formuler et soumettre des projets de R-D et d'innovation de qualité. L'équilibre entre l'offre et la demande de fonds mixtes devra être modifié de façon à donner aux États un plus grand pouvoir de gestion des sommes attribuées aux institutions relevant de leur compétence. La décentralisation de la politique devrait s'accompagner d'une décentralisation de la gestion[15] et d'une décentralisation accrue des ressources. Cela permettrait d'alléger considérablement la charge administrative qui pèse jusqu'à maintenant sur le CONACYT, car les fonds mixtes fusionneraient à terme avec – ou complèteraient – le budget scientifique et technologique

des États pour financer les projets présentés ou conduits par les institutions locales. L'ampleur du rééquilibrage des fonctions de gestion et de financement entre les organes fédéraux et ceux des États varierait évidemment en fonction de la situation régionale.

S'agissant des États les moins développés, l'instauration d'un mécanisme similaire à celui des fonds structurels de l'Union européenne – pour combler les disparités régionales – mériterait d'être examinée par le Congrès.

Évaluation

Une gouvernance de qualité suppose des évaluations régulières permettant de dresser le bilan des politiques menées et ayant une influence réelle sur les décisions concernant leur poursuite ou leur réforme. Au Mexique, la culture de l'évaluation en est au stade embryonnaire : l'évaluation des politiques se limite trop souvent à une description de l'allocation des ressources, à une vérification que les procédures ont bien été respectées, et parfois à un examen de la qualité de la gestion. Il est très rare que des questions telles que la rentabilité de l'instrument d'action et son efficacité par rapport aux objectifs déclarés fassent l'objet d'une évaluation. S'alignant sur les pratiques qui deviennent de plus en plus courantes dans les autres pays, le CONACYT et les autres ministères chargés du financement des programmes ou projets STI devraient mettre au point des systèmes de suivi et d'évaluation reposant sur des informations et des indicateurs qualitatifs et quantitatifs. L'objectif des programmes de soutien ainsi que les effets et résultats attendus devraient être spécifiés dès le début. Le suivi et l'analyse *a posteriori* des politiques devraient aider à déterminer le besoin de faire évoluer leur conception et leur financement.

Recommandations spécifiques

Améliorer l'assortiment de mesures destiné à stimuler la R-D et l'innovation dans les entreprises

- *Réduire le plafond des ressources budgétaires affectées au système d'incitation fiscale.* Remplacer les procédures de prise de décision discrétionnaires par des procédures automatiques, et fixer un montant maximal pour chaque entreprise bénéficiaire. Simplifier les critères d'éligibilité en n'acceptant que les projets comprenant des activités de R-D et d'innovation, quel que soit le secteur ou l'entreprise concerné. Envisager la création en faveur des PME d'un système de soutien à deux niveaux, en volume et en accroissement, en leur accordant un taux de crédit d'impôt préférentiel. Réduire les coûts de gestion pour les bénéficiaires potentiels afin de ne pas dissuader les entreprises de petite taille. Créer une commission conjointe composée de représentants du CONACYT et du ministère des Finances, qui sera chargée de définir et de mettre en œuvre les nouvelles règles de fonctionnement du système d'incitation fiscale réformé. Ces réformes devraient permettre de réduire le poids budgétaire de l'incitation en termes de perte de recettes fiscales.

- Parallèlement à la réduction du soutien indirect accordé sous forme d'incitations fiscales, il convient d'*accroître le volume des aides directes* apportées aux entreprises via les dispositifs de financement concurrentiel existants (ou réformés) en fournissant des aides sous forme de fonds de contrepartie, de prêts subventionnés ou, dans certains cas, de subventions. Accorder une prime aux

projets menés en collaboration. Simplifier les critères d'amissibilité. Accroître les aides permettant le développement des nouvelles entreprises à caractère technologique, réduire les obstacles à leur création et faciliter leur accès aux marchés financiers. Cette augmentation des aides directes devra être financée en partie par les économies résultant de la rationalisation du système d'incitation fiscale[16].

- Gérer les dispositifs de soutien direct en recherchant une augmentation des *contributions complémentaires du secteur financier* (garanties, fonds d'amorçage et capital risque), notamment de la part de l'organe public qui le représente (la NAFIN). Renforcer les *capacités d'évaluation des projets* dans les structures chargées de la gestion des programmes de soutien.
- Accroître l'effet d'entrainement de la recherche publique sur l'investissement privé dans les activités de R-D présentant un caractère prioritaire à l'échelle nationale en favorisant les *partenariats public-privé pour la recherche et l'innovation* (AERI).
- Conditionner les *programmes de soutien sectoriel* à l'apport de ressources adéquates de la part des entreprises, des institutions intermédiaires et des autorités régionales. Utiliser cet instrument pour favoriser le développement de pôles d'activités. Reproduire le programme PROSOFT dans d'autres domaines prioritaires.
- Mettre au point une *politique de marchés publics* propice à l'innovation, inspirée des bonnes pratiques au niveau mondial et compatible avec les accords internationaux, le but étant de promouvoir l'innovation dans des secteurs présentant une forte demande sociale (santé, énergie, transport, environnement, éducation). Cela obligerait probablement à modifier la loi sur les marchés publics (*Ley de adquisiciones*).
- Répondre au besoin d'informations et de *services technologiques* (métrologie, certification) des PME en facilitant leur accès à ces ressources, et encourager la mise en concurrence de l'offre publique et privée de ces services. Renforcer les programmes de *diffusion de la technologie* en favorisant la collaboration entre les institutions publiques et les associations industrielles.
- Renforcer la mission de l'IMPI en matière de *diffusion d'informations à caractère technologique par un accès plus facile à sa base de données sur les brevets* et la prestation de services pour faciliter les procédures de dépôt de brevets.

Renforcer la recherche publique et stimuler sa contribution à l'innovation

- Consolider le *financement institutionnel (non concurrentiel) des établissements d'enseignement supérieur* en incluant les dépenses d'infrastructure. Évaluer régulièrement les résultats de ce financement. Utiliser le financement institutionnel pour favoriser la décentralisation des capacités de recherche.
- *Accroître le volume et la part du financement concurrentiel*, à la fois pour les travaux de recherche fondamentale et de recherche appliquée menés dans le cadre de programmes de R-D et d'innovation qui concernent des domaines présentant un caractère prioritaire à l'échelle nationale. Réserver un traitement préférentiel aux travaux de recherche menés en collaboration.

- Utiliser le futur fonds IMPI-CONACYT pour encourager la création systématique de *bureaux de transfert de technologie ou de délivrance de licences* – ou de liens d'affiliation avec ces bureaux – dans les organismes de recherche publics, y compris les établissements d'enseignement supérieur, afin de permettre la diffusion des résultats des activités de recherche.
- Simplifier les règles et les procédures utilisées dans les *accords* contractuels entre les organismes publics de recherche et le secteur privé.
- *Améliorer les critères d'évaluation du SNI* afin de mieux prendre en compte les travaux des chercheurs qui contribuent à l'innovation.
- Lancer auprès des autorités administratives et de la communauté scientifique une consultation sur *l'avenir à long terme du SNI.*
- *Mettre en place des structures de gouvernance et des obligations communes* dans tous les centres de recherche publics ; plus particulièrement, *étendre les accords de performances* aux centres de recherche supervisés par des ministères sectoriels. Modifier les accords de performances existants en tirant les enseignements pour le Mexique de l'expérience des autres pays de l'OCDE.
- Continuer de promouvoir une *autonomie croissante des centres de recherche publics en matière de gestion* des investissements et du personnel. Supprimer les contraintes de gestion imposées par la loi sur les entités parapubliques qui pèsent sur la conduite des activités scientifiques et technologiques, en particulier celles menées en collaboration avec le secteur privé. Envisager un niveau d'auto-financement accru, voire la possibilité d'une privatisation, pour les centres de recherche publics les plus engagés dans le développement et le transfert de technologie.
- Confier au Conseil consultatif sur les sciences et/ou à l'Académie des sciences mexicaine la mission de préparer des rapports annuels sur les moyens par lesquels la communauté scientifique peut le mieux concourir à relever au mieux les défis sociaux et économiques du Mexique.

Favoriser le perfectionnement, l'insertion et la mobilité des ressources humaines hautement qualifiées

- Adopter une approche plus stratégique dans la mise en œuvre du programme de bourses de l'enseignement supérieur, en introduisant un certain degré de sélectivité disciplinaire dans l'octroi des bourses.
- Faciliter les affectations temporaires dans l'industrie de diplômés du troisième cycle travaillant dans les centres de recherche publics.
- Renforcer les programmes existants qui facilitent l'*insertion de professionnels hautement qualifiés dans le secteur privé* et supprimer les obstacles à la mobilité des chercheurs d'une institution à une autre[17].

Renforcer les capacités scientifiques, technologiques et d'innovation régionales

- En concertation avec les conseils scientifiques et technologiques des États, élaborer *pour le moyen ou le long terme un plan-cadre sur la coopération entre les organes fédéraux et ceux des États* concernant le développement de l'infrastructure scientifique et technologique.
- Améliorer *les infrastructures scientifiques et technologiques régionales* grâce au financement institutionnel des établissements d'enseignement supérieur et des centres de recherche publics.
- Envisager la création d'un « fonds structurel » consacré spécialement au *développement de l'infrastructure scientifique et technologique dans les États les moins développés*.
- Utiliser les fonds d'investissement sectoriel pour favoriser la création de *pôles régionaux d'activités d'innovation* grâce à l'apport de ressources adéquates de la part des États, des autorités locales et des associations industrielles.
- Accroître *l'autonomie des États en matière de gestion* afin qu'ils puissent décider de l'attribution et du décaissement des crédits fédéraux/des États pour les projets de recherche et d'innovation.

Conclusions

Le présent rapport montre que le Mexique a progressé trop lentement vers un sentier de croissance alimentée par l'innovation, qui lui permettrait, à court terme, de renforcer sa compétitivité fondée sur le savoir et de tirer le même parti de la mondialisation que les économies émergentes les plus dynamiques. Sur le long terme, cette croissance donnerait au Mexique la possibilité de combler le large écart de niveau de vie qui le sépare encore des pays de l'OCDE plus riches.

Le rapport suggère que le gouvernement mexicain, dans le cadre d'un ambitieux « programme national d'innovation » de grande envergure, privilégie sans délai les réformes et les politiques qui permettront d'accroître les capacités dans tous les secteurs de l'économie et de stimuler l'innovation.

Il réitère pour commencer l'appel lancé dans d'autres rapports de l'OCDE en faveur de réformes de certaines des politiques qui définissent les conditions-cadres de l'innovation, en particulier celles de l'éducation et de la concurrence (OECD, 2006a, 2007a, 2007b, 2009a).

S'intéressant surtout au rôle de la politique de la science, la technologie et l'innovation au sens strict – dont l'objectif premier et explicite est d'améliorer les capacités d'innovation dans les secteurs public et privé – le rapport propose la hiérarchisation et l'ordonnancement suivants des initiatives gouvernementales.

Sur le court terme, la volonté accrue du gouvernement de stimuler l'innovation devrait se traduire par :

- l'amélioration des structures de gouvernance, afin d'assurer un encadrement plus efficace et une plus grande cohérence dans la formulation, la mise en œuvre et l'évaluation des politiques requises au niveau fédéral et des différents États.

- La poursuite de l'effort budgétaire en faveur de la R-D et l'innovation, tout en améliorant la conception et de la gestion des programmes financés avec l'argent public. Plus précisément, l'effort budgétaire global en faveur de l'innovation dans les entreprises (défini comme la somme du manque à gagner fiscal et du coût des aides directes) devra au minimum être maintenu, mais un nouvel équilibre devra être trouvé entre les incitations fiscales et les subventions, la priorité étant accordée aux secondes.

Sur le long terme, le gouvernement devrait entreprendre ou envisager d'autres réformes en ce qui concerne l'infrastructure et les structures d'incitation du système d'innovation mexicain. Outre l'avenir du SNI, il lui faudra également réexaminer le rôle des centres de recherche publics et des universités au sein d'un système d'innovation de plus en plus centré sur les entreprises.

Notes

1. Voir *OECD Reviews of Innovation Policy: China* (OECD, 2008a).
2. La part d'autofinancement des centres du CONACYT s'élevait en 2006 à 35 %.
3. Ce fut le cas, par exemple, du laboratoire national de génomique pour la biodiversité (LANGEBIO) de Guanajuato.
4. Et derrière des pays comme la Chine (1.43 %), le Brésil (1 %), l'Afrique du Sud (0.9 %) et le Chili (0.7 %).
5. Les enveloppes du CONACYT se sont, quant à elles, accrues de 20 %.
6. Quinze priorités sectorielles pour le fonds Economía-CONACYT.
7. C'est-à-dire l'ensemble des fonds d'investissement sectoriel, sauf celui de SEP-CONACYT et d'Economía-CONACYT.
8. 4.2 % du budget du CONACYT pour 2002-06.
9. Les crédits ont cependant été accrus en 2008, 350 millions MXN ayant été alloués aux « projets stratégiques », soit au minimum 30 millions MXN par projet.
10. Entre 1997 et 2006, la part du Mexique dans la production scientifique mondiale est passée de 0.52 à 0.75 %.
11. Mesurée par le nombre de citations par article scientifique.
12. Il ne s'est réuni que trois fois en six ans.
13. À l'heure actuelle, le Forum se compose de quatorze représentants du milieu universitaire et de trois de l'industrie.
14. Ces défaillances peuvent créer différents types d'obstacles à l'innovation concernant par exemple l'accès au financement, l'accès à la technologie propriétaire, ou la disponibilité d'un personnel qualifié.
15. À l'instar de la coordination entre les organes fédéraux et ceux des États, cette décentralisation serait plus facile si la structure administrative des organismes publics chargés de la politique et des programmes scientifiques et technologiques était plus homogène.
16. Le calcul de ces économies doit tenir compte du coût résiduel des crédits d'impôt accordés dans le cadre du programme d'incitation fiscal antérieur.
17. Cela peut obliger à réformer la loi sur l'emploi, dans la mesure où le statut du personnel des organismes de recherche publics est concerné.

Chapter 1

Economic Performance and Framework Conditions for Innovation

Mexico's economic performance in terms of growth of GDP per capita has been respectable but still insufficient to close the gap vis-à-vis *the most advanced OECD countries in terms of the population's living standards, and overcoming widespread poverty.*[1] *To shift the economy to a path of higher, sustainable growth, Mexico's economic policy needs to boost productivity growth. In the past, it has been sluggish. Given the salient role of innovation in driving longer-term productivity growth, the challenge is to encourage innovation throughout the Mexican economy. Achieving this goal will require significant, broad-based reform and dedicated efforts.*

1.1. Economic performance

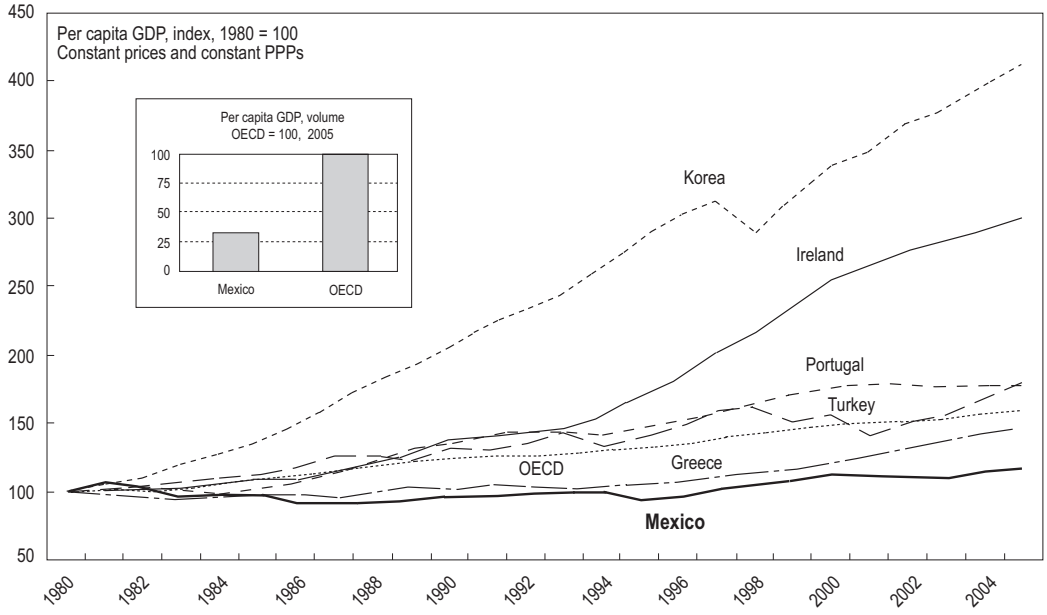
1.1.1. Macroeconomic performance

Since the 1994-95 peso crisis, Mexico's macroeconomic performance has improved significantly. It has benefited from structural reforms and the opening of the economy and achieved broad macroeconomic stability. From 2001 to 2007, GDP per capita has grown at a rate slightly above the OECD average. Underpinned by buoyant exports, strong investment and sustained domestic demand, GDP growth reached a robust 5.1% in 2006, slowing in 2007 to 3.3% following a drop in manufacturing exports. Given its specific international linkages, including its export specialisation patterns, Mexico has been severely hit by the current economic crisis, and both exports and domestic demand have fallen sharply. As the recession deepened in the United States – by far Mexico's main export destination – industrial production fell sharply and growth turned markedly negative in the first quarter of 2009. Continued difficulties, notably in the automotive industry, have reinforced the downturn. It is expected that the impact of a weak US economy, particularly on the manufacturing sector, and declining oil extraction will keep export growth negative during 2009 (OECD, 2009b).

In a longer term perspective, some economic analysts have called Mexico's post-NAFTA per capita GDP growth "reasonable but unremarkable" (Tornell *et al*., 2004, p. 34).[2] While economic performance in terms of growth of GDP per capita improved in the decade preceding the current crisis, Mexico's economic dynamism has not matched that of the better-performing emerging markets, nor has it been sufficient to sustain a process of convergence with the more advanced OECD economies:

- *Mexico's economic performance has not been outstanding in the longer term.* Mexico has not achieved the growth performance in terms of GDP per capita of the world's two most populous countries, China and India, over 1987-2007. Ireland, Portugal and Turkey have also performed better on this measure, as has Korea, with an exceptionally successful catching-up process despite the setback it suffered in the Asian crisis of the late 1990s (Figure 1.1). In Latin America, Chile provides an example of economic success and higher growth performance. However, Mexico has performed better than major emerging markets such as Brazil, the Russian Federation (which went through a transition crisis in the 1990s) and South Africa in terms of per capita GDP growth.

Figure 1.1. Per capita GDP in selected countries



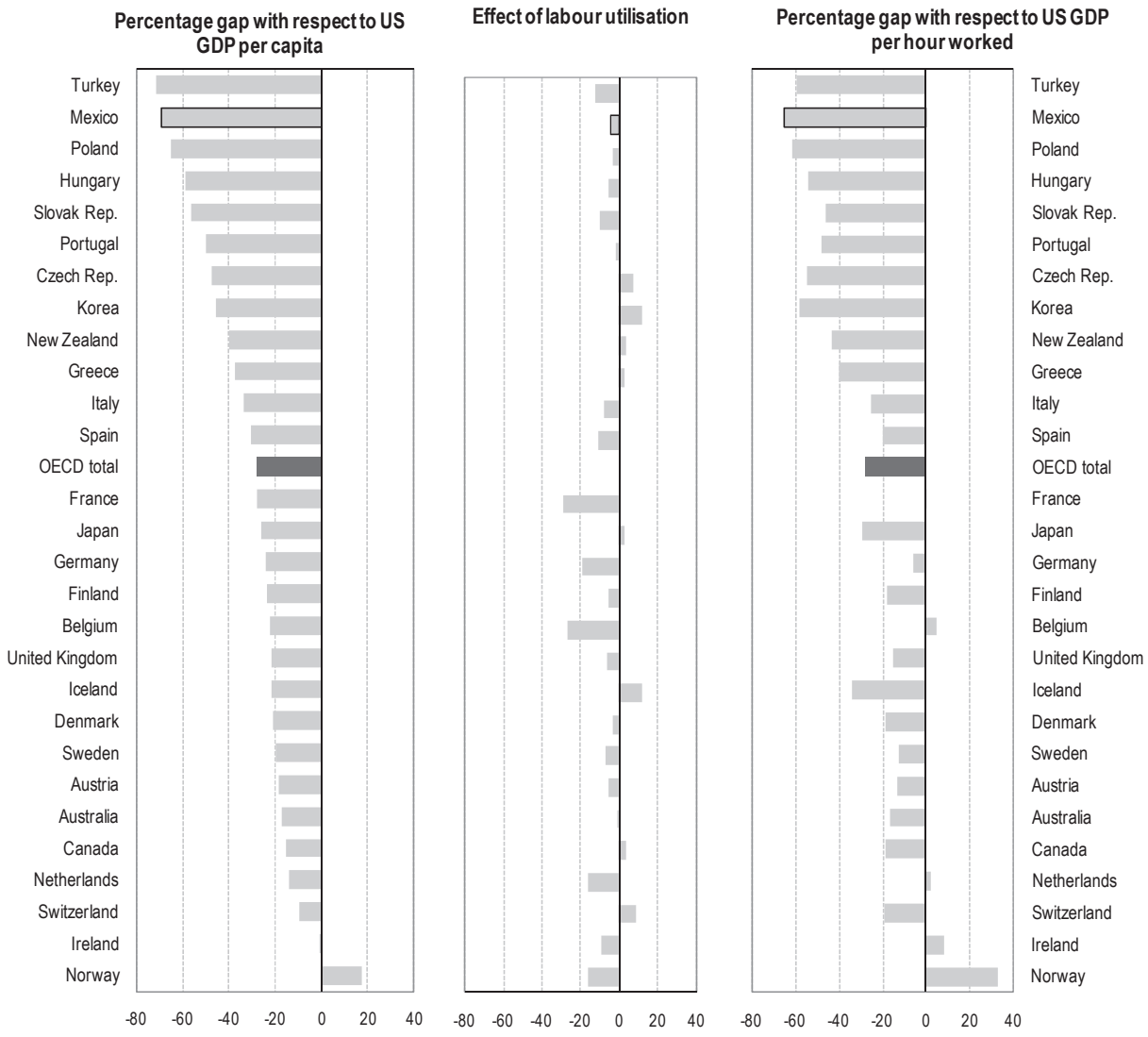
Source: OECD (2007), *Economic Survey: Mexico*, OECD, Paris.

- *However, growth performance improved in the decade preceding the current crisis*. Mexico's growth of GDP per capita was around 2% a year over 1997-2007, which implies a significant boost in performance as compared to the preceding decade (1987-97).

- Yet, Mexico's growth performance has not achieved convergence to the OECD average and particularly to the stronger performers among high-income countries. Mexico's level of GDP per capita remains the second lowest among OECD countries. In 2007 the gap *vis-à-vis* the United States amounted to 69 percentage points, and was almost completely (65 percentage points) accounted for by lagging labour productivity (as measured by GDP per hour worked). Lower labour utilisation accounted for only a very small part of this gap (Figure 1.2). In fact the level of labour productivity is the lowest in the OECD. As will be seen, the Mexican productivity gap has not been narrowing over time.

Figure 1.2. Income and productivity levels, 2007

Percentage point differences with the United States



Source: OECD (2009), *OECD Factbook 2009*, OECD, Paris.

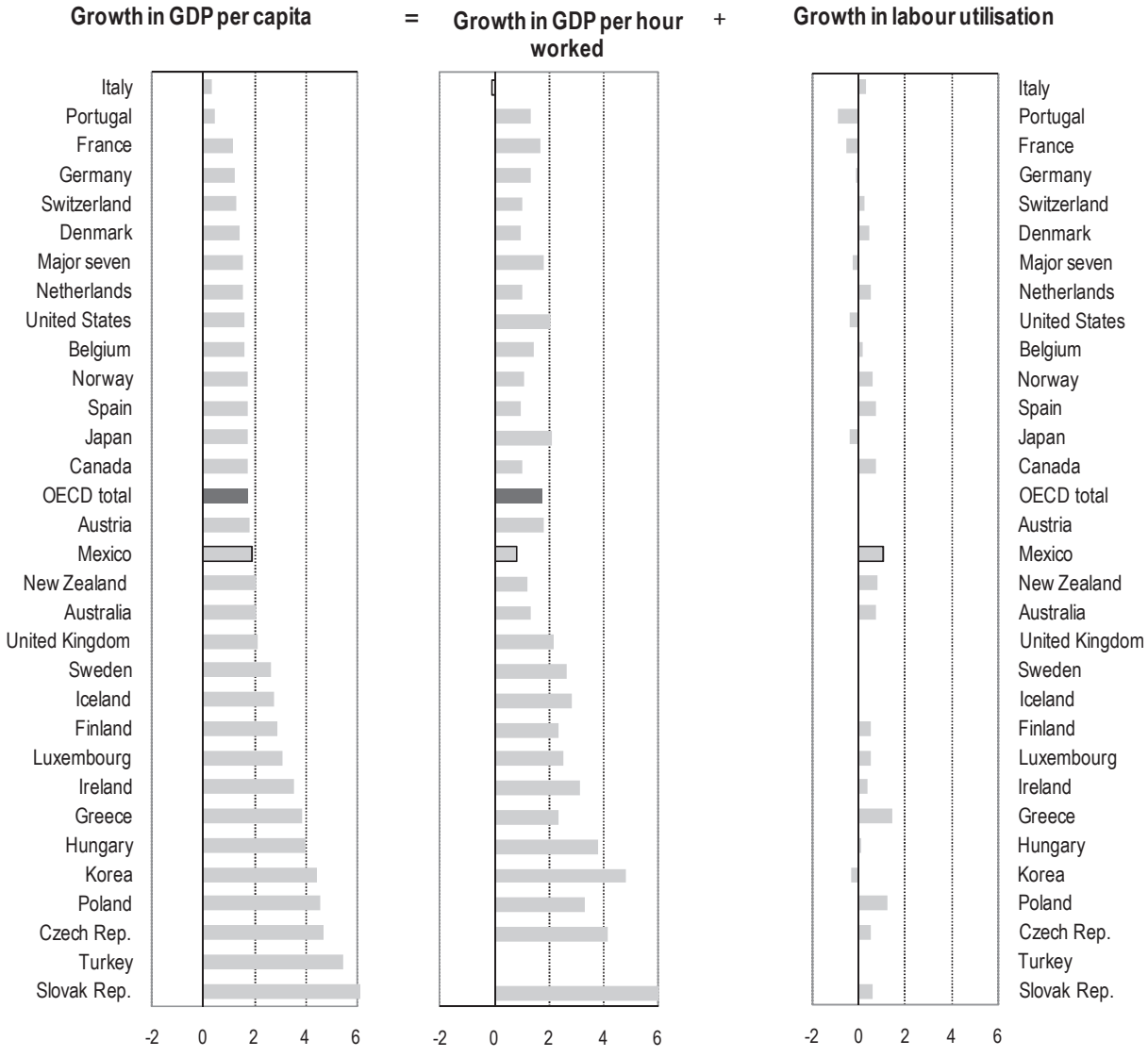
1.1.2. Productivity growth

Mexico's sluggish productivity growth stands in the way both of convergence of its per capita GDP and living standards with those of the advanced OECD countries and of keeping pace with high-performing emerging economies. Mexico's labour productivity growth (measured in terms of GDP per hour worked) has been among the lowest among OECD countries since 2000 (Figures 1.3 and 1.4). Mexico is the only OECD country in Figure 1.3 in which increased labour utilisation contributes more to growth of GDP per capita than labour productivity over 2001-07. It has been observed that Mexico's economic growth has been primarily based on augmentation of inputs of production factors rather than on higher productivity growth. From 1987 to 2007, Mexico's growth pattern has been "extensive", that is, based on increased labour utilisation (measured as

the ratio of those employed to persons of working age, *i.e.* 15 to 64 years) and on changes in the demographic structure (an increase in the ratio of the population of working age to the total population). Over the same period better-performing countries such as Chile, China, India and Turkey have tended to pursue an "intensive" growth path, relying more on labour productivity growth (OECD, 2009a).

Figure 1.3. Contribution of labour productivity and labour utilisation to GDP per capita, 2001-07

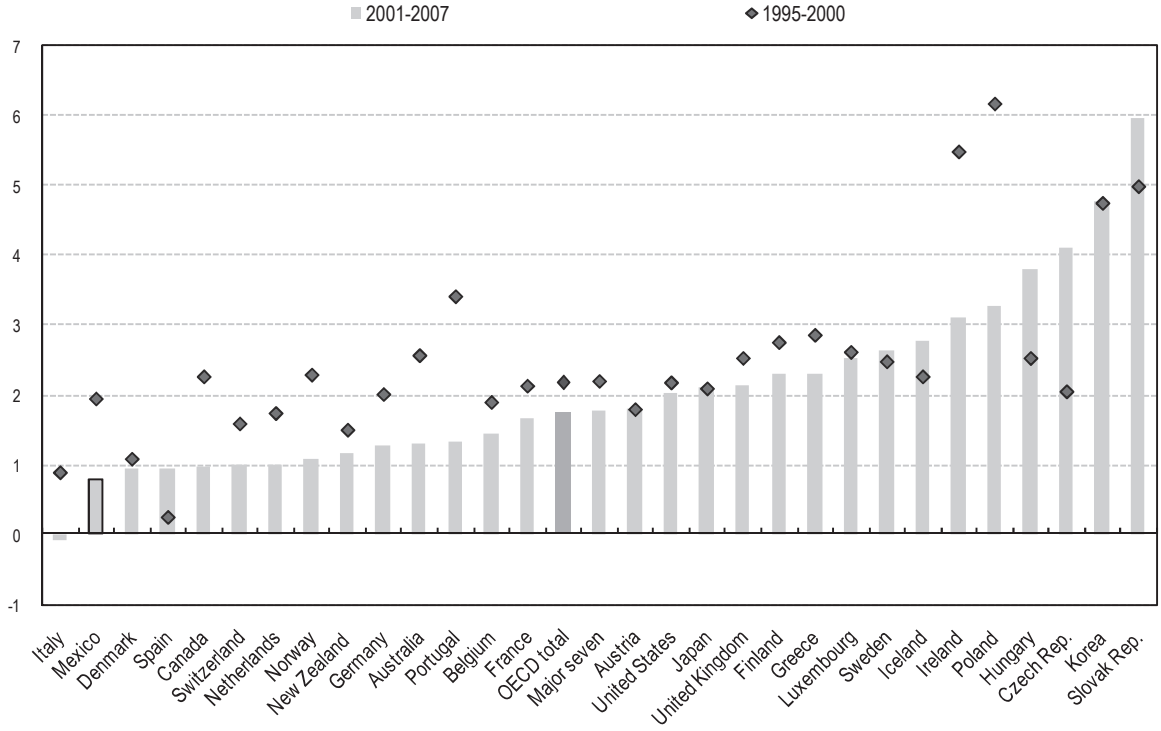
Percentage change at annual rate



Source: OECD (2009), *OECD Factbook 2009*, OECD, Paris.

Figure 1.4. Growth in GDP per hour worked, 1995-2000 and 2001-07

Percentage change at annual rate



Source: OECD (2009), *OECD Factbook 2009*, OECD, Paris.

There is evidence of some shift in the patterns of productivity growth. In recent years, productivity growth has been mostly driven by within-sector rather than between-sector growth (OECD, 2009a). The latter captures re-allocation of labour resources between sectors, while the former is associated with capital accumulation and technical change. Between-sector productivity growth tends to be characteristic of countries in earlier stages of economic development as they shift from low-productivity agriculture to other sectors, such as manufacturing. Thus, the observed shift in the pattern of productivity growth implies that it has become more similar to that of more advanced countries.

The overall weakness of productivity growth is partly related to a lack of innovation capacity. At the sectoral and firm level, the preference for imported technology over the development of indigenous innovation capacity has led to less technology diffusion and transfer than would have been expected from increased international (including intra-sectoral) trade and flows of foreign direct investment (FDI). The problem has been compounded by framework conditions that are in some respects not conducive to the adoption of innovative strategies – which entail funding and managing the inherent risks. This is reflected in the very low level of patenting by Mexican industry. Moreover, industries classified as high-technology do not invest significantly more in R&D and innovation as a share of value added than lower-technology ones. As a result, they do not play a driving role in the dissemination of knowledge and technology throughout the business sector or in the formation of technology-based value chains. At an economy-wide level, this points to an under-performing innovation system.

Productivity growth can be fostered by improving educational outcomes, upgrading the infrastructure, further boosting international trade and FDI, increasing competition, lowering the cost of doing business, and facilitating access to finance for business enterprises, notably innovative start-ups. The *OECD Economic Survey of Mexico 2007* investigated a broader set of these issues in depth (OECD, 2007a). There is significant potential in the Mexican economy for the adoption of such policies. Yet, these broad policies need to be complemented by targeted measures aimed at improving Mexico's innovation performance.

1.2. International trade and foreign direct investment

In the global economy, international trade and foreign direct investment are important pillars of growth.[3] Openness to international trade and FDI affects a country's innovation performance in various ways.

Mexico began to liberalise international trade and to ease restrictions on foreign investment in the 1980s. In 1986, Mexico became a member of the GATT (General Agreement on Tariffs and Trade, later the World Trade Organization – WTO). Mexico has also made significant progress in opening the economy to international trade by lowering tariffs through bilateral and multilateral regional free trade agreements (RTAs). Mexico's RTAs now encompass its main trading partners and main players in global trade, notably the United States and Canada (through the North American Free Trade Agreement, NAFTA, in force since 1994), the European Union (2000) and Japan (2005). In practice, NAFTA is by far Mexico's most significant RTA. The integration of the Mexican and the US economy is particularly important; the United States is the source of much FDI and the destination of 85% of Mexican exports. Mexico's import sources are more diversified (Table 1.1).

As a result of two decades of reform, Mexico is much better integrated in the global economy today than it was at the beginning of the liberalisation process in the 1980s. Yet, as will be discussed below, there remain important barriers to further economic integration. According to the KOF Index of Globalisation 2009,[4] which provides a synthetic measure of economic, social and political globalisation, Mexico ranks 65th on all three dimensions taken together, and 79th on the economic dimension of globalisation, a low rank for an OECD country. Economic globalisation is captured by a synthetic indicator which encompasses actual flows (trade, FDI stocks and flows, portfolio investment and income payments to foreign nationals) and restrictions (hidden import barriers, mean tariff rate, taxes on international trade, current account restrictions).[5] Mexico's low rank in terms of economic globalisation is mainly due to remaining restrictions. These are dealt with in some detail later in the chapter.

Table 1.1. Trade in goods between Mexico and the United States, 1992-2008

	1992	1995	2000	2005	2008
Share of Mexico's exports destined to the United States	69.8	91.1	87.1	88.9	84.9
Share of Mexican imports originated in the United States	67.9	70.0	74.5	62.0	51.1
Share of US exports destined to Mexico	7.3	9.0	11.6	13.5	12.9
Share of US imports originated in Mexico	6.0	6.8	10.2	10.7	10.4

Note: ISIC Rev. 3 divisions 01-37.

Source: OECD STAN Bilateral Trade Database.

The opening of Mexico's economy has resulted not just in increased trans-border trade and capital flows and significant structural change, it has also helped to improve the functioning of product markets, creating a more favourable general business environment.

1.2.1. International trade

The expansion of international trade, underpinned by economic reform, has been a major driver of economic growth. NAFTA very significantly increased the size of the markets that are freely accessible to Mexican exporters. With the opening of the economy, Mexico's trade in goods and services (defined as the average of the share of exports and imports) increased from 17.5% of GDP in 1994 to a peak of 29.2% in 2007. A jump in Mexico's trade in goods and services (by 9 percentage points) occurred between 1994 and 1995 (26.5%), with the coming into force of NAFTA, but the increase was insignificant in subsequent years. Following a relative decline during the early years of this decade it reached this level again in 2007. Mexico's combined share of exports and imports has increased from 39% of GDP in 1990 to 58% in 1995 (the year after NAFTA came into force) and 67% in 2007.

Both exports and imports of goods have grown rapidly (nearly fivefold between 1994 and 2007 to approximately USD 270-280 billion), *i.e.* faster than the OECD average. Mexico has developed an export specialisation in manufactured goods, which now account for over 85% of all goods exports; the automotive sector and electrical and television equipment furnish the main export items (see below). The share of Mexico's exports of manufactured goods in world manufactured imports (in value terms) increased from 1.5% in 1994 to 3% in 2000 and 2001, before declining to around 2.3%, where it remained between 2004 and 2006 (Haugh *et al*., 2008). Yet, the dynamism of Mexico's exports has not matched that of goods exports from emerging economies such as Brazil, China, India, Indonesia, Russia or Turkey. The level of exports and imports of services is much lower and has grown much less rapidly than exports and imports of goods (not even doubling in the period concerned). Indeed, during the last decade, growth in Mexico's service exports was one of the lowest among OECD countries. Import penetration, measured as a share of domestic demand, has also increased, but at around 30% it is still among the lowest in the OECD area. As mentioned, Mexico's international trade has been severely affected by the current economic crisis.

Trade liberalisation, especially through NAFTA, created new opportunities and very significantly expanded the size of markets available to Mexican exporters. It also increased the exposure of Mexican firms to import competition in the domestic market and intensified competition in export markets, especially in the United States. Openness thus creates opportunities but also poses formidable challenges for Mexican firms and for the government to provide broad framework conditions that are conducive to business activities.

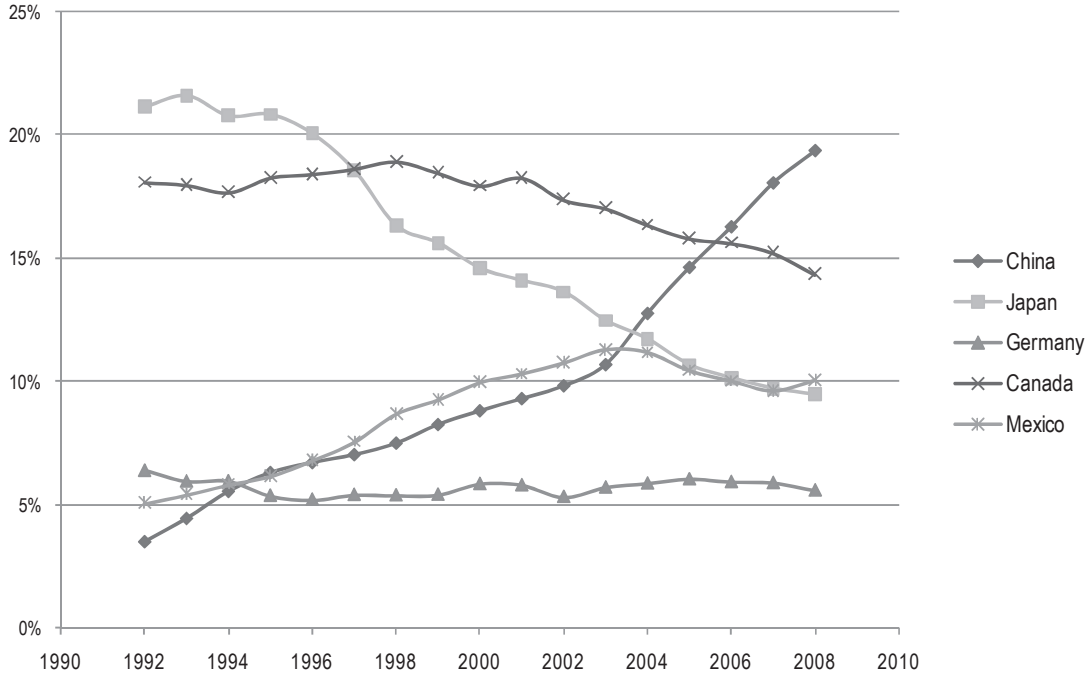
This challenge is illustrated by OECD work on Mexico's export performance (Haugh *et al*., 2008). Mexico's export performance was very strong in 1994-2000, and its share of the world market for manufactures rose by 92%. Using constant market share analysis, Haugh *et al.* (2008) show that two-thirds of this increase was due to the "market share effect", as Mexican products gained market share in their individual markets. Following the coming into force of NAFTA, Mexico also benefited from its strong export specialisation in the US market at a time when US import growth exceeded the world average.[6] As a result, "geographic specialisation" contributed 14 percentage points of the total change. Mexico's export "product mix" contributed 6 percentage points to the total

change in world market share. In 2001 export performance weakened significantly, and market share started to decline in 2002. In all, Mexico's world market share dropped by 18.4% over 2001-06. This can be largely attributed to Mexico's geographic specialisation, which accounted for 14.4 percentage points of the decline, owing to slower growth of US imports relative to world imports. Mexico's product specialisation had no part in the decline in market share. However, the market share effect – which drove strong export performance in 1995-2000 – was clearly negative (contributing -5.6 percentage points), particularly in the United States.

This result is consistent with the observation that the entry of firms from emerging economies, notably China, into the US market led to more vigorous competition for Mexican firms exporting to the United States, especially after the accession of China to the WTO in 2000, and a loss in competitiveness aggravated by a gradual real exchange rate appreciation. The current decade saw the spectacular rise of China as the "workshop of the world". Chinese exports to the United States expanded very rapidly. By 2005 its share of US imports of manufactures had risen to 15%. As a result, all major exporters to the United States – including Mexico – lost market shares over the period, with Japan suffering the largest losses. As of 2004, China had overtaken Mexico and Japan to become the second largest exporter of manufactured goods to the United States after Canada. It later rose to first position (Figure 1.5).

Figure 1.5. Shares of major exporters to the United States, 1992-2008

Manufacturing imports as a percentage of total US imports



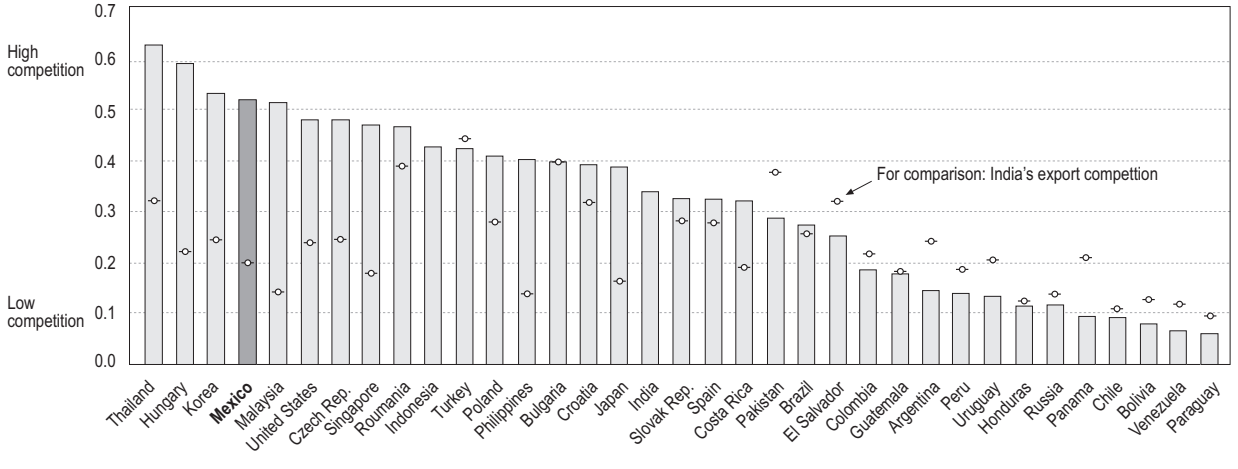
Source: OECD STAN Bilateral Trade Database.

Gallagher *et al*. (2008) find that more than half of Mexico's non-oil exports were under direct or partial threat from Chinese competition. Mexico was able to retain its position in exports based on low-skill assembly operations with higher transport costs and on NAFTA's rules of origin, which serve as local content rules and mandate that production must stay in North America (Gallagher *et al*., 2008, p. 1376).

In light of the increased competition from Chinese exporters, Mesquita Moreira (2006) revisits the long-standing debate about the role of manufacturing in Latin America's future development.[7] The issue is particularly important for Mexico because of its comparatively large manufacturing sector. In addition, the specialisation of Mexican exports is quite similar to China's. Figure 1.6 shows the similarity of export structures between China and selected Latin American and emerging economies. A high measure indicates similarity in export structures, as determined by the specialisation and conformity coefficients.[8] Based on this measure, Mexico appears potentially to be the most exposed of Latin American countries to Chinese competition. Along with Mexico, exports from Hungary, Malaysia and Thailand (all of which have an export-oriented manufacturing sector) also closely resemble those from China. By contrast, the similarity of Mexico's export structure to that of India and thus to potential competition is much weaker.

Figure 1.6. Export competition with China, selected countries, 2000-05

Average coefficients of specialisation and coefficients of conformity



Source: OECD (2007), *Latin American Outlook 2008*, based on WITS and Comtrade data (2007).

Given this background, a number of factors may have contributed to the fact that the shares of Mexico's main non-oil exports to the US market have either declined or grew at a slower pace than China's. They include the rising real exchange rate of the peso relative to the US dollar (notably in conjunction with the dollar/yuan exchange rate), weaknesses in Mexico's infrastructure, limited access to bank credit and a lack of innovation (Gallagher *et al*., 2008). Low innovative performance of the business sector as a whole (as indicated by innovation outputs or the creation of technology-based firms) and low productivity growth have contributed to the decline in international competitiveness of Mexican firms. The rise of unit labour costs during the second half of the 1990s in an environment of increased competitive pressure from emerging economies also had a part in eroding Mexican competitiveness.

Although the evidence suggests that Mexico's export performance was on the way to recovery before the onset of the current economic crisis (Sargent and Matthews, 2008), competition from exporters in emerging markets will almost certainly remain strong. Moreover, it can reasonably be expected that "China is bound to have a spectrum of comparative advantages" (Mesquita Moreira, 2006). China, and to a lesser extent Brazil, have outpaced Mexico in innovation-related investment as a share of GDP or manufacturing value added. There is strong evidence that China's effort will be sustained, with investments in education, science, technology and innovation (OECD, 2008a). While China may face initial disadvantages in research productivity relative to the scientifically and technologically more advanced OECD countries, it is exceptional in many respects, including its size, which may be an advantage for spreading the cost of R&D, and its proven ability to sustain a coherent effort to reach long-term goals. As a result, China can be expected to retain its existing comparative advantages and to develop new ones in a broad range of products both in the low-skill and in knowledge- and technology-intensive segments of production.

1.2.2. Foreign direct investment (FDI)

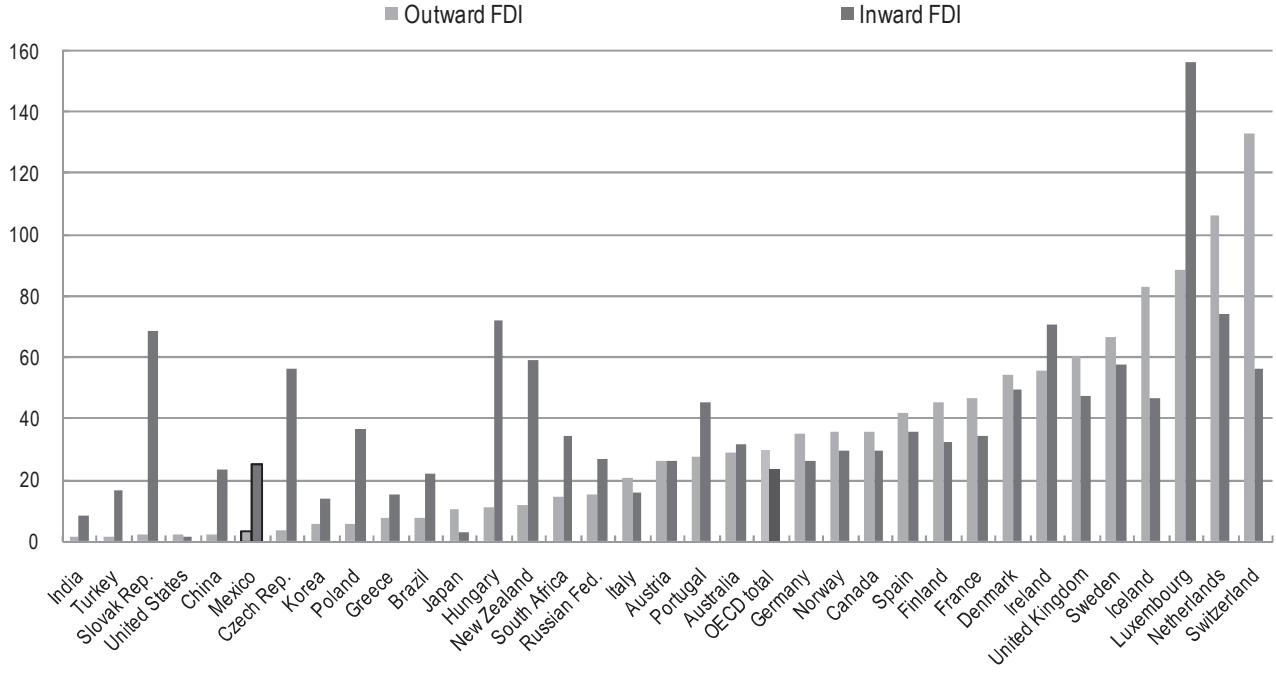
At 25% of GDP, Mexico's inward FDI stocks are slightly above the OECD average (2006), and relatively larger than those of major emerging markets such as Brazil, China, India and Turkey (Figure 1.7). Between 1990 and 2006 Mexico's inward direct investment stocks increased more than tenfold (in USD). Yet, Mexico does not seem to have made full use of its potential. UNCTAD (2008) lists Mexico among the countries with high inward FDI potential but low performance.[9] Outward FDI stocks (3.3% of GDP) are small, as they are for many other emerging economies (with the exception of the Russian Federation and South Africa). However, some Mexican companies have developed a strong presence through subsidiaries abroad. For example, Cemex is among the global leaders in the cement industry.

In recent years, gross FDI inflows relative to GDP were close to the OECD average. Yet, during 2000-06 a number of catching-up economies, including some OECD members, have been able to attract significantly higher inflows of direct investment. From 1994 to 2005, manufacturing accounted for approximately half of the gross FDI inflows to Mexico. However, except for financial services there have not been complementary large inflows of direct investment in the services and infrastructure sectors. This imbalance may have a negative impact on the development of the manufacturing sector in the longer term as there are already some bottlenecks as regards services and infrastructure provision.

In principle, FDI can serve many purposes in the overall context of a country's economic development. It is closely related to goods trade and, especially in service industries, commercial presence is one of the main modes of cross-border service supply. Higher inward FDI increases competitive pressures in the economy. It is also an important vehicle for technology spillovers and stimulates innovative activity (Nicoletti *et al*., 2003). There is empirical evidence that openness to international trade and FDI is an important channel for the international R&D spillovers which are an important source of total factor productivity growth (Coe *et al*., 2008).

Figure 1.7. FDI stocks, 2006[1]

As a percentage of GDP



1. Or latest available year.

Source: OECD (2009), *OECD Factbook 2009*, OECD, Paris.

FDI has contributed to Mexico's economic growth in various ways. Foreign-owned manufacturing firms play a major role in export-oriented industries. In principle, multinational enterprises can be a source of learning about advanced methods in production, finance and marketing, and thus can help foster innovation. In this way they can contribute indirectly to improving economic performance. However, these positive spillover effects do not accrue automatically. The empirical evidence suggests that the degree and quality of spillovers depend on the absorptive capacities of the host country (human capital, capabilities of firms in a variety of dimensions).[10] In Mexico, spillovers from inward FDI appear to be limited. Improving the ability to attract more FDI and increase the benefits of spillovers of FDI to domestic firms is strongly related to business firms' capabilities, which largely reside in their human capital stock (see below).

Through competition, trade, and technology transfers, FDI is an important driver of growth. There is also empirical evidence that it boosts labour productivity, both directly by augmenting the capital stock, and indirectly, by inducing greater domestic capital investment (Ramirez, 2006). However, as the section on framework conditions for innovation will show, the barriers to FDI in Mexico are still among the highest in the OECD area.

1.3. Economic structure and structural change

There has been a significant change in Mexico's structure of production and trade. The export-oriented manufacturing sector has received significant flows of FDI, primarily from the United States, and has been an important engine of growth, especially after NAFTA came into force. Mexico's international trade has also undergone structural changes, and its composition differs markedly from that of the vast majority of Latin American countries.

1.3.1. Industry and trade

Between 1970 and 2006, the share of agriculture in GDP has declined in real terms, a process which has accelerated in the last decade. Mining, including oil extraction, also lost weight albeit marginally. As in other countries, the contribution of the services sector to GDP has increased, most strongly in financial and transport and telecommunication services. Unlike many developing countries and some natural-resource-based emerging economies, Mexican manufacturing largely maintained its share in GDP, driven by the stunning performance of its export-oriented, globalised segment; the expansion recorded up to 2000 was followed by a (possibly temporary) loss of share towards the mid-2000s. Growth in the globalised segment offset the decline in parts of manufacturing which are not strongly linked to global value chains. Chemical substances and oil derivatives lost shares, and the contribution of textiles, leather and footwear products declined as well in relative terms. The part of the manufacturing sector that significantly increased its contribution to GDP was metal products, machinery and equipment; this is mainly due to the dynamism of the automotive and electronics (radio, TV sets, computers) industries, all of them strongly export-oriented.

The export-oriented sector of the economy is the source of more than 90% of high-technology manufacturing exports. Upper-medium or high-technology industries (electronics and auto parts) dominate the *maquila* sector, which also produces low-technology goods (textile products). The PITEX programme was centred on medium-high-technology products such as automobiles. Mexican manufacturing has specialised in segments of the manufacturing process that require little domestic R&D. Under standard classifications, some of the products are nevertheless in the high-technology category (since production of the same product categories is R&D-intensive in more advanced countries). R&D expenditure (as a percentage of value added) is only slightly higher in the segments of the Mexican economy that produce goods commonly classified as high-technology. In addition, many of those activities are not or only weakly linked to local production – a significant share of inputs are imported – or with the larger national innovation system.[11] Industries oriented towards the (less dynamic) domestic markets are characterised by high technological heterogeneity and typically low-technology activity. Leading firms recorded significant productivity growth but productivity gaps between industries and sectors are increasing. Best practices relating to technology and productivity performance fail to diffuse smoothly across industries.

Along with other important – albeit often incomplete – structural reforms, trade liberalisation had a profound impact on the direction and speed of structural change in Mexico's economy. Not only has the volume of trade expanded, the structure of trade flows has also changed radically during the past two decades. Mexico's export specialisation today is primarily in manufactured goods, reflecting an increasing specialisation in

economic activities that are integrated in global value chains. The main export items are manufactured goods related to the automotive industry and electrical and television equipment (Table 1.2).

Table 1.2. Main categories of manufactured exports by value, 2001-06

Average share in percentage

Sector	% of manufactured exports
Transport equipment (primarily autos and auto parts)	20
Radio and TV equipment	14
Wires, cables, circuits and components	11
Computers and office machines	8
Electric motors and appliances	6
Clothing and footwear	6
Base metals	6
Chemicals, rubber and plastics	5

Source: Haugh *et al*. (2008), "Maximising Mexico's Gains from Integration in the World Economy", Economics Department Working Paper No. 657, OECD, Paris, based on OECD International Trade by Commodities Statistics.

Mexico's export structure differs markedly from that of other Latin American countries:

- The share of inter-industry trade is high. It has been argued that inter-industry trade in manufactures provides relatively larger opportunities for (technological) learning, especially compared to commodity exports. However, this potential depends on the precise nature of economic activities and the capabilities of domestic actors.
- Mexico has comparative advantages in a relatively broad range of goods.[12]

In the wake of trade liberalisation, Mexico significantly increased the variety of its exports in the 1990s (Feenstra and Kee, 2007). China did so as well and in some industries to a greater degree than Mexico. A high degree of product variety can be important. For example, there is some evidence that the greater variety of imports helped to raise welfare in the United States (Broda and Weinstein, 2006). Greater variety in exports seems to have a positive impact on the exporting country's aggregate productivity, although it does not explain much of between-country differences (Feenstra and Kee, 2008).

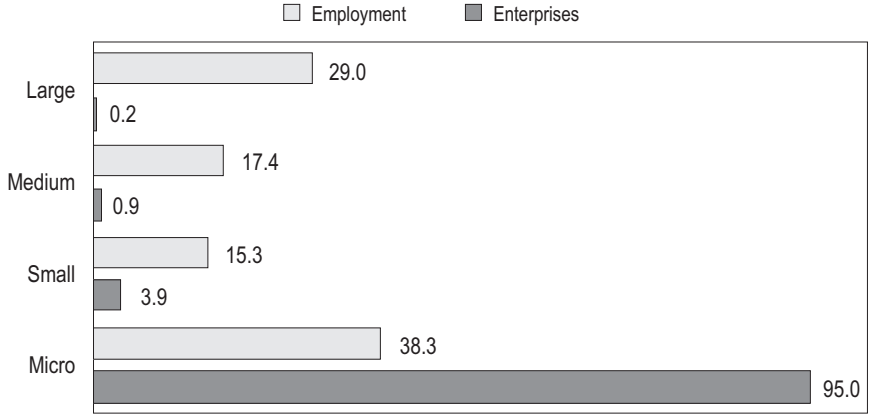
In principle, the differentiated comparative advantage linked to fast-growing intra-industry trade may be seen as an advantage.[13] However, the expansion of Mexico's international trade, underpinned notably by NAFTA and the *maquila*/PITEX programmes that allowed rapid expansion of manufactured exports, resulted from low labour costs rather than high and rising productivity and innovative capacity. In view of the changing international environment and strong competition from emerging economies, this may become an even greater constraint in the future.

1.3.2. Firm size

The size distribution of the total population of firms is important since firms' size is related to their capabilities, not least in the area of R&D and innovation, the role they play in the national innovation system and specific requirements for facilitating their operations. The Mexican industrial ecology[14] is dominated by micro-enterprises, with more than 4 million in the formal economy, whereas the number of large and medium-sized firms is extremely small at just 6 700 in 2003 (Figure 1.8). As Table 1.3, which refers only to manufacturing, shows, the predominance of micro-enterprises is greater than in most other OECD countries. Small enterprises account for just about 10% of employment in the manufacturing sector, much less than in other OECD countries (Table 1.4). However, large firms (more than 250 employees) and micro-enterprises account for a larger share in total employment in the manufacturing sector than in many other OECD countries. The informal sector is believed to include as many micro-enterprises as the formal sector. Mexico has high levels of self-employment compared to most other OECD countries (Figure 1.9).

The evidence points to a fragmented production structure and a highly polarised profile of employment and productivity levels (OECD, 2007b). The typical firm is small and mostly owned and run by a family. Around 90% are located in retail, services and agriculture and their output is oriented towards local markets. Only a small share of micro-enterprises are in manufacturing (just over 300 000). In contrast, a few internationally competitive firms, mainly situated in the metropolitan areas of Mexico City and Monterrey, have modern equipment and a strong innovation culture (Mittelstädt and Cerri, 2008). In addition there are the *maquiladoras*, defined as factories or assembly plants operated in Mexico under preferential tariff programmes. In 2004, there were almost 3 000 *maquilas* employing more than 1 million workers. Many are operated by multinational enterprises and their suppliers. A main weakness of Mexico's smaller firms is their outmoded product design and the low product quality, outdated equipment, and inadequate marketing. This is related to limited access to finance, low levels of human capital and inadequate use of technology, as illustrated by Mexico's gap in the diffusion of information and communication technologies (ICTs). There is no own R&D effort in large parts of the sector of small and medium-sized enterprises (SMEs).

Figure 1.8. Distribution of employment and enterprises by firm size, 2003



Source: OECD (2007), *SMEs in Mexico: Issues and Policies*, OECD, Paris.

Table 1.3. Share of enterprises by size class in the manufacturing sector, 2003

	1-9	10-49	50-249	250+
Mexico	**90.9**	**6.0**	**2.2**	**0.9**
Czech Republic	90.2	7.1	2.1	0.6
Hungary	86.2	10.2	2.8	0.8
France	82.8	13.2	3.2	0.8
Italy	82.6	15.1	2.0	0.3
Portugal	79.8	16.3	3.5	0.4
Spain	78.0	18.7	2.8	0.5
Netherlands	74.5	19.1	5.3	1.1
Austria	72.6	20.6	5.3	1.5
Denmark	71.7	20.9	6.0	1.4
United Kingdom	71.3	21.4	5.9	1.4
Germany	60.2	29.7	8.0	2.1
United States	58.2	33.7	5.1	3.0

Note: For the United Kingdom and the United States data are for 2002. Size class discrepancies: United States: 20-99, 100-499, +500; Mexico: 0-10, 11-50. Size classes for all countries but Mexico have been merged for 10-19 and 20-49.

Source: OECD Database Business by Size Class. Data for Mexico are from INEGI.

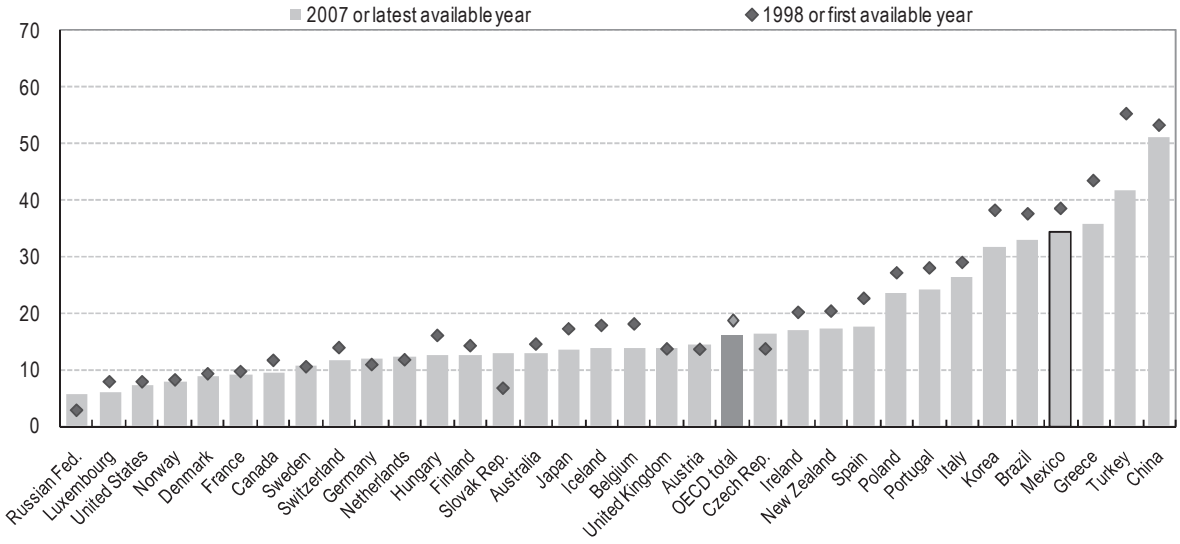
Table 1.4. Percentage of employees by size class in the manufacturing sector, 2003

	1-9	10-49	50-249	250+
Portugal	18.7	29.4	30.3	21.6
Mexico	**18.1**	**10.3**	**19.3**	**52.3**
Spain	14.8	33.2	24.5	27.5
Italy	14.6	34.0	24.8	26.6
Japan	12.6	28.3	30.0	29.1
Korea	11.3	34.8	25.0	28.9
Hungary	10.4	18.0	25.3	46.3
France	10.2	19.3	22.5	48.0
Netherlands	10.1	22.7	29.7	37.5
United Kingdom	8.8	19.2	26.7	45.3
Austria	7.8	19.0	27.9	45.3
Denmark	6.0	19.2	26.9	47.9
Czech Republic	5.5	17.5	28.5	48.5
Germany	5.2	15.6	23.8	55.4
United States	4.3	20.7	17.1	57.9

Note: For the United Kingdom and the United States data comes from 2002. Size class discrepancies: United States: 20-99, 100-499, +500; Mexico: 0-10, 11-50; Korea: 50-199, 200+. Size classes for all countries but Mexico have been merged for 10-19 and 20-49.

Source: OECD Database Business by Size Class. Data for Mexico are from INEGI.

Figure 1.9. Total self-employment rates, 1998 and 2007



Source: OECD (2009c), *OECD Factbook 2009*, OECD, Paris.

1.4. Framework conditions for innovation

Innovation cannot flourish in a business environment that restricts competition, imposes undue regulatory, administrative or financing burdens on the creation of new enterprises, discourages intangible investment, overprices infrastructure costs or raises undue barriers to the mobility of the labour force. Reforms introduced in recent years to improve the business environment of Mexican firms have certainly borne fruit, but they remain incomplete, insufficiently implemented and enforced. This situation is partly due to administrative inefficiencies or lack of resources, but it also reflects resistance by entrenched interests.

Achieving good innovation performance requires framework conditions that are conducive to innovation. Seriously flawed framework conditions can frustrate the work of innovation policy. Framework conditions encompass macroeconomic stability, international openness, vigorous competition and intellectual property rights, innovation-friendly regulation and taxation, a well-functioning system of financing innovative firms and projects, a well-functioning infrastructure, good corporate governance, efficient information systems, etc.

Innovation policy needs to be carefully designed in order not to crowd out private-sector efforts and initiatives. Successful innovation policy will enable the market to play its proper role in spurring innovation. Appropriate framework conditions should aim at ensuring that private innovation activity can improve entrepreneurs' economic position. Specific innovation policy measures are required to correct for specific instances of market or systemic failure in knowledge transactions which may arise in the interplay of different market and non-market actors of the innovation system.

There are several reasons why favourable framework conditions and a healthy business environment are essential for boosting innovation:

- Innovation activity requires a medium- or long-term planning horizon and thus a sufficiently stable environment in which to perform it. This is particularly important for R&D and other more complex types of innovation activity.
- A competitive environment provides powerful incentives for business enterprises to innovate.
- The regulatory framework is of crucial importance for the speed of diffusion, and in some cases also for the generation of specific new technologies. This was demonstrated on a global scale in recent decades by developments in the telecommunications sector.
- Framework conditions also have an impact on the effectiveness of innovation policy itself. Unfavourable framework conditions may reduce the effectiveness of specific policy measures designed to foster innovation: No amount of dedicated innovation policy measures can compensate for the absence or the serious malfunctioning of markets or other fundamental economic institutions.

The following is a discussion of some important elements of the overall framework conditions for fostering innovation: the macroeconomic framework, competition and intellectual property rights.

1.4.1. Macroeconomic framework

As mentioned above, the macroeconomic management of the Mexican economy has improved substantially since the financial crisis of the mid-1990s. This is apparent in the drop in inflation, small current account and fiscal deficits, and low public and foreign debt. OECD experience shows that a stable macroeconomic environment – in particular strong and robust rates of output growth – provides better conditions for business firms to pursue the medium- to long-term goals that are a salient feature of R&D investment and of the more demanding types of product, process and organisational innovation. A sound macroeconomic framework may also help investment in R&D and innovation through low and stable inflation rates by reducing the level and volatility of real interest rates (Jaumotte and Pain, 2005b; OECD, 2006b). Apart from these direct effects of macroeconomic conditions on the level of business R&D, indirect effects may be operating through the policy-making process. Under tight budgetary conditions public expenditure directed towards long-term objectives may be crowded out by other expenditure which is perceived as more urgent. As a result, long-term issues tend to move down on policy makers' lists of priorities.

Mexico's commitment to macroeconomic stability has already become an important factor in improved economic performance; it is also a necessary – albeit not a sufficient – condition for better innovation performance.

1.4.2. International openness

Despite major progress in opening its economy, Mexico's trade policy remains more restrictive (on a combined measure of tariff and non-tariff barriers) than the OECD average and than in other emerging economies (Haugh *et al*., 2008).[15] A combination of high protection of low-productivity industries and bilateral trade agreements can have harmful effects on innovation and productivity growth (see the example of trade diversion discussed in Box 1.1).

Box 1.1. Trade diversion, productivity and employment

The combination of relatively high protection of low-productivity sectors and bilateral trade agreements can lead to the expansion of low-productivity sectors and trade diversion. Trade diversion occurs when two economies have lower tariffs between them than with the rest of the world, so that trade between them increases at the expense of more efficient trade with other economies outside the trading bloc. For the importing economy this results in higher import costs and for the exporting economy it can result in the expansion of low-productivity sectors that drag down overall productivity performance and growth.

Evidence suggests that trade diversion has almost certainly occurred to some degree in NAFTA, especially in the clothing industry. The creation of NAFTA, together with high US and Mexican external import barriers for clothing, created a strong bias towards US imports from the Mexican clothing sector, which is labour-intensive and has lower labour productivity than other parts of the economy. This led to a large expansion of the sector in Mexico, with employment growing and Mexico posting large market share gains in the United States in the 1990s, while the Asian market share was falling. The adjustment of Mexico's sector was only postponed. During the early 2000s, as the United States began to reduce its barriers to imports of clothing from rest of the world markets and imports from other countries into the United States grew, Mexico's market share fell.

Although the expansion of the clothing sector helped absorb part of the rapidly growing workforce in the non-farm sector, it is also one of the reasons why Mexico's productivity growth performance has failed to match that of other middle-income countries. It is important to create enough employment to absorb the very rapid increases in the labour force, but increased employment in low-skilled protected sectors, such as the clothing industry, is only a short-term, second-best, solution. As the experience of the clothing industry illustrates, continued protection will maintain or increase jobs in low-skilled industries only temporarily, postponing the adjustment. Sooner or later, developments beyond Mexico's control, such as trade policy in other countries, technology changes and structural measures in other countries that improve the cost competitiveness of foreign firms, will eventually put pressure on the industry and lead to job losses.

Hence, Mexico should move ahead to gradually reduce protection in favoured industries, while at the same time ensuring that adequate retraining programmes are available for displaced workers with temporary income support if appropriate. Raising human capital is the only way to ensure sustainable higher productivity employment growth in the long run.

Source: Haugh *et al.* (2008), "Maximising Mexico's Gains from Integration in the World Economy", Economics Department Working Paper No. 657, OECD, Paris.

Mexico also maintains certain barriers to FDI[16] which are high compared with those in place in most other OECD countries, and also higher than in Latin American countries such as Argentina, Brazil and Chile. Comparatively tight ownership restrictions account for the larger part of these. Screening and notification procedures are also relatively complex, while management (*e.g.* reservation of a certain proportion of positions for nationals) and operating restrictions (*e.g.* local content requirements) are broadly in line with those in many other OECD countries. The four main types of ownership barriers and the sectors of particular importance for trade and productivity performance are summarised in Table 1.5.

Table 1.5. Summary of FDI ownership restrictions[1]

Restriction	Sector/activity
Activities reserved to the state	Petroleum and hydrocarbons, electricity
Activities reserved to Mexican nationals	Domestic land transport, gasoline retail sales and distribution of liquefied petroleum gas (propane)
Ownership limits	Up to 25% in airlines. Up to 49% in telecommunications, insurance companies, retirement funds management and coastal shipping
Ownership above 49% with government approval	Cellular telecommunications, airports, railways, ports, legal services, insurance agents, construction of pipelines for distribution of petroleum products, drilling of petroleum and gas wells

1. The complete list of sectors covered by these barriers is listed in Annex A4 of Haugh *et al.* (2008), "Maximising Mexico's Gains from Integration in the World Economy", Economics Department Working Paper No. 657, OECD, Paris.

Source: Haugh *et al*. (2008), "Maximising Mexico's Gains from Integration in the World Economy", Economics Department Working Paper No. 657, OECD, Paris.

Barriers to FDI are higher than the OECD average across all the main sectors of the economy (Table 1.6). The electricity sector is closed and restrictions are relatively tight in the financial sector, the transport sector (especially air and maritime transport) and the telecommunications sector (especially the fixed-line segment). Overall regulatory restrictiveness is well above the OECD average and that of some emerging economies. Restrictions in the construction, distribution, hotels and restaurants, and manufacturing sectors are lower but still above the OECD average and tighter than in many of the emerging economies included in this comparison. Mexico has below-average restrictions in the business services sector (legal, accounting, architecture and engineering services).

Table 1.6. OECD FDI regulatory restrictiveness index for Mexico by sector[1]

	Mexico	OECD average	Rank out of 29 countries (best to worst)
Business services	0.206	0.152	21
Telecoms	0.356	0.184	24
Construction	0.125	0.074	24
Distribution	0.125	0.072	24
Finance	0.502	0.152	24
Hotels and restaurants	0.125	0.072	24
Transport	0.428	0.299	26
Electricity	1	0.326	29
Manufacturing	0.125	0.076	24
Total	**0.278**	**0.187**	**28**

1. Index scale of 0-1 from least to most restrictive. This indicator-based international comparison covers nine sectors (and 11 subsectors) in 29 OECD countries and 13 non-OECD economies.

Source: Koyama and Golub (2006), "OECD's FDI Regulatory Restrictiveness Index: Revision and Extension to More Economies", Economics Department Working Paper No. 525, OECD, Paris.

The sectors mentioned as subject to tight restrictions and highlighted in Table 1.6 provide inputs for downstream industries. They are therefore important for Mexico's overall economic performance, its external trade performance and the country's attractiveness to foreign investors. They also play an important role in overall innovation performance. For example, the supply of high-quality telecommunications services at low cost is important for the rapid diffusion of ICTs and for innovation and productivity performance in the business sector as well as in the public sector.

FDI is closely related to goods trade and, especially in service industries, local presence is one of the main modes of cross-border service supply. Higher inward FDI increases competitive pressures in the economy andI is also a stimulus to innovative activity and an important vehicle for technology spillovers (Nicoletti *et al*., 2003). Through this set of channels (competition, trade, technology transfer), FDI is an important driver of economic growth. There is also empirical evidence that FDI boosts labour productivity both directly, by augmenting the capital stock, and indirectly, by inducing greater domestic capital investment (Ramirez, 2006).

Despite progress over the past two decades, further easing restrictions and regulations on trade and FDI would facilitate innovation and growth.[17] It would help maintain competitiveness, for example by giving easier access to higher-quality production inputs at lower prices. It can also help by increasing competition, encouraging greater returns to scale, further promoting supply chain links and technology spillovers between foreign and domestic firms. Reducing restrictions could increase the stock of FDI in Mexico substantially (Nicoletti *et al*., 2003). There have been significant inflows of FDI in the past in sectors where barriers are lower (such as manufacturing) or have been reduced (such as financial services). Encouraging flows of foreign capital to the services and infrastructure sectors would help raise the quality and cost competitiveness of the inputs used by the manufacturing sector, thereby assisting trade performance. In some of these sectors (insurance and transport), it would also open up possibilities for increasing Mexican services exports. The impact of reform would be maximised under a consistent policy framework. For example, boosting export growth or Mexico's attractiveness to foreign investors would be substantially facilitated by improving the transport infrastructure (see below).

1.4.3. Competition and regulatory regimes

Competition is the most powerful driver of innovation, which lies at the heart of superior innovative performance of market economies (Box 1.2).

Box 1.2. Competition and innovation

Product market competition is a driver of productivity growth either directly or indirectly through a positive impact on innovation (Baumol, 2002), at least until a certain intensity of competition is reached. Aghion *et al*. (2005) established an inverted-U relation between competition and innovation. It appears that the type of product-market competition is also important for favouring particular types of innovation activity (Aghion and Howitt, 2006). Although the relation between competition and innovation is complex, empirical evidence, as summarised by Ahn (2001, 2002) shows that:

- While there is no clear-cut relationship between market concentration or firm size on the one hand and innovation activity on the other, there is a robust relation between product market competition and productivity growth (which can be expected to be closely related to innovation activity in the long term). An increase in the intensity of competition (*e.g.* through regulatory reform, opening of markets to foreign suppliers) results in an increase in productivity growth and higher consumer welfare.
- Competition has long-lasting, dynamic effects on firms' behaviour.
- Competition between existing firms is important, but competition from innovative new firms may be even more important in securing productivity gains at the cutting edge of technology; hence the importance of free entry.

The interactions between competition in product, labour, and financial markets have important influences on innovation and growth. In particular, narrow illiquid capital markets and inflexible labour markets hold back most types of innovation activity.

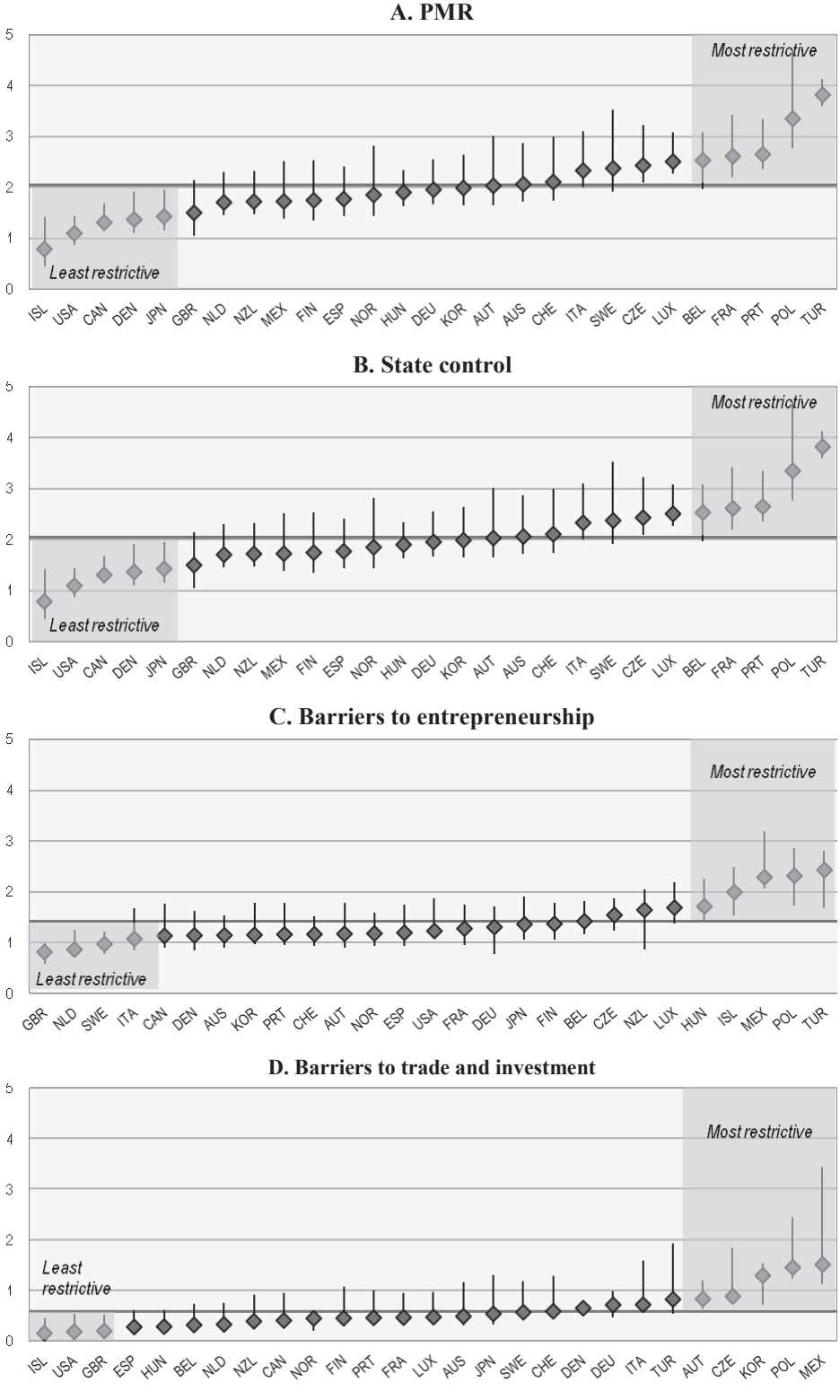
Source: OECD (2008), *OECD Reviews of Innovation Policy: Norway*, OECD, Paris.

Increased competition and better product market regulations could boost productivity and economic growth. Despite improvement of competition regimes in goods and services markets – linked to reforms of legal and regulatory frameworks by the Federal Competition Commission (CFC) and other sectoral regulatory agencies – there is relatively little competition in key sectors such as financial and telecommunication services, energy production and distribution, and transport infrastructure. In these sectors, *de jure* or *de facto* public or private monopolies and/or high market concentration, as well as the perverse effects of abuse of *amparo* procedures,[18] result in high input prices (for downstream firms) and induce barriers to entry that compound other obstacles to the creation of innovative enterprises. The current regulatory framework, for example, does not provide adequate, non-discriminatory third-party access to networks in areas such as telecommunications and railways (OECD, 2007a). The result is high levels of concentration and less than vigorous competition in a number of sectors.

Regulation of network industries such as telecommunications and energy requires particular attention since it may affect innovation, *e.g.* the uptake of new technologies and applications, and adversely affect downstream producers. A lack of competition can slow the uptake of new technologies. This appears to have been the case for the diffusion of some ICT applications. While progress has been made, prices for various telecommunication services are still relatively high by international standards.

Figure 1.10. Countries' relative positions in product market regulation, 2008

Index scale of 0-6 from least to most restrictive



1. Countries are ranked according to the indicator score on aggregate or domain. Diamonds represent the indicator scores, lines represent confidence intervals. *Source*: OECD Product Market Regulation Database.

Insufficient competition, together with restrictive foreign trade and FDI policies, weakens incentives to innovate. However, innovation is a key driver of high and sustainable productivity growth, and OECD work suggests that there are a number of links between product market policies and growth performance (Nicoletti and Scarpetta, 2005). Lower barriers to trade and competition in less tightly regulated countries seem to have increased the level and rate of growth of productivity by stimulating business investment and promoting innovation and technological catch-up.[19] Apart from directly creating barriers to effective competition, the regulatory framework does not facilitate the entry of new firms. Yet this is an important aspect of the dynamic competition which is crucial for rejuvenating the economy.

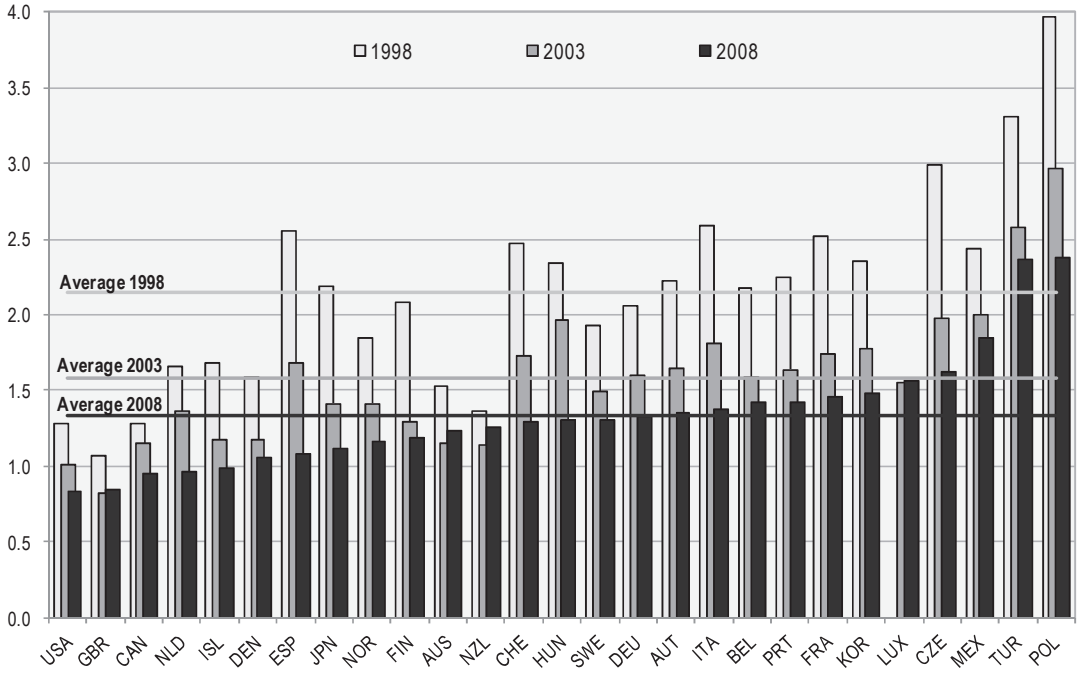
Figure 1.10 provides an overview of OECD member countries' regulatory policy stance in 2008 (see OECD, 2009d, Chapter 7; and Wölfl *et al*., 2009). The stringency of regulatory policy is represented on a scale from 0 to 6 (from least restrictive to most restrictive to competition). At the aggregate level, Mexico – together with the Czech Republic, Luxembourg, Poland and Turkey – is one of the countries with significantly higher restrictions than the OECD average (Figure 1.10, panel A). In line with the general trend among OECD countries, Mexico has adopted a more pro-competitive stance over time. However, it has made less progress than other countries. As in the majority of OECD countries, deregulation slowed during 2003-08 as compared to 1998-2003 (Figure 1.11).

Panels B to D of Figure 1.10 present the three domains of product market regulation.[20] Mexico is the most restrictive country with respect to barriers to trade and investment (panel D) which covers barriers to foreign ownership of firms, tariffs and other non-tariff barriers. Mexico – after Poland and Turkey – is also among the most restrictive countries for barriers to entrepreneurship (panel C), including obstacles to easy access to information on existing regulation, general or sector-specific administrative burdens for business start-ups, and other general or sector-specific regulations that hinder market entry of firms. Mexico is less anti-competitive than the OECD average in the regulatory domain state control (panel B), which reflects the extent to which governments influence firm decisions through public ownership, price controls or other forms of coercive – instead of incentive-based – regulation.

There is still significant potential for boosting productivity by strengthening competition through better regulation and rigorous enforcement of competition policy. Reforms to facilitate access to network industries can help gain competitive advantage. Mexico's decision to conduct a competition assessment review of its current regulatory policies is a major step in this direction.[21]

Figure 1.11. Development of aggregate product market regulation since 1998

Index scale of 0-6 from least to most restrictive



Source: OECD Product Market Regulation Database.

1.4.4. Intellectual property rights

In some areas of the business environment more directly related to technological infrastructure and which affect the capacity or propensity of firms to innovate, advances in institutional development in Mexico have not always met expectations. This is notably the case for intellectual property rights (IPR) regimes and standards and quality certification. Both IMPI (the Mexican Institute of Industrial Property) and CENAM (the National Metrology Centre) are sound, well-qualified institutions but they still fall short of being able to deliver and diffuse their technological services efficiently throughout the productive structure and particularly to SMEs. More importantly, they have been unable to stimulate demand for such services, which remains too low.

Most public research institutions (research centres of the National Council on Science and Technology – CONACYT) play a positive role in metrology services and technology transfer but, unlike most OECD countries, Mexico also suffers from a lack of private intermediary institutions such as "technology brokers" active in knowledge transfer and provision of technology upgrading services.

In general, protection of intellectual property rights, through patents or in other forms (copyright, trademarks) stimulates research by enabling successful innovators to reap rewards and avoid free riding. Their publication requirements also contribute to the dissemination of scientific and technological knowledge and help preventing costly duplication of research efforts. These benefits have to be weighed against the social cost arising from the delayed diffusion and thus reduced use of the invention over the lifetime of the patent, administrative costs, etc. While the relation between IPRs and innovation is a complex one (Jaumotte and Pain, 2005a), modern IPR legislation is an essential part of the overall framework conditions for innovation.

1.4.5. Entrepreneurship, and administrative burden and financing innovation

While administrative barriers to entrepreneurship have decreased with the introduction of the SARE fast-track system for start-ups, the system does not yet seem to have complete national coverage. In a number of respects, regulations related to starting an entrepreneurial activity could still be eased (Table 1.7), not least with a view to facilitating shifting entrepreneurial activities from the informal sector to the formal sector. Dualism and informality remain impediments to higher economic growth.

Table 1.7. Steps for starting an entrepreneurial activity, 2009

Activity	Mexico	Latin America	OECD
Starting a business			
Number of procedures	9	9.7	5.8
Duration (days)	28	64.5	13.4
Cost (% of per capita income)	12.5	39.1	4.9
Minimum capital (% of per capita income)	11.0	3.4	19.7
Dealing with construction permits			
Number of procedures	12	16	14
Duration (days)	222	206	147
Cost (% of per capita income)	159.0	381.2	75.1
Registering property			
Number of procedures	5	6.8	4.7
Duration (days)	74	71.4	30.3
Cost (% of property value)	4.8	6.0	4.7

Source: World Bank (2008), *Doing Business in 2009*, International Bank for Reconstruction and Development and the World Bank, Washington, DC.

Despite some progress, Mexico lags in the financial sector not only compared to more advanced OECD countries but also to some emerging economies.

> *"Domestic credit to the private sector at about 20% of GDP is low compared to countries with similar income levels. For example, Chile and China were close to 80%. Adding credit directly from abroad increases the ratio only to 25% of GDP. Stock market capitalisation has grown from 32% of GDP in 1996 to 42% in 2006, it still remains well below the OECD average of 121% and levels in other fast-growing emerging markets including Chile, China, India and Korea."* (OECD, 2009a, p. 117)

Historically, Mexico's bank overhead costs and net interest margins have been among the highest in the OECD area, an indication of a lack of efficiency in the banking system. The lack of financing at low cost is a major impediment to enterpreneurial activities in Mexico.

Moreover, financing is marked by sharp asymmetries between large and small companies. As Table 1.8 shows, SMEs face greater difficulties for accessing bank financing given their higher risk and lack of access to foreign borrowing. While larger companies in tradable sectors have access to bank credit, SMEs rely mainly on costly suppliers' credit (Bonturi, 2002). This has adverse effects on investment and innovation activities. In 2005, suppliers' credit accounted for two-thirds of finance for small enterprises (see Table 1.8). In comparison, in nearly 80% of cases banks are the main source of financing for EU-based SMEs (OECD, 2007e).

Table 1.8. Sources of enterprise finance in Mexico, 2005

Percentages

Source of finance	Companies			
	Small	Medium	Large	AAA
Suppliers' credit	66.7	57.2	52.3	44.8
Commercial banks	13.7	19.8	21.1	34.5
Foreign banks	0.9	2.9	3.1	6.9
Development banks	1.7	1.2	3.1	0.0
Other sources [1]	17.0	18.9	20.4	13.8
Total	100	100	100	100

Note: Includes head office and other companies of corporate groups.

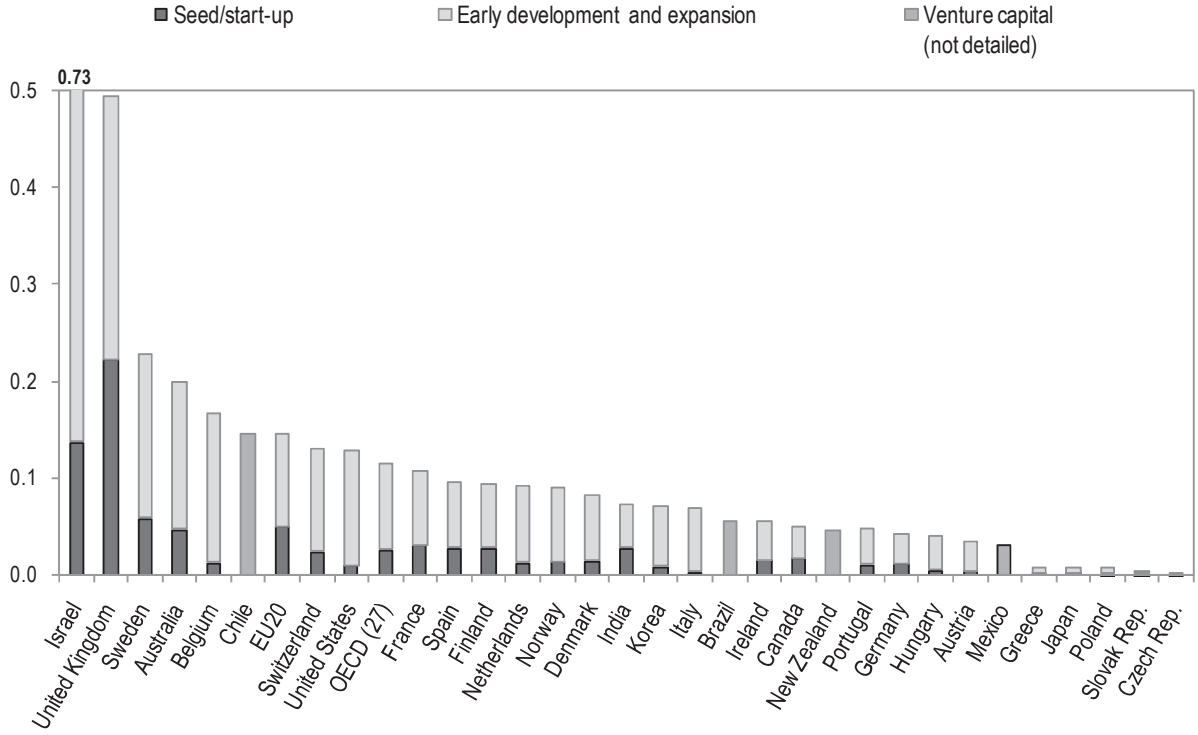
Source: OECD (2007), *SMEs in Mexico: Issues and Policies*, OECD, Paris; data from CANACINTRA and Banxico, 2005.

The supply of bank credit to the business sector has been further limited by the longstanding lack of adequate rules for recovering guarantees and by uncertainties surrounding the application of the new legal framework following the 2003 reform (OECD, 2004a). Shortcomings in the application of the bankruptcy and credit guarantee law and in credit assessment affect smaller firms more acutely than larger ones, thus creating important asymmetries.

Access to capital by new technology-based firms remains especially difficult as the effects of the traditional conservatism of the banking system, naturally adverse to financing intangibles, are compounded by the scarce and costly systems of guarantees and the paucity of alternative sources of finance. Furthermore, financing instruments such as private investment and venture capital remain particularly underdeveloped. Accordingly, provision of venture capital is very low by international standards (Figure 1.12). This situation reflects a systemic failure that hampers the creation of new firms by "freelance" innovative entrepreneurs. At the same time, it seems to indicate a revealed preference for acquisition of technology over original R&D investment in the development of innovative activities.

Mexico introduced reforms earlier in the decade to improve the regulation of the financial sector, and credit growth accelerated before the crisis. Given the large gap between the depth of the financial sector in Mexico and faster-growing countries, Mexico should reinforce reforms in this area, including those related to the rule of law. A well-developed financial system is also a prerequisite for better innovation performance.

Figure 1.12. Venture capital investment as a percentage of GDP, 2006



Source: OECD (2007), *Science, Technology and Industry Scoreboard 2007*, OECD, Paris.

1.4.6. Infrastructure

Recent OECD work shows that improving the infrastructure can have positive effects on economic growth (OECD, 2009d, Chapter 6). As pointed out in subsequent *OECD Economic Surveys of Mexico* (most recently OECD, 2007a and 2009a), Mexico faces a number of challenges in this area. Infrastructure provision in Mexico is low by OECD standards. Inadequate and inefficient infrastructure limits overall efficiency and prevents Mexico from taking full advantage of its natural geographical advantage in trade, most importantly with the United States. Low transport costs could give Mexico-based firms an advantage over international competitors operating from distant locations such as China. Mexico's geographic situation also provides Mexican enterprises with an opportunity to participate in trans-border commercial operations that require short delivery times, such as just-in-time logistics in the automotive sector. However, Mexico does not fully realise this potential advantage as shortcomings in the transport infrastructure and border facilities increase transport costs.

Network industries such as telecommunications are of great importance for innovation and productivity both in the industry itself and in other industries. Prices are relatively high compared with other OECD countries for electricity as well as telecommunication services (OECD, 2007a). Expensive telecommunication services and scarcity of credit are powerful disincentives to innovation. Indeed, in telecommunications Mexico performs less well than other emerging economies on a number of indicators (mainline telephones, fixed, mobile and broadband subscriptions per capita, and international Internet bandwidth). Promoting competition could help to fully realise the potential benefits of lower prices, more innovation and higher productivity in tele-

communications and many other industries. A high-quality infrastructure can help maintain and further develop a strong manufacturing sector that has the potential to become a major pillar of innovation activity in Mexico.

1.5. The role of innovation in Mexico's economic development

Mexico's reforms, especially those that have resulted in increased macroeconomic stability and integration in the global economy, notably through international trade and FDI, have paid off. They have underpinned strong growth of exports and reduced macroeconomic imbalances following the 1995 financial crisis. The economy is now far better integrated in the world economy than it was two decades ago, increasing the pressure on firms to innovate, especially in the more exposed manufacturing sector.

Mexico has made progress in boosting growth of GDP per capita but not enough to sustain a process of catching up with the higher-income OECD countries or to remain in line with the strongly performing emerging economies. Mexico's relatively weaker economic growth performance is largely due to sluggish labour productivity growth, and convergence of productivity levels does not occur automatically.

There are different ways of spurring productivity; a broad set of structural reforms (including strengthening the rule of law) can play a major role. However, innovation plays a key role in driving long-term, sustainable economic growth.[22] Raising innovation capabilities, including for R&D-based innovation, throughout the economy is a major challenge for securing long-term productivity growth and rising living standards for the Mexican population.

International diffusion of technological knowledge is clearly very important for small countries and especially for countries lagging behind the technological frontier such as Mexico.[23] However, even for large, technologically advanced economies such as the United States or the European Union, cross-border knowledge diffusion is of key importance for economic performance in the longer term.[24] Consequently the diffusion of technology and international best practices in organisation and management will continue to play an important role in productivity growth, especially in countries for which the catching-up process is far from complete. Insufficient capabilities of domestic firms limit the benefit from international R&D spillovers.

At the same time countries can benefit from strengthening their own base for R&D and innovation, notably for the following reasons:

- Successful innovators need "absorptive capacities" (Cohen and Levinthal, 1989 and 1990) in order to be able to adopt and make efficient use of existing technological knowledge. The appropriation of technology requires a solid knowledge base. Lederman and Maloney (2006) regard national learning capacity as the missing complement in a situation like that of Mexico. Own domestic R&D activity may help to build and maintain this capacity. There is some evidence that more productive firms benefit more from spillover opportunities created by foreign multinational investments.

- Innovation based on domestic R&D can be expected to become relatively more important as the income and productivity gap *vis-à-vis* the leading countries gradually narrows and a country moves closer to the world technological frontier. To maintain growth under these changing circumstances requires research and technological development activities to feed a constant flow of innovation within the economy.

Given its geographical location, Mexico's potential gains from further trade and investment liberalisation are high.[25] While integration in the global economy offers high potential for technology transfer, it is not sufficient. For Mexico to benefit from the long-term trend towards expansion of the global market "implies a deep restructuring and adjustment in the composition of exports" (OECD, 2007a, p. 32).[26]

Some emerging economies, including China, are set to compete based not just on their traditional comparative advantage – primarily the abundance of unskilled labour – but increasingly also on the basis of economic activity with higher knowledge content (OECD, 2008a). A major challenge for Mexico is to ensure that business enterprises – beyond fully exploiting their current comparative advantages – move up the technology ladder and diversify their export-oriented activities. To maximise the benefit of globalisation under changing conditions entails diversification of the economy and developing new comparative advantages, including in segments of advanced manufacturing.

The globalisation of R&D (OECD, 2008d) provides new opportunities but also increases competition from a larger number of actors. Some emerging countries are also becoming significant destinations of FDI for R&D. Mexico will need to take measures to strengthen its R&D capabilities and related infrastructure in order to be competitive as a location of such activities.

In the face of new competition, Mexico needs to make a very substantial effort to build a well-functioning and high-performing innovation system in order for its business firms to compete in the longer term. Conducive framework conditions for innovation such as macroeconomic stability, vigorous competition, intellectual property rights, an innovation-friendly regulatory framework, financial system and infrastructure are indispensable to such an innovation system. However, necessary as they are, they are not sufficient. They need to be complemented by more targeted efforts to foster innovation performance.

1.6. Performance in science, technology and innovation in an international comparison

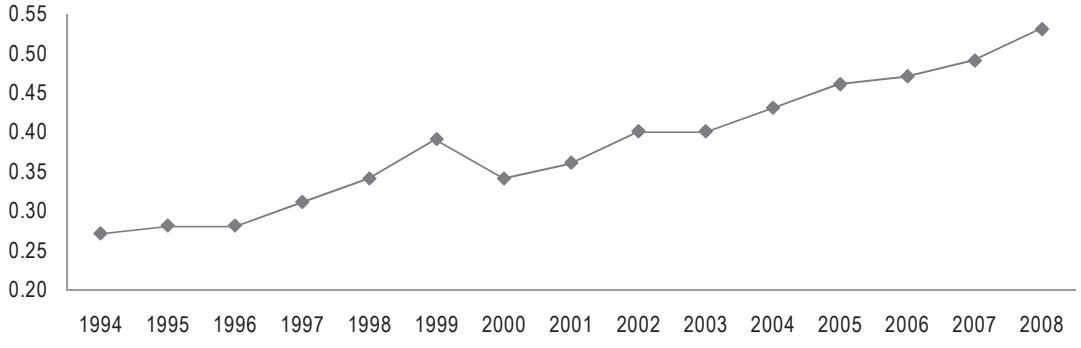
This section provides an overview of the performance of the Mexican innovation system, outlining major trends and developments, based on available quantitative indicators. This is done comparatively, by benchmarking Mexican innovation performance against that of other OECD (and occasionally Latin American) countries. The section begins by reviewing innovation inputs – including R&D spending, human resources and ICT investments – followed by an assessment of innovation outputs, namely scientific publications and patents. It then highlights the concentration of innovation activity in a small number of regions. A final section examines international linkages.

1.6.1. R&D performance and expenditure

Mexico has one of the lowest levels of R&D spending in the OECD area as a percentage of GDP. Gross domestic expenditure on R&D (GERD) in 2005 amounted to approximately USD 6 billion (2005 PPP), while R&D intensity (GERD as a percentage of GDP) was just 0.46%. As Figure 1.13 shows, the level of spending has been increasing steadily over the last decade or so and is expected to reach 0.53% in 2008. Although this amounts to one of the highest rises in R&D intensity in the OECD area (Figure 1.14), the very low levels of spending still leave Mexico well short of achieving an R&D intensity of 1.0% – a target set in the 2002 S&T Law to be reached by 2006. Moreover, as Figure 1.15 shows, R&D intensity remains well below that of a number of non-OECD countries, such as China (1.4%), Brazil (1.0%), South Africa (0.9%) and Chile (0.7%).

Figure 1.13. R&D intensity of the Mexican economy, 1994-2008

GERD as a percentage of GDP



Source: OECD Main Science and Technology Indicators.

Figure 1.14. International comparison of R&D expenditures

GERD as a percentage of GDP, 2005; annual growth rate of GERD, 1995-2005

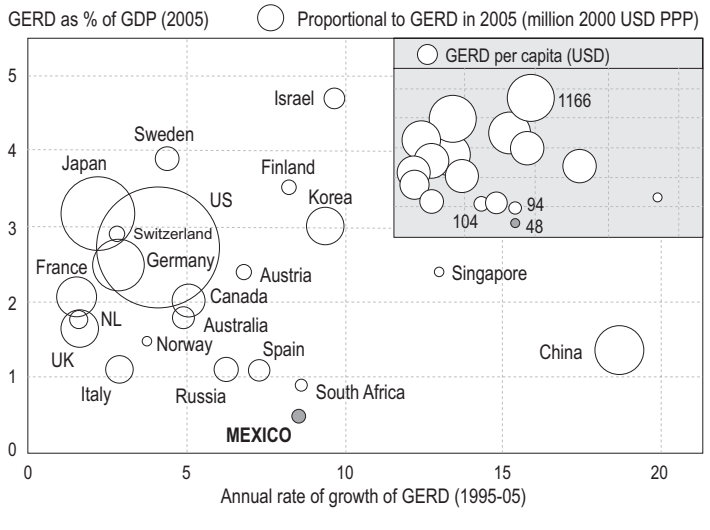
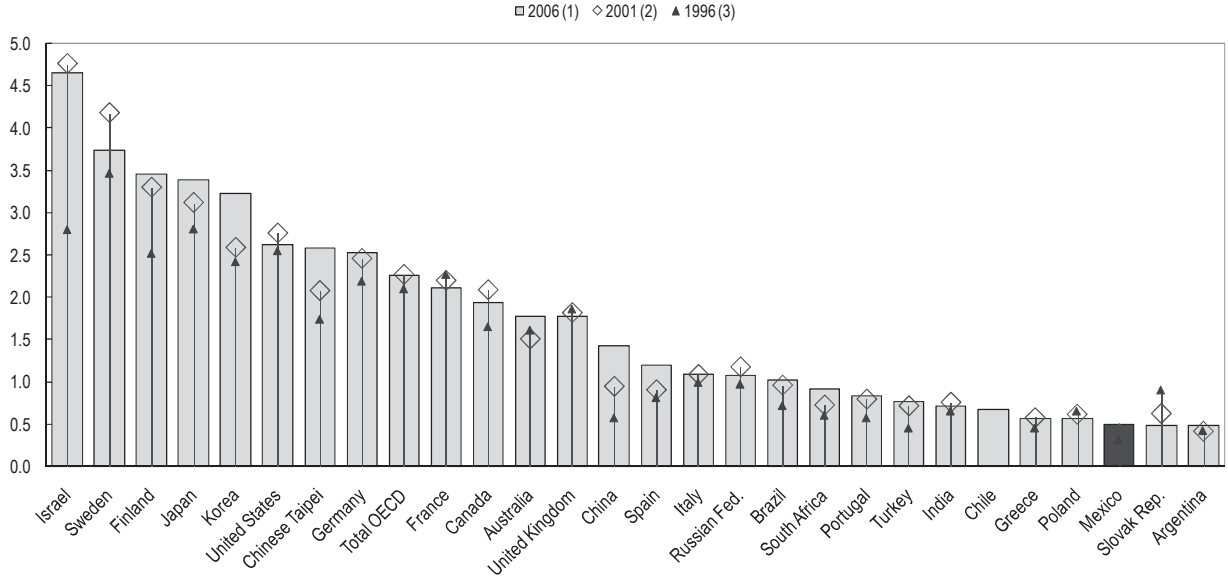


Figure 1.15. R&D intensity in OECD and selected non-OECD economies, 1996, 2001 and 2006

GERD as a percentage of GDP



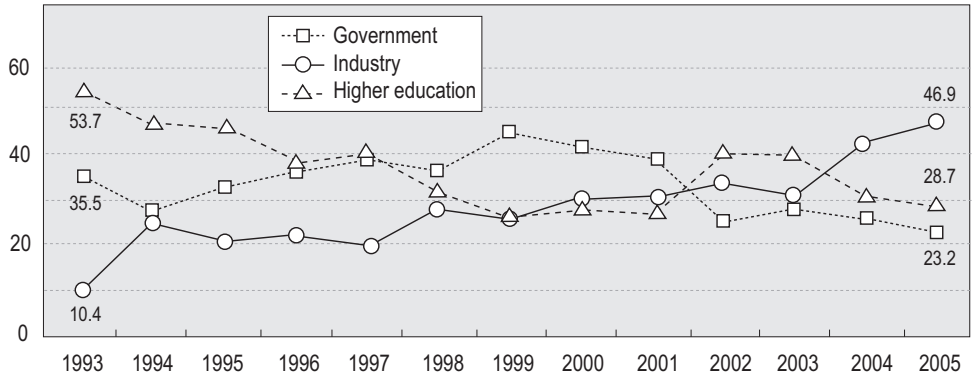
1. 2004 instead of 2006 for Australia, Chile, India; 2005 for Italy, Mexico and South Africa.
2. 2000 instead of 2001 for Australia.
3. 1997 instead of 1996 for Sweden and South Africa.

Source: OECD Main Science and Technology Indicators.

The business sector performs more R&D (in terms of expenditure) than the government or higher education sectors, accounting for 47% of GERD in 2005. As Figure 1.16 shows, the prominent role played by business is very recent and is due to direct and, perhaps more importantly, indirect government support for business R&D, with the latter largely mediated through fiscal incentives. Nevertheless, Mexico still has one of the lowest levels of business R&D intensity in the OECD area, and a level lower than Brazil and Chile (Figure 1.17). This can to some extent be "explained" by the structure of Mexican industry, which is dominated by small enterprises. Such firms are usually unable to take advantage of economies of scale and lack the capacity to make high-volume investments in R&D and equipment embodying new technology.

Figure 1.16. R&D by sector of performance in Mexico, 1993-2005

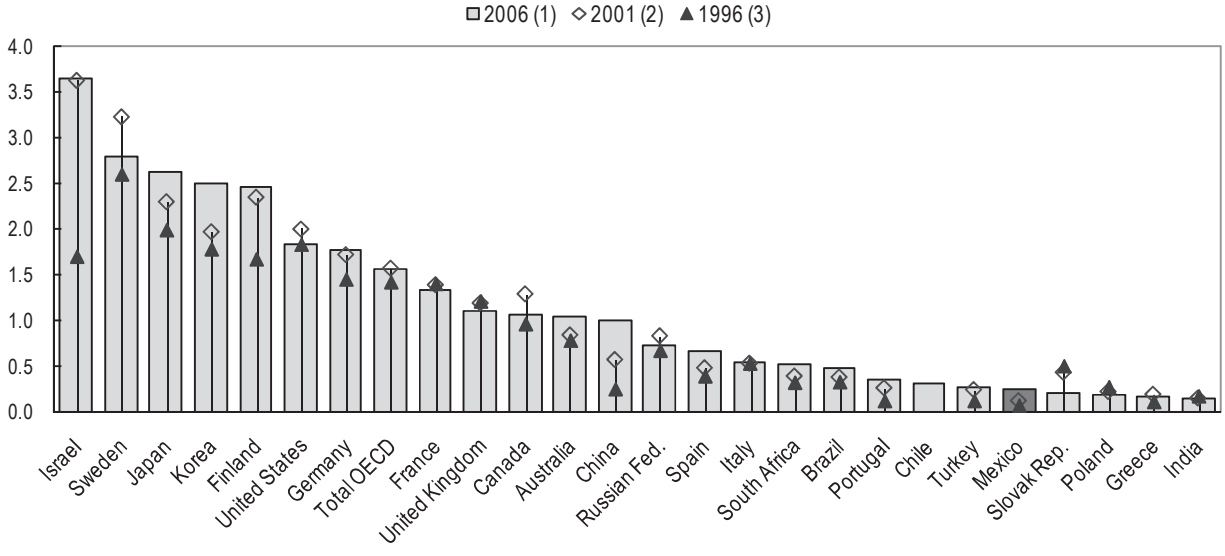
As a percentage of total R&D



Source: CONACYT.

Figure 1.17. Business R&D intensity in OECD and selected non-OECD countries, 1996, 2001 and 2006

As a percentage of GDP

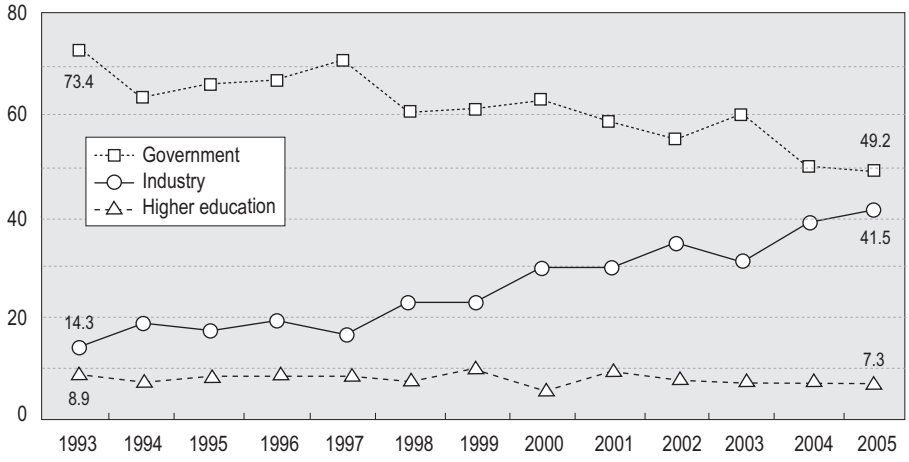


1. 2000 instead of 2001 for Australia.
2. 2005 for Australia, Mexico, and South Africa; 2004 for Chile and India.
3. 1997 for South Africa.

Source: OECD Main Science and Technology Indicators.

Figure 1.18. R&D by financing sector in Mexico, 1993-2005

As a percentage of total R&D



Source: CONACYT.

An increased emphasis on public policy programmes in support of business innovation, and the growing awareness of regional authorities and parts of industry of the benefits to be gained from sustained innovation capacity building have led not only to a significant increase in the volume of business R&D performed, but also in the share of total R&D financed by the business sector (Figure 1.18). This upward trend, which highlights significant growth in the number of firms engaged in S&T-related activities over the last seven years, has been boosted by an increase in direct and indirect public

support. Between 2002 and 2005 the share of direct government financing of total business R&D investment increased from 1.5% to 5.7%. At the same time, the fiscal incentive put in place by CONACYT in 2002 represented more than 75% of total public support in 2006.[27] Since 2001, the number of firms and institutions accredited by the National Registry of S&T Institutions and Firms (RENIECYT), which entitles them to R&D and innovation-related support, has increased more than 15-fold.

As Table 1.6 shows, the increase in business R&D financing as a percentage of total R&D spending mirrors a pattern seen in many other countries. The increase in Mexico is, however, the most startling, albeit from a very low starting base, as figures for the proportion of business R&D financing converge towards levels in other OECD countries. While this would seem to be a positive development, it is partly explained by a slight decline over the last decade in the federal budget for S&T activities as a share of GDP (Figure 1.19). International comparisons show that in better-performing countries, an increasing share of the business sector in total R&D expenditures is not achieved in a sustainable manner when absolute public R&D expenditures decline. In most OECD countries, public expenditures continue to grow (Figure 1.20), albeit at a slower rate than private expenditures, but their leverage on business spending increases because of more efficient incentives and better synergies within the science, technology and innovation (STI) system. This wedge between the evolution of private and public expenditures is certainly an impediment to the strengthening of Mexico's innovation system. Increasing articulation and collaboration between the private and public sectors requires the development of interactions between two dynamic partners. It cannot be achieved if the resources allocated to one of them stagnate or decrease.

Table 1.6. R&D by funding source, 1995 and 2005

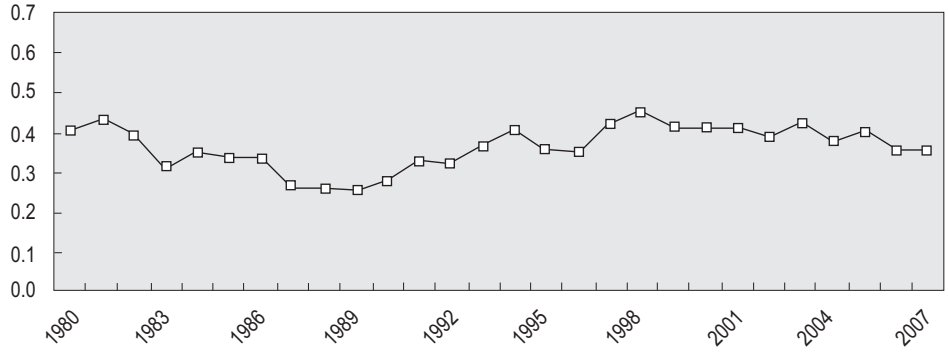
As percentage of total R&D

	Government		Industry		Others	
	1995	2005	1995	2005	1995	2005
Japan	22.8	16.8	67.1	76.1	9.9	6.8
Korea	19.0	23.0	76.3	75.0	4.7	1.3
China	-	24.7	-	69.1	-	-
Germany	37.9	28.4	60.0	67.6	0.3	0.3
United States	35.4	30.4	60.2	64.0	4.4	5.7
Canada	35.9	32.9	45.7	47.9	6.9	10.5
Spain	43.6	43.3	44.5	46.3	5.2	5.0
Chile	58.4	44.5	26.5	45.7	9.0	2.1
Mexico	**66.2**	**49.2**	**17.6**	**41.5**	**16.2**	**9.3**
Brazil	59.1	58.3	38.2	39.4	2.3	2.2
Argentina	46.6	64.3	27.7	31.4	22.4	3.2

Source: OECD Main Science and Technology Indicators.

Figure 1.19. Federal expenditure on S&T activities in Mexico, 1980-2007

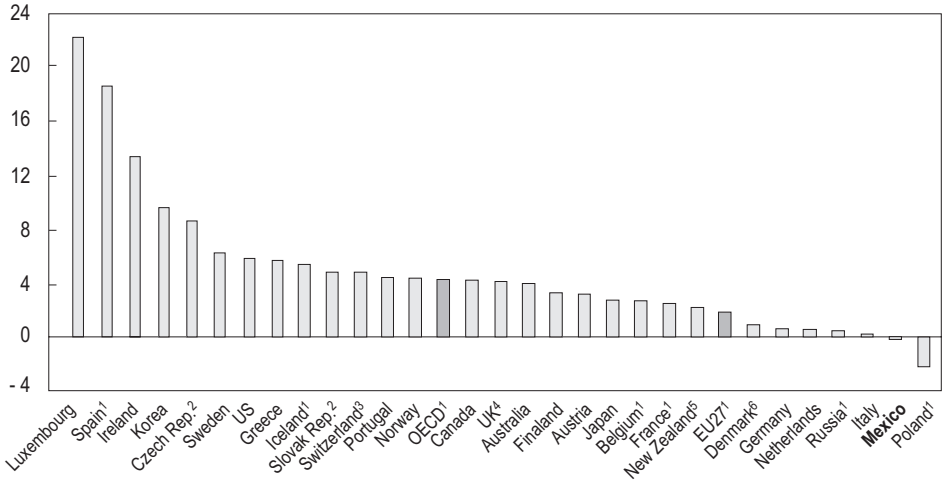
As a percentage of GDP



Source: CONACYT.

Figure 1.20. Change in government R&D budget, 2000-06

Average annual growth rate of GBAORD



GBAORD: Government budget appropriations or outlays for R&D.
1. 2000-05.
2. 2002-06.
3. 2000-04.
4. 2001-05.
5. 2001-03.
6. 2001-06.

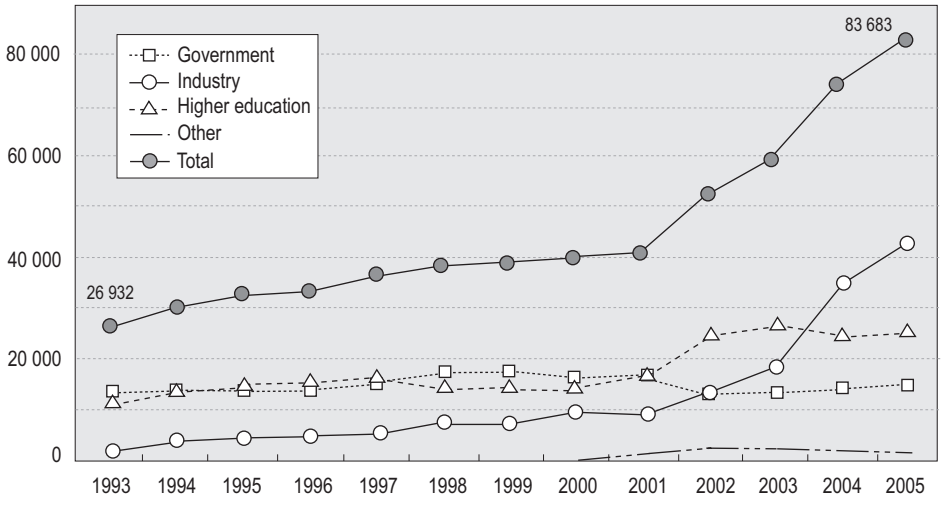
Source: OECD Main Science and Technology Indicators.

Whatever the soundness of framework conditions, the merits of institutional reforms, or the efficiency of support programmes in fostering scientific and innovative activities, no countries have advanced decisively up the ladder of innovative economic performance without sustained investment in tangible and intangible S&T assets. In countries like Mexico that suffer from a fragmented innovation system that limits the production, diffusion and productive use of knowledge for economic growth and social welfare, increasing the volume of resources devoted to R&D and developing the absorptive capacities to put them efficiently to use are a prerequisite for engaging in a virtuous dynamic in which increased public and private investment in innovation complement each other to ensure rising social returns to investment in knowledge.

1.6.2. Human resources in R&D

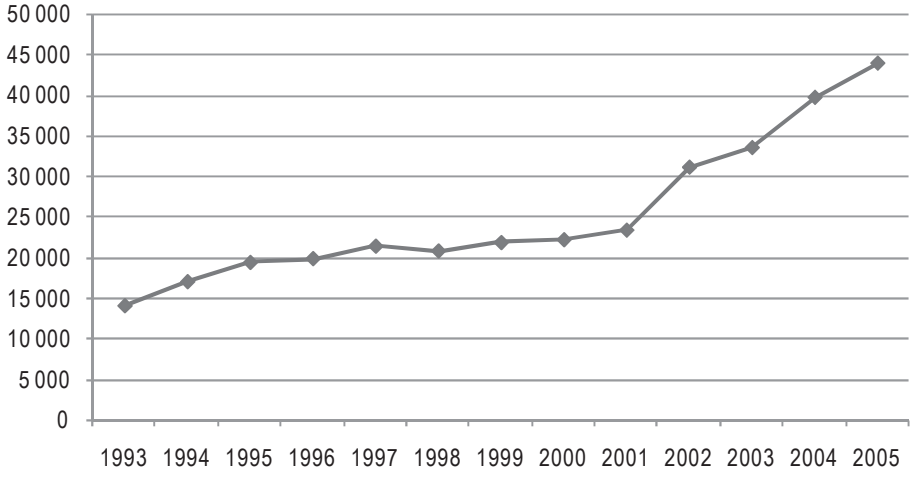
The number of R&D personnel (full-time equivalents) in Mexico stood at almost 84 000 in 2005 (Figure 1.21), of which 44 000 are researchers (Figure 1.22). Mexico has the highest growth rate in human resources for R&D in the OECD in recent years (Figure 1.23). From 1996 to 2005 the average annual growth rate was 10.4% for researchers and 11.4% for total R&D personnel. Accordingly, R&D personnel grew from around 27 000 to 84 000 between 1993 and 2005, while the number of researchers more than tripled from 14 000 to 44 000. Mirroring shifting spending patterns, these increases can be mainly attributed to business enterprises and, to a lesser extent, higher education, whereas employment levels in the government sector have fallen slightly (Figure 1.21). The largest increases in numbers of R&D personnel and researchers have occurred since 2000, again reflecting increased spending levels on R&D. Despite these positive developments, these figures remain very low by international standards when compared to levels of total employment (Figure 1.24).

Figure 1.21. Total R&D personnel by sector of employment in Mexico, 1995-2006



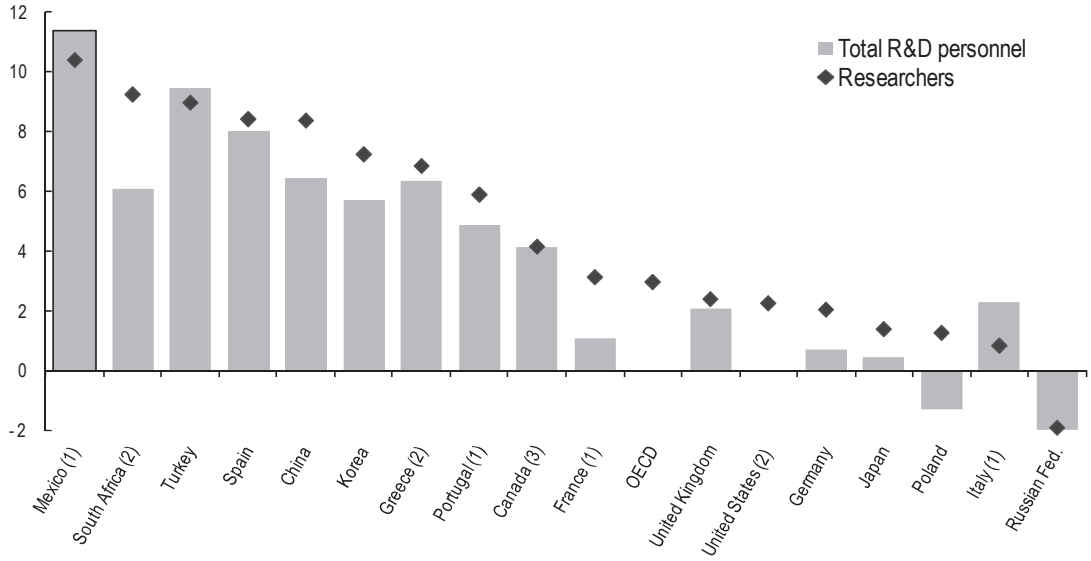
Source: CONACYT.

Figure 1.22. Number of researchers in Mexico, 1993-2005



Source: CONACYT.

Figure 1.23. Percentage average annual growth rate of R&D personnel, 1996-2006

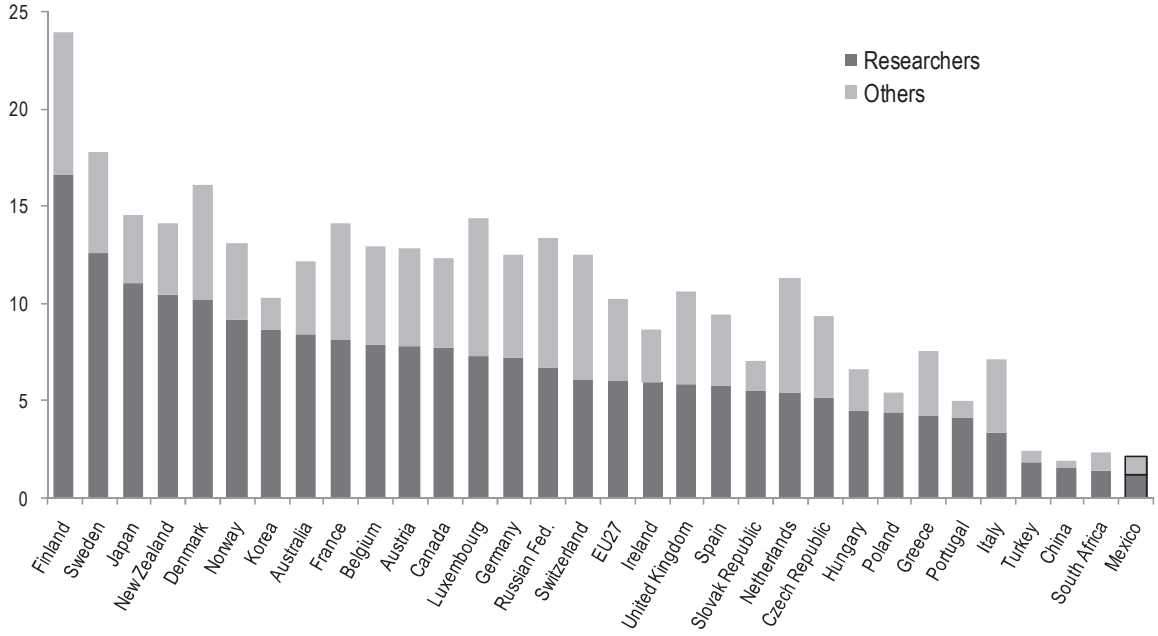


1. 1996-2005 for Italy, Portugal and Mexico.
2. 1997-2005 for South Africa, Greece and the United States.
3. 1996-2004 for Canada.

Source: OECD Main Science and Technology Indicators.

Figure 1.24. R&D personnel, 2006

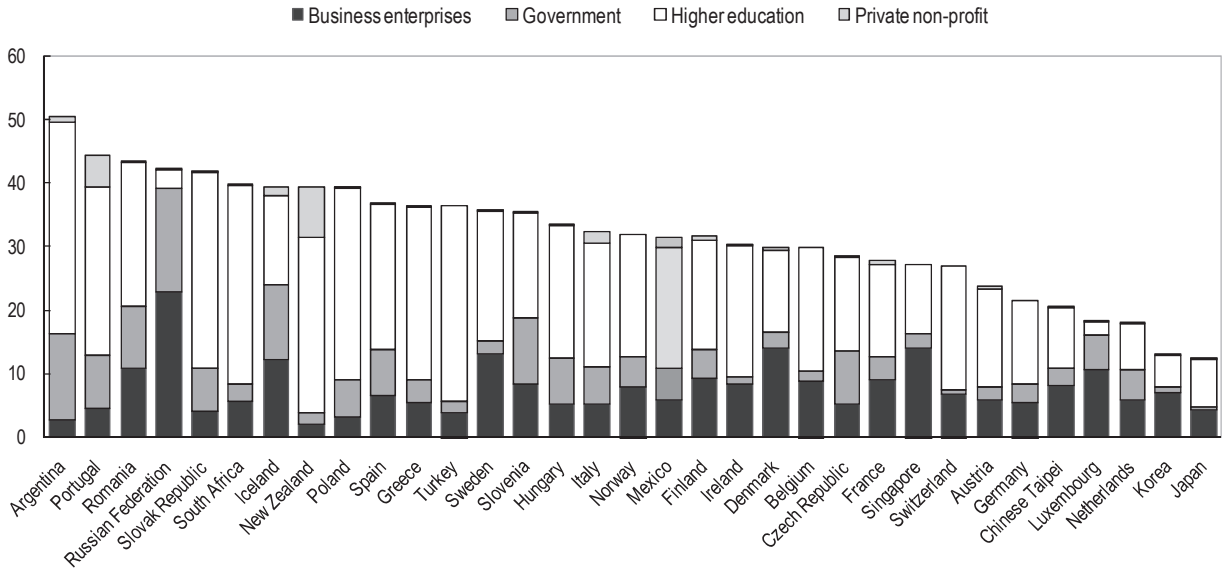
Per thousand total employment



Source: OECD Main Science and Technology Indicators.

Figure 1.25. Women researchers by sector of employment, 2006

As a percentage of total researchers



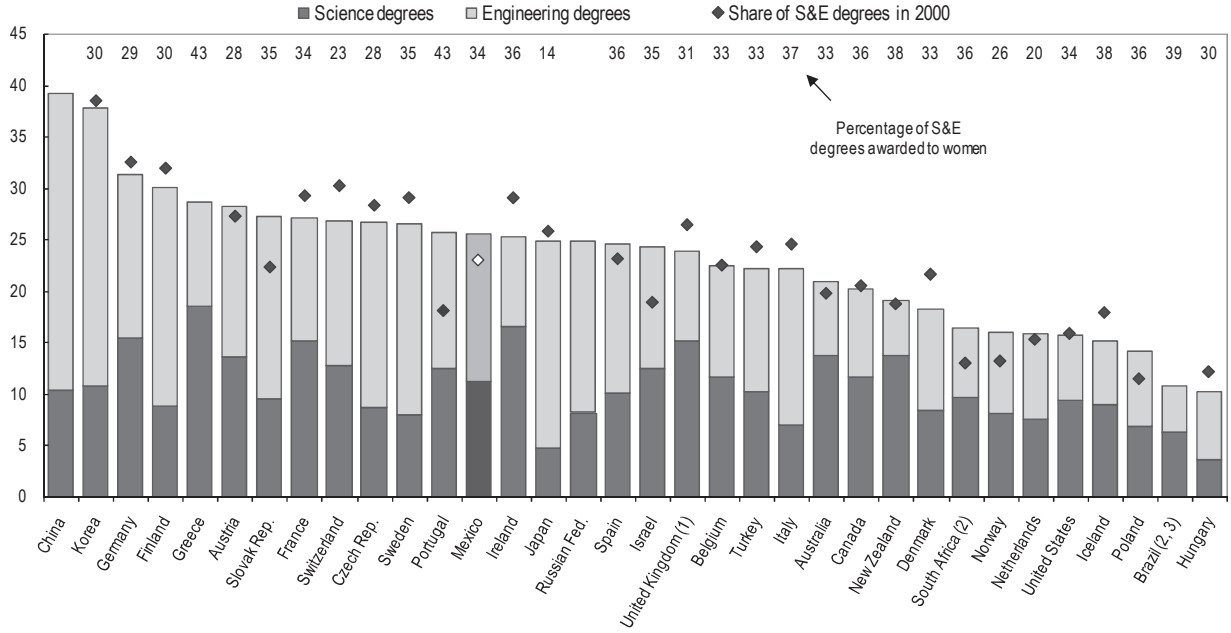
Source: OECD Main Science and Technology Indicators.

The new distribution of researchers represents one of the most important structural transformations in the Mexican innovation system. Previously, with the majority of researchers working in the government and HEI sectors, research was mostly basic in orientation. With a greater number of researchers working in industry, basic research now accounts for a much smaller proportion of research spending in Mexico. In terms of the gender composition of researchers, around one-third are female, a situation comparable to many other OECD countries (Figure 1.25). As in most other OECD countries the HEI sector accounts for the most female employment, while the business sector, despite being the largest employer of researchers, accounts for just a small proportion.

As for the supply of researchers and other human resources for science and technology (HRST), just over one-quarter of university graduates gained science and engineering (S&E) degrees in 2005, a small increase in the proportion of S&E graduates since 2000. This is a relatively large proportion by international standards (Figure 1.26). About one-third of PhD degrees are awarded in S&E disciplines, a proportion comparable to levels in most other OECD countries. However, the number of PhD graduates as a proportion of the total population is extremely low compared to other OECD countries, though growing rapidly from a low base (Figure 1.27). As for student gender, in 1969-70, women represented around 30% of the university population, and 30 years later, in 2000-01, the proportion had almost doubled so that there are now more women studying in universities than men. Nevertheless, women account for only one-third of the S&E degrees awarded in Mexican universities, a figure broadly comparable to most OECD countries (Figure 1.26).

Figure 1.26. Science and engineering degrees, 2005

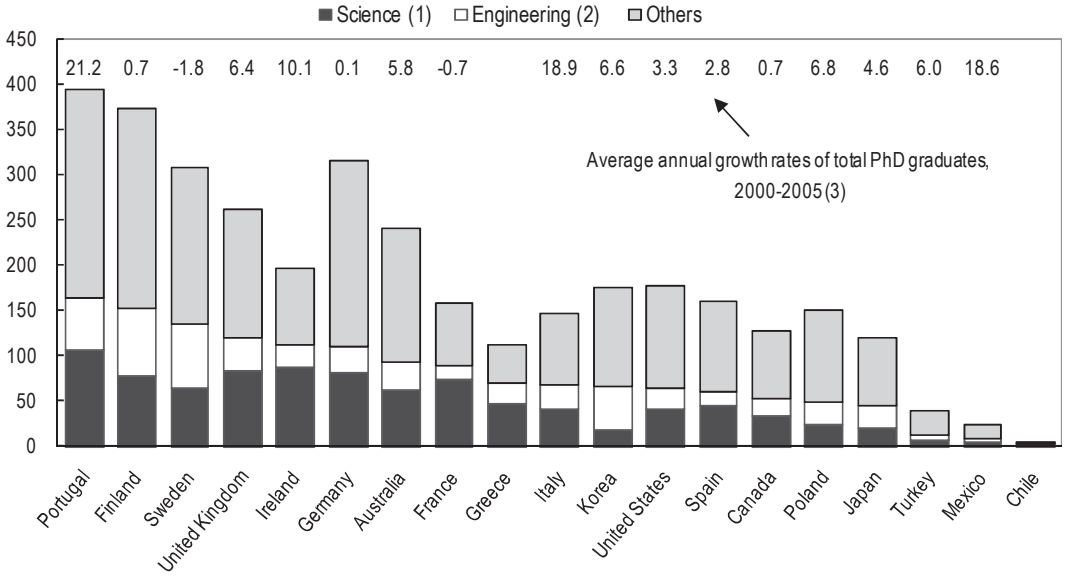
As a percentage of total new degrees



1. UK data are for the year 2003.
2. ISCED 5B programmes are included with ISCED 5A/6; for South Africa, the share of S&E degrees awarded to women is for the year 2003.
3. For Brazil, the share of S&E degrees awarded to women is for the year 2003.

Figure 1.27. PhD graduates in science and engineering and other fields, 2005

Per million population

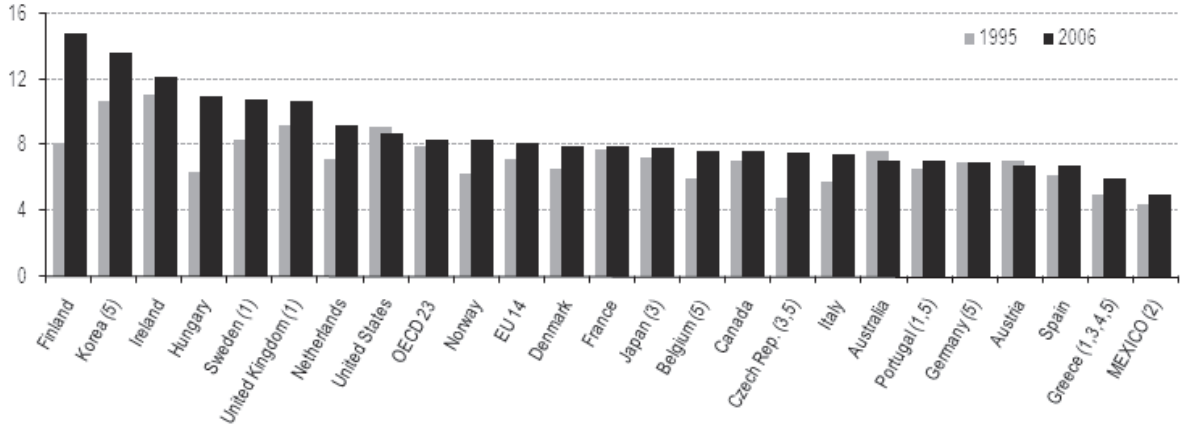


1. Includes life sciences, physical sciences, mathematics and statistics and computing.
2. Includes engineering and engineering trades, manufacturing and processing and architecture and building.
3. Or nearest available years.

1.6.3. ICT investments

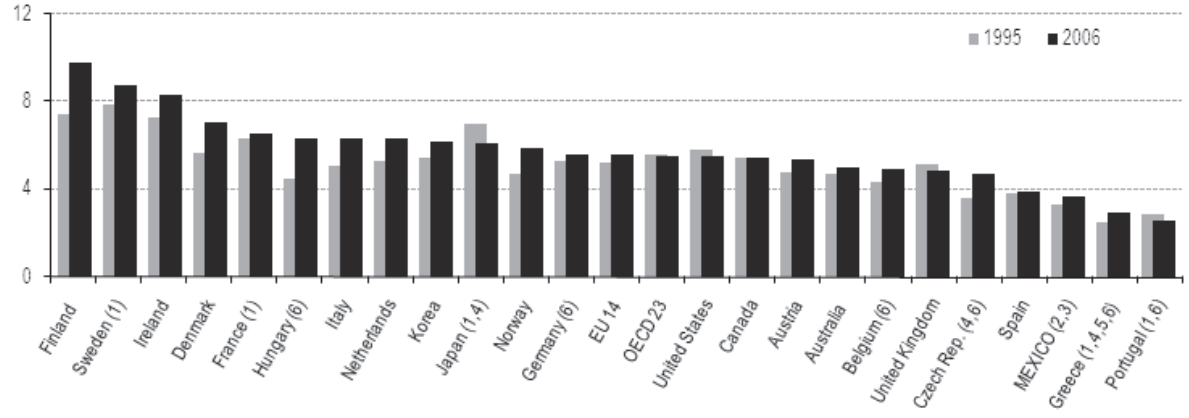
Information and communication technologies have been a major driver of growth in most OECD countries in the past decades – as a growing sector of production or as a main driver of productivity growth. Countries that have specialised in the production of ICTs or have reaped the benefits of rapid ICT diffusion into different areas (eBusiness, eGovernment, eHealth, etc.) have tended to have a better growth record. Mexico has been unable so far to gain very much from this growth potential. For example, the share of ICTs in business sector value added is the lowest among OECD countries (Figure 1.28). Furthermore, the share of ICT in business sector employment remains one of the lowest in the OECD area (Figure 1.29).

Figure 1.28. Share of ICT in business sector value added, 1995 and 2006



1. 2005 instead of 2006. 2. 2004 instead of 2006. 3. ICT wholesale (5150) is not available. 4. Telecommunication services (642) included Postal services. 5. Rental of ICT goods (7123) is not available.

Figure 1.29. Share of ICT in business sector employment, 1995 and 2006



1. 2005 instead of 2006. 2. 2004 instead of 2006. 3. Based on employees figures. 4. ICT wholesale (5150) is not available. 5. Telecommunication services (642) included Postal services. 6. Rental of ICT goods (7123) is not available.

Several indicators also point to weaknesses in the diffusion and use of ICTs. In rankings by the ITU and UNCTAD (2007), which combine several synthetic "information society" indicators, Mexico does not perform favourably on important dimensions such as availability of skills for the information society and networking, ranking below several other Latin American countries (Table 1.7).

Table 1.7. Information society indicators for selected countries, 2007

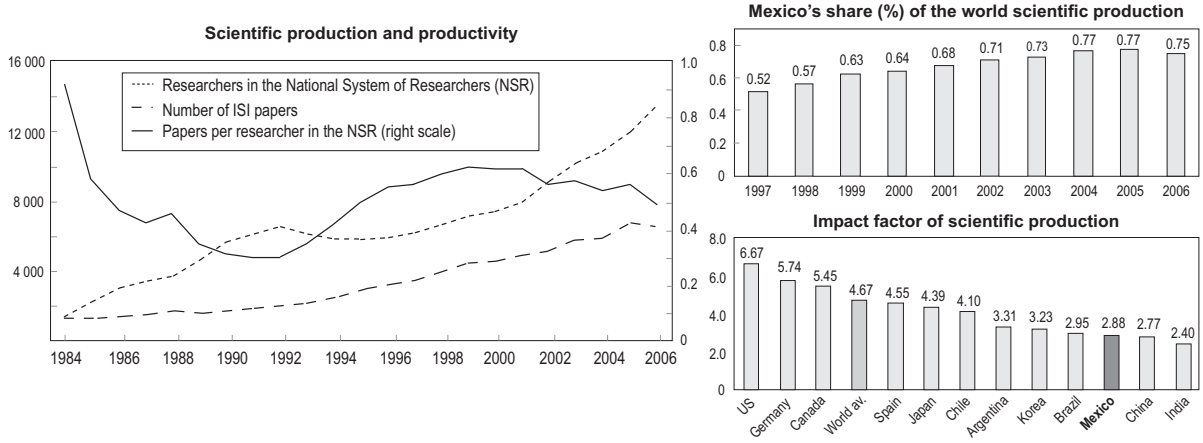
Rank	Country	Network index	Skills index	Diffusion index
1	Sweden	605.1	153.8	464.5
11	Canada	398.5	136.0	422.1
13	United States	346.7	143.3	443.6
22	Korea	254.1	144.9	392.3
29	Spain	331.9	142.3	255.2
36	Portugal	253.4	134.8	184.3
46	Poland	190.7	137.5	211.6
48	Greece	252.2	139.2	140.2
50	Chile	176.0	122.4	157.0
60	Argentina	149.4	137.1	135.3
63	Russia	161.9	139.2	144.7
64	Brazil	124.2	121.0	168.6
66	Costa Rica	121.2	105.0	197.2
67	Turkey	158.6	116.0	109.6
70	**Mexico**	**113.7**	**108.8**	**150.9**
76	Venezuela	102.0	114.6	120.0
79	China	113.3	106.1	81.6
80	Colombia	131.4	110.9	87.3

Source: ITU and UNCTAD.

1.6.4. Research publications

Research publications are one quantitative indicator available for evaluating and assessing scientific output. Publication counts have traditionally been used as an indicator of the scientific productivity of universities, public research centres, companies, individuals or nations. Figure 1.30 shows that Mexico's share of scientific output accounted for 0.75% of the world's total in 2006, up from 0.52% in 1997. However, the "impact factor" of this output, *i.e.* the extent to which scientific articles are cited in other scientific articles, is one of the lowest in the OECD area and also lags other Latin American countries such as Argentina, Brazil and Chile. Furthermore, the productivity of Mexico's leading researchers, as measured by publication levels in ISI journals by researchers registered in the National System of Researchers (SNI), has declined as the number of researchers covered by the SNI has increased. There are at least two possible explanations for this decline: first, it could indicate that the quality of researchers registered in the SNI has been gradually eroded as the SNI becomes a "standard" source of academic remuneration. Second, it could reflect the relative decline in government funding of public sector research.

Figure 1.30. Scientific production in Mexico, 2005

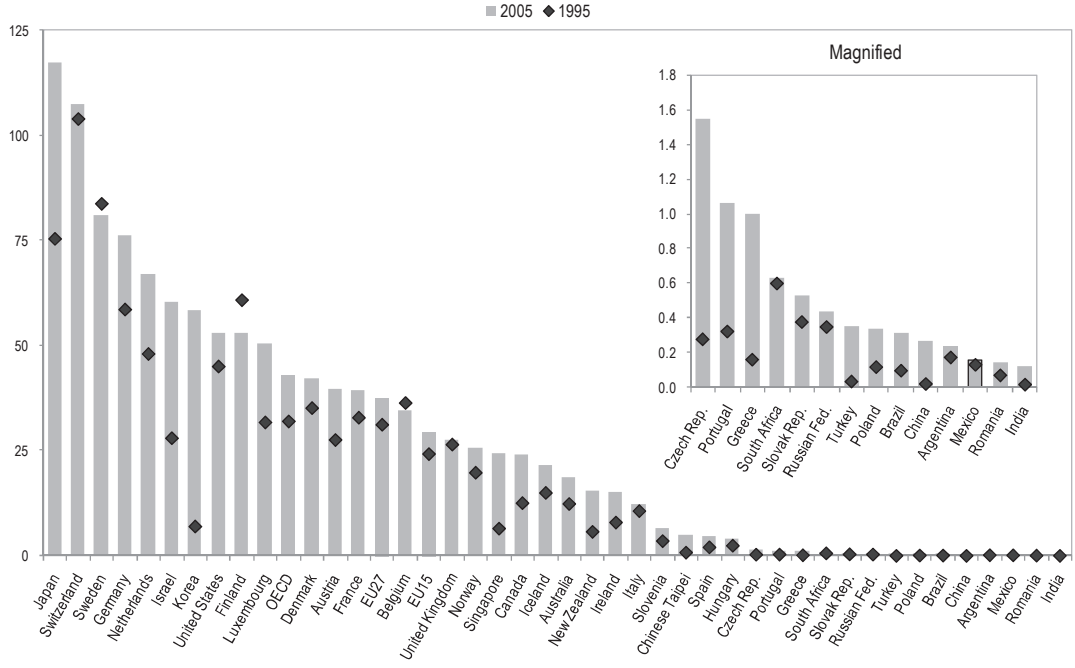


Source: OECD, based on data from CONACYT.

1.6.5. Patenting

Patenting and other activities related to intellectual property rights, both of business firms and public research organisations, are weak by international standards. In particular, Mexican firms are far less active in filing applications for patents, industrial design and trademarks than counterparts in more advanced OECD economies. In fact, as Figure 1.31 shows, Mexico has one of the lowest levels of patents filed per capita at the European Patent Office (EPO), the United States Patent and Trademark Office (USPTO) and the Japanese Patent Office (JPO) which protect the same invention (triadic patent families). Moreover, this situation has barely improved over the ten-year period between 1995 and 2005, contrary to the situation in many other industrialising countries, where the number of triadic patent applications has often surged.

Figure 1.31. Triadic patent families per million population, 1995 and 2005

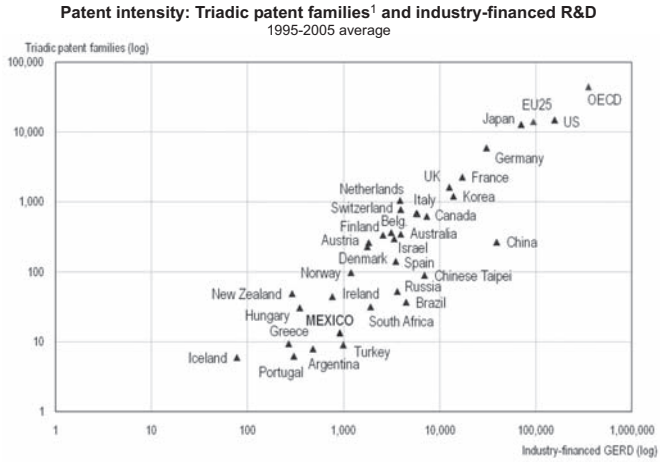


The data for patent applications in Mexico show only a marginally better picture, with applications from Mexican nationals increasing by a little under 50% during the period 1998-2005, *i.e.* from 386 applications in 1998 to 574 in 2005 (Figure 1.32). More than half of the applications made in 2005 came from independent inventors, while just a quarter came from business enterprises. At the same time, the number of applications from foreigners more than doubled between 1998 and 2005, from 6 365 to 14 928. In other words, foreigners accounted for more than 96% of patent applications in Mexico in 2005.

Taken together, these data indicate an apparent paradox in that increased levels of business spending on R&D and the increased number of researchers working in enterprises over the last seven or eight years appear not to have translated into a marked increase in patenting activity. There are several possible explanations for this.

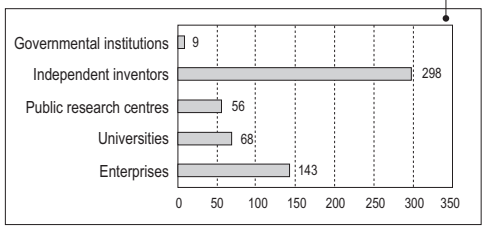
First, Figure 1.32 suggests a strong link between levels of BERD and the number of triadic patent families applications filed. Although the level of BERD has increased in recent years, it is still very low compared to other OECD countries (Figure 1.17) and might explain low levels of patenting. Even so, Mexico might be expected to file more triadic patent applications than it does given its level of BERD. For example, New Zealand, Hungary and Ireland all file many more applications than Mexico on lower absolute levels of BERD.

Figure 1.32. Patenting intensity and number and source of patent applications in Mexico



Patent applications in Mexico
1996-2006

Number	1996	1998	2000	2002	2004	2006
Total	*6 751*	*10 893*	*13 061*	*13 062*	*13 194*	*15 500*
By foreigners	6 365	10 440	12 630	12 536	12 629	14 926
By nationals	386	453	431	526	565	574



1. Patents filed at the European Patent Office (EPO), the US Patent and Trademark Office (USPTO) and the Japan Patent Office (JPO) which protect the same invention.

Source: OECD and IMPI.

Second, the number of researchers working in enterprises only started to really take off in 2001 (Figure 1.21), while significant increases in BERD did not occur until 2003 (Figure 1.18). Some lag in translating these inputs into outputs in the form of patents should surely be expected and may go a considerable way towards explaining low levels of patenting in 2005 (the latest date for which data are available).

Finally, it is quite possible, and perhaps even reasonable to expect, that much R&D performed in Mexican firms is directed towards adapting existing technologies and incremental innovation, given the history of technological innovation in Mexico. As technology adaptation and incremental innovation tend to require little recourse to patent protection, continuing low levels of patenting might be expected, at least in the short to medium term.

Figure 1.33. Mexico's regional S&T and innovation landscape, 2006

	% of national GDP	Number of NSR[1] researchers	Number of HEIs[2] with doctoral programmes	Number of S&T institutions and enterprises in RENIECYT[3]	% of R&D tax incentives	% of Mixed Funds
Distrito Federal (DF)	21.84	5 846	30	864	43.6	--
México	9.48	797	13	221	7.7	0.9
Nuevo León	7.43	449	5	260	22.1	14.0
Jalisco	6.31	688	9	245	4.2	1.7
Chihuahua	4.33	152	5	112	3.6	1.6
Veracruz	4.17	311	9	70	2.0	2.7
Guanajuato	3.60	415	12	251	3.0	12.1
Puebla	3.55	534	11	75	5.1	0.6
Baja California	3.50	412	8	67	2.4	3.3
Coahuila	3.37	189	9	120	0.9	2.8
Tamaulipas	3.34	110	6	42	1.3	5.2
Sonora	2.68	245	4	97	0.0	3.9
Michoacán	2.21	390	4	47	0.2	3.9
Sinaloa	1.99	151	6	41	0.2	1.4
San Luis Potosí	1.81	253	3	50	0.2	2.6
Querétaro	1.72	281	6	83	2.6	1.4
Chiapas	1.70	116	4	27	0.1	6.4
Guerrero	1.68	39	1	5	0	0.7
Quintana Roo	1.64	53	0	23	0.0	1.9
Oaxaca	1.52	119	6	26	0.0	0
Yucatán	1.41	276	5	37	0.0	2.5
Morelos	1.38	753	9	46	0.1	2.1
Durango	1.33	60	5	33	0.1	1.2
Hidalgo	1.30	173	1	65	0.2	4.8
Tabasco	1.25	78	1	27	0.0	6.7
Campeche	1.24	59	2	11	0	1.6
Aguascalientes	1.23	69	1	51	0.1	2.6
Zacatecas	0.76	95	1	12	0.0	6.0
Baja California Sur	0.60	183	3	7	0.0	0.4
Tlaxcala	0.57	68	2	16	0.1	1.5
Nayarit	0.54	17	1	4	0.0	1.3
Colima	0.53	104	1	23	0.2	0.7

1. NSR = National System of Researchers (SNI). 2.Higher education institutions. 3. National Register of S&T Institutions and Firms.
Source: OECD, based on data from CONACYT.

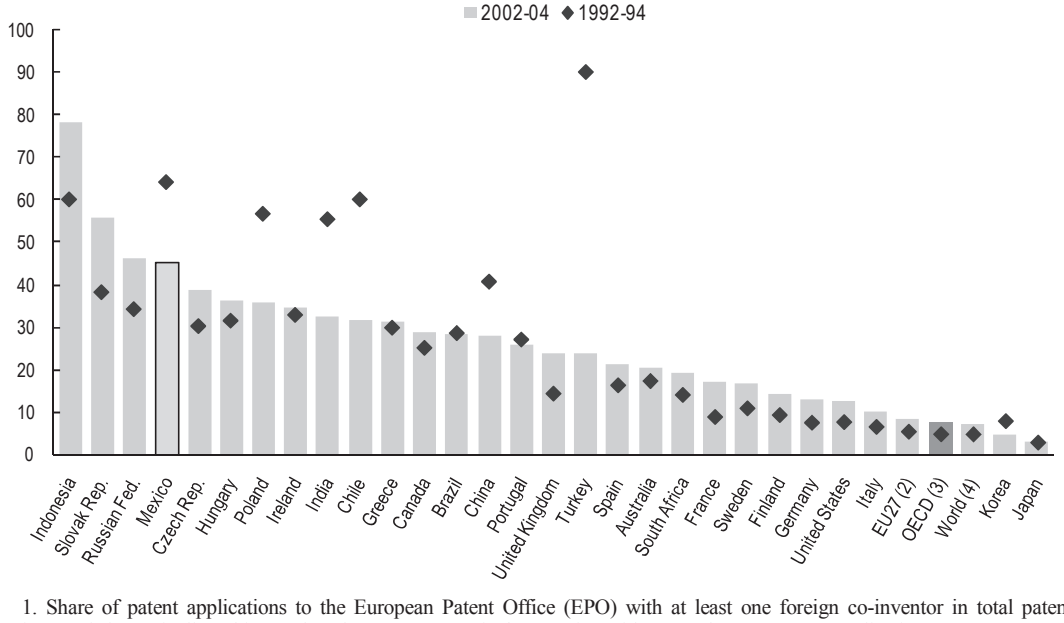
1.6.6. Regional disparities in innovation capacity

As Figure 1.33 shows, there are very considerable disparities in regional science and innovation activity. By far the dominant region is the Distrito Federal, the capital region, which accounts for 43% of SNI researchers in Mexico and 44% of the R&D tax incentives taken up by enterprises. Three other regions have more than 5% each of the total number of SNI researchers: Estado de Mexico, Morelos and Jalisco. Three regions besides Distrito Federal also account for more than 5% of the R&D tax incentives taken up by enterprises: Nuevo Leon, Estado de Mexico and Puebla. On the whole, proportions of SNI researchers and uptake of tax incentives are broadly aligned. The main exceptions are Nuevo Leon, where regional enterprises account for 22% of R&D tax incentives while only around 3% of SNI researchers are based in the region and Morelos, where almost 6% of SNI researchers are based while the percentage of R&D tax incentives take-up is negligible (0.1%).

1.6.7. International linkages

Low levels of patenting by Mexican individuals and entities have already been highlighted, as has the dominance of foreigners in domestic patenting. But it is also apparent that a considerable level of patenting by Mexicans is done in co-operation with foreign co-inventors (Figure 1.34). However, this has decreased somewhat over the last decade, suggesting a growing independence in invention activities, although the numbers are still extremely small. The level of funds from abroad as a proportion of BERD is low by international standards, suggesting that multinational firms tend not to conduct much of their research in Mexico (Figure 1.35). Furthermore, this proportion has fallen sharply in the last decade (Figure 1.36), no doubt owing in part to marked increases in R&D spending by domestic firms.

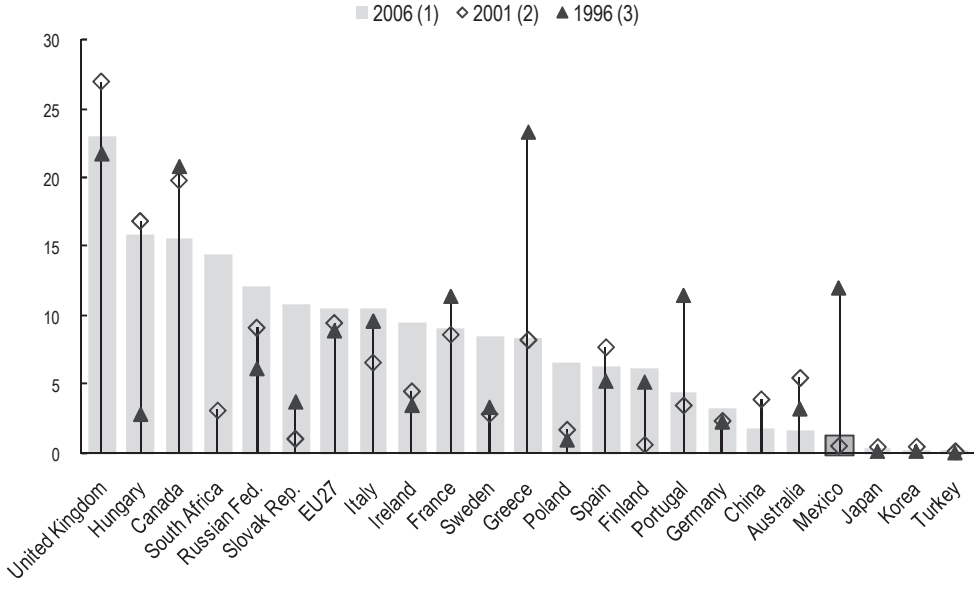
Figure 1.34. Patents with foreign co-inventors,[1] 1992-94 and 2002-04



1. Share of patent applications to the European Patent Office (EPO) with at least one foreign co-inventor in total patents invented domestically. This graph only covers countries/economies with more than 200 EPO applications over 2002-2004. 2. The EU is treated as one country; intra-EU co-operation is excluded. 3. Patents of OECD residents that involve international co-operation. 4. All EPO patents that involve international co-operation. *Note:* Patent counts are based on the priority date, the inventor's country of residence, using simple counts. *Source:* OECD Patent database.

Figure 1.35. R&D funds from abroad, 1996, 2001 and 2005

As a percentage of business R&D (BERD)

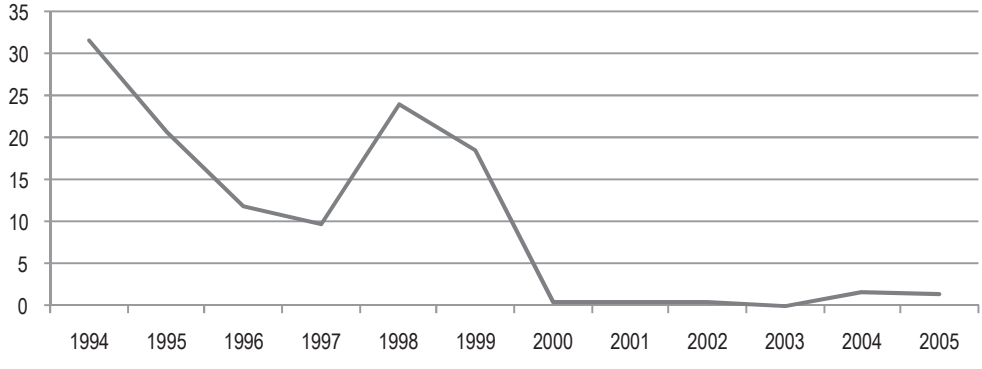


1. 2005 for Australia, France, Greece, Mexico, Portugal, South Africa, Sweden, EU-27.
2. 2000 for China.
3. 1997 instead of 1996 for Finland and Sweden.

Source: OECD Main Science and Technology Indicators.

Figure 1.36. R&D funds from abroad in Mexico, 1994-2005

As a percentage of business R&D (BERD)



Source: OECD Main Science and Technology Indicators.

Notes

1. A recent study (OECD, 2008b) shows that in the mid-2000s, Mexico tops the league in income inequality (measured by the Gini coefficient) among 30 OECD countries, with income inequality twice that of the country with the lowest measure of inequality (Denmark). Independent of the particular threshold used – the share of individuals with equivalised disposable income of less than 40%, 50% or 60% of the median for the entire population – relative poverty rates are always highest in Mexico, Turkey and the United States. However, Mexico (together with Greece, Italy and the United Kingdom) is among the countries in which poverty rates declined by around 1 point or more over the past decade.

2. "Given Mexico's far-reaching reforms, the signing of NAFTA, and the large capital inflows into Mexico, many observers expected stellar growth performance" (Tornell *et al*., 2004, p. 34). The authors present evidence that less than stellar performance may be due to a credit crunch, underlying deterioration in contract enforceability and an increase in non-performing loans.

3. On the link between trade and growth, see, for example, Winters (2004) on exports and productivity at the firm level, and Wagner (2007).

4. The data are available on the KOF (Swiss Economic Institute) Index of Globalization website: *http://globalization.kof.ethz.ch*. For a more detailed description see Dreher *et al.* (2008).

5. The two sets of variables – actual flows and restrictions – are given an equal weight of 50% each.

6. The collapse of the domestic market at a time when the US economy was growing, as well as the large gains in cost competitiveness following the depreciation of the peso also contributed to Mexico's strong export performance at the time (Haugh *et al*., 2008).

7. This debate can be traced back more than half a century (Prebisch, 1950).

8. See OECD (2007c, Statistical Annex, Methodological Note).

9. The inward potential index tries to capture several factors that seem relevant for a country's attractiveness for FDI (beyond market size).

10. For a survey of the literature on FDI spillovers see Görg and Greenaway (2004) and Crespo and Fontoura (2007).

11. "Mexico has already developed many pockets of excellence and high productivity associated with multinationals operating in high-tech and higher middle-tech industries, and with national conglomerates operating in mature industries. These are no longer maquila operations because they employ many professionals and have in-house design and engineering. Yet these pockets of excellence are often enclaves with few linkages to the rest of the economy." (Kuznetsov and Dahlman, 2007, p. 7)

12. As a result, concentration of revealed comparative advantages (RCAs) as measured by a Herfindahl index, is relatively low, especially compared to commodity exporters such as Chile (OECD, 2003a, p. 148; Oliveira-Martins and Price, 2004; OECD, 2007c).

13. The creation of new or higher quality products is a key feature of R&D-based endogenous growth models, such as those of Romer (1990) or Grossman and Helpman (1991). In these models, the creation of new or higher quality products is linked to R&D activities; their availability as intermediate goods translates into higher productivity.

14. The following definitions are used here to categorise Mexican SMEs: *Micro enterprise* – between 0 and 10 employees in manufacturing, retail and services; *Small enterprise* – between 11 and 50 employees in manufacturing and services, and up to 30 employees in retail; *Medium-sized*

enterprise – between 51 and 250 employees in manufacturing, 51 and 100 employees in services, and 31 and 100 employees in retail.

15. Further reductions in tariffs were announced at the end of 2008.

16. According to the Foreign Investment Law (1993) and amendments as well as a number of sectoral laws.

17. Emphasising the importance of capabilities in a model in which firms differ in quality and productivity, Sutton (2007, p. 492) concludes that "in a world in which quality matters and intermediate goods are freely traded, a middle group country may be a loser in the first stage of the process. Yet, it is the middle-group countries … who are best placed to be the most dramatic beneficiaries of the present globalisation, not – or not primarily – because of trade liberalisation per se, but because of the virtuous dynamic that follows as part of the general package of liberalisation of foreign direct investment and capability transfer."

18. An *amparo* remedy or action is an instrument for protecting an individual's constitutional rights.

19. There are several caveats, however, concerning the regulation-growth linkage. Nicoletti and Scarpetta (2005, p. 17) point out that the analysis contains "only indirect evidence of the effects of product market reforms on innovation. More specific analysis of the link between regulation (including intellectual property rights) and aggregate innovative activity is needed."

20. For a description of the structure of the integrated product market regulation (PMR) indicator, see Wölfl *et al*. (2009).

21. This process involves identifying and modifying regulations and policies that unnecessarily restrict competition using the *OECD Competition Assessment Toolkit* (OECD, 2007d).

22. The outstanding role of innovation is acknowledged by modern theories of economic growth (see Grossman and Helpman, 1991; Helpman, 2007; Aghion and Howitt, 2009).

23. See the works of Gerschenkron (1962) and Abramovitz (1986), and the survey by Fagerberg (1994).

24. The importance of international knowledge diffusion was illustrated by Eaton and Kortum (1996). On this issue also see Eaton and Kortum (1999), and the surveys by Gong and Keller (2003) and Keller (2004).

25. See the evidence from a panel of OECD countries (OECD, 2003).

26. There is also another dimension in which increased diversification can be beneficial in the Mexican context. A more diversified range of trading partners would help reduce Mexico's exposure, notably to shocks in the United States and in this way contribute to enhancing macroeconomic stability.

27. If the cost of fiscal incentives is added to the amount of direct support, the percentage of business R&D financed by government reaches about 25% in 2005 and probably more in subsequent years.

Chapter 2

Main Actors of Innovation

The way innovation systems are defined has major implications for the balance and mix of policies needed to improve innovation system performance and for the amount of communication and co-ordination required to create holistic innovation policies. To the extent that countries operate within the confines of a narrow "innovation system map" focused on science and technology and the formal R&D system, they are likely to be guided into making policy choices that optimise the formal part of the system at the expense of the whole. However, over the last decade or so, a broader perspective on innovation systems has emerged, which increasingly underpins attempts by governments to develop more holistic innovation and research policies.

With this broader perspective in mind, this chapter provides an overall assessment of the innovation and research activities of the business sector, the public science and education systems, and the stock and flow of human resources. It begins with the central actors in any well-functioning innovation system – business firms – and further explores explanations for low levels of R&D spending but also broadens the perspective on firm innovation by taking into account non-R&D and non-technological innovation. The chapter then considers the public-sector research system, starting with the public research centres (PRCs). This is followed by an exploration of Mexican higher education institutions, which perform the largest share of publicly funded R&D in Mexico and are responsible for tertiary education. A final section covers the human resource dimension of innovation.

2.1. Business sector

As noted in Chapter 1, levels of business enterprise R&D (BERD) in Mexico are very low by OECD standards but gradually rising. The latest innovation survey (ESIDET) paints a picture of Mexican enterprises increasingly undertaking R&D as part of their innovation activities. This section explores the relation between R&D spending by enterprises and the specialisation and structure of the Mexican economy. Innovation survey data are then used to illustrate the importance of non-R&D innovation for Mexican firms. Much of the section is devoted to a discussion of linkages between large and small firms and between industry and public science. A final section highlights the barriers facing innovating firms in Mexico.

2.1.1. Research in firms

Mexico has one of the lowest business R&D intensities in the OECD area (Table 2.1), although it more than doubled over 2000-05 to 0.23%. Almost half of the R&D carried out in Mexico in 2005 was performed in business firms, again a major increase compared to the level five years earlier. This increased activity has been accompanied by marked increases in the number of researchers working in business enterprises[1] and by an almost five-fold increase over the six years to 2008 in the number of firms registered in the National Register of Scientific and Technological Firms and Institutions (RENIECYT)[2] (Figure 2.1).

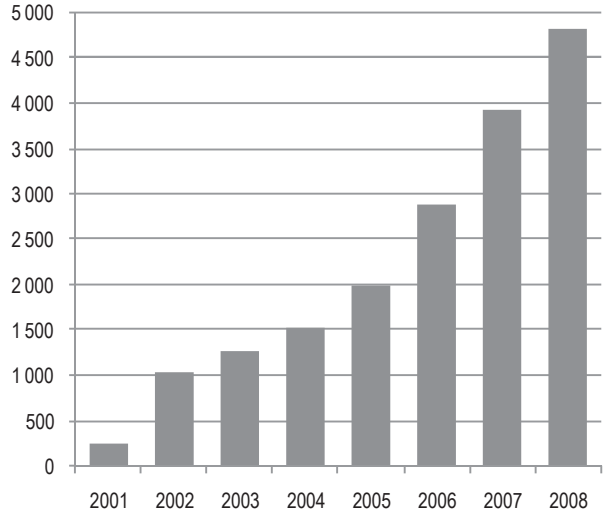
Table 2.1. Main R&D indicators for the Mexican business sector, 1999-2006

	2000	2001	2002	2003	2004[1]	2005
% of GERD financed by industry	29.5	29.8	34.7	34.7	44.0	46.5
% of GERD performed by business sector	29.8	30.3	34.1	34.6	46.6	49.5
BERD (million current PPP USD)	998	1 100	1 421	1 518	2 380	2 927
BERD (% of GDP)	0.10	0.11	0.14	0.14	0.20	0.23
Business enterprise researchers (FTE)	n.a.	n.a.	n.a.	8 663	20 958	24 367
% of BERD financed by industry	90.1	89.8	97.6	96.8	92.9	92.6
% of BERD financed by government	9.3	9.6	1.5	2.6	5.4	5.7
% of BERD financed by other national sources	0.1	0.0	0.4	0.6	0.1	0.3
% of BERD financed by abroad	0.5	0.6	0.5	0.0	1.6	1.4

1. Break in series with previous year for which data are available.

Source: OECD Main Science and Technology Indicators.

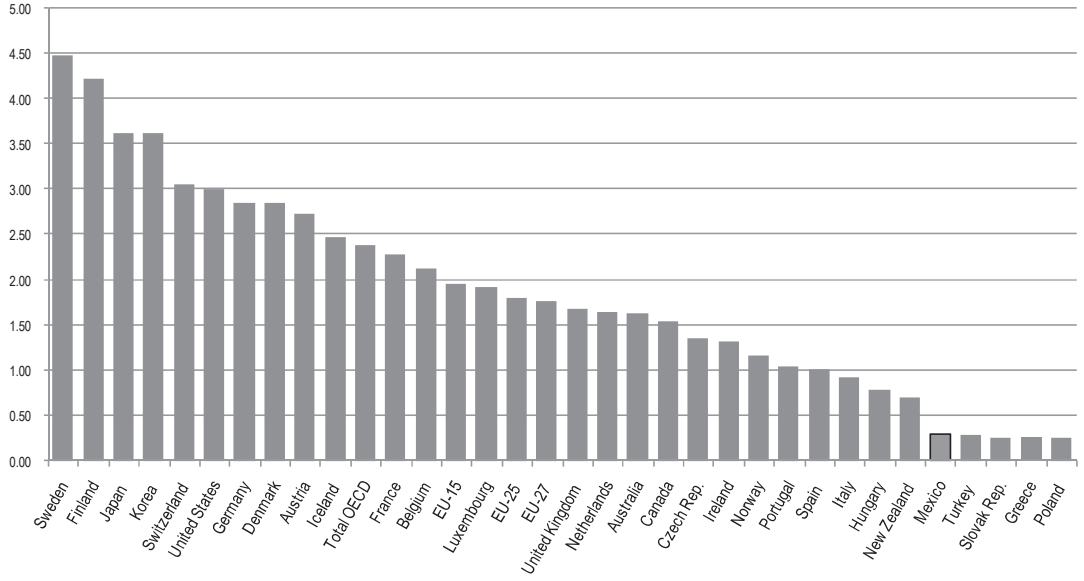
Figure 2.1. Firms and institutions registered in the RENIECYT, 2001-07



Source: CONACYT.

Despite these seemingly promising developments, the level of BERD as a percentage of value added in industry remains one of the lowest in the OECD (Figure 2.2). This low R&D intensity can be largely attributed to the country's industrial structure, which is dominated by micro-enterprises and SMEs operating mostly in services and low- and medium-technology (LMT) manufacturing sectors. It is well known that small firms are less likely to conduct R&D than their larger counterparts; the same is true for firms in the services and LMT manufacturing sectors. As Figure 2.3 shows, a little over 40% of Mexican BERD conducted in firms employing more than 50 persons is spent in smaller firms (with 50-250 employees), a comparatively high proportion. Larger firms play a less prominent role in Mexico than in many other OECD countries, particularly the larger ones, such as Germany, Japan and the United States, where large firms often play a leading role in structuring markets, in carrying out large-scale innovations and even in co-ordinating smaller firms.

Figure 2.2. BERD as a percentage of value added in industry, 2007[1]

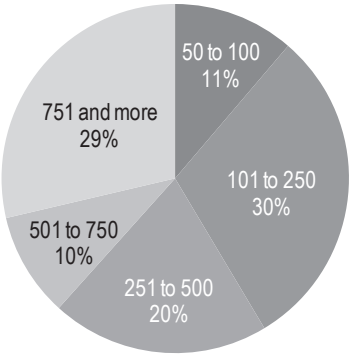


1. Or nearest available year.

Source: OECD Main Science and Technology Indicators.

Figure 2.3. BERD by firm size in Mexico, 2005

Number of employees



Source: Background report, CONACYT.

Table 2.2 indicates that in 2005, around 18% of Mexican BERD was spent in the services sector, a figure comparable to that of the European Union but a little more than half that of the United States. This would seem to be in line with Mexico's larger than average manufacturing sector. Table 2.3 completes the picture of BERD, showing that despite the traditional low levels of R&D spending in LMT manufacturing sectors in OECD countries, the Mexican LMT sector accounts for the highest proportion of BERD in the OECD area. Furthermore, high-technology industries account for one of the lowest proportions of BERD. These figures are to be expected, given the dominance of LMT sectors in the Mexican economy.

Table 2.2. BERD by industry in Mexico, 2005

In millions of constant 2006 MXN

Industry	Amount
Agriculture	3
Mining	80
Manufacturing	15 112
Food, beverages and tobacco	2 900
Textiles, clothing, fur and leather	951
Wood, paper, printing and publishing	252
Coke, petroleum, nuclear fuel, chemicals & rubber and plastic products	4 954
Non-metallic mineral products	861
Base metals	284
Manufactured metal products (except machinery and equipment)	1 241
Machinery, equipment, instruments and transport equipment	3 602
Furniture and other manufactures not specified elsewhere	66
Electricity, gas and water supply	88
Construction	2
Services sector	3 407
Total	**18 692**

Source: Background report, CONACYT.

2.1.2. Technological innovation

According to the results of the 2006 Encuesta sobre Investigación y Desarrollo Tecnológico (ESIDET) innovation survey (Box 2.1), a quarter of surveyed firms indicated that they had undertaken some type of technological innovation in 2004-05. Although not directly comparable, data from a similar survey conducted in 2001 show there to have been no increase in the proportion of innovative firms in recent years (Table 2.4). In line with the results of innovation surveys carried out in many other countries, the 2001 survey indicates that larger firms tend to be more innovative. This pattern breaks down in the 2006 survey, however, with medium-sized firms apparently the most innovative.

Table 2.3. Percentage of BERD performed in different industries in OECD countries, 2006[1]

	High-technology industries	Medium high-technology industries	Medium-low-technology and low-technology industries	Service industries
Australia	10.0	11.7	16.9	39.7
Austria	31.0	27.8	12.9	27.4
Belgium	41.2	23.7	15.7	17.0
Canada	32.4	9.1	11.0	41.9
Czech Republic	22.3	35.6	8.7	31.8
Denmark	39.4	16.2	8.5	35.0
Finland	63.8	13.5	12.1	8.2
France	44.6	29.9	11.5	8.4
Germany	29.6	52.2	8.3	9.4
Greece	21.8	13.8	17.2	44.9
Hungary	53.7	16.0	6.6	21.4
Iceland	25.0	6.9	5.7	59.7
Ireland	48.0	9.0	9.3	33.6
Italy	33.1	29.1	8.0	26.8
Japan	44.7	40.4	2.9	10.4
Korea	53.8	27.9	8.3	7.1
Mexico	**9.7**	**21.8**	**35.1**	**32.6**
Netherlands	40.9	27.8	8.5	17.4
Norway	12.6	16.3	12.6	50.3
Poland	13.9	23.7	9.1	50.6
Portugal	17.6	17.6	10.9	44.0
Spain	20.5	18.8	15.1	41.8
Sweden	38.7	29.8	5.2	24.8
Turkey	16.3	42.0	14.5	25.8
United Kingdom	49.0	18.8	7.6	23.2
United States	40.3	16.6	6.4	36.1
EU15	38.7	34.9	9.2	15.0

1. Or nearest available year.

Note: High-technology industries include aerospace; office and computing equipment; pharmaceuticals; radio, TV and communication equipment; medical, precision and optical instruments. Medium-high-technology industries include motor vehicles; chemicals; electrical machinery; other transport; machinery and equipment. Medium-low-technology and low-technology industries include rubber and plastics; non-metallic mineral products; shipbuilding; ferrous and non-ferrous metals; metal products; petroleum; other manufacturing industries.

Box 2.1. The 2006 ESIDET innovation survey

Like the well-known Community Innovation Surveys (CIS) of the European Commission, the 2006 ESIDET innovation survey of Mexican firms was based on the second edition of the OECD *Oslo Manual* for collecting and interpreting technological innovation data (OECD, 1996). Accordingly, the survey used two definitions of innovation:

1. *Technological product innovation* relates to the use of ideas and concepts to create new products which are then introduced on the market to offer something new or improved. A *technologically new* product may be developed based on radically new technologies or result from existing technologies used in new ways or may make use of new knowledge. A *technologically improved* product is one whose performance is significantly improved by utilising new components or materials or through integration of new subsystems.

2. *Technological process innovation* relates to the implementation and/or adoption of new or significantly improved production methods. This may involve changes in equipment, human resources, working methods or a combination of these. Such methods must be aimed at producing technologically new or improved products that cannot be produced using conventional production methods.

Non-technological innovation was not covered by the survey, although this is likely to be a significant phenomenon in Mexican firms. In fact, non-technological innovation is increasingly recognised as an important driver of transformative change in enterprises across all OECD countries. According to the third edition of the *Oslo Manual* (OECD, 2005), it can be broken down into two main components: organisational innovation, which refers to important changes in the organisational structure or the administration of an enterprise; and marketing innovations, which cover important changes in the design or packaging of products or important changes in sales or distribution methods.

The 2006 innovation survey was administered as a module of the biennial ESIDET survey of firms and covered the years 2004 and 2005. It follows a similar innovation survey module administered in 2001. A total of 16 398 firms answered the 2006 innovation module of the survey and are classified according to size (determined by number of employees: 50-100, 101-250, 251-500, 501-750, and 751 or more) and industry branch.

Source: CONACYT (2007), *Informe general del estado de la ciencia y la tecnología* 2007.

While not directly comparable with the results of the ESIDET survey, data from the fourth Community Innovation Survey (CIS4) for the 27 members of the European Union (EU27) for the period 2002-04 show that 40% of European firms surveyed had engaged in innovation – a significantly greater proportion of firms than in Mexico.[3] The distribution of innovative firms in European countries varies widely, however, with 65% of German enterprises active in innovation compared to only 16% in Bulgaria. In fact, the share of innovative enterprises in Mexico is broadly comparable to the levels of new EU member states.

Table 2.4. Share of Mexican companies undertaking technological innovation

As indicated by the ESIDET surveys and compared with the latest European survey

Company size	2001 survey	2006 survey	CIS4 survey
50-100	23	22	53
101-250	21	29	
251-500	34	28	71
501-750	41	26	
751+	43	20	
Total	**26**	**25**	**40**

Note: CIS4 total includes data for smaller firms (10-49 employees).

Source: CONACYT and Eurostat (2008).

Although the share of innovative firms is similar in both the 2001 and 2006 ESIDET surveys, there is a striking difference in firms' expenditures by type of innovation activities (Table 2.5). While less than 10% of innovative firms' expenditures on innovation were devoted to R&D in 2001, this share reached more than 40% in the 2006 survey. Even if the data in these two surveys are not fully comparable, the magnitude of the shift suggests a considerable increase in firms' R&D activities; this is confirmed by the BERD data presented earlier. This picture varies considerably among sectors, however. For example, continuing low R&D spenders include firms in the following sectors: clothing and leather (0.2% of innovation expenditures), financial intermediation (10.6%), carbon, petroleum derivatives and nuclear energy (14.6%), mining (19.2%), and textiles (20.2%). By contrast, the share of R&D expenditures in innovative activities is high in firms in the following sectors: office equipment, accounting and computing machinery (73.9%), non-metallic minerals (66.9%), agriculture (65.0%), and food and drink (63.6%).

Table 2.5. Firms' expenditures by type of innovative activity in Mexico

Percentage of total investment in innovation

Expenditures	2001 survey	2006 survey
Acquisition of machinery and equipment related to innovation in products and processes	66.2	39.7
Acquisition of other technologies related to innovation in products and processes	7.5	8.9
Industrial design and/or other expenditures to initiate production of new or improved products	8.3	3.6
Training programmes linked to innovation activities	2.7	2.8
Expenditures in marketing linked to innovative technologies	6.8	2.5
R&D	8.5	42.5
Total	100.0	100.0

Source: ESIDET results, CONACYT.

In spite of the overall increase in R&D activities, the majority of expenditures on innovative activities are not used to perform R&D. Instead, the acquisition of machinery and equipment (almost 40%) and other technologies (almost 9%) related to innovation in products and processes account for almost half of all innovation expenditures. This is hardly surprising given Mexico's industrial ecology and its "catching-up" status. Indeed, analytical work on innovation survey data in Europe (Arundel *et al*., 2008) suggests that R&D is correlated with certain firm characteristics. For example, non-R&D innovators are likely to be smaller firms active in LMT manufacturing and services sectors and located in countries with trailing or lagging average innovative capabilities. Innovation processes in such firms are often less formal and more related to modification and incremental change, design and process optimisation.

It is important to recall that acquisition of machinery and the like should not be viewed as somehow inferior to R&D or in need of "correction". While it is widely thought that most productivity improvements and performance outcomes are due to innovative activities based on R&D (particularly in high-technology industries), innovation theory and empirical studies suggest that such assumptions are unfounded. Recent analysis of European innovation data (Arundel *et al*., 2008) shows little difference in performance, as measured by a change in revenue, between innovative firms that do

and do not perform R&D. This confirms that innovation rests not on discovery but on learning, which can be based on activities that recombine or adapt existing forms of knowledge (Smith, 2002). Box 2.2 provides a few examples of innovation approaches that do not necessarily involve R&D.

Box 2.2. Non-R&D performing innovators

How do firms that do not perform R&D innovate? The innovation literature points to four main methods:

1. *Technology adoption*: Firms can acquire innovative products and processes from sources external to the firm, with little or no further work required. For example, a computer assembler can purchase faster hard drives or wireless cards from specialist firms for inclusion in a notebook computer, or a food processing firm can purchase improved packaging equipment. CIS data used by Evangelista and Mastrostefano (2006) show that the acquisition of new machinery and equipment is one of the most common innovation activities across firms. Similarly, firms can acquire ideas for organisational innovations from other firms.
2. *Minor modifications or incremental changes* to products and processes, including the use of engineering knowledge (Kline and Rosenberg, 1986). Modifications can be made to both purchased products and processes or to technologies previously developed by the firm itself. These innovation activities are particularly common for process innovation (Evangelista *et al*., 2002; Nascia and Perani, 2002). Lhuillery and Bogers (2006) estimate that 15% of overall cost reductions are from incremental innovations made by employees to production processes. Incremental change can depend on learning by doing, as a firm gets better at what it already does (Cohen and Levinthal, 1989).
3. *Imitation, including reverse engineering*: Many activities to replicate products or processes that are already available, including some solutions to circumvent a patent (Kim and Nelson, 2000), do not require R&D. This method of innovating may be especially common in less developed countries or for innovations that are not patentable.
4. *Combining existing knowledge in new ways*: This can include some types of industrial design and engineering projects (Grimpe and Sofka, 2007; Huston and Sakkab, 2006). The Italian "informal learning systems" are used by SMEs in traditional industries and mechanical and electrical/electronics sectors to create new products (Evangelista *et al*., 2002). These systems build on tacit knowledge, engineering skills and cumulative learning processes that are located in the system rather than in a specific firm (Gottardi, 1996). Informal contacts and highly skilled and mobile personnel move tacit knowledge from firm to firm.

There are also situations in which a firm adopts solutions developed by users (with users possibly doing some unreported R&D work). Von Hippel (2005) argues that user innovation is much more widespread than earlier thought. It thrives when there are methods for sharing information and breaking down a problem into components (*e.g.* innovation toolkits). These enable users to innovate without new R&D and improve the ability of users to combine and co-ordinate their efforts (*e.g.* over the Internet). User innovation can also serve as an important source of solutions for firms. Von Hippel calls users' ability to develop what they need instead of buying what is available the "democratisation of innovation".

Source: Arundel *et al*. (2008), "Neglected Innovators – How Do Innovative Firms That Do Not Perform R&D Innovate?", INNO-Metrics Thematic Paper, MERIT, University of Maastricht.

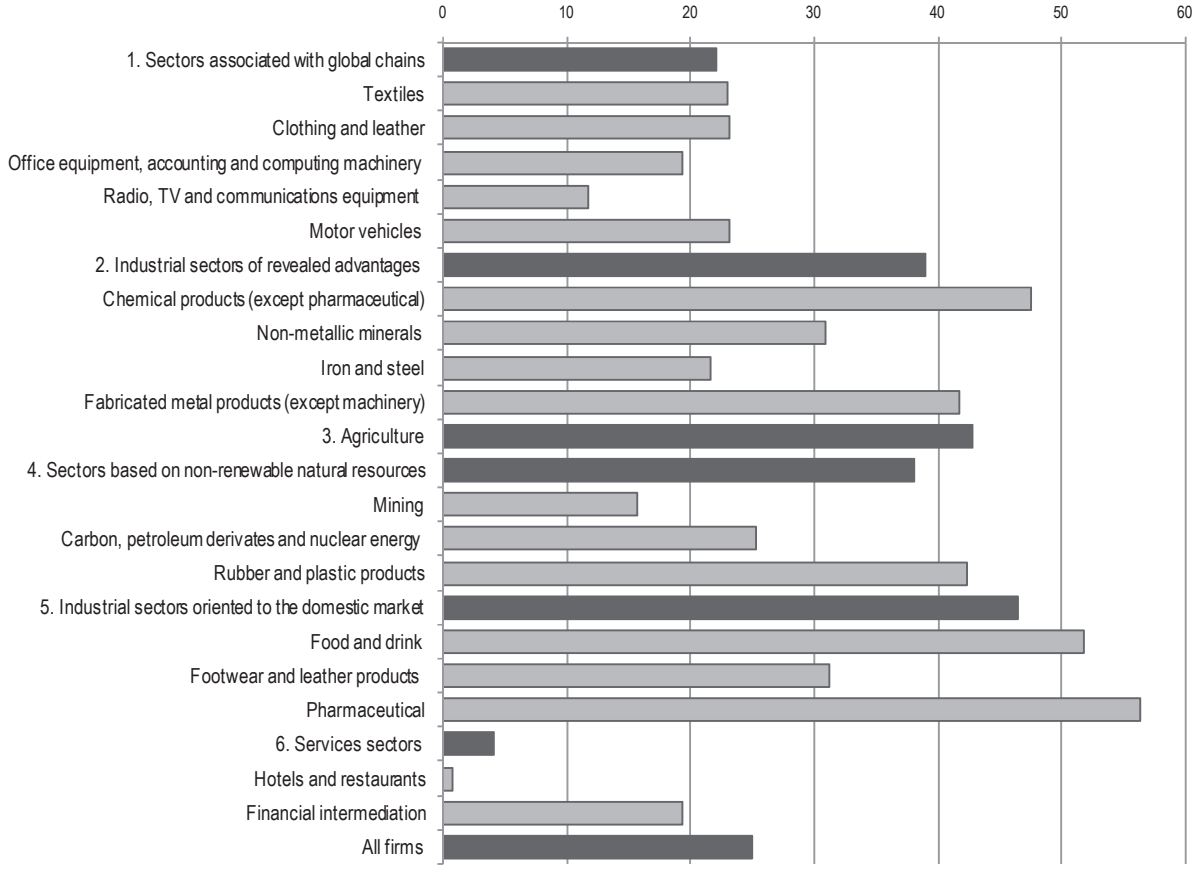
Table 2.6. Different "types" of business sector and their characterisation

Sector types	Main sectors/products	Type of firms	Main states
1. Sectors associated with global chains	Automotive, electronics, office equipment, clothing	Subsidiaries, large domestic firms and some supplier SMEs	Chihuahua, Baja California, Jalisco, Edo México, Puebla, Aguascalientes, Guanajuato, Coahuila and Querétaro
2. Industrial sectors with revealed comparative advantages	Iron and steel, glass, chemicals	Large domestic firms, some subsidiaries, and supplier SMEs	Nuevo León, Querétaro, DF
3. Sectors with revealed comparative advantages based on agriculture, stockbreeding, forest and fishing	Tequila, coffee, vegetables, shrimp	Large domestic firms, commercial producers of different sizes, associations and co-operatives of producers	Jalisco, Sinaloa, Sonora, Guanajuato, Querétaro, Chiapas, Veracruz
4. Sectors based on non-renewable natural resources	Petroleum derivates, petrochemicals and mining	Large domestic private firms and state-owned firms	Tabasco, Veracruz, Tamaulipas
5. Industrial sectors oriented to the domestic market	Cement, pharmaceuticals, food, footwear, software	Large domestic firms, subsidiaries, and traditional and high-technology SMEs	DF, Jalisco, Edo México, Guanajuato
6. Services sectors	Tourism, banking	Large domestic firms, subsidiaries, SMEs and associations	Baja California Sur, Guerrero, Yucatán, Quintana Roo, Jalisco, Oaxaca, Nuevo León, DF

Source: Background report, CONACYT.

Among Mexican firms with innovative projects, 82% were from manufacturing and 17% from services (a further 1% were from other sectors, including agriculture). As business firms face different scientific-technological challenges depending on the types of market in which they operate, their ownership structure, their size, and their area of business activity, it is useful to construct a typology in order to take such distinctions into account. Therefore, Table 2.6 sets out six "types" of productive profile which are selectively used in subsequent analysis of ESIDET survey data. While it would be wrong to assume there is homogeneity within each sectoral "type" (Figure 2.4), the groupings are nevertheless useful to explore some of the dependencies between innovative activities and factors such as firm size, ownership and market. For example, Figure 2.4 shows that services firms are far less likely to engage in technological innovation than their manufacturing counterparts – a not unexpected result. In the services sector, financial intermediation firms are an important exception owing to their high levels of acquisition of software linked to technological innovation.

Figure 2.4. Percentage of innovative firms by sector in Mexico, 2004-05



Source: ESIDET results, CONACYT.

Results for other sectors are perhaps more surprising, at least on an initial viewing. For instance, agriculture is often thought of as a low-technology, low-innovation sector, yet the ESIDET data show that more than 40% of firms surveyed in the agricultural sector conducted some form of innovative activity in 2004-05. Moreover, more than 60% of innovation expenditures were devoted to R&D, one of the highest proportions among all sectors. However, this is less surprising when the types of firms surveyed are considered: suppliers of machinery, seed, fertiliser, animal feed, etc., all require R&D for their development.[4]

A further "surprise" concerns the apparently greater innovativeness of industrial firms serving largely domestic markets (Table 2.6. sector 5) than those associated with global value chains (sector 1). A phenomenon that may be similar was reported by Dussel Peters *et al.* (2007) using data from Mexico's 2004 economic census. Focusing more narrowly on R&D, the authors find a negative association between foreign direct investment (FDI) and expenditures on technological R&D by big manufacturing firms. Specifically, they use a typology of Mexico's large manufacturing firms – divided into three groups: *i*) those with FDI from 0.1% to 49%; *ii*) those with no FDI; and *iii*) those with an FDI share above 50% of its capital – to show that firms with no FDI have the highest R&D intensity, followed by those with more than a 50% FDI capital share and then those with less than 50%. This pattern is reproduced in two of the main FDI sectors in Mexico,

automotive and electronics. Taken together, these results suggest that Mexican subsidiaries of overseas transnational corporations (TNCs) and the firms that supply them do not, on the whole, function as innovation platforms. This has implications for the potential of FDI to generate significant knowledge spillovers to the rest of the Mexican economy (see Box 2.3).

Box 2.3. Investment strategies of transnational corporations and the scope for knowledge spillovers

In spite of the many positive effects associated with FDI, it has largely failed to live up to expectations in terms of promoting the industrial and technological upgrading of Mexican firms through the generation of useful knowledge spillovers. A contributing factor is the nature of the corporate strategies of many investing TNCs. Dunning (1993) created a typology that distinguishes between four principal focal points of TNC operations from the perspective of corporate FDI strategies, as follows:

- *Natural-resource-seeking strategy*: firms that are motivated to invest abroad to acquire specific resources at a lower cost than could be obtained in their home country;
- *Market-seeking strategy*: firms that invest in a particular country or region in order to serve local markets;
- *Efficiency-seeking strategy*: firms that seek to rationalise their production, distribution and marketing activities through common governance of and synergy-building among geographically dispersed operations;
- *Technological/strategic-asset-seeking strategy*: firms that seek to promote their strategic objectives, for example, through the accumulation of technological capabilities.

In Mexico, strategic asset-seeking FDI is almost non-existent. Instead, most FDI comes from efficiency-seeking TNCs that establish platforms as part of their regional or international systems of integrated production. These local assembly operations of mainly US TNCs are primarily cost centres for high- and medium-technology manufacturing, such as automotive and electronics. Global competition in these industries obliges TNCs to search for lower-cost, large-scale production sites close to major markets for the labour-intensive aspects of their production processes. Mexico offers privileged access to the North American market through NAFTA and has therefore seen considerable levels of investment by US TNCs. As a result, Mexico's international competitiveness has improved dramatically, as measured by its increased market share of automotive and electronic products in the US market.

In the automotive industry mostly US FDI in new plants during the 1990s converted an uncompetitive industry focused on the national market into a highly competitive platform aimed at the North American market. Investment has been driven by proximity, lower salaries, and preferential market access through NAFTA, all in the context of increasing competition from Asian auto manufacturers. Between 1985 and 2002, the production capacity of the Mexican automotive industry rose from 400 000 to almost 2 million units. Exports rocketed from almost zero to about 1.4 million units with Mexican plants accounting for 14% of vehicle imports to North America.

However, TNC operations in Mexico focus on static rather than dynamic host country advantages (such as skilled human resources and local technology capabilities). As a result, the dependence of assembly operations on imported components means that local productive linkages are weak. This leads to very limited cluster formation and thus severe limits on the industrial and technological upgrading of the industry in Mexico. In other words, the overall impact of this "transnationalisation" process has been much less than expected in terms of "ripple effects" on the host economy and companies.

Source: Based on Mortimore (2006), "The Transnationalisation of Developing America: Opportunities and Challenges", ECLAC, Santiago.

Box 2.4. The automotive sector in Mexico: its importance, evolution and challenges

The automobile industry is the largest branch of Mexico's manufacturing. In 2005, the sector accounted for 15.1% of manufacturing GDP, 13.7% of manufacturing employment and close to 20% of manufactured exports. In the past decade, it has gone through several export phases, with vehicle and parts exports to the United States growing by an average of 21% from 1995 to 2000, before falling by an average of –2% between 2001 and 2005. In 2006, following a period of re-tooling, vehicle and vehicle part exports grew at 26%. Going forward, export growth will principally depend on the strength of the US market and also the auto product cycle. Part of the strong export growth in 2006 was due to an upswing in production from the launch of new models. Developments in the industry suggest that Mexico has a growing comparative advantage in auto manufacturing. In January 2005, the Ford Motor Company announced the shutdown of 12 of its plants in the United States by 2012. At the same time it projected an increase of its operations in Mexico. Today Mexico is exporting a range of higher value cars to the biggest markets in the world, while importing cheaper cars for domestic use.

Evolution

The development of the Mexican automobile sector has gone through periods of contrasting policies, from import substitution in the 1950s and 1960s to export promotion in the 1980s. The most important rules governing automobile exports are set out in NAFTA. In the case of new cars, NAFTA requires around 60% of the car to be produced in NAFTA countries in order for it to be exported from Mexico to the United States and Canada.

Over time different factors have determined the establishment of factories in certain regions of Mexico. Initially, car factories were established near Mexico City because of its large market. Later, the companies were established in the northern part of the country, close to in-bond industries (*maquiladoras*). There is evidence that this later localisation was due to productivity advantages rather than low wages. The more recent localisation of investments seems to be dictated by the systemic competitiveness that can be gained from the integration of car industries with large local supply chains. This is reflected in increasing regional specialisation in the north and two central areas of Mexico.

Challenges

One of the advantages that could be expected from FDI in the sector is the spillovers and linkages it can potentially generate for the Mexican economy, specifically through the development of chains of suppliers. However, this has so far been limited. The automobile sector has relied on large tier 1 suppliers from Canada, the United States or Mexico (direct suppliers to an auto manufacturer which are often involved in design and manufacture, but not marketing of final products), but it has only developed limited linkages with small Mexican suppliers for tiers 2 and 3 (sub-contracting manufacturers to tier 1 not normally involved in design). To enter the production chain, smaller suppliers have to comply with high international standards of quality and meet large production requirements. Up until now, low quality and limited flexibility and reliability, partly due to poor managerial skills, have been the main obstacle for smaller Mexican suppliers to develop and cluster with the car assembly plants. In this context, despite ongoing efforts, foreign direct investors have not been able to provide the much needed training and managerial skills that small suppliers need. In many cases, small suppliers do not qualify to tender for business (because they lack the sales volume or the necessary ISO quality ratings) and therefore cannot benefit from the knowledge that car factories can provide.

The challenge for Mexico is to continue to improve support strategies that will encourage a more integrated and deeper manufacturing base. There are many government policies aimed at helping small firms. To ensure that the policy mix is cost-efficient over the medium term, there needs to be greater co-ordination and systematic policy evaluation. For this to be possible, surveys and data collection about small firm performance have to be improved. See OECD (2007b) for a review of current SME policies in Mexico.

Source: OECD (2007), *Economic Surveys: Mexico*, OECD, Paris.

2.1.3. Linkages between large firms and small firms

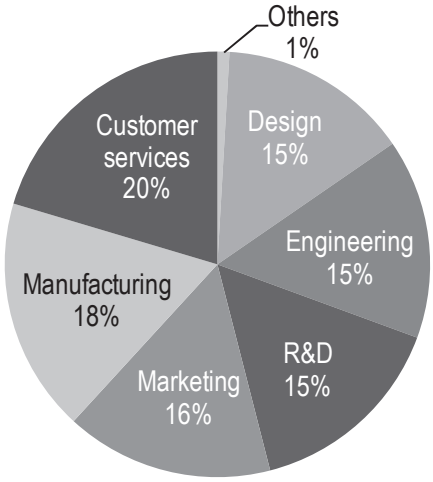
Knowledge spillovers from large firms to smaller ones occur when part of the knowledge generated by the larger organisation spills over its boundaries and becomes available to other organisations. Typical mechanisms include backward linkages to suppliers, human capital accumulation and mobility, and training effects. Of particular interest are backward linkages, which are widely lauded by proponents of FDI as the most important mechanism for knowledge spillovers. These tend to occur in two ways: either customer firms establish supportive linkages to supplier firms, increasing their capabilities directly; and/or customers put pressure on their suppliers to produce inputs that satisfy requirements of quality, quantity, delivery time and price, a mechanism that forces suppliers to improve quality and efficiency (Jordaan, 2005).

As Chapter 1 has pointed out, Mexico's industrial ecology is dominated by micro firms, with very few large or medium-sized firms. This structure limits the potential for the supply chain linkages that can help smaller firms to grow and increase their productivity. This has meant that Mexican firms have sometimes been unable to supply transnational corporations in the electronics and automobile sectors owing to a lack of scale and technical capabilities and quality. While links between foreign investors and their direct domestic suppliers (tier 1 suppliers) are reasonably strong, there are only weak links between the tier 1 suppliers and their generally smaller suppliers (tier 2 and tier 3 suppliers) (OECD, 2007a). Box 2.4 describes the automotive supply chain in Mexico.

2.1.4. Knowledge transfer through information sourcing and co-operation

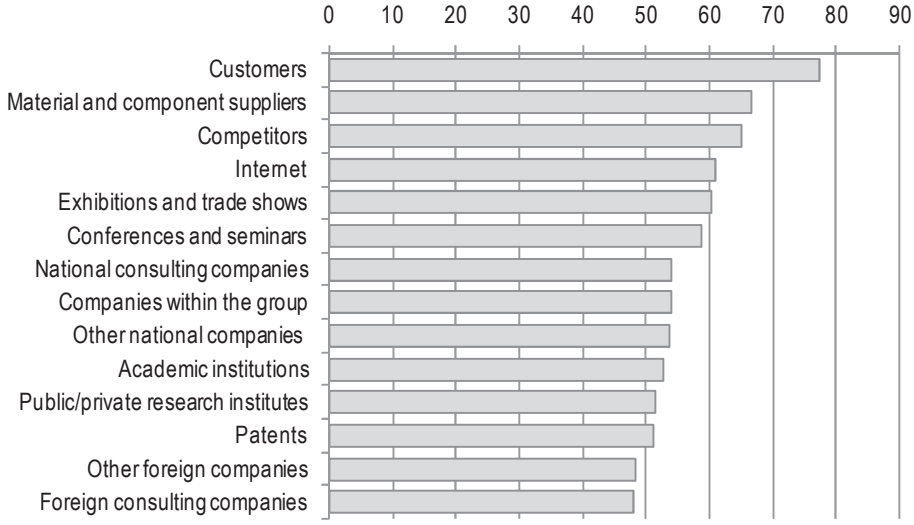
Firms' internal sources of innovation are not dominated by R&D departments as is sometimes mistakenly believed. In line with findings in many other countries, R&D departments are just one of many sources of innovation in Mexican firms and not the most important one (Figure 2.5). Customer services departments are more likely to be the source of innovations than any other department. This is not surprising given the well-known importance of customers and clients for innovation. Figure 2.6 shows in fact that the top three external sources of information for innovation are customers, suppliers and competitors. The importance of suppliers reflects the predominance of acquisition of machinery and equipment in Mexican innovation and probably accounts also for the popularity of exhibitions and trade fairs. In line with the results of innovation surveys conducted in other parts of the world, higher education institutions (HEIs) and public research centres (PRCs) are less likely sources of information for innovative Mexican enterprises.

Figure 2.5. Main "internal sources" of information for innovation in Mexico, 2004-05



Source: ESIDET results, CONACYT.

Figure 2.6. Main "external sources" of information for innovation in Mexico, 2004-05

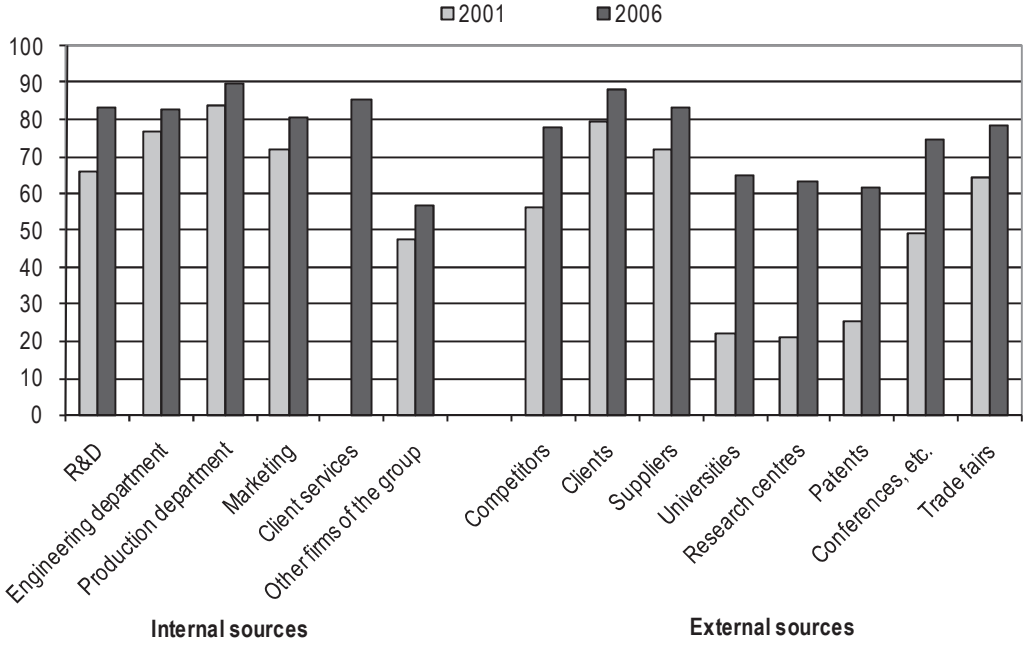


Source: ESIDET results, CONACYT.

Figure 2.7 compares the results of the 2001 and 2006 ESIDET surveys for the manufacturing sector and shows that firms report increases across all sources of innovation. The most dramatic increases involve HEIs and PRCs, which are reported by three times as many firms in 2006 than in 2001 to be sources of innovation information. This would seem to be a promising development that coincides with the growth of firms' own R&D activities.

Figure 2.7. Evolution of sources of innovation in Mexico between 2001 and 2006

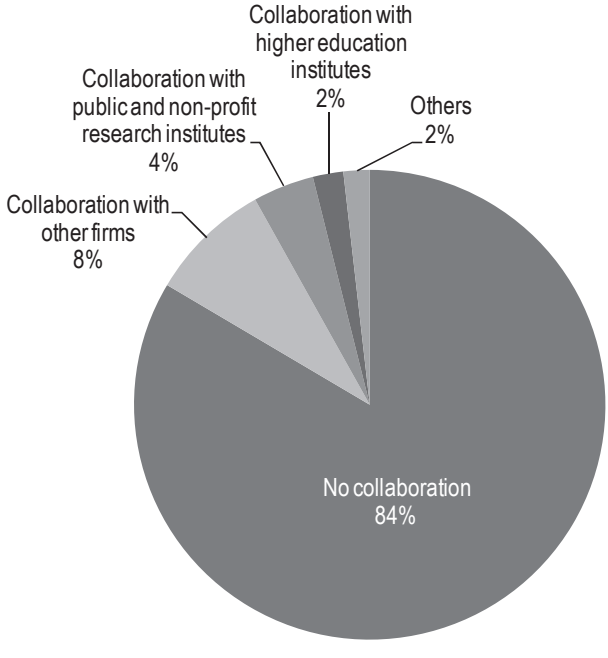
ESIDET surveys for the manufacturing sector



Source: EDISET results, CONACYT.

Figure 2.8. Innovation co-operation arrangements in Mexico, 2004-05

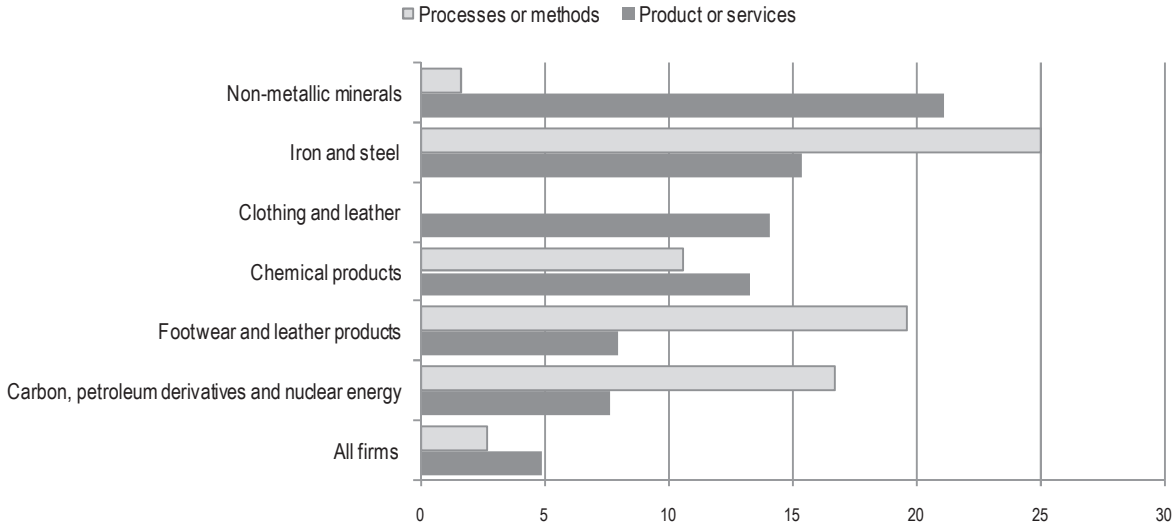
As a percentage of innovative enterprises



Source: EDISET results, CONACYT.

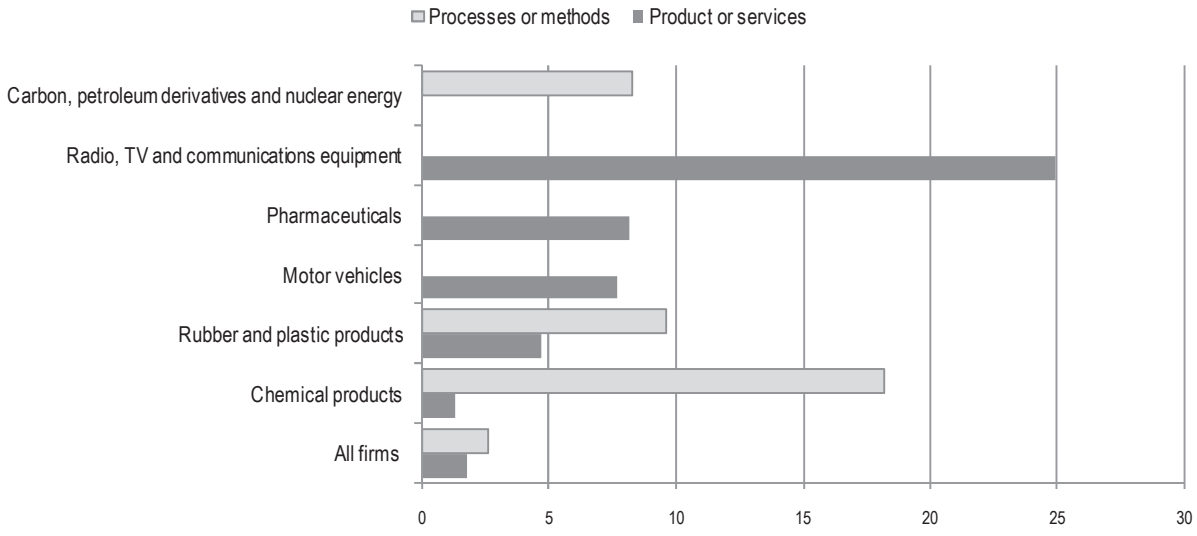
Data on co-operation for innovation is less encouraging, however. As Figure 2.8 shows, 84% of innovating firms reported no co-operation, a much higher proportion than in innovation surveys carried out in other countries. The pattern of co-operation is, on the other hand, largely what would be expected, with other firms by far the most popular partner, followed some way behind by PRCs and HEIs. The level of co-operation with the PRCs, at 4.2%, is not far from the level reported by CIS4 for the EU27 (5.6%). On the other hand, the level of co-operation with HEIs, at 2%, is especially low by international standards. These results are hardly surprising given the low levels of spending by Mexican firms on R&D, although there is some sectoral differentiation. For example, firms in industries such as textiles, radio, TV and communications equipment, iron and steel, carbon, petroleum derivatives and nuclear energy, and financial intermediation show well-above-average levels of co-operation with other firms. Similarly, firms in several sectors co-operate with PRCs and HEIs at well-above-average levels. Figure 2.9 highlights sectors in which the proportion of firms co-operating with PRCs is more than twice the average. It shows that co-operation is strongest in sectors with revealed comparative advantage (sector 2 in the typology in Table 2.6), as well as in a few sectors in which Mexico has traditionally been active, such as textiles, footwear and leather, and carbon, petroleum derivatives and nuclear energy. It is of course true that many of the PRCs were established to serve these very industries. The sectoral patterns of co-operation with HEIs are somewhat different. Figure 2.10 shows sectors in which the proportion of firms co-operating with HEIs is more than twice the average. They include high- and medium-high-technology sectors associated with global value chains, such as office equipment, accounting and computing machinery and motor vehicles; other high- and medium-high-technology sectors (*e.g.* pharmaceuticals); and medium-low-technology sectors based on non-renewable natural resources (sector 4 in the typology in Table 2.6). Some expected outcomes from industry-academic linkages are described in Box 2.5.

Figure 2.9. Proportion of firms co-operating with PRCs on innovation in Mexico, 2004-05



Source: ESIDET results, CONACYT.

Figure 2.10. Proportion of firms co-operating with HEIs on innovation in Mexico, 2004-05



Source: ESIDET results, CONACYT.

Box 2.5. Rationales and outcomes of industry-academic co-operation

An analysis of 11 collaborative projects between large Mexican firms and academic institutions illustrates characteristics of industry-academic linkages in Mexico. The actors involved are located in the states of Nuevo León and Coahuila, both of which are characterised by dynamic industrial development. These states also concentrate important public and private HEIs and PRCs. The cases relate to three fields with an interest in knowledge production or specific practical aspects: materials, polymers, and metallurgy. In six of the eleven cases analysed, the firm took the initiative in seeking out public academic centres, whether to collaborate on the formation of highly specialised human resources at the Master's level or to carry out research activities oriented towards new products and/or processes or to improve existing products and/or processes. In several cases, these objectives were achieved in a collective manner.

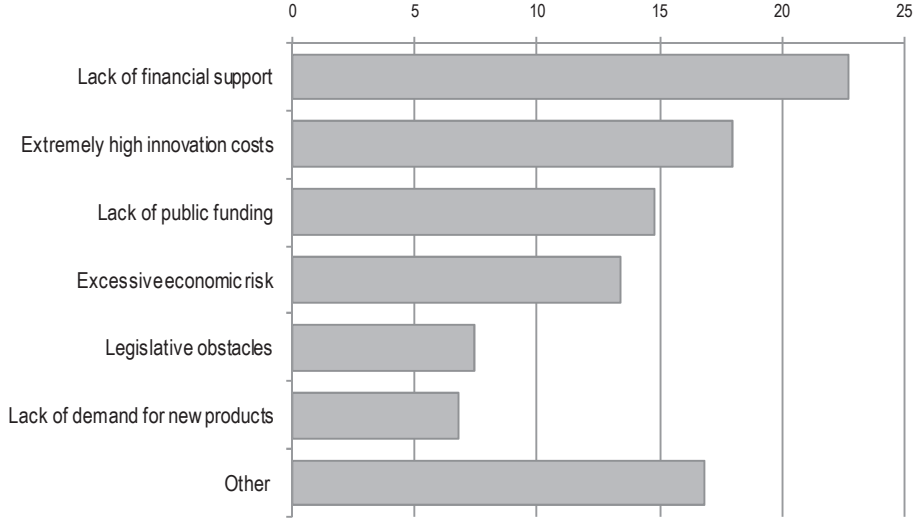
From the perspective of academia, more information was shared on procedures than on scientific and technical information. For the firms, technical and procedural and scientific information were equally important. One aspect that stands out in the analysis is the weight of codified and tacit knowledge in the projects. Codified knowledge was shared through technical laboratory reports of progress in the projects. Tacit knowledge was the most common form of exchange between academia and business enterprises. Here, ideas, skills, experiences, that is, individuals' abilities which have been acquired through formal and informal training, are generally exchanged in face-to-face relationships between network participants. Channels for exchange of knowledge emphasised by both actors include visits from academic investigators or firms' technicians, academic training courses, student residencies, and meetings of professional organisations.

For academia, the most important results of collaboration were related to the development of human resources, many of whom were taken on as employees once their studies were completed. Also important were improvements of processes and the solution of problems, the principal impacts of which for the firm were increased competitiveness through lower costs and higher quality. For the firms, only the training of human resources was considered important. These findings suggest that even though collaboration with academia was important for the firms, their perception was that it generated few results in terms of incremental and radical innovations and the solution of technical problems.

Source: Casas (2005), "Exchange and Knowledge Flows between Large Firms and Research Institutions", *Innovation: Management, Policy and Practice*, Special Issue on Innovation and Economic Development, Vol. 7, Nos. 2-3.

Figure 2.11. Risk factors for innovation projects in Mexico, 2004-05

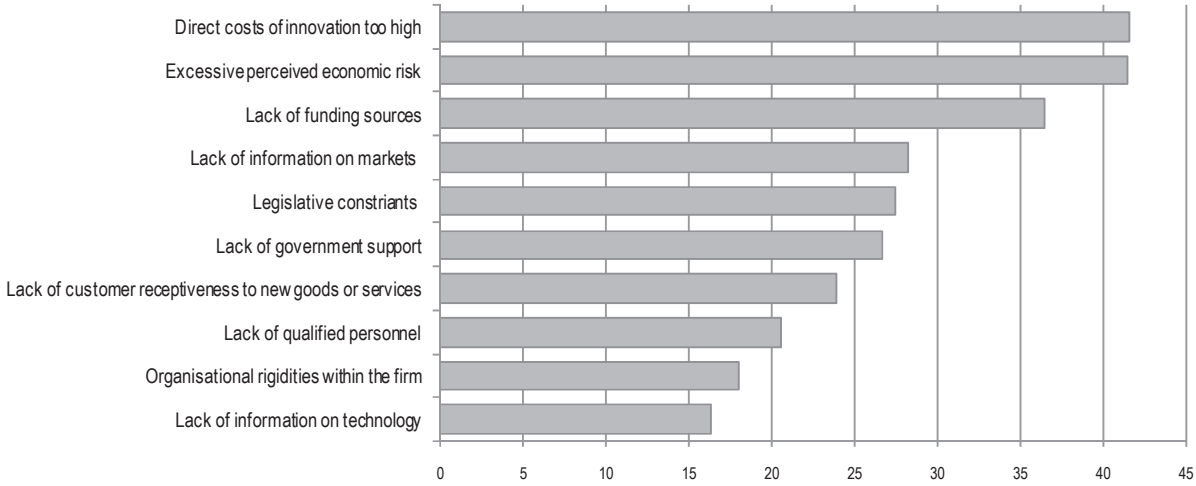
As identified by innovative firms, percentage



Source: ESIDET results, CONACYT.

Figure 2.12. Innovation constraints of medium and high importance in Mexico, 2004-05

Percentage

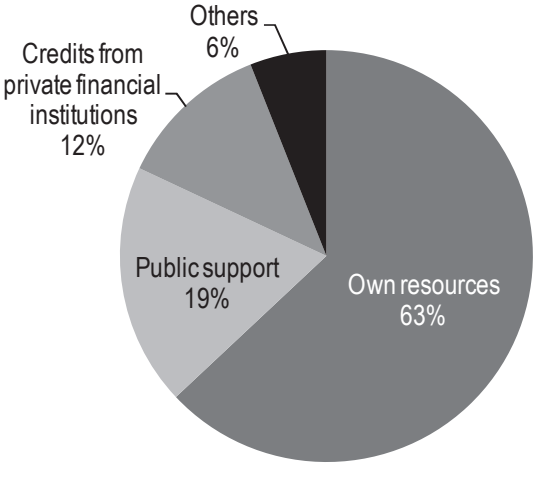


Source: ESIDET results, CONACYT.

2.1.5. Barriers to innovation

The firms that innovated, as identified in the 2006 ESIDET survey, also report several risk factors associated with their projects. As Figure 2.11 shows, these are dominated by concerns over financing; market concerns are lower on the list. This pattern was often reported when firms were asked about constraints to innovation. Figure 2.12 shows that various cost factors were the most often mentioned barriers and lack of information on technology the least mentioned. The pattern varies a little by sector. For example, firms from non-metallic minerals and financial intermediation report relatively fewer constraints in all categories, while firms from the radio, TV and communications equipment sector report constraints well above the average for all sectors. Firms from motor vehicles and pharmaceuticals face far fewer problems in securing funding sources. On the whole, these results confirm firms' difficulties for financing innovation, as highlighted in Chapter 1. Accordingly, the majority of firms' innovation financing had to be found from own resources (63%), with firms reporting just 12% coming from private financial institutions, a proportion even lower than the 19% provided by the public sector (Figure 2.13).

Figure 2.13. Sources of finance for innovation activities among innovative firms in Mexico, 2004-05



Source: ESIDET results, CONACYT.

2.2. Public research centres

Public research centres (PRCs) are an important part of the Mexican research system; they performed around 23% of Mexican gross domestic expenditure on R&D (GERD) in 2005. They are parastatal entities which have been granted a certain level of autonomy by presidential decree as stipulated by the Science and Technology Law (STL) and other regulations. As such, they are autonomous in terms of budget management, as well as the management of technical, operative and administrative aspects. There are two sets of PRCs: those supervised by CONACYT, the national council for science and technology, which account for about one-third of PRC research activity, and those supervised by other ministries which account for the remainder.

Table 2.7. Public research centres supervised by CONACYT

	Natural sciences and mathematics
CIAD	Centro de Investigación en Alimentación y Desarrollo, A.C.
CIBNOR	Centro de Investigaciones Biológicas del Noroeste, S.C.
CICESE	Centro de Investigación Científica y de Educación Superior de Ensenada, B.C.
CICY	Centro de Investigación Científica de Yucatán, A.C.
CIMAT	Centro de Investigación en Matemáticas, A.C.
CIMAV	Centro de Investigación en Materiales Avanzados, S.C.
CIO	Centro de Investigaciones en Óptica, A.C.
INECOL	Instituto de Ecología, A.C.
INAOE	Instituto Nacional de Astrofísica, Óptica y Electrónica
IPICYT	Instituto Potosino de Investigación Científica y Tecnológica, A.C.
	Social sciences and humanities
CIDE	Centro de Investigación y Docencia Económicas, A.C.
CIESAS	Centro de Investigaciones y Estudios Superiores en Antropología Social
CENTRO GEO	Centro de en Geografía y Geomática "Ing. Jorge L. Tamayo", A.C.
COLEF	El Colegio de la Frontera Norte, A.C.
COLMICH	El Colegio de Michoacán, A.C.
COLSAN	El Colegio de San Luis, A.C.
ECOSUR	El Colegio de Frontera Sur
MORA	Instituto de Investigaciones Dr. José Maria Luis Mora
	Technology development
CIATEC, A.C.	Centro de Innovación Aplicada en Tecnologías Competitivas
CIATEJ	Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco, A.C.
CIATEQ, A.C.	Centro de Tecnología Avanzada
CIDESI	Centro de Ingeniería y Desarrollo Industrial
CIDETEQ	Centro de Investigación y Desarrollo Tecnológico en Electroquímica, S.C.
CIQA	Centro de Investigación en Química Aplicada
COMIMSA	Corporación Mexicana de Investigación en Materiales, S.A. de C.V.
FIDERH	Fondo para el Desarrollo de Recursos Humanos
INFOTEC	Fondo de Información y Documentación para la Industria

Source: CONACYT.

The CONACYT PRCs are a set of 27 research institutes grouped into three main scientific and technological areas: ten research centres cover mathematics and the natural sciences; eight conduct research in social sciences and humanities; and eight specialise in innovation and technology development (Table 2.7). A further centre is dedicated to providing financial support for postgraduate studies. According to their mission statement, their main goals are as follows:

- diffuse science and technology methods and findings to society at large;
- promote local technology development and foreign technology adaptation to local conditions;
- innovate in the creation, assimilation, application and development of scientific and technological knowledge;
- build strong linkages between S&T activities and the social and productive sectors in order to solve social and productive problems;
- facilitate the private sector's contribution to the development of science and technology by creating appropriate mechanism and incentives;
- strengthen students' scientific and technological skills by integrating them into scientific and technological research activities;
- increase institutional research capacities in science, technology and the humanities;
- promote a scientific, technological and humanistic culture as a key part of Mexican society.

The PRCs are engaged not only in research, but also in training and extension activities, each of which is outlined further below. Given their emphasis on diffusion and adaptation and on local development, 75% of the main activities of the CONACYT PRCs were conducted outside of the Mexico City area in 2006. Figure 2.14 shows the distribution of CONACYT PRCs across Mexico. The rationale is to ensure a significant distribution of knowledge in different regions of the country – through scientific and technological work – and to maximise the impacts of projects and the multiplier effects of spending.

Figure 2.14. Locations of CONACYT PRCs

Source: CONACYT.

In addition to the CONACYT-supervised PRCs, several ministries have their own research centres, most of which were founded during a period of public sector expansion (1940-80). The initial goal assigned by the government to these institutes was to provide innovation and technological developments to other public organisations and companies related to energy, agriculture, health, natural resources and the environment. Table 2.8 lists the most important institutes.

Table 2.8. Some of the main PRCs administered by ministries

Ministry of Energy (SENER)	• The Electrical Research Institute (IIE), • Mexican Institute of Petroleum (IMP) • Research Institute for Nuclear Research (ININ)
Ministry of Agriculture, Livestock, Rural Development, Fishing and Food (SAGARPA)	• Institute for Forestry and Farming Research (INIFAP) • Mexican Institute for Water Technology • College of Postgraduates
Ministry of Health (SSA)	• National Institute for Public Health (INSP) • National Institute of Cardiology (INC) • The Paediatrics Institute (IP) • Salvador Zubiran National Nutrition Institute (INNSZ) • 16 other centres and research institutes in the health sector

2.2.1. Research activities of PRCs

The PRCs performed around 23% of Mexico's total R&D activities during 2005. This translates into around 45% of the research effort of the public research sector, the rest being taken up by higher education institutions. International comparisons of government expenditures on R&D (GOVERD) – which represent the greatest share of PRCs' R&D activities – show Mexican spending to be relatively low at 0.10% of GDP (Figure 2.15). Moreover, as Table 2.9 shows, the level of GOVERD declined sharply at the start of the 2000s although it has since stabilised. Such low proportions of GERD spent in the government sector are normally associated with a prominent role for higher education R&D (as in Sweden and the United Kingdom) and/or an absence of defence R&D (as in Belgium and Ireland). While both of these conditions apply to some extent in Mexico, the low levels of GOVERD can be better ascribed to the generally low levels of R&D spending by the Mexican government.

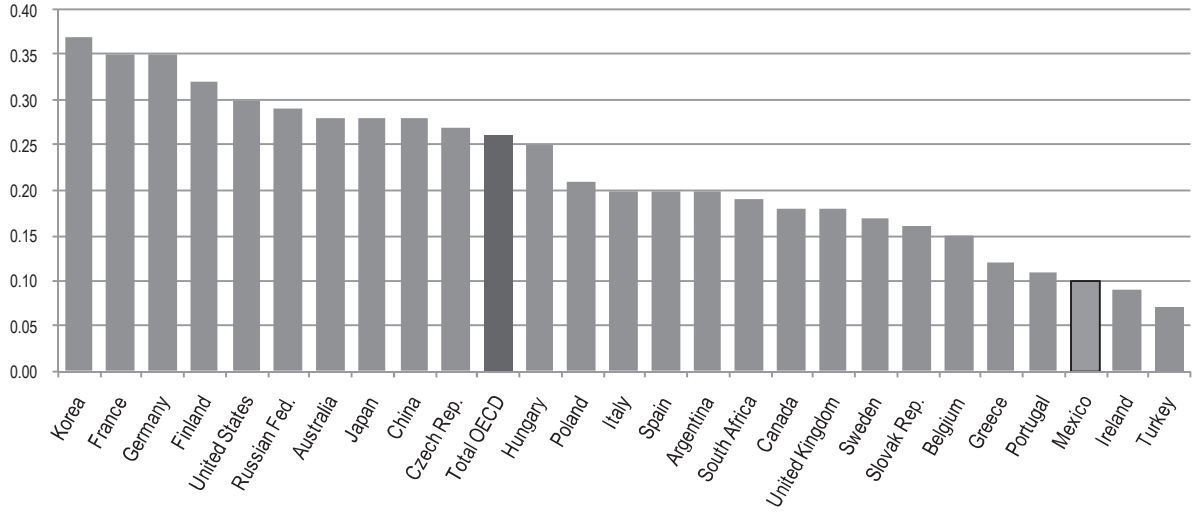
Table 2.9. GOVERD indicators for Mexico, 1999-2005

	1999	2001	2003	2004	2005
GOVERD (% of GDP)	0.18	0.14	0.10	0.10	0.10
GOVERD (USD millions, current PPP)	1 577	1 418	1 148	1 233	1 308
Government researchers (FTE)	7 540[1]	n.a.	6 397	6 754[1]	6 589[1]

1. National estimate.

Source: OECD Main Science and Technology Indicators.

Figure 2.15. GOVERD as percentage of GDP in selected countries, 2006[1]

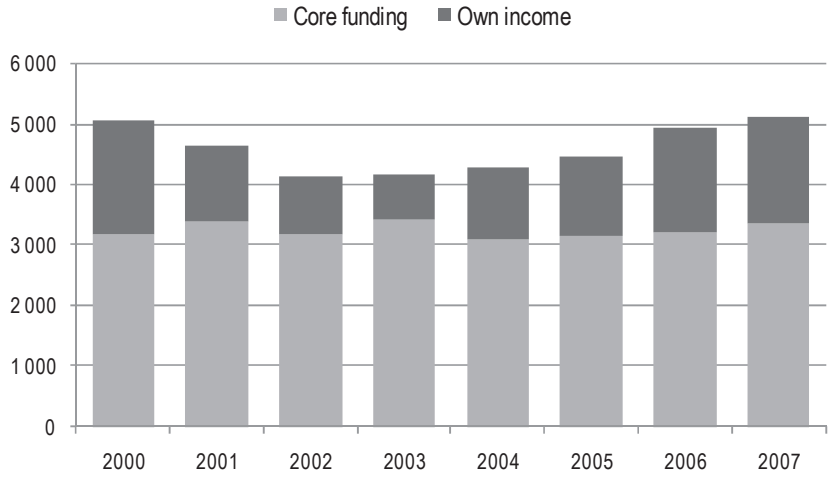


1. 2005 data for Mexico and South Africa.

Source: OECD Main Science and Technology Indicators.

Figure 2.16. Budget of CONACYT PRCs

MXN millions at 2007 prices



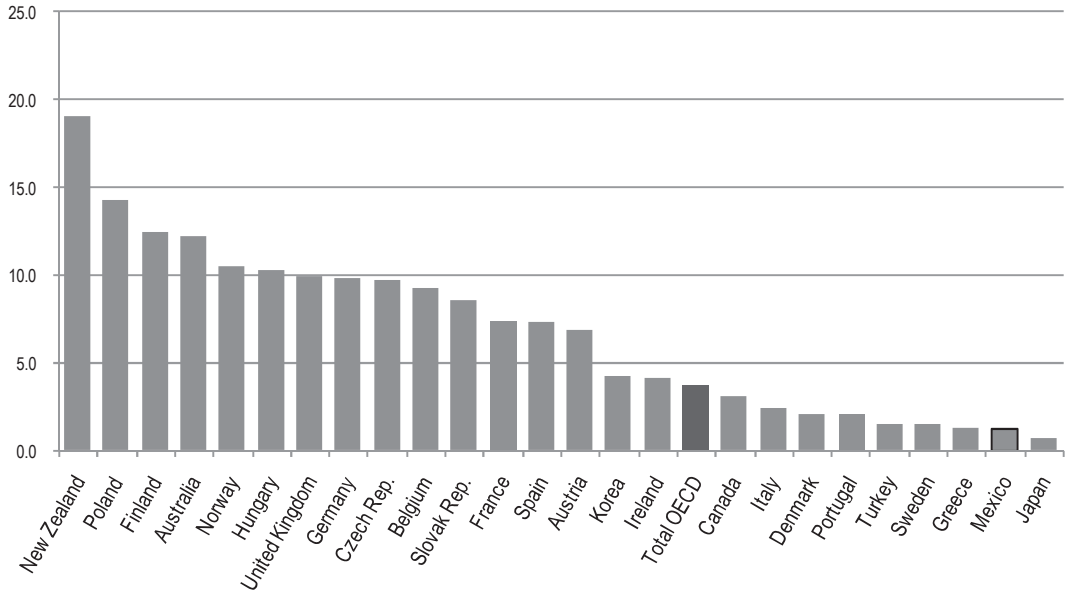
Source: CONACYT.

In 2007, the total budget of the CONACYT PRCs was estimated to be MXN 5.1 billion (Figure 2.16). Around two-thirds of the budget comes from CONACYT core funding, although the level varies considerably among the PRCs. The centres principally generating their own income from selling products and services to the public and private sectors were COMIMSA and INFOTEC. Each acquired around half of its funding in this way, followed closely by CIATEQ with 40%. In fact, these three centres accounted for almost 40% of the total income generated by the 27 CONACYT PRCs, with the majority of PRCs obtaining less than 10% of their funding in this way. These figures reflect changes

in funding allocation arrangements – away from institutional funding and towards more competitive funding – which have led many CONACYT PRCs to adopt a more market-oriented approach in their strategic decisions concerning their research activities in order to increase their co-operation with the private sector and other institutions to which they provide technological services. They also reflect the premium given to projects involving co-operation between public research institutions and enterprises in submissions for financial support to CONACYT and other funding bodies such as the Ministry of Economy. A particular example is the increased share of projects involving co-operation with PRCs among those supported by the Economia-CONACYT S&T Fund for economic development. They reflect the fact that CONACYT PRCs are not a homogeneous set, as some have as their core mission the promotion of scientific activities in various disciplines or socio-economic areas, while others are more specifically oriented towards technology development and diffusion, generally along sectoral lines. These differences are reflected in their financing structure, with the latter able to count more on self-financing through the provision of technological services.

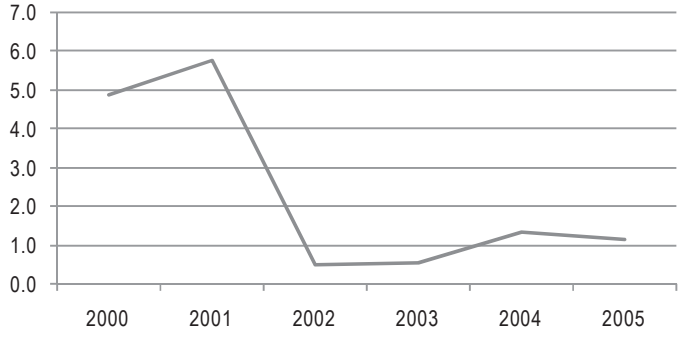
Across all of Mexican GOVERD – including research performed in a wider array of institutes than those supervised by CONACYT – the share of income accruing from the business sector, a mere 1.2% in 2005, is low by international standards (Figure 2.17) and appears to have been on a downward trajectory in recent years (Figure 2.18). This suggests that the sector as a whole largely fails to function as a provider of applied research for Mexico's business sector.

Figure 2.17. Percentage of GOVERD financed by industry in selected OECD countries, 2005



Source: OECD Main Science and Technology Indicators.

Figure 2.18. Percentage of Mexican GOVERD financed by industry, 2000-05



Source: OECD Main Science and Technology Indicators.

As Table 2.10 shows, the number of researchers (full-time equivalent – FTE) working in the sector has declined less sharply than the overall budget. The CONACYT PRCs employed 4 664 R&D personnel (FTE) in 2006, of which 2 006 were researchers and 2 658 were technicians and assistants (Table 2.10). The centres' researcher population represents less than one-third of all government researchers and a little less than 10% of the total number of public-sector researchers in Mexico. Of the 2 006 researchers, 1 436 hold doctorates, 356 hold a master's degree, and 212 are educated to the bachelor level. In other words, over 70% of the CONACYT researchers have a PhD, a proportion that compares very favourably internationally for public research institutes but suggests a rather academic orientation. This is perhaps confirmed by the fact that almost 60% of CONACYT researchers are registered in the SNI (Figure 2.19), a proportion in line with the overall picture across the Mexican public sector research base.

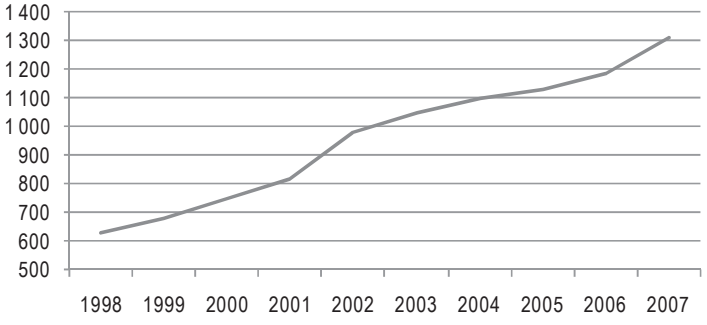
Table 2.10. Employees at CONACYT research centres, 2006

Full-time equivalent

Research staff			Non-research staff			Total
Researchers	Technicians and assistants	Sub-total	Administration and support	Other	Sub-total	
2 006	2 658	4 664	1 751	444	2 195	**6 859**

Source: CONACYT.

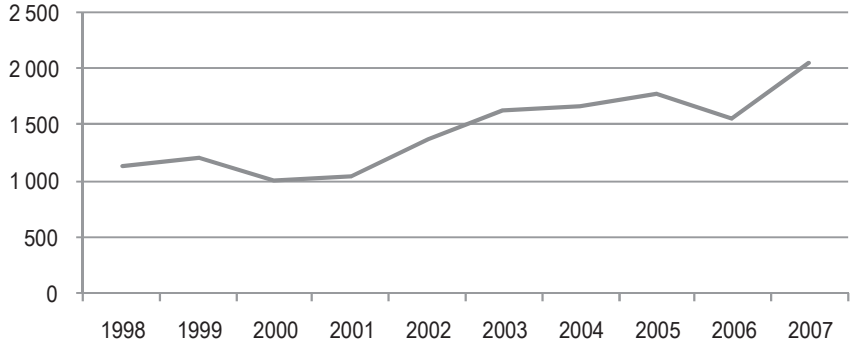
Figure 2.19. Number of SNI members in CONACYT PRCs, 1998-2007



Source: CONACYT.

A traditional indicator of research productivity is the number of journal articles generated by researchers. More than 2 000 journal articles were authored by CONACYT PRC researchers in 2007, three-quarters of which were published in international journals. As Figure 2.20 shows, the number of journal articles produced has climbed steadily, roughly doubling over the past decade. Similar patterns can be seen in other countries and reflect in part the increasing use of publication data in evaluations of researcher and institute performance. In the case of the CONACYT PRCs, the financial and reputational rewards associated with SNI membership have strongly helped increase publication rates.

Figure 2.20. Published journal articles from CONACYT PRC researchers, 1998-2007

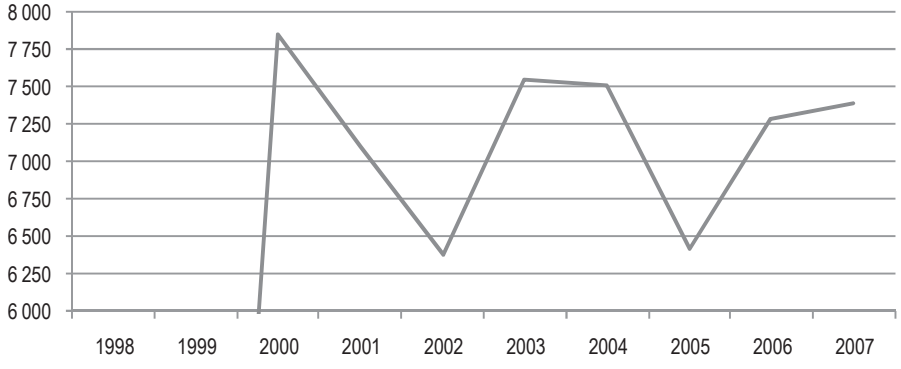


Source: CONACYT.

2.2.2. Training, extension and commercialisation activities

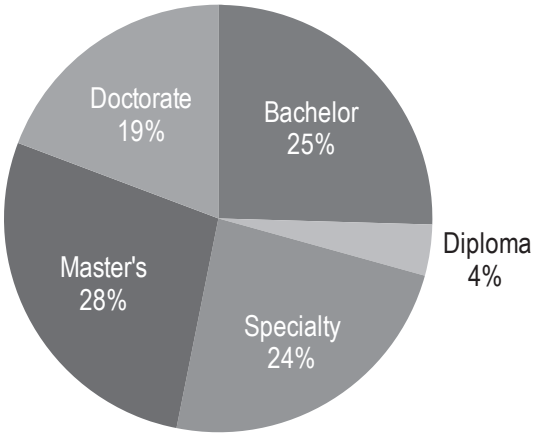
Besides conducting research, CONACYT PRCs also offer teaching programmes, with an average of around 7 000 students enrolled in any one year over the past decade (Figure 2.21). A large proportion of these are registered at the postgraduate level (Figure 2.22). In 2006, 80 programmes at the master's and PhD levels were offered, the vast majority outside the Mexico City area. These resulted in around 1 000 postgraduate theses in 2006.

Figure 2.21. Number of students enrolled at CONACYT PRCs, 1998-2007



Source: CONACYT.

Figure 2.22. Enrolled students at the CONACYT PRCs, 2006



Source: CONACYT.

Despite the stated sectoral mission of PRCs and their regional distribution, too few efforts and resources are devoted to technology diffusion and the provision of technological services to the vast majority of firms that do not have access to technology information and financing. This is a common challenge for PRCs across the world. In many smaller firms, especially in the low- to medium-technology sectors that constitute the bulk of the Mexican economy, innovation tends to be a temporary activity because of limited resources; in larger firms innovation is frequently a continuous activity. Their innovation also tends to be incremental rather than radical and therefore does not demand the sophisticated research produced in public labs and HEIs. But even where enterprises, and more specifically SMEs, need the services of public research, communication barriers frequently affect or prevent collaboration. These may arise from lack of motivation at the PRCs, differences in competence levels between partners, or the fact that the cost in terms of time and money for getting acquainted with a large number of small partners and their problems is comparatively higher than with a larger partner.

For the commercialisation of research findings, legal modifications introduced in 2006 empower PRCs' governing bodies to establish the conditions of use and to appropriate the results generated by their researchers. They can set confidentiality conditions when profitable knowledge is generated in the framework of joint PRC-industry projects or in technology-based firms created by PRCs. It is expected that these reforms will improve PRCs' performance in terms of industrial property rights granted. Until now, only the Mexican Institute of Petroleum (IMP) and the Electrical Research Institute (IIE) have been proactive in applying for and obtaining patents. In fact, IMP stands out as one of the most important patentees in Mexico, with 610 national and 60 international patents and 90 trademarks. By contrast, the CONACYT PRCs submitted just 27 patent applications among them in 2006.

In addition to these changes in intellectual property regimes, the degree of autonomy of CONACYT PRCs – concerning the orientation and organisation of their activities – has increased in recent years. In accordance with the Law of S&T and its 2006 reforms, they can now co-operate with public and private firms, realise joint projects with them, form technology-based firms and obtain funds for scientific research and technological development by means of self-generated resources and donations. All decisions relating to budget, technical, operative and administrative matters are the responsibility of their

governing bodies. Similar changes have occurred in many other non-CONACYT PRCs (Box 2.6).

Box 2.6. Reforms at INIFAP

The *Instituto de Investigaciones Forestales, Agrícolas y Pecuarias* (INIFAP) was established in 1985 through the merger of three formerly independent research institutes, each of which had been founded some 25 years earlier. It employs more than 1 000 researchers working on the improvement and generation of new crops and plant varieties and on improving livestock. It consists of 6 national disciplinary research centres, 8 regional centres and 81 experimental field stations. Nowadays, INIFAP operates under the Secretary for Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA). Its goals are to contribute to sustainable rural development by improving competitiveness and preserving the Mexican natural resources base and to do so by bringing together efforts and funding from public and private organisations linked to the rural sector. Some important features of the activities carried out by the Institute over the period 2004-07 include:

- Modification of INIFAP's legal status which increased its technical, financial and operational autonomy to perform its activities. These can therefore be better co-ordinated with national development goals as stated in the 2007-12 Plan Nacional de Desarrollo (PND). Autonomous evaluations carried out by independent third parties should assess INIFAP's performance according to the institute's strategic plan, currently for the period 2006-11. Research and other activities are already aligned or in process of alignment with the strategic plan.
- The first external evaluation (2003) documented the pertinence and quality of INIFAP's research activities for the country as a whole. Yet, important gaps remain at the regional level. Some improvements would have been obtained by adopting funding mechanisms based on competitive grants. Recommendations also led INIFAP to develop its first formal policy for technological innovation and the application, since 2002, of the first guidelines for the provision of incentives to researchers based on productivity. In addition, there are new guidelines for the conduct of research and for the administrative operation of the institute.
- Regionalisation efforts are also evident. Besides the movement of 12% of its personnel from the central to regional units, the share of mid-rank managerial positions in the latter grew from 51% in 2004 to 63% in 2005. Regional consolidation of infrastructure and research activities also brought down the number of experimental fields from 82 in 2004 to the current 36 fields and 3 business sites.
- Aligning research to the renewed goals of the institute has been possible by placing current and prospective demands of regional "end users" at the forefront of the "innovation chain". Up until 2007, 15 workshops had been carried out according to a three-step process that looked at: *i)* available products resulting from previous research; *ii)* current and future research projects which had translated into specific projects as of 2006; and *iii)* the conformity of regional innovation networks with some strategic plans defining specific deliverables. A catalogue of 32 such networks has already been prepared.
- Definition in 2005 of the "Grand Vision" project to respond to future needs of the economy and society at large. These include: water, genetic resources, biotechnology, climate change and alternative energy sources. Funding for research on these topics comes from INIFAP's own funds.
- Regarding IPRs, actions include the registration of the trademark "INIFAP" to support commercialisation of products generated by the institute.
- INIFAP signed 96 agreements with national and 14 with foreign organisations, including universities, firms and governments in relation to S&T in the agriculture sector.

Despite these promising reforms, some significant challenges remain. For example, renewal of the research body is increasingly urgent. The annual rate of researcher turnover since the 1980s has been less than 1%. Moreover, the average age of researcher staff is 50 years, while the mean for the period of service is 25 years. By 2020, a significant share of the personnel will be retiring owing to age or number of years in service. Yet, attempts to open new positions have so far been less successful than hoped.

Although not yet sufficiently developed to have a significant impact on the intensity of science-industry relationships, these changes are a positive trend that could gather momentum if remaining constraints to PRCs' autonomy are reduced. These concern, in particular, regulatory frameworks that submit equipment investment and personnel management to centralised control, which tends to adversely affect contractual arrangements with private enterprises and the management of intellectual property rights (IPR) regimes. This is discussed further in Chapter 3.

2.3. Higher education institutes

Mexico's higher education system consists of universities, technological institutes, state educational institutions, and normal schools (for the training of teachers). The system's foundations were put in place and consolidated during the era of import substitution. The most important public and private HEIs, such as the National University of Mexico (UNAM), the National Polytechnic Institute (IPN), the Technological Institute of Higher Studies of Monterrey (ITESM), the Metropolitan Autonomous University (UAM), as well as various state universities were established between 1930 and 1980. The number of HEIs grew from 26 to 84 from 1950 to 1980. However, it was during the latter part of the 20th century that Mexico experienced an unprecedented explosion in higher education in terms of the number and variety of institutions, students, faculty and research. By 2005, Mexico had 2 807 HEIs, of which 40% are public and 60% private, located all over the country (Table 2.11). While fewer in number, public HEIs attracted nearly 68% of undergraduate and 58% of postgraduate students in 2006. The proportion of students attending private HEIs is on the rise, however, increasing from 18.5% of the undergraduate total in 1990 to 32% in 2006.

Table 2.11. Typology of Mexican higher education institutions

Public		Private	
Universities	355	Universities	550
Institutes	362	Institutes	445
Centres	118	Centres	424
Normal schools	247	Schools	223
College	21	College	60
Total public	1 103	Total private	1 702
Total: 2 807			

Source: ANUIES.

It is important to understand the contributions that HEIs make to innovation. All too often, policy attention is overly focused upon the production of codified knowledge through research and its subsequent diffusion and exploitation through various "third stream" activities and industry-academic linkages. However, the innovation studies literature makes clear that the most significant contribution of HEIs to innovation often lies in the creation of capabilities through teaching and research training activities. Accordingly, this section begins with consideration of the role of Mexican HEIs in providing tertiary education before turning to their research activities. It then reviews governance arrangements, with particular reference to the autonomous status of HEIs and the quality assurance mechanisms in place.

2.3.1. Tertiary education

Higher education is conceived as one of the principal ways by which Mexico is to be modernised. It is viewed as a national enterprise to create human capital, greater social integration and greater participation by youth in education in order to stimulate and ensure long-term economic growth. Accordingly, over the last half century or so, participation rates in higher education have increased from 1% to one-quarter of the 19-23 age group (Table 2.12). In 2006, approximately 380 000 students gained a tertiary education qualification: 87.3% a first degree, 3.1% a specialty, 9.1% a master's and 0.5% a PhD. In Mexico, 61% of those who enter undergraduate degree programmes go on to successfully complete their studies. This is below the OECD average of 69% (OECD, 2008e), partly on account of poorer students' difficulties for supporting themselves financially during their studies.

Table 2.12. Flows of graduates by degree level, 1997-2007

Year	Undergraduates	Postgraduates		
		Specialty	Master	Doctorate
1997	183 417	5 466	14 509	893
1998	184 258	7 907	15 958	714
1999	200 419	9 155	18 877	911
2000	209 795	9 266	19 373	1 035
2001	227 095	10 314	23 632	1 085
2002	249 085	10 307	26 253	1 446
2003	268 155	10 099	26 840	1 390
2004	287 676	10 515	29 395	1 657
2005	309 157	11 302	32 044	1 783
2006	331 807	11 718	34 393	1 910
2007	N/A	12 890	37 832	2 101

Note: Data for 2006 and 2007 are estimates.

Source: ANUIES.

Institutions derive their revenues from four major sources: federal subsidies, state subsidies, student tuition fees and external sources of income (*e.g.* research contracts, provision of services, industry training). No systematic data are available regarding the relative importance of each of these sources. Public subsidies are not allocated to tertiary education institutions on the basis of a widely agreed funding framework covering the entire system. Federal public universities are publicly funded by the federal government only. Autonomous state public universities receive mixed public funding from both the federal and the state governments; their relative contributions are the subject of an agreement between them and the individual institution.

The federal subsidy has three main components: *i)* an ordinary subsidy; *ii)* an extraordinary subsidy, which can be classified as targeted funding; and *iii)* a subsidy linked to the annual expansion and diversification of the educational supply base. In turn, the state subsidy has two components: an ordinary subsidy and a subsidy related to the expansion of the educational supply base. By far the most significant of these various funding components is the ordinary subsidy, which can be considered a "block grant" that covers current expenditure related to the regular activities of institutions. It is formally

based on the size of an institution's academic body but more often than not reflects historical trends or the lobbying power of the institution. About 90% of the total public subsidy for tertiary institutions is concentrated in the ordinary subsidy which also includes the basic funding for research. No quality-related indicator is used in determining the ordinary subsidy, which means there are few levers to provide incentives for institutions to strengthen teaching (and research) quality (OECD, 2006a).

During 2000-05, Mexico saw modest increases of expenditure per student at the tertiary level. This coincided with a 20% increase in enrolments, although tertiary education enrolment rates remain among the lowest in the OECD area (31% in 2006 compared to the OECD average of 56%). Spending per student is, at USD 6 402 in 2005, slightly more than half of spending per student at the OECD average level (USD 11 512). Although the figures are low in absolute terms, they represent 1.3% of GDP, a figure higher than in many OECD countries and comparable to the OECD average of 1.4%. Public spending on tertiary education in Mexico rose by 19% between 2000 and 2005 (below the OECD average of 26%). However, private spending increased by 106%, with the result that the private share of funding in tertiary education in Mexico increased from 21% to 31% (OECD, 2008e).

Mexico's financing of tertiary education faces important challenges. A first matter for concern is whether the current heavy reliance on public money is sustainable. Even though the principle of cost-sharing between the government and individual beneficiaries of tertiary education has been introduced, the extent to which (more affluent) students contribute to the costs of their tertiary education seems fairly limited. At the same time, Mexico has the largest gap in the OECD area between per-student expenditure for tertiary education and for lower levels of education. There is therefore growing pressure to shift some resources from tertiary education to school education.

2.3.2. Research activities of HEIs

Almost one-half of research activity in the HEI sector is concentrated in just four institutions, namely the National Autonomous University of Mexico, the Centre for Research and Advanced Studies (CINVESTAV), the Metropolitan Autonomous University and the National Polytechnic Institute. Outside of Mexico City, the University of Guadalajara (UdG) and the Autonomous University of Puebla (BUAP) are two of the largest state universities conducting research. The most prominent private HEI in this respect is the Monterrey Technological Institute for Higher Education (ITESM). Each of these institutions is briefly described in Box 2.7 and the geographical distribution of HEIs offering PhD programmes is shown in Figure 2.23.

Box 2.7. Major research HEIs in Mexico

UNAM: Formally established in 1910, UNAM is the oldest and largest HEI in Mexico. UNAM's research centres and research institutes are distributed across the country, though most are concentrated in Mexico City. In 2007 these centres and institutes employed 2 337 researchers and 1 693 technicians. Scientific production consisted of 3 084 articles, 1 283 reports in internal yearbooks, 397 books and 948 book chapters. UNAM is the most important centre for training human resources at the postgraduate level. In the 2006-07 academic year, almost 21 000 were enrolled in different programmes and disciplines, with 17% of these accounted for by doctoral programmes.

IPN: Founded in 1936, IPN is strongly oriented to technological research, although excellence in some scientific research areas is also well recognised. Research at IPN is mostly concentrated in its 19 research centres located across the country. In 2007, 1 579 researchers conducted 436 projects in all research centres. Between 1997 and 2006, its researchers published 5 536 articles in international journals. IPN offers 90 postgraduate programmes. In the 2006-07 academic year, a total of 5 199 students were enrolled in postgraduate programmes, with a little over 20% of these accounted for by PhD programmes.

UAM: Founded in 1974, UAM is the third largest HEI in Mexico, with practically all of its academic activities carried out in four campuses located in Mexico City. In 2006, 2 193 full-time researchers worked in around 140 research areas. During 1997-2006, UAM researchers published 5 708 articles in international journals. In the 2006-07 academic year, approximately 45 000 students were enrolled at undergraduate level, with a further 1 857 students enrolled in 21 postgraduate programmes.

CINVESTAV: Founded in 1961, CINVESTAV is organised into 28 academic departments located in 9 centres, two of which are in Mexico City. In 2005, its 549 researchers produced 904 scientific articles in international journals. CINVESTAV is the leading national academic institution in patenting and in transferring technologies to the private sector. It holds 105 national and 52 international patents, and 30 technologies developed by CINVESTAV researchers have been transferred. CINVESTAV offers several postgraduate programmes at the Master and PhD level, with around 3 500 students enrolled in the 2005-06 academic year.

BUAP: Formally founded in 1937, BUAP is one of the most important universities in terms of research outside Mexico City. In 2005, it had 534 researchers. During 1997-2006 a total of 2 680 scientific articles were published. The BUAP offers 58 postgraduate programmes, with around 15% of the cohort enrolled at PhD level.

UdG: Founded in 1925, UdG is the country's fourth largest HEI, located in the Guadalajara Valley. In 2006, nearly 3 000 academics (not all of whom are active in research, and around 500 registered in the SNI) worked at UdG. Its researchers published around 2 000 scientific papers in international journals over the ten years to 2006. Over the last decade, UdG has developed important linkages with the electronics sector, a major employer in the region. UdG offers a total of 147 postgraduate programmes, with 3 900 enrolled in 2006-07, around 8% of whom registered in PhD programmes.

ITESM: Founded in 1943 by a prominent entrepreneur in Monterrey, ITESM is the leading private HEI in Mexico and has 33 campuses across 21 states. In 2007, 2 787 full-time personnel were devoted to teaching and research activities, 235 of whom were SNI members. Around 11 000 students were registered in 53 Master and 9 PhD programmes in 2007.

Figure 2.23. Higher education institutions hosting doctoral programmes

Number of HEIs by state

Source: CONACYT.

In 2005, HEIs accounted for almost 29% of Mexico's total research effort and were the second largest employers of researchers (around 16 700 FTE). Higher education expenditures on R&D (HERD) increased by around 75% between 1999 and 2005 (from USD 923 million to USD 1 623 million in current PPP). As a percentage of GDP, however, HERD increased only marginally during that time from 0.10% to 0.13% (Table 2.13). This placed Mexican HERD among the lowest in the OECD, comparable to that in countries where non-university public research organisations play a more prominent role in the research system (Figure 2.24).

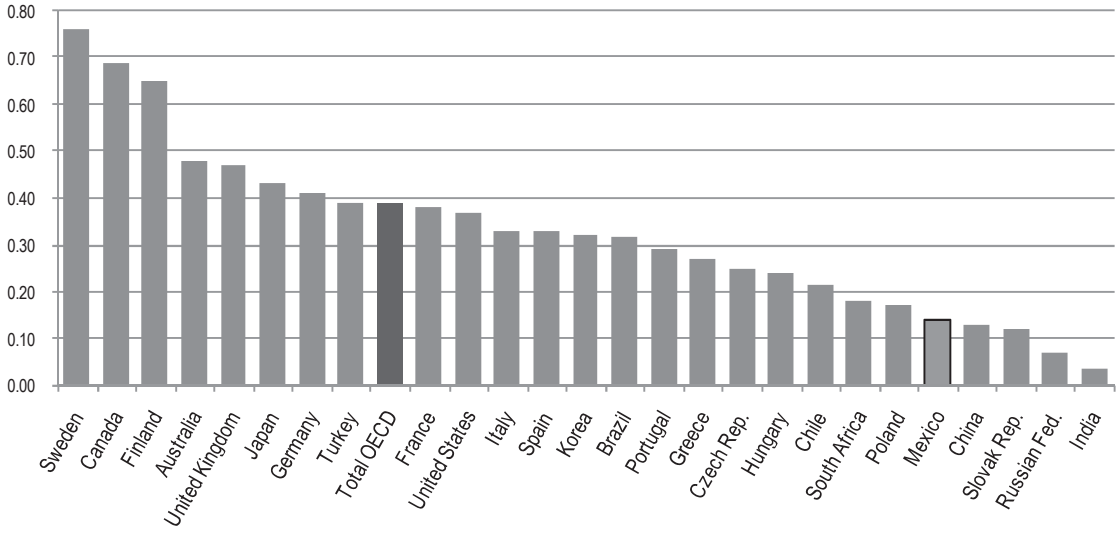
Table 2.13. HERD indicators for Mexico, 1999-2005

	1999	2001	2003	2004	2005
HERD (% of GDP)	0.10	0.11	0.15	0.12	0.13
HERD (million current PPP USD)	923	1 104	1 664	1 442	1 623
HE researchers (FTE)	10 648[1]	n.a.	17 135	16 043[1]	16 691[1]

1. National estimate.

Source: OECD Main Science and Technology Indicators.

Figure 2.24. HERD as a percentage of GDP in selected countries, 2006[1]

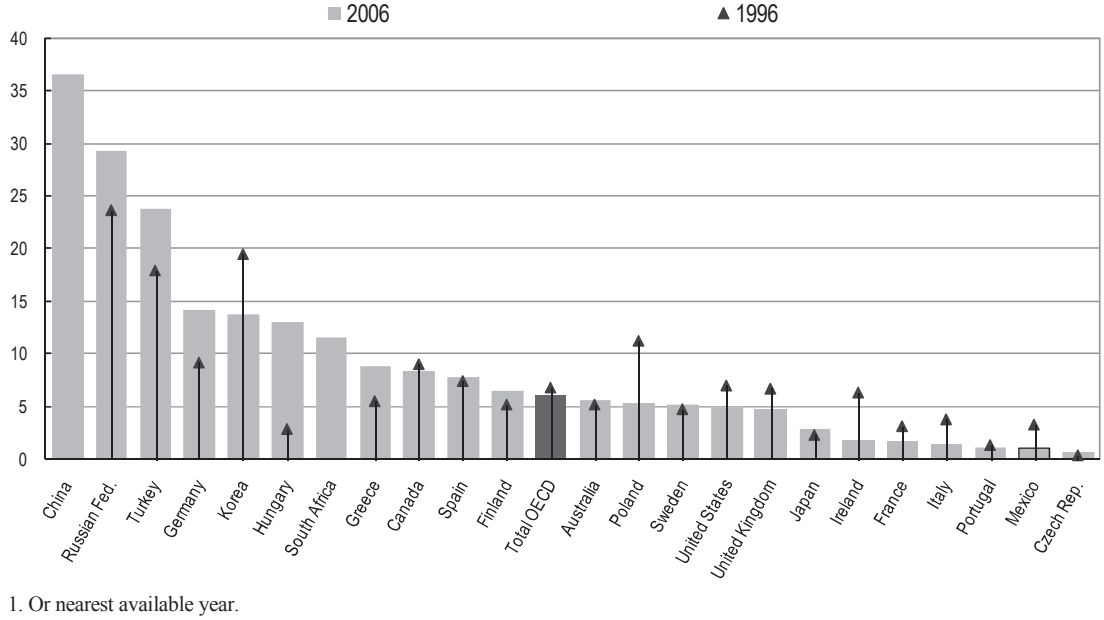


1. Or nearest available year.

Source: OECD Main Science and Technology Indicators.

The level of HERD financed by industry stood at around 1% in 2005, a figure well below the OECD average (Figure 2.25). Moreover, as in the case of industrial funding of GOVERD, the percentage of HERD financed by industry has declined in recent years (Figure 2.26). This reflects in part increased government spending on HERD.

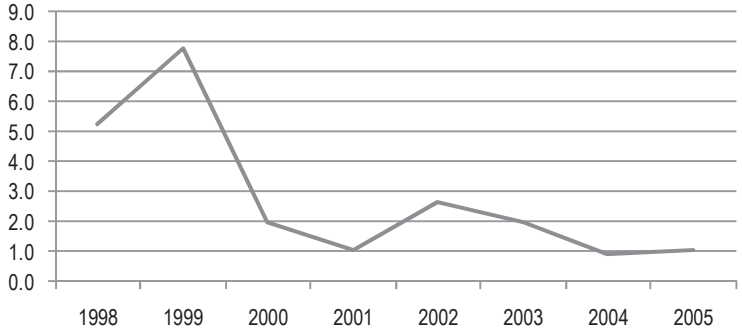
Figure 2.25. Percentage of HERD financed by industry in selected countries, 1996 and 2006[1]



1. Or nearest available year.

Source: OECD Main Science and Technology Indicators.

Figure 2.26. Percentage of Mexican HERD financed by industry, 1998-2005



Source: OECD Main Science and Technology Indicators.

2.3.3. Governance – autonomy and quality assurance

Tertiary education governance, co-ordination and regulation take place at the federal and state levels. At the federal level, policy is established by the Ministry of Public Education (*Secretaría de Educación Pública* – SEP), specifically through the Higher Education Under-secretariat (*Subsecretaría de Educación Superior* – SES). At the state level, co-ordination of tertiary education is the responsibility of the respective state ministries of public education through different administrative units (*e.g.* higher education departments or general directions of higher education).

As in other national tertiary education systems, Mexico must continually review the appropriate balance between governmental steering and institutional autonomy in pursuit of better alignment between the system's operation and national socio-economic development goals. While universities' autonomy is guaranteed by the Mexican Constitution, their governance is quite diverse. For example, public federal and some state universities enjoy autonomy and self-government according to their statutes, while a second group of public institutions –non-autonomous state universities, technological, polytechnic and intercultural universities, and state and federal technological institutes – do not have autonomous status. They report directly to the federal and/or state government (through SEP and/or states' Department of Education) but in practice they do have significant autonomy (OECD, 2006a). Private-sector institutions, while theoretically fully autonomous, are dependent upon federal or state authorities to award them university status and to approve their degree programmes.

This autonomy necessitates the development of effective systems of institutional monitoring and quality assurance. A number of complementary approaches are used for teaching programme quality assurance. Some are wholly internal to institutions, while others are external, involving, for example, accreditation by non-governmental organisations or programme approval by SEP. At postgraduate level, programme-wide assessments were introduced by SEP and CONACYT in 2002 in the framework of the National Registry of Graduate Programmes (PNP). Programmes that receive a positive assessment are listed in the registry under two categories, namely "international quality" or "high quality". By mid-2006, 660 programmes in 48 public and private institutions were listed in the PNP (OECD, 2006a). Furthermore, various instruments have been put in place to enhance the quality of research. The most prominent of these is the National System of Researchers (SNI) where individual researchers can apply for the distinction of

"recognised researcher". This is awarded by CONACYT on the basis of a peer review of publications, generally every three years. In addition, the growing amount of research funds distributed on a competitive project basis (see Chapter 3) has allowed for the introduction of research quality measures as part of the criteria for project selection.

2.3.4. Academic workforce

In the 2004-05 academic year, close to 250 000 academic staff were employed in Mexican HEIs, 62% in public institutions and 38% in private ones. The staff increased by 85% over the previous decade, slightly more than the 79% increase in student numbers. Despite this increase, the workforce faces several challenges. To begin with, the base salary of academic staff in Mexico is very low and considered insufficient to sustain a middle-class lifestyle. It is perceived as being uncompetitive *vis-à-vis* salaries offered in the private sector, especially at the early career stage. Furthermore, part-time academic staff, who are a majority in Mexican institutions, receive only modest payment for each course they teach. Remuneration typically comprises three components: the base salary, a merit-based component (which requires a voluntary application by the academic), and a supplement for members of the SNI. In 2005, only 17% of Mexican full-time academics had achieved SNI membership. For those who are SNI members, the base salary may represent just one-third of their overall remuneration. For others, the merit-based supplement will represent a significant proportion of their remuneration (OECD, 2006a).

A further problem is that pension benefits are generally linked only to the base salary, which provides little incentive for academics to retire given the considerable fall in income that this entails. This is leading to an ageing of the academic workforce in some institutions, particularly in those, such as federal universities, where few new posts are created. Matters are not helped by very limited mobility of academic staff in Mexico. Typically, an individual starts his/her career in a given institution and remains there throughout his/her working life. This is encouraged by career structures that are defined mostly at the institutional, rather than at the national, level (OECD, 2006a).

2.4. Human resources

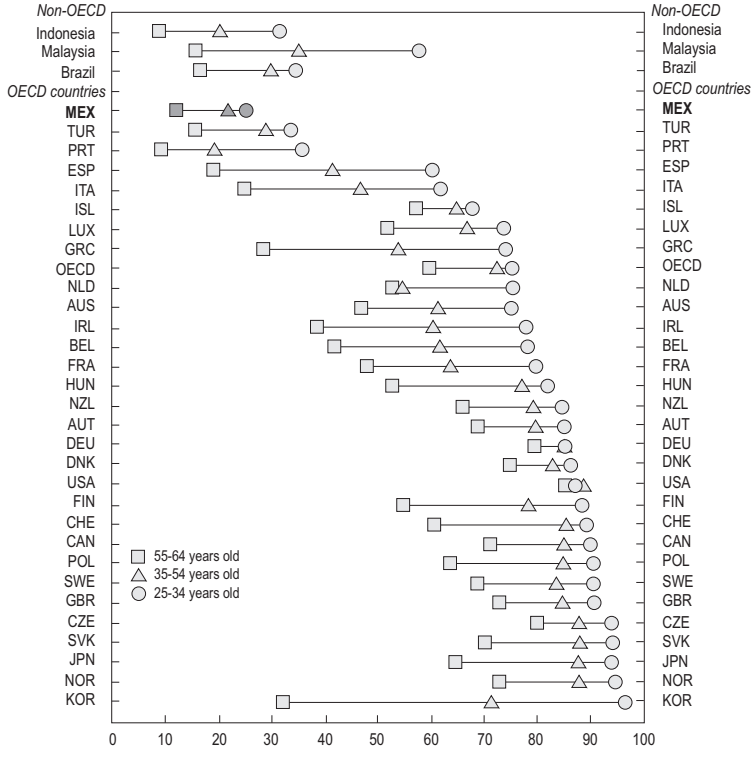
Human resources constitute perhaps the main pillar of knowledge-based economies and as such are a major concern of innovation policy. This section begins with a discussion of the performance and productivity of the secondary and tertiary education sectors, followed by discussion of supply and demand issues around the highly skilled. It finishes with a brief review of lifelong learning provision.

2.4.1. Education system: spending and performance

Mexico still fares poorly by OECD standards in the quantitative and qualitative formation of human capital at all stages of education, from primary schooling to lifelong learning. This relatively poor performance is reflected in particular in the low level of educational attainment of the working age population (Figure 2.27).

Figure 2.27. Educational attainment of the working-age population, 2003[1]

Population with at least an upper-secondary qualification



1. Percent of each group. 2002 for the Czech Republic, Iceland, Italy and Netherlands.

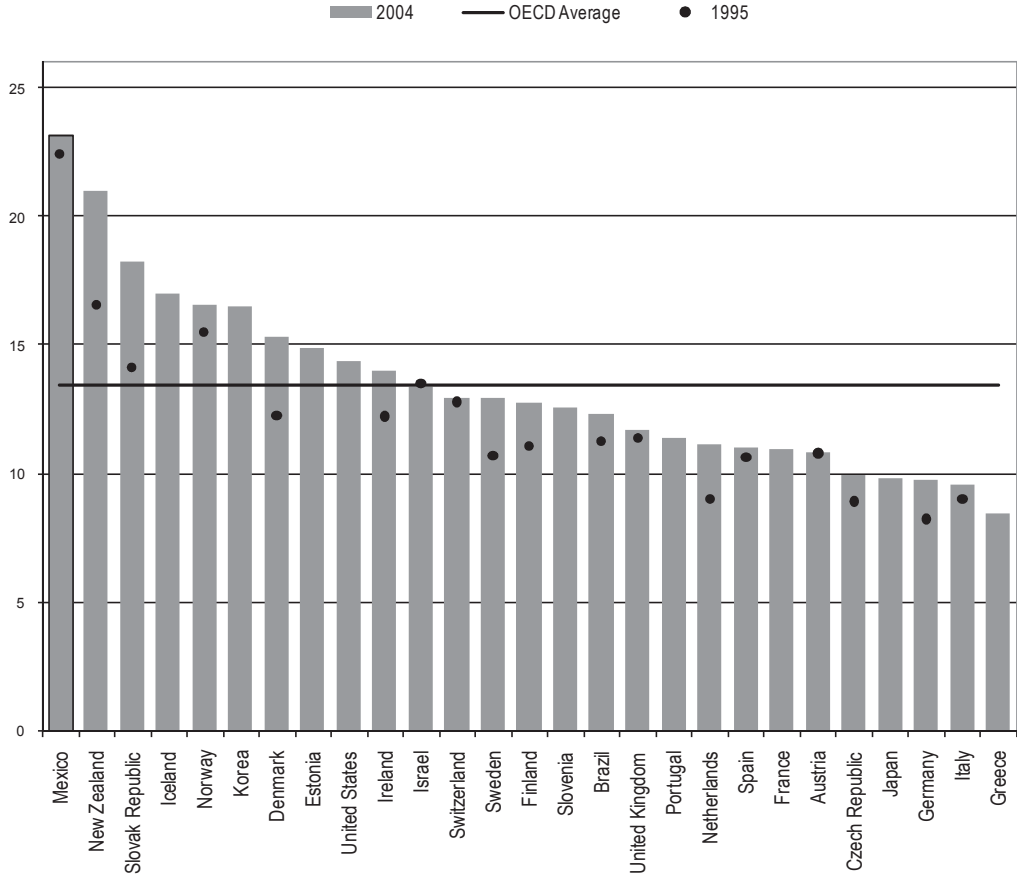
Table 2.14. Main elements of the Mexican education system

Type of education	Level	School-based	Non-school-based
Basic education	Initial education	Initial education	
	Pre-school	General	
		Community	
		Indigenous	
	Primary	General	Primary for adults
		Community	
		Indigenous	
	Lower secondary	General	Lower secondary for adults
		Community	
		Indigenous	
	Vocational training	Technical training	Vocational training
Upper secondary education	Technical professional	Technical professional	Open and distance learning
	Baccalaureate	General	
		Technical	
Higher education	Higher technical	Higher technical	Open and distance learning
	Bachelor's degree	Teacher training	
		University degree	
		Technical degree	
	Postgraduate education	Specialist	
		Master's degree	
		PhD degree	

Source: SEP.

Mexico has one of the largest and most complex education systems in Latin America, composed of federal and state education institutions, decentralised organisations, private education institutions and a number of public universities. As Table 2.14 shows, the system provides education at three levels: basic education, upper-secondary education and higher education. Throughout most of the 20th century, only primary education was compulsory, but in 1993, lower secondary education was made mandatory and in 2002, education at pre-school level. Over the last decade or so, the share of public spending on education has been the highest among OECD countries, standing at 23% in 2004, a figure almost twice the OECD average (Figure 2.28). This is mostly due to low tax receipts, which permit the Mexican government to focus on the provision of core services such as education. Educational spending as a percentage of GDP increased from 5.6% in 1995 to 6.4% in 2004, and is above the OECD average of 5.8% (Table 2.15).

Figure 2.28. Expenditure on education as a percentage of total public expenditure, 1995 and 2004



Note: Direct public expenditure on educational institutions plus public subsidies to households (which include subsidies for living costs), and other private entities as a percentage of total public expenditure, for all levels of education combined and by year. Countries are ranked in descending order of total public expenditure on education at all levels of education as a percentage of total public expenditure in 2004.

Source: OECD (2007), *Education at a Glance*, OECD, Paris.

Table 2.15. Expenditure on educational institutions as a percentage of GDP, 1995, 2000 and 2004

By levels of education, from public and private sources

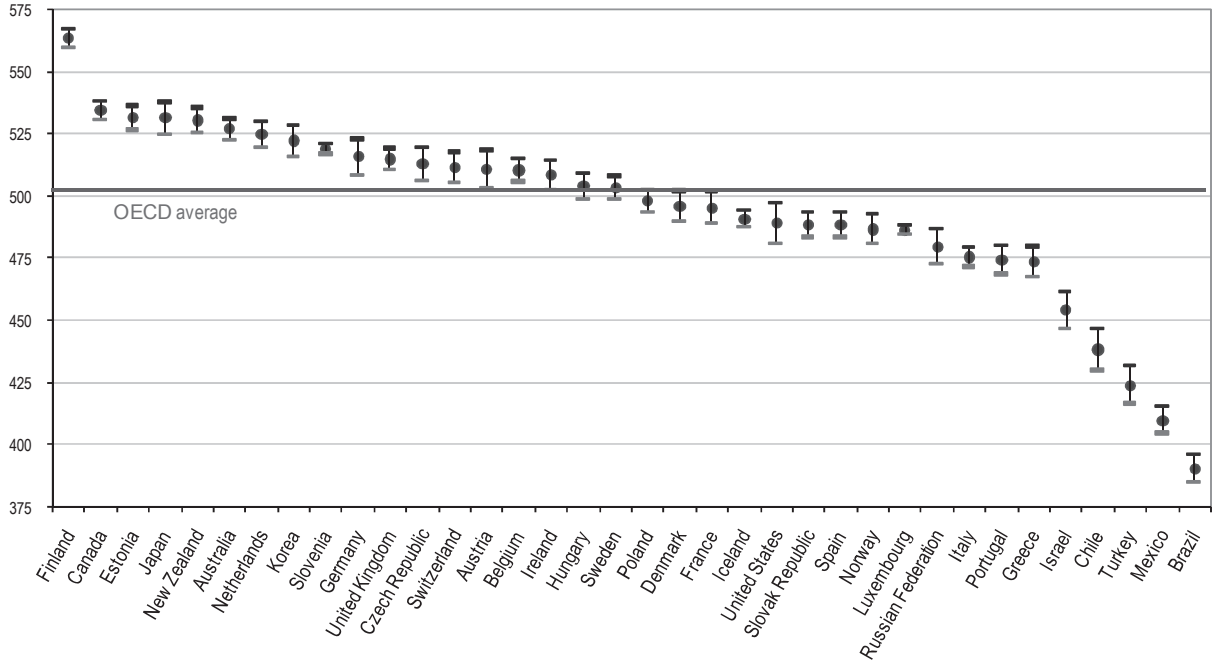
	2004			2000			1995		
	Primary, secondary and post-secondary non-tertiary education	Tertiary education	Total all levels of education	Primary, secondary and post-secondary non-tertiary education	Tertiary education	Total all levels of education	Primary, secondary and post-secondary non-tertiary education	Tertiary education	Total all levels of education
France	4.1	1.3	**6.1**	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Germany	3.5	1.1	**5.2**	m	m	n.a.	3.7	1.1	**5.4**
Greece	2.2	1.1	**3.4**	2.3	0.7	**3.1**	1.8	0.5	**2.3**
Hungary	3.5	1.1	**5.6**	2.9	1.1	**4.9**	3.5	1.0	**5.3**
Italy	3.4	0.9	**4.9**	3.2	0.9	**4.8**	n.a.	0.7	n.a.
Japan	2.9	1.3	**4.8**	3.0	1.3	**4.8**	3.1	1.1	**4.7**
Korea	4.4	2.3	**7.2**	4.0	2.6	**7.1**	n.a.	n.a.	n.a.
Mexico	**4.3**	**1.3**	**6.4**	**3.8**	**1.1**	**5.5**	**4.0**	**1.1**	**5.6**
Poland	3.8	1.5	**6.0**	3.9	1.1	**5.6**	n.a.	n.a.	n.a.
Portugal	3.8	1.0	**5.4**	3.9	1.0	**5.4**	3.6	0.9	**5.0**
Spain	3.0	1.2	**4.7**	3.2	1.1	**4.8**	3.8	1.0	**5.3**
Turkey	3.1	1.0	**4.1**	2.4	1.0	**3.4**	1.7	0.7	**2.4**
United Kingdom	4.4	1.1	**5.9**	3.6	1.0	**5.0**	3.9	1.2	**5.5**
United States	4.1	2.9	**7.4**	3.9	2.7	**7.0**	3.9	2.4	**6.6**
OECD average	**3.8**	**1.4**	**5.8**	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Brazil[1]	2.9	0.7	**3.9**	2.8	0.7	**3.8**	2.5	0.7	**3.6**
Chile[2]	3.8	2.0	**6.4**	4.3	2.2	**6.9**	3.1	1.7	**5.1**

1. Expenditure from public sources only.
2. Year of reference 2005.

Source: OECD (2007), *Education at a Glance*, OECD, Paris.

Despite these reforms and the large proportion of public spending on education, Mexico still has one of the lowest levels of years of schooling in the OECD area. One reason is that the absolute levels spent on education are low compared to other OECD countries. This has implications for educational attainments, as indicated by Mexico's relatively weak performance in the OECD's Programme for International Student Assessment (PISA) exercise. PISA examines, through tests and surveys of 15-year-olds, how well individual national education systems are doing in equipping their young people with essential skills. The latest round of PISA, carried out in 2006, set out to measure the science performance of 15-year-olds. Figure 2.29 shows Mexican performance to be the lowest in the OECD area.

Figure 2.29. Distribution of student performance on the PISA science scale, 2006



Note: Figure shows the mean score on the PISA science scale, with 95% confidence interval around the mean score.

Source: OECD (2008), *Education at a Glance,* OECD, Paris.

Unlike many traditional assessments of student performance in science, PISA is not limited to measuring students' mastery of specific science content. Instead, it measures the capacity of students to identify scientific issues, explain phenomena scientifically and use scientific evidence as they encounter, interpret, solve and make decisions in life situations involving science and technology. This is important, since if students learn merely to memorise and reproduce scientific knowledge and skills, they risk being prepared mainly for jobs that are disappearing from labour markets in many countries. For today's global economy, students need to be able to solve problems for which there are no clear rule-based solutions and also to communicate complex scientific ideas clearly and persuasively (OECD, 2007h). Mexican students performed relatively better on science questions for which they were asked to identify scientific issues. They found it relatively easier to figure out the key features of a scientific investigation. But they struggled to use scientific evidence and had difficulties analysing data and experiments.

PISA also divides student performance scores into six proficiency levels based on the difficulty of questions and the kinds of science competencies students have. While basic competencies are generally considered important for the absorption of new technology, high-level competencies are critical for the creation of new technology and innovation. For countries near the technology frontier, this implies that the share of highly educated workers in the labour force is an important determinant of economic growth and social development. There is also mounting evidence that individuals with high-level skills generate relatively large externalities in knowledge creation and utilisation, compared to an "average" individual (OECD, 2007h). On average across OECD countries, 9% of 15-year-olds reach levels 5 and 6, the top levels of the PISA 2006 science scale. In Mexico only 3% of students achieved these levels and very few reached the top level,

i.e. demonstrated that they could consistently identify, explain and apply scientific knowledge in a variety of complex life situations. This is a very important finding because, even if PISA cannot establish the causal nature of the relationship, the proportion of students performing at levels 5 and 6 at age 15 appears to be a good predictor of a country's research intensity. It explains 70% of OECD cross-country variation in the share of researchers in total employment (OECD, 2007h).

At the same time, the percentage of students at very low proficiency levels is an important indicator of the extent to which young people are being prepared to participate fully in society and in the labour market. At level 2, students start to demonstrate the science competencies that will enable them to participate actively in life situations related to science and technology (OECD, 2007h). Almost 20% of 15-year-olds in the OECD did not reach this level, while the figure for Mexican students was closer to one-half; again, one of the weakest performances in the OECD area.

With a large share of public spending already committed to education, it is probably unrealistic to expect major budgetary increases in the sector in the absence of increased tax receipts or greater use of private co-payments. This means that existing resources will need to be used more effectively and more efficiently if Mexican PISA performance is to reach levels closer to the OECD average.

Table 2.16. Trends in entry rates at the tertiary level, 1995, 2000 and 2005

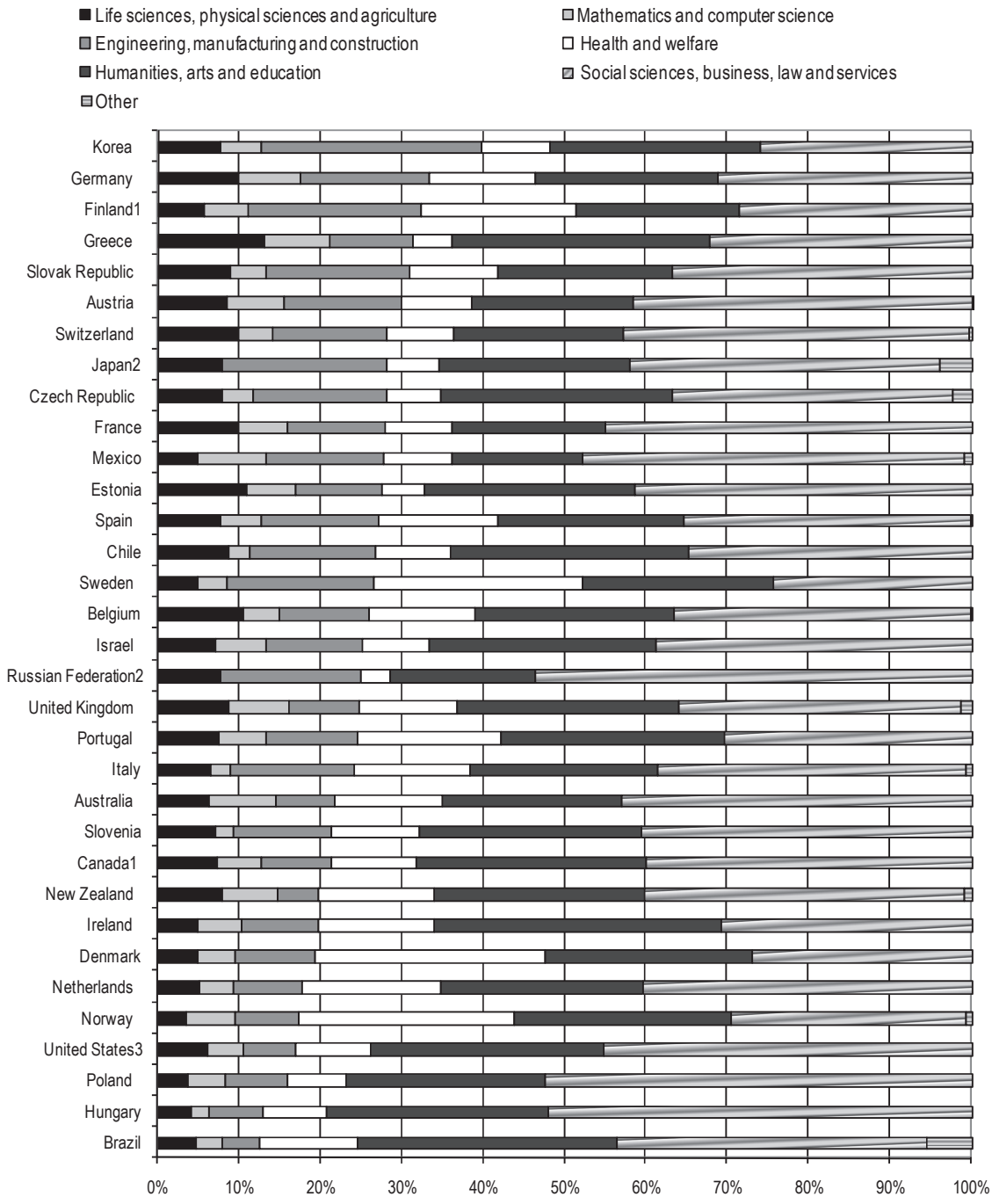
Sum of net entry rate for each year of age

	Tertiary 5A[1]			Tertiary 5B		
	1995	2000	2005	1995	2000	2005
Germany[2]	26	30	36	15	15	14
Greece	15	30	43	5	21	13
Hungary	n.a.	64	68	n.a.	1	11
Italy[2,3]	n.a.	39	56	n.a.	1	a
Japan[2,3]	30	35	41	31	29	30
Korea[2,3]	41	45	51	27	51	48
Mexico	n.a.	**27**	**30**	n.a.	**1**	**2**
Spain	n.a.	47	43	n.a.	15	22
Turkey	18	21	27	9	9	19
United Kingdom	n.a.	47	51	n.a.	29	28
United States	n.a.	43	64	n.a.	14	x(7)
OECD average	**37**	**47**	**54**	**18**	**15**	**15**
Chile[2,3]	n.a.	n.a.	48	n.a.	n.a.	n.a.

1. Entry rate for tertiary type A programmes included advanced research programmes for 1995, 2000, 2001, 2002, 2003.
2. Entry rate for tertiary type B programmes calculated as gross entry rate.
3. Entry rate for tertiary type A programmes calculated as gross entry rate.

Source: OECD (2007), *Education at a Glance*, OECD, Paris.

Figure 2.30. Tertiary graduates by field of education, 2005



Note: Includes only graduates with tertiary-type A and advanced research qualifications. Countries are ranked in descending order of the proportion of qualifications in life sciences, physical sciences and agriculture; mathematics and computer science; and engineering, manufacturing and construction.

1. Year of reference 2004.
2. Physical sciences, mathematics, statistics and computing are included in life sciences.
3. ISCED 5B programmes are included with ISCED 5A/6.

Source: OECD (2007), *Education at a Glance*, OECD, Paris.

2.4.2. Tertiary education attainment

Although it ranks among the lowest in the OECD area in university-level attainment, Mexico has seen impressive growth in tertiary qualifications over past generations, rising from 8% among 55-to-64-year-olds to 18% among 25-to-34-year-olds. Rates of current participation suggest that graduation rates will continue to increase. The increase in tertiary enrolment between 1995 and 2004, which will influence graduation rates, was, at 53%, considerably above the OECD average level of 41%. This trend is further underlined by Mexico's increasing entry rates to university. The proportion of Mexico's age cohort entering tertiary-type A programmes increased from 27% in 2000 to 30% in 2005 (Table 2.16). As Figure 2.30 shows, Mexico compares favourably to other OECD countries in the proportion of graduates gaining degrees in science and engineering subject areas.

In contrast to other OECD countries, Mexico has put much less emphasis on vocational tertiary education (tertiary-type B level programmes) during the last two decades, with an entry rate of just 2% for these programmes in 2005, well below the OECD average of 15% (Table 2.16). This is an area requiring urgent attention, since such programmes focus on practical and technical skills that have the potential to quickly enhance the performance of Mexican enterprises.

2.4.3. Skills supply and demand

The rate of growth in employment of Mexicans with tertiary education is well above the OECD average for both men and women (Table 2.17). Clearly, this is a positive development but it should be viewed in the context of initial low levels of graduate employment. A study by ANUIES (2003) shows that over 1990-2000, the labour market mostly absorbed tertiary education graduates – the net supply of graduates was 1.9 million while the aggregate demand for graduates stood at around 1.8 million. However, nearly half of all graduates appear not to have found employment in an area matching the competencies and skills acquired in tertiary education. Furthermore, about half of these were employed in less specialised areas in which most employed individuals did not hold a graduate degree. This suggests that the supply of jobs requiring tertiary level skills and competencies did not match the number of graduates with such skills (OECD, 2006a).

Table 2.17. Employment growth of tertiary-level graduates, 1998-2004

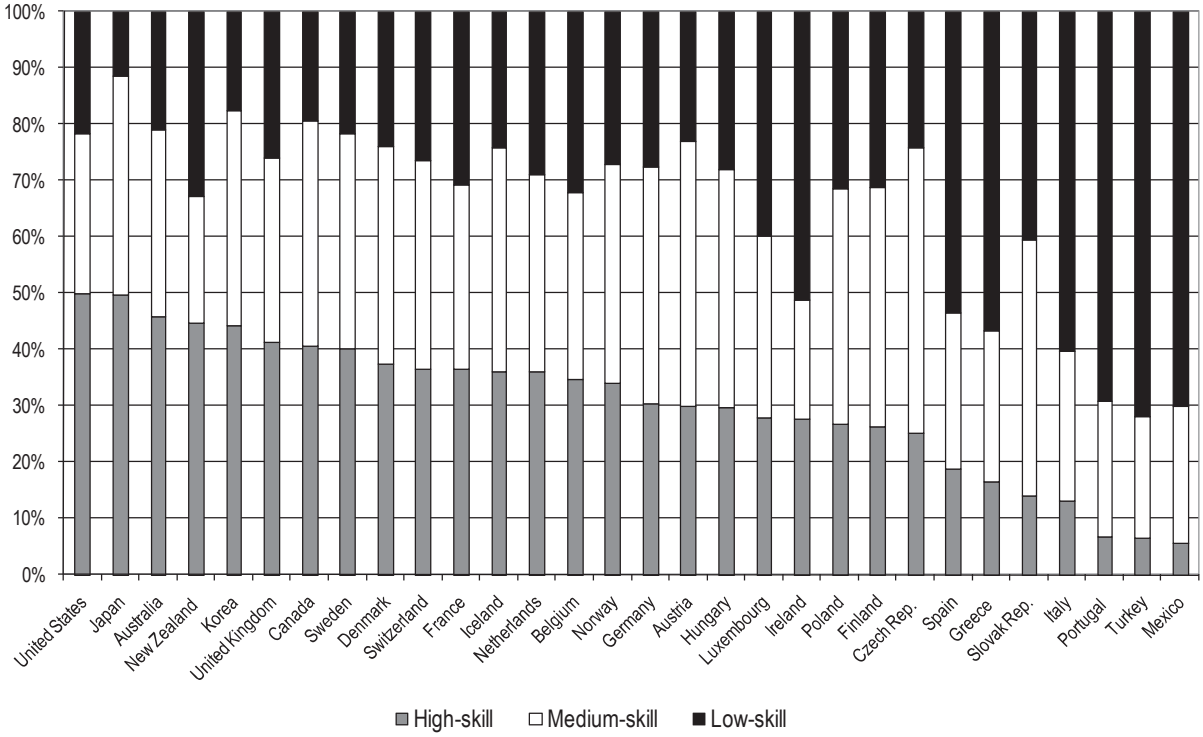
	Total employment growth	Tertiary-level employment growth	
		All-gender	Women
Mexico	1.8	5.2	7.4
OECD (1999-2004)	0.8	3.6	4.5

Source: OECD (2007), *OECD Science, Technology and Industry Scoreboard*, OECD, Paris.

Such "job mismatches" suggest that the skill mix supplied by the educational and training system is somewhat misaligned with the needs of the labour market. One interpretation of this situation is that recent increases in graduation rates have led to "over-education" of young Mexicans whose expectations of high-skill employment cannot be met in local labour markets. From this viewpoint, the growth in the supply of tertiary graduate skills has outpaced the demand by employers for such skills, thereby forcing graduates to accept jobs for which they are over-qualified or to seek better employment opportunities overseas.

The "brain drain" is not as strong in Mexico as in many other OECD countries, no doubt owing to the greater attention paid to the much larger proportions of unskilled Mexicans that seek to emigrate to the United States. Indeed, Mexico is the only OECD country for which general expatriation is greater than highly skilled expatriation as a percentage of the native-born (OECD, 2008f). As Figure 2.31 shows, Mexico has the lowest proportion of highly skilled expatriates in the OECD area. Nonetheless, given the very large overall number of Mexican emigrants, the actual number of highly skilled migrants is one of the highest in the OECD area. With a small inflow of similarly skilled labour, Mexico has the largest net outflow of skilled migrants in the OECD area (Figure 2.32).

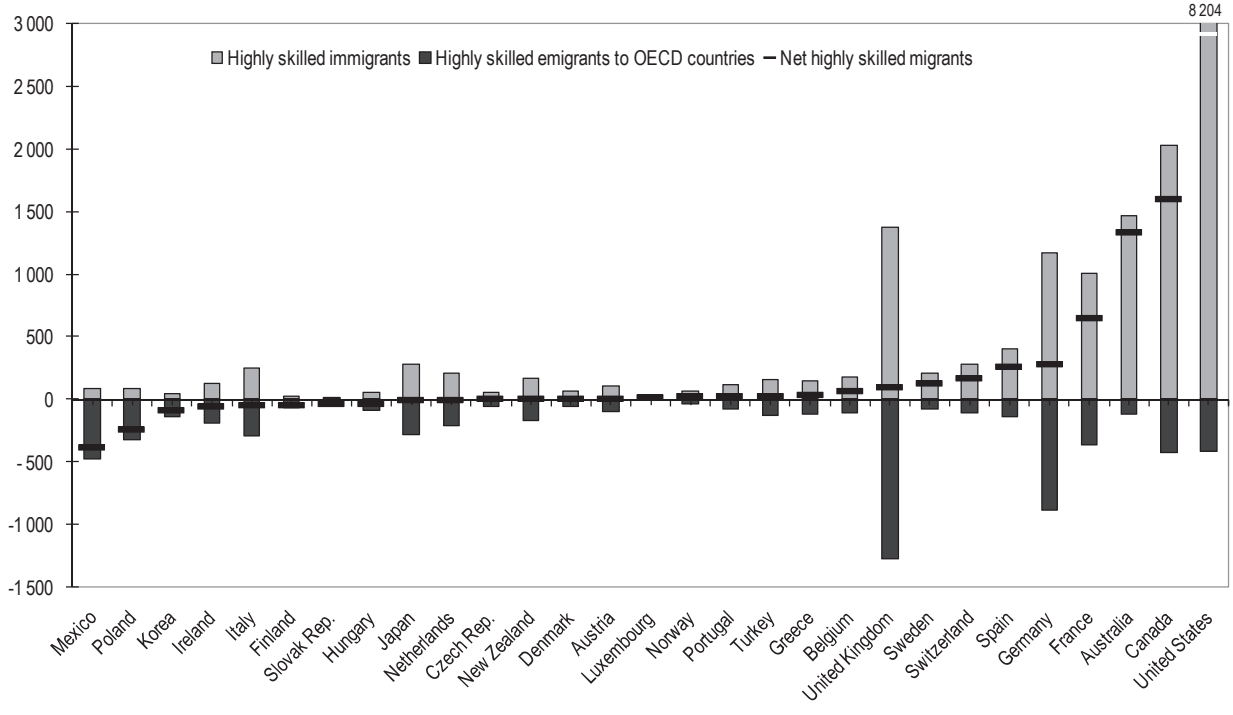
Figure 2.31. Distribution of expatriates by skill level and country of origin, 2001[1]



1. Or nearest available year.

Source: OECD (2008), *The Global Competition for Talent: Mobility of the Highly Skilled*, OECD, Paris.

Figure 2.32. Immigrant and emigrant population 15 years and over with a tertiary education, 2001[1]



1. Or nearest available year.

Source: OECD (2008), *The Global Competition for Talent: Mobility of the Highly Skilled*, OECD, Paris.

Another interpretation of the skills mismatch relates to the professional orientation available to university students and the ability of the university system to respond to changes in the labour market. For example, a recent review of Mexican tertiary education (OECD, 2006a) found that a few subject areas seem to concentrate too many graduates. As Figure 2.33 shows, around 45% of Mexican graduates studied "social sciences, business, law and services" in 2005, one of the highest proportions in the OECD. Yet, with only 30% of employed graduates having studied one of these topics, there would seem to be an oversupply of such tertiary programmes.

A number of initiatives have been put in place to try to improve the articulation of graduate supply and demand (Box 2.8), but there appear to be considerable outstanding challenges in linking the tertiary education system to the labour market. For example, there is no national forum where representatives of business and industry can contribute to the development of tertiary education policy. Furthermore, there is little tradition of active involvement of industry in the daily activities of institutions. The formal participation of employers and representatives of industry as external members of institutions' governing bodies is a phenomenon largely limited to technological universities and some technological institutes and polytechnic universities. In other institutions, in particular autonomous institutions, their presence in governing bodies is scarce (OECD, 2006a).

Box 2.8. Articulation between the tertiary education system and the labour market

The articulation between the tertiary education system and the labour market takes place essentially at three levels.

First, several mechanisms seek to ensure that new educational offerings and the updating of existing offerings result from their relevance to the economy and the labour market. This was reflected in the 2001-06 strategy for education (PRONAE), which required the expansion and diversification of the educational supply in states to be associated with developmental plans designed by each state's COEPES. These reflect, among other things, an investigation of regional labour market needs. Individual institutions are also encouraged to improve their educational supply on the basis of graduate labour market outcomes, feedback from graduates and views of employers. It is notable that, over the ten years to 2004-05, out of the 290 public institutions created, 164 are part of the technology-oriented subsystems that lay particular emphasis on their links to the labour market (50 technological universities, 96 federal and state technological institutes and 18 polytechnic universities).

Second, partnerships between institutions and employers are encouraged. These include internship opportunities for students and teachers in industry, the contribution of professionals from industry to the delivery of programmes in institutions, the existence of offices in institutions to ensure liaison with employers and business organisations, and the participation of representatives of employers and businesses in advisory or governing bodies of institutions.

Third, detailed information about labour market outcomes is produced and made available to students, employers, institutions and policy makers. In 2005, the federal government launched the Mexican Observatory of the Labour Market (*Observatorio Laboral Mexicano*), an Internet platform (*www.observatoriolaboral.gob.mx*) with extensive information about trends and characteristics for a large number of occupations and professions. In addition, most institutions conduct surveys of graduates, receive governmental support to develop these and use the corresponding results to improve the organisation of their programmes.

Source: OECD (2006), *Thematic Review of Tertiary Education: Mexico*, OECD, Paris.

2.4.4. Lifelong learning

It is not enough to expand and improve secondary and tertiary education for coming generations. Such reforms must be accompanied by the development of an adult education and training sector that will not only provide continuous upgrading of the labour force, but will also respond to the long history of private and public under-investment in education. Furthermore, in an era in which new developments in science and technology are emerging constantly, investment in knowledge acquisition should be frequent and continuous. Qualification requirements and personal progress do not cease after attaining tertiary education. Constant education and training is thus considered an important step towards achieving a more effective educational system. Yet, Mexico has one of the lowest rates of participation of 25-to-64 year-olds in job-related training among OECD countries.

This is likely to limit both on the innovativeness of Mexican firms and their ability to adopt new technologies and business practices. The situation is complicated by the fact that the demand for skills is lower than that of several other economies because a large proportion of Mexican enterprises have adopted low-specification product strategies. This locks much of Mexican industry into a low-skill equilibrium. Consequently, there is a lack of training culture in the Mexican workplace, whereas in many OECD countries, employers tend to provide considerable opportunities for upgrading skills (OECD, 2004b). The dominant feature of the enterprise structure, *i.e.* the large number of SMEs,

no doubt contributes to this. Matters are not helped by the tertiary education institutions, whose lifelong learning offerings remain underdeveloped. The opportunities for adults to undertake tertiary education after an experience in the labour market are also hindered by the absence of policy provisions to allow attendance on the basis of a person's assessed competencies instead of formal qualifications (OECD, 2006a).

Notes

1. It should be noted that a significant proportion of the 242% increase between 2003 and 2004 can be ascribed to measurement effects.
2. RENIECYT is the national register for firms and institutions wishing to qualify for various government schemes and incentives in support of S&T activities.
3. It should be noted that the CIS4 figures also include innovative firms with fewer than 50 employees. As such firms tend to be less innovative than their larger counterparts, it can be assumed that the proportion of innovative EC firms comparable in size to the Mexican sample (*i.e.* larger than 50 employees) would be even higher than the 40% cited here.
4. On the other hand, data for firms from the agricultural sector should be treated with caution owing to the extremely small sample of firms from this sector participating in the ESIDET survey.

Chapter 3

The Role of Government

This chapter first briefly reviews the evolution of Mexico's S&T and innovation policy over the last four decades, describes and assesses recent policy initiatives concerning the institutional framework and the support programmes, and proposes some strategic orientations to improve the efficiency of policy design and delivery and achieve higher innovation performance by the Mexican economy.

The Mexican government has been slow to develop a comprehensive innovation system with a set of institutions and support policies explicitly designed to strengthen the country's scientific base, foster the innovative capacity and competitiveness of its productive sector, and better articulate the relationships between public research and industry.

As in other large Latin American countries, institution building started – often with the support of international organisations such as the Inter-American Development Bank – with the consolidation of research capacities in the academic sector, the promotion of human capital in S&T and the creation, under the aegis of sectoral ministries, of public research and technology centres entrusted with missions of knowledge creation and dissemination in areas related to social challenges, the development of natural resources and the improvement of competitiveness in import-substitution industries. The relative strength of the public research system favoured a linear view of innovation based on "S&T push". This view underpinned the mission entrusted to the National Council on Science and Technology (CONACYT), created in 1970 as an agency mainly responsible for the allocation of funding to the public research sector and the promotion of highly skilled human resources. Meanwhile, other government agencies were independently funding and managing support programmes to promote industrial development; these included instruments to upgrade the technological capacities of domestic private enterprises. These programmes were designed and implemented without much interaction with CONACYT.

Then, and particularly after the 1982 crisis which paved the way to the opening of the Mexican economy, government initiatives to shape the S&T and innovation system were influenced by the interplay of the main stakeholders: *i)* the academic community, whose main concerns remained the priority given to its two basic missions, the development of knowledge and the formation of skilled human capital, and the safeguard of its autonomy; *ii)* the enterprise sector – notably large enterprises including foreign affiliates – which claimed an increasing part of the S&T budget for technological capacity building and support to investment in private R&D and innovative activities; and *iii)* the variety of

ministries or government bodies wishing to maintain their responsibilities over the funding and management of policies and programmes in support of S&T activities in academia, sectoral public research centres and the productive sector. Given the scarcity of public resources, this led to the dispersion of resources and the fragmentation of programmes and a lack of mutual leverage between knowledge creation and demand for knowledge for innovative applications. This situation has left Mexico in a "low-level equilibrium trap" without positive feedback between scientific push and innovation pull effects ((Dutrenit *et al.,* 2008; Casas, 2006).

Since the middle of the 1990s the notion of a comprehensive national S&T and innovation system and the critical role of science-industry interactions in knowledge creation, dissemination and application have entered public debate. The importance of strengthening synergies between the supply and demand of knowledge began to gain ground at a conceptual level (OECD, 1994), but its translation into effective institutional changes and modes of governance, budgetary appropriations, and well-adapted support programmes and incentives failed to materialise successfully owing to low political commitment at the highest level of government, administrative inertia and stagnant public resources.

The first noteworthy efforts to develop a comprehensive and coherent S&T and innovation system came with the adoption of the 1999 S&T Law, which was revised in 2002, the change of status of CONACYT, and the adoption of the Special Programme for Science and Technology 2001-06 (PECYT) with newly designed support instruments. However, the PECYT did not fulfil its ambitious objectives. It is to be hoped that the newly adopted Special Programme for Science, Technology and Innovation 2008-12 (PECITI), adopted in September 2008 (CONACYT, 2008), along with the budgetary increases and the institutional and policy reforms that should accompany it, following recommendations made in this report, will prove more successful in improving the performance of Mexico's S&T and innovation (STI) system.

3.1. The evolution of Mexico's S&T and innovation policies

3.1.1. The initial phases prior to the creation of CONACYT

Aside from the National University of Mexico, founded in 1910, government efforts to promote institutions devoted to the development of scientific and technological capacity, mainly in the higher education sector, or the technological upgrading of enterprises began in the mid-1930s under President Lázaro Cárdenas.

The National Polytechnic Institute (IPN) was created in 1936 with the explicit dual mission of carrying out applied research and training of highly skilled professionals for industry.[1] Over the next three decades many sectoral public research institutes were established in areas such as health, agriculture and mining. The Centre of Research and Advanced Studies (CINVESTAV), an autonomous world-class advanced scientific teaching institution, was founded in 1961. It has increasingly engaged in S&T activities designed to contribute to the solution of national strategic problems.

Up to the creation of CONACYT in 1970 there were almost no established policies or programmes providing direct or indirect financial support for R&D and innovation activities in the business sector. Business investment in R&D and innovation activities was essentially undertaken by a few large public or private enterprises (domestic and foreign) in sectors such as steel, automotive, chemicals and cement. By and large, the

only support to the enterprise sector's technological development was provided on an *ad hoc* basis by public financial institutions such as the National Development Bank (NAFIN) or the Mexican Bank of Foreign Trade.

3.1.2. From the creation of CONACYT to the 1982 crisis

The main reason for the creation of CONACYT under the Ministry of Planning and Budget (SPP) was not the emergence of a new rationale for the government's role in the promotion of S&T and innovation relating to perceived market or systemic failures. The scientific community played an active role in its creation, which explains its academic orientation. Putting the CONACYT under the SPP was seen as insurance against budgetary fluctuations and constituted an attempt to subordinate the support provided by the state to the two main pillars of S&T capacity building (strengthening of public S&T institutions and formation of human capital) to the planning and budgeting logic that prevailed at the time.[2]

Indeed, in its beginnings, CONACYT's main instruments were the postgraduate scholarship programme and programmes for the development of the exact, natural and social sciences in public research institutions. Through CONACYT, new institutions were created, such as the Mexican Petroleum Institute (IMP) and the Electrical Research Institute (IIE) in connection with public enterprises in the energy sector. During that period, which was marked by strong state intervention and the major role of the scientific community in shaping CONACYT's action, new public higher education institutions were created both at the federal and state levels.[3]

3.1.3. The first transition period after the 1982 crisis to the end of the 1990s

During the following period Mexico's STI policy was characterised by important changes prompted by the 1982 crisis and the subsequent opening of the Mexican economy, as well as by the gradual emergence of new views of the role of government in supporting S&T capacity building in both research institutions and the productive sector.

First, in the successive national programmes for S&T development prepared during the period[4] the policy emphasis on promotion of technology and innovation gradually increased. This reflected the realisation that the Mexican economy's international competitiveness depended in part on the technological capacity of the productive sector and technology transfer mechanisms. However, this increased emphasis was not yet part of a systemic vision encompassing both the production of knowledge and its diffusion and application or of a comprehensive framework for policy design and implementation. Moreover, the dispersion of responsibilities for public research institutions among several ministries or agencies[5] and the lack of efficient governance mechanisms hindered a co-ordinated approach to the design, financing and implementation of STI policy.

Then, in the 1990s, it was recognised that the market and systemic failures that stopped industry from developing technology and innovative capabilities could be the object of specific support policies. Special programmes and new regulations therefore aimed at encouraging private R&D and innovation: examples include the Fund for R&D and Technological Modernization (FIDETEC), which later became the Programme to Support the Technological Modernization of Industry (PROMTEC); and the Fund for Strengthening Scientific and Technological Capacities (FORCCYTEC). CONACYT also created a special programme to promote academic-industry links (PREAEM) and the Incubator Programme for Technology-based Enterprises (PIEBT).[6] In addition the

government introduced several regulatory changes intended as incentives for innovation and technology transfer in industry. The law on patents and trademarks was modified to protect industrial property rights for a longer period, and quality standards and metrology were updated. The government promoted foreign direct investment (FDI) and free trade agreements to accelerate industry's technological modernisation. This evolution suggests that the S&T push model was beginning to be balanced by more emphasis on "demand-pull" policies.

At the beginning of the period, in 1984, the Mexican National System of Researchers (SNI) was established to mitigate the effects of researchers' worsening remuneration and working conditions following the 1982 crisis and the increasing risks of brain drain. It has played a very positive role in the constitution and development of a community of qualified researchers, who are selected, promoted and rewarded with non-taxable complements to their remuneration according to criteria based on the volume and excellence of their scientific production, essentially peer-reviewed scientific publications. Without this system, centrally managed by CONACYT and financed on its budget, the level of excellence of Mexico's research activities and the number and diversity of its internationally recognised researchers would not be what they are today. At the same time, the integration of academic personnel into the system and the number of SNI researchers among them became a main component of the evaluation of postgraduate studies programmes, higher education institutions and public research centres. The SNI has remained basically unchanged for more than two decades.[7] This system presently absorbs a significant part of CONACYT's budget. As will be seen below it requires further reforms.

In brief, this period was marked by important changes that affected supply and demand: on the one hand, the consolidation of the scientific workforce through the establishment of the SNI and the extension of the scholarship programme; and, on the other, the fostering of the innovative capacities of enterprises. However, this did not allow Mexico's STI system to escape the "low-level equilibrium trap". Linkages between the research and enterprise sectors remained poor, the governance of the overall system was extremely feeble, notably as regards its capacity to define priority orientations, facilitate consensus among stakeholders and ensure policy co-ordination, and budgetary efforts to promote S&T investment were weak (OECD, 1994).

3.1.4. Moving towards a comprehensive S&T and innovation policy: a second transition in progress

The second transition started at the end of the 1990s with the enacting of the first S&T Law in 1999, followed by the approval of the PECYT, and the amended S&T Law in 2002. It has seen major initiatives aimed at improving the design and implementation of Mexico's STI policy.

At the conceptual level, the PECYT explicitly recognised the complementarity and synergies between the demand and supply approach to S&T policies and the need for a systemic and comprehensive framework for such policies. This implied changes in the policy mix to put more emphasis on support to innovation and industry/science linkages, more rapid formation of human resources for S&T in basic and applied research, and a strengthening of the S&T infrastructure.

At the political level there appeared to be a consensus to substantially increase resources, notably budgetary, for science and technology. The 2002 S&T Law set a target for R&D expenditures of 1% of GDP by 2006, with a growing share financed by industry. It was also recognised that to ensure greater stability, S&T policy should be disconnected from Mexico's six-year political cycle. Greater attention was given to regional aspects of S&T policy through co-operation mechanisms between the federal and state levels in the definition, financing and implementation of S&T capacity building and R&D projects.

At the institutional level CONACYT attempted, with mixed success, to strengthen its co-ordination of various ministerial departments and agencies involved in STI policy. In the framework of the Organic Law of 2002, CONACYT obtained direct access to the newly created Council of Scientific Research and Technological Development chaired by the President of the Republic.[8] An Advisory Forum for Science and Technology (FCCyT) was established by the 2002 S&T Law to ensure the involvement of scientific and business stakeholders in the policy making process and to facilitate consensus building.

At the programmatic level efforts were made to better define medium- to long-term S&T strategic orientations in line with the 2001-06 National Development Plan priorities and to revamp support instruments for R&D and innovation. The PECYT pointed out the need to define and channel increased support to STI activities in the fields with the largest potential contribution to sustainable development and identified strategic priority sectors in which sustained public investment in S&T could lead to innovation-based growth and competitiveness and/or better satisfy collective needs.

Various funds were established to provide direct support to priority projects jointly defined and financed by CONACYT and sectoral ministries (sectoral funds) or by CONACYT and federal states (mixed funds). With the support of Congress, an R&D tax incentive was established in 2001 to foster private investment in R&D and innovation activities. Several support programmes were designed with explicit allocation criteria which favoured linkages between industry and research institutions.

However, in terms of implementation these initiatives proved much less effective than anticipated owing, among other things, to the low level of resources for S&T policy and individual support programmes[9] and the dilution of priorities, as a defective co-ordination among funding departments led to a fragmentation of programmes and bureaucratic procedures in their management and implementation.[10] In fact CONACYT experienced difficulties in assuming its inter-ministerial co-ordinating role in priority setting and resource allocation.

The transition initiated by the PECYT is therefore still under way. Taking stock of the PECYT's diagnosis of the weaknesses of the STI system but also of its limited progress in improving the system's performance, the Mexican government, at the beginning of the present administration, undertook a critical assessment of past policies with a view to addressing more effectively the chronic weaknesses of the system.[11] The preparation of the new Special Programme for Science, Technology and Innovation (PECITI), approved in September 2008, as well as the new STI law benefited from the results of this assessment process.

3.2. Institutional setting and governance

Legislative and regulatory initiatives implemented between 1999 and 2006 helped to shape the current institutional setting and governance of Mexico's STI system. They create a complex set of rules and decision-making processes that influence the interactions among the actors of the system, in the federal and state government, in public research institutions and the business sector. The tensions between the institutional architecture, with formal rules that must be followed, and the actual governance of the system reflect a balance of power among the actors that can give rise to inefficiencies and high transaction costs.

3.2.1. Recent institutional and regulatory initiatives

The main institutional initiatives concern CONACYT's Organic Law and the 2002 S&T Law and the regulatory measures related to its application. These measures include:

- the guidelines and legal, administrative and economic instruments in support of scientific and technological research included in the S&T Law and other applicable regulations;
- the procedures for the negotiation, co-ordination, participation and linkages defined by the S&T Law (2002) and other applicable regulations;
- the rules and norms governing S&T activities in higher education institutions (HEIs).

In 2005 and 2006, the public research centres (PRCs) were granted greater management autonomy regarding capability to manage their budgets, engage in contractual agreements with public and private firms to provide services or to perform joint technological development projects, and use the revenue from such contracts for their own investment in S&T infrastructure. However, they were given less autonomy for the management of human resources and for participation in the creation of spin-offs.[12]

The legal changes allow the PRCs' governing organisms to establish the conditions of appropriation and use of the results generated by their researchers, and to set rules of confidentiality when profitable knowledge is generated by joint PRC/industry projects or technology-based firms created by PRCs.[13] However, no clear rules or guidelines govern the sharing of the proceeds of the sale of intellectual property rights (IPRs) or licensing between PRCs, research groups and enterprises.

Staff researchers of PRCs and universities are civil servants and as such their conditions of employment, remuneration and pensions are governed by the relevant federal labour laws pertaining to public servants. This may entail rigidities in the management of human resources in public research institutions. As will be seen, it has also some perverse effects on the links between the management of the SNI and the age structure of researchers as SNI compensations cannot be included in pensions.

3.2.2. Governance

The government body ultimately responsible for the design and implementation of STI policy is the General Council for Scientific Research and Technological Development chaired by the President of the Republic. The Council includes the Minister of Finance, eight sectoral ministers with budgets for S&T programmes[14] and four members of the FCCyT invited by the President. CONACYT's director general is a member of the Council and acts as its executive secretary. While the Council should have an important role in defining strategic policy orientations, in inter-ministerial policy co-ordination and in the allocation of budgetary appropriations in the S&T area, this role has remained largely formal. Since its creation the Council has met no more than six times, in particular to formally approve the successive S&T plans.

CONACYT has, in principle, the authority to ensure inter-ministerial co-ordination of the design, financing and implementation of S&T policy, but, in practice, many factors hinder this. First, there is the question of its institutional status in the government structure.[15] The director general of CONACYT is not a member of the government and does not have real authority for policy co-ordination and even less for the allocation of budgetary appropriations. Moreover, CONACYT is governed by a Board chaired by a government minister.[16] Second, CONACYT's S&T budget is less than a third of the overall S&T budget[17] and the financing of many of the programmes it manages depends on the participation of sectoral funds of various ministries. Given CONACYT's institutional weakness in terms of policy co-ordination and the consequences in terms of budgetary allocation, two inter-ministerial committees assume these functions. The Inter-ministerial Budget Committee, under the Ministry of Finance, reviews the financing requirements of the ministries and agencies responsible for the implementation of STI support programmes and integrates them in the annual budget plan, *de facto* operating arbitrations among requirements. The Inter-sectoral and Linking Committee reviews and promotes proposals to create programmes involving several ministries and/or agencies; it can also propose agreements and specific support programmes involving co-operation between the federal and state or local governments.

The Advisory Forum for Science and Technology (FCCyT) was established by a government initiative in 2002 under the S&T Law. It is an independent civil organisation with its own budget. Its mission is to advise the President, the General Council for Scientific Research and Technological Development, CONACYT'S Board, and Congress. The Forum has a Board composed of 19 members representing academic and business institutions as well as government agencies involved in S&T policy and has a number of specialised committees. While the Forum has produced or commissioned studies or assessments of quality and relevance, its advisory role has not been as effective as that of S&T Councils composed of similar stakeholders in other countries, such as the Nordic countries or Chile, in defining a national STI strategy and priority actions. Its large membership (including the members of specialised committees) and the fact that its Board is composed of representatives of institutions rather than independent individuals probably explains why the Forum has found it difficult to forge a consensus among stakeholders regarding the orientations of S&T policy and the legislation or policy instruments needed to implement it.

The growing emphasis on decentralisation of STI policy and the strengthening of STI capacity at regional level has led to the establishment or development of decentralised and local government institutions. CONACYT has six regional offices, each of which is in charge of several federal states, all of which have established S&T councils. The regional offices and the S&T councils select S&T-related projects (including infrastructure). Their implementation is jointly funded by CONACYT and the federal states. The National Conference of Science and Technology was established by the 2002 S&T Law to address issues regarding collaboration between the state and federal level of governments on issues of policy priority and the design and implementation of support programmes. Chaired by the director general of CONACYT, it includes representatives of all state bodies with STI responsibilities.

This overview of the institutional setting and governance of Mexico's STI system highlights the fact that there is no real separation of the functions of policy design and of delivery in terms of financing and implementation. Ministries involved in the promotion of STI activities and CONACYT assume both functions either alone or in collaboration. This situation, compounded by inefficient co-ordination procedures and weak evaluation practices, underscores the need to improve the governance of Mexico's STI policy. Recommendations concerning possible paths for improvement are developed at the end of the chapter.

3.3. Financing, priority setting and policy mix

3.3.1. Financing of STI policy and resource allocation

The S&T regulations introduced by the government in 2002 created a new budget classification that in principle allows the tracking of all federal funds allocated to ministries, federal entities and public companies for S&T-related expenditures. At the same time, these regulations created a specific budgetary line (called "Ramo 38") for this agency.

In Mexico, the federal financing of S&T policy has three main channels:

- budgetary appropriations of sectoral ministries that fund research institutions operating under their responsibility, and S&T funds or programmes that they manage directly or in collaboration with other government bodies;
- budgetary appropriations of CONACYT which include the fiscal resources allocated to CONACYT to finance the S&T funds, programmes and support instruments it manages (or co-manages), and the fiscal resources allocated to the 27 CONACYT research centres;
- foregone budget revenue derived from the R&D fiscal incentive introduced in 2001; this can be readily measured as the fiscal incentive measure has an annual ceiling set by the Ministry of Finance enacted in the federal budget law.[18]

As shown in Tables 3.1 and 3.2 the bulk of the federal S&T budget (97.2%) is allocated to six sectoral ministries (Education, Energy, Agriculture, Health, Economy, Environment) and CONACYT.

Table 3.1. Federal expenditures in S&T, 2002-08

Millions of 2006 MXN

Sector	2002	2006	2007	2008
Education	9 679	11 873	10 381	11 480
CONACYT	9 870	10 282	11 477	13 175
Energy	6 080	4 921	5 656	6 305
Agriculture	2 370	2 108	2 290	3 331
Health	1 311	2 036	2 126	2 181
Economy	736	658	954	633
Environment	527	558	588	827
Others[1]	762	356	152	151
Total	**31 335**	**32 791**	**33 624**	**38 083**

1. Including Communications and Transport, and Foreign Affairs.

Source: CONACYT.

Table 3.2. Federal S&T expenditures by government department and main activity funded, 2006 (%)

	Education	Energy	Agriculture	Health	Environment	Economy	Communication and transport	CONACYT[1]	Others	Total APF[2]
Elementary education	0.3	-	-	-	-	-	-	-	-	0.1
Upper-secondary education	0.1	-	-	-	-	-	-	-	-	0.0
Tertiary education (ISCED 5A, 5B)*	0.1	-	-	-	-	-	-	-	-	0.0
Postgraduate education (ISCED 6)*	34.7	-	19.4	-	-	-	-	0.3	-	13.3
Education services support	0.3	-	-	-	-	-	-	-	-	0.1
Scientific research	54.9	87.1	80.5	100	33.5	-	-	23.6	-	52.0
Technological development	0.2	-	-	-	66.5	-	100.0	14.5	73.7	6.6
Scientific and technological (S&T) services	9.3	12.9	-	-	-	-	-	4.5	-	6.8
MSMES[3]	-	-	-	-	-	18.2	-	-	-	0.4
Innovation and competitiveness	-	-	-	-	-	81.8	-	-	-	1.9
Support to S&T development	-	-	-	-	-	-	-	53.9	-	17.5
Others	0.0	-	0.1	-	-	-	-	3.2	26.3	1.2
Total	100	100	100	100	100	100	100	100	100	100
Total budget (USD millions)	1 006.0	515.1	221.9	120.5	55.7	70.0	6.8	965.4	13.9	2 975.3
Share of total budget	33.8	17.3	7.5	4.0	1.9	2.4	0.2	32.4	0.5	100

1. Includes the budget allocated to CONACYT and CONACYT Research Centres.
2. Public Federal Administration (APF).
3. Micro, small and medium enterprises.

* UNESCO (1997), International Standard Classification of Education (ISCED): 5A and 5B include first degree and higher technical education; ISCED 6 refers to Specialties, Master and PhD education levels.

Source: S&T National Accounts.

3.3.1.1. Federal ministry funding and internal resource allocation

The Ministry of Education (SEP) was the best endowed until 2006 with more than a third of the total federal S&T budget. The largest share of its S&T expenditures goes to:

- scientific research and infrastructure (55%) funded either through institutional block grants to public higher education institutions[19] or through its contribution to the SEP/CONACYT sectoral fund for basic research;
- postgraduate education (34.7%), which includes its contribution to scholarships.

The Ministry of Energy (SENER) allocates almost its entire S&T budget to the financing of the research institutions under its responsibility, the Mexican Petroleum Institute (IMP), the Institute of Electrical Research (IIE) and the National Institute for Nuclear Research (ININ).[20]

The Ministry of Health (SS) divides its resources between the financing of basic and applied research in hospitals and a number of specialised institutes and laboratories.[21]

The Ministry of Economy splits its S&T budget resources between the following activities:

- support of technological upgrading of SMEs and innovative activities in micro, small and medium-sized enterprises (MyPyME Fund);
- promotion of innovative clusters;
- provision of technological services through institutions under its responsibility, the Mexican Institute of Industrial Property (IMPI) and the National Metrology Centre (CENAM);
- subsidisation of private law intermediary institutions that facilitate technology transfers to enterprises;
- contribution to the sectoral Technological Innovation Fund co-financed and co-managed with CONACYT.

The Ministry of Agriculture mainly allocates its S&T resources to research institutions under its responsibility, principally the National Institute of Forestry, Agriculture and Stockbreeding Research (INIFAP). It also shares with CONACYT the financing and management of sectoral funds.

With the exception of the Ministries of Education and of Economy, all other sectoral ministries devote an overwhelming share of their S&T resources to the institutional funding of specialised research institutes under their responsibility. Thus, their financial participation in CONACYT sectoral funds that finance S&T projects with selectivity criteria that approach competitive funding procedures is limited.[22]

3.3.1.2. CONACYT central administration funding and resource allocation

Since 2002, the first year in which it had its own line in the federal budget, and up to 2006 CONACYT's budgetary resources have stagnated in real terms. The share available to the central administration to fulfil its missions has diminished relative to that allocated to its 27 research centres.[23]

Table 3.3 illustrates the evolution of CONACYT's allocation of its resources among the programmes it supports and the funds it finances (or co-finances) according to broad S&T policy areas between 2002 and 2006. The area that receives by far the largest amount of funding is development of human resources, in particular the postgraduate scholarship programme and the financing of the SNI.

Table 3.3. CONACYT budget allocation by instrument and policy focus

USD (year 2003) millions

Instrument	2002	2006	Accumulated 2002-06 (%)	Financing and/or management responsibility
Human resources development				
National researchers system (SNI)	111.2	133.1	23.5	CONACYT
Postgraduate scholarships	190.4	188.1	36.0	CONACYT
Post-doctorate scholarships	0	8.5	0.9	CONACYT
Other[1]	6.4	13.1	1.6	CONACYT
Subtotal	372.2	361.2	61.1	
Basic research				
Education/CONACYT Fund	64.2	18.5	6.8	Shared
Others[2]	0	3.8	0.2	CONACYT
Subtotal	64.2	22.3	7.0	
Problem-oriented research and technological development (sectoral)				
Sectoral funds (other than education and economy)	32.8	19.9	3.6	Shared with sectoral ministries
Public/private partnerships	0	18.9	0.9	CONACYT
Subtotal	32.8	38.9	4.5	
Applied research and technological development (regional)				
Mixed funds	24.6	16.8	4.2	Shared with states
Support to business R&D and innovation				
Economy/CONACYT Fund	11.6	7.5	1.7	Shared
AVANCE	0	0	1.0	CONACYT
Entrepreneur and Guarantee Fund	0	2.6	0.4	Shared
Other	3.5	0.5	0.3	
Sub-total	15.1	10.6	3.4	
Other				
Miscellaneous[3]	75	90.5	19.9	CONACYT
Total CONACYT (central administration)	519.7	500.5	100	
CONACYT research centres	*369.5*	*432.9*		

1. Includes scientist repatriation programme.
2. Includes special funding of HEI laboratories (*e.g.* CINVESTAV).
3. Includes CONACYT administrative expenditures and operating subsidies to various institutions (*e.g.* the Mexican Academy of Sciences, FCCyT, ADIAT).

Source: FCCyT (2007) and own calculations.

- The postgraduate scholarship programme launched in 1971 has contributed significantly to Mexico's relatively good performance in the training of engineers and technicians. Other government departments also contribute to the financing of this programme, mainly the Ministry of Education and, to a lesser extent, the Ministry of Health. CONACYT's share in the total number of scholarship granted by the federal government increased from 33.4% in 1997 to about 58.5% in 2006.
- The financing of the National Researchers System (SNI) absorbed close to a third of CONACYT's central budget in 2006. This budget line is the one that grew the fastest and the volume of resources should grow mechanically with the regular increase of SNI members.[24]

CONACYT's financing of basic research from its central administration budget is essentially its contribution to the Basic Science Fund co-funded by the Ministry of Education. This fund finances projects presented by individual researchers or groups of researchers from public and private institutions.[25] It is operated on a competitive basis through peer review. Resources devoted to the fund have decreased regularly since 2002.

CONACYT also finances basic research and scientific infrastructure indirectly through its institutional block grant to its research centres which develop knowledge and teaching activities in exact, natural and social scientific disciplines.[26]

Funding of problem-oriented research and technological development is mainly channelled through the sectoral funds and mixed funds introduced in 2002 as well as through small-scale public/private partnership research and innovation support programmes:

- The 17 sectoral funds jointly financed by sectoral ministries (other than Education and Economy) or other federal institutions are for the implementation of projects that promote the development of STI capacities in the production of goods and services in sectors under the competence of these ministries/institutions and, in principle, according to their strategic needs. Projects are selected through administrative procedures involving peer review.
- The 32 mixed funds financed jointly with the federal states fund STI capacity building projects in priority areas defined by the states. CONACYT is involved in the selection of the projects.
- CONACYT launched two public/private partnerships that also fall in the category of support to problem-oriented research, the megaprojects and consortiums programme. They have been very poorly endowed and are little more than policy experimentation.

Over the PECYT period CONACYT became involved in support to business R&D and innovation. This support remained limited in volume and was channelled mainly through:

- The Economy/CONACYT Trust Fund,[27] which benefits from concurrent resources from the Ministry of Economy, supports innovation projects presented by the enterprise sector. Grants are provided to selected projects on the condition of matching funds by the enterprise(s).

- The AVANCE programme to support science-based innovative projects of enterprises during the transition from research to application. The programme's total funding remained limited over the period. It provides grants and, jointly with the Mexican Development Bank (NAFIN), can lower the cost of access to complementary risk capital and guarantee schemes. In principle, supported projects are in areas defined as priority in the PECYT.

While CONACYT's allocation of resources among the programmes it supports and the funds it finances (or co-finances) should in principle reflect the STI priorities defined by the PECYT, the actual allocation pattern shows strong inertia and strong fragmentation. This highlights the fact that CONACYT's initiatives were taken at the margin of its mainstream actions and lacked critical mass. This was particularly the case for programmes in support of applied research or linkages between science and industry. This fragmentation also raises the question of the focus of CONACYT's action and of its role in the overall governance of Mexico's STI system. This question is addressed further below.

3.3.1.3. R&D fiscal incentive

With the support of Congress CONACYT has played a major role in the creation of the fiscal incentive system. The rationale for this system was the need to support R&D and innovation in the enterprise sector not only to raise its competitiveness but also to stimulate demand for R&D and thus leverage linkages with the supply side, in particular with public research institutions, and to stimulate the recruitment of highly qualified human resources by enterprises.

From its inception in 2001 the resources devoted to the R&D fiscal incentive system (in terms of foregone budget revenues) increased eight-fold from MXN 500 million to MXN 4 billion in 2006 (in current MXN).[28] In comparison, total federal direct appropriations for S&T remained largely stagnant at an average of around MXN 33 billion over the period, while government expenditures on R&D grew moderately for an average level of around MXN 26 billion. This highlights a major quantitative and qualitative shift in the Mexican S&T policy mix, particularly as regards the emphasis on support to business R&D.

3.3.2. Priority setting and policy mix

3.3.2.1. Priority setting: reality or rhetoric

While the main challenges affecting the performance of the STI system were increasingly recognised during the period from the 1982 crisis to the end of the 1990s, priority setting in terms of broad policy areas or of S&T areas, target groups and types of R&D and innovation remained ineffective. Lack of prioritisation induced by weak governance hindered the government's capacity to steer the STI system to overcome the "low-level equilibrium trap" and foster the emergence of a virtuous dynamic in which public S&T investment and incentives effectively leverage private investment in R&D and innovation activities to meet social needs and raise competitiveness. Conflicts among interest groups, bureaucratic rivalries and stakeholders' opportunistic behaviour in a context of scarce budgetary resources and weak evaluation processes added to the problem.

Based on a sound diagnosis of the challenges and the obstacles hindering efficient steering of STI policy, the PECYT, the 2002 S&T Law and the Organic Law establishing CONACYT under the authority of the President of the Republic represented a valuable attempt to steer STI policy according to relatively well-defined priorities with adequately endowed and efficiently managed programmes in a context of a political commitment to substantially increase resources devoted to R&D.

In general terms, strategic orientations of the PECYT were not very original: *i)* promotion of state S&T policy through more efficient governance of the STI system with a more prominent role (and more resources) for CONACYT; *ii)* strengthening of national STI capacity through better funding of public research institutions and development of human resources for S&T; and *iii)* raising the innovative capacity of the enterprise sector.

The PECYT proved more innovative in establishing specific funds and programmes, incentive schemes, legislative and regulatory changes, and financing instruments to implement the strategic orientations. It also defined priority or strategic S&T areas that would benefit from a critical mass of resources, dedicated funding programmes, or the use of criteria that favour these areas when selecting projects for support by various programmes or financial instruments.

Strategic S&T areas were selected on the basis of their importance for socioeconomic development, the existence of a critical mass of researchers, the potential to reduce technological dependence, and the opportunities for the creation of internationally competitive businesses (CONACYT, 2001, pp. 95-96). The areas selected were Information and communication technologies, Biotechnology, Advanced materials, Design and manufacturing processes, and Infrastructure and rural and urban development, including their socioeconomic aspects.

While the PECYT expected that investment in strategic areas would be channelled through sectoral programmes, this did not happen largely because CONACYT did not have the necessary authority, in particular to tap sectoral ministries S&T budgets to fund these programmes and participate in their management. As a result, the strategic priorities were diluted in the projects selected, mainly for sectoral funds. Another reason was of course the lack of sufficient public resources in spite of the political commitment to increase Mexico's investment in R&D to 1% of GDP by the end of the PECYT in 2006.

Priority setting therefore was unable to overcome the inertia or opposition of the institutions involved in the governance of the STI system. The FCCyT, which should in principle have at least a consultative role in determining priorities, could not reach a consensus.

CONACYT managed to muster the institutional and financial means to implement one policy priority: support to R&D and innovation in the enterprise sector through the establishment of the fiscal incentive scheme. This was largely due to the fact that the resources to finance the scheme were not subtracted from those allocated to any other fund or support programme.

The PECITI has maintained the principle of setting S&T priority areas in line with the strategic orientations defined by the sectoral ministries and has kept the jointly operated sectoral funds as the main means of implementation.

3.3.2.2. The implicit policy mix

The adaptation of the S&T policy mix to new priorities and the evolution of challenges to the STI system appears largely constrained by institutional inertia, modes of co-operation among funding departments and entrenched interests. This situation cannot easily be overcome with weak governance mechanisms and a low level of resources. The implicit policy mix is apparent in the allocation of resources among funds, support programmes and incentive schemes and in qualitative changes in the regulatory framework that impinge on the performance of actors of the system.

Tables 3.1 and 3.2 show the allocations of S&T resources between CONACYT and sectoral ministries and within CONACYT and highlight the relative importance of various policy areas in the policy mix. They do not include the increasing weight of support to business R&D and innovation through the fiscal incentive. When this is taken into account the main characteristics of the evolution of the policy mix over the period 2002-06 are:

- On average the main component is support for human resources for S&T through the financing of the SNI and scholarship programmes.
- Support to R&D and innovation in the enterprise sector gradually becomes the major component, primarily owing to the fiscal incentive but also to the much more modest Economy/CONACYT Technological Innovation Fund.
- Support to problem-oriented applied research, including S&T infrastructure, mainly to research centres of CONACYT and sectoral ministries is the third largest component. In this category, support to public/private partnerships remained marginal.
- The relative importance of support to basic research, including scientific infrastructure, in public research centres and academic institutions through institutional funding of the Education Ministry and CONACYT and the Education/CONACYT Fund has decreased slightly over time, although resources for SNI also help support basic research;
- The development of regional STI capacities has taken on increasing importance owing to the establishment of the mixed funds and joint funding by CONACYT and the states. The development of innovative clusters has received increasing attention and support.[29]

Changes in the regulatory environment of STI actors, in policy implementation or in the mode of selecting beneficiaries of support programmes can also be seen as ways to modify the policy mix. The changes include:

- The radical shift from direct grant financing to indirect financing measures to support business R&D and innovation in the enterprise sector following the introduction of the fiscal incentives scheme.
- Greater management autonomy for public research centres which allowed them to keep revenue from the provision of S&T services and the results of co-operation with enterprises. The counterpart was a decrease in institutional funding.
- A modest shift in the financing of basic research, with a slight increase in the share of competitive funding of research projects.

3.4. The portfolio of instruments and programmes: a critical assessment

In the PECYT Mexico developed an unusually large number of programmes to support STI activities. They had many eligibility criteria and very cumbersome decision-making procedures. Alone or in co-ordination with other federal government or state bodies, CONACYT manages over 60 funds or support programmes. Given that only around 30% of CONACYT's total budget is devoted to these programmes – most of the rest is committed to financing the SNI and scholarships – many are poorly endowed and more akin to policy experimentation measures than to fully fledged support instruments. Two support programmes that deserve closer attention are the sectoral funds and the mixed funds available to enterprises and research institutions registered in RENIECYT (National Registry of Scientific and Technological Institutions and Enterprises).

3.4.1. Sectoral and mixed funds

3.4.1.1. Sectoral funds

The 17 sectoral funds are financed and operated in conjunction with sectoral ministries to promote STI capabilities according to the "strategic needs" of the participating "sector".[30] In the preparation of the PECYT their creation constituted a compromise between CONACYT and the sectoral ministries for the implementation of the strategic priorities defined in the PECYT. In fact, the selection criteria generally correspond to sectoral ministry priorities, usually defined at a very detailed level.[31] This distorts the selection process. Their budgetary endowments are quite small, averaging less than USD 100 million a year overall (Table 3.4). There is no fixed rule regarding the respective shares of the partners. Except in the case of the funds operated with the Ministries of Environment and of Agriculture, CONACYT is the major funder. The beneficiaries of sectoral funds are public research institutions, universities or research centres, although in principle enterprises are not excluded.

Table 3.4. Budget of the sectoral funds, CONACYT and partners

Total 2002-07, USD millions

	CONACYT	Partner	Total amount
Total sectoral funds	**308.9**	**230.0**	**538.8**
Education/ CONACYT	163.1	80.5	243.6
Environment/CONACYT	18.7	19.6	38.3
Economy/CONACYT	40.8	29.3	70.0
Health/CONACYT	26.9	32.8	59.7
Agriculture/CONACYT	20.0	25.3	45.3
Other sectoral funds[1]	39.4	42.4	81.8

1. Other ministries, including Communications and Transport, and Foreign Affairs.

Source: CONACYT and FCCyT.

Rejection rates are high.[32] Possible reasons are high demand with respect to available funding, poor qualifications of applicants, weak project relevance, bureaucratic conflicts between CONACYT and the partner ministry, and/or unclear criteria. Given the limited

amount of support these funds can offer, high rejection rates are likely to entail very high administrative costs for project selection.

To maintain the priorities set for the strategic areas of the PECYT, there may be a case for replacing sectoral funds focused on thematic research[33] by sectoral priority programmes with a larger contribution from the S&T budgets of sectoral ministries and funding on a competitive basis. This would be in line with practices increasingly observed in other OECD countries, in which the definition of priorities is accompanied by the setting of a budget of pooled resources allocated competitively by a "means agency" with oversight responsibility. This practice would be appropriate for sectoral funds oriented towards thematic basic or applied research, but probably less so for the Education/CONACYT and the Economy/CONACYT funds. It would also allow for more participation of the enterprise sector in projects financed by these funds.

3.4.1.2. Mixed funds

Progressively developed since 2001 and jointly administered and financed by CONACYT and state government bodies,[34] the 32 mixed funds were meant to play a significant role in fostering research and/or innovation capacity at the regional level and in articulating federal and regional STI policies and support programmes. These funds represented 4.2% of the CONACYT budget over the period 2002-06 and financed over 1 600 projects with an average investment per project of USD 1 000. CONACYT's financial contribution to individual projects varies but is never less than 50%. Although the mixed funds constitute in principle a valuable means of federal/state co-ordination, their present record is not strong:

- In many cases they have suffered from a lack of well-defined demand on the part of the states owing (at least in part) to inefficient co-ordination among stakeholders, especially in less developed states. On the whole they have been of greater benefit to the narrowly defined S&T interests of locally established research centres and HEIs.[35]
- The amount allocated per project has generally been quite small and mixed funds have supported a narrow base of projects with limited spillovers to regional innovative capacity.[36]
- Their management and effectiveness have often suffered from lengthy selection and disbursement processes and from a number of states' weak capacity to develop and submit adequate R&D and innovation projects.

In light of experience, their success would seem to depend on several factors:

- enhanced capacity at state level to develop an innovation strategy involving local stakeholders;
- support for projects with critical mass which build on local public S&T capacity to enhance collaboration, notably for technological cluster development as several states have done;
- increased federal support to build such capacity in less developed states;
- streamlining of management procedures.

3.4.1.3. Management issues

More often than not countries that have established funds that are co-financed and managed by different government bodies have encountered problems of implementation. Mexico is no exception and, apart from requiring more substantial resources, the funds need clearer and more efficient rules for managing the schemes. Among beneficiaries there seems to be widespread consensus that, in addition to their limited endowment, sectoral and mixed funds suffer from inefficient management and delayed disbursement of funds to selected projects. Moreover, the advisory panels responsible for screening projects are generally composed of SNI members who may have a bias towards basic research projects. Therefore, decision processes are at times influenced by vested interests and, in the case of mixed funds, they are often complicated by differences in objectives and procedures between federal and state entities. However, CONACYT has recently taken steps to streamline the management of these funds.

3.4.2. Direct support of business R&D and technological innovation

A number of programmes or financing instruments to support business R&D and innovation were developed and implemented in the PECYT. These initiatives have generally had a positive effect on enterprises' investment in R&D and innovation-related activities, as illustrated by the growth of business R&D expenditures over the period and the increasing share of business in the financing and performance of total domestic R&D activities. This upward trend, which highlights important growth in the number of firms engaged in S&T-related activities over the last seven years,[37] has been boosted by the increase in public support. Indeed, between 2002 and 2005 the share of direct government financing of total business R&D investment increased from 1.5 to 5.7% (OECD, 2007f). Moreover, if the budgetary cost of fiscal incentives is added to the amount of direct support, the percentage of business R&D financed by government reached about 25% in 2005 and probably more in subsequent years.

At central level, CONACYT and the Ministry of Economy[38] are the main sources of support for business R&D and innovation, along with some intermediary institutions. In this area there is an important bias in the policy mix: the wide discrepancy between the amount of resources allocated to the fiscal incentive scheme and the amount allocated to other instruments, given the nature and relative importance of market or systemic failures the various instruments are meant to address.[39]

3.4.2.1. The Technological Innovation Fund (Economy/CONACYT Trust Fund)

This fund, created in 2002 under the PECYT,[40] is jointly funded and operated by CONACYT and the Ministry of Economy and provides financial support to innovative projects proposed by individual firms or groups of enterprises. Supported projects should involve the development of new products, services or processes. They are selected on a competitive basis with criteria (or selection preferences) related to priority sectors, linkages with public research institutions, and size of the enterprise. Funding can cover up to 50% of the innovation-related costs and requires matching funds. Selection is made by administrative and expert committees.

Over the PECYT period the fund's endowment remained rather small. Between 2002 and 2006 the fund distributed around USD 63 million, of which CONACYT's share was close to 60%. Rejection rates were high throughout the period, approaching 90% in all but one year.

Funding mainly benefited medium-sized and large firms until 2005[41] and a majority of funded projects involved co-operation with federal or state public research institutions (Tables 3.5 and 3.6) but very little with other firms.

Table 3.5. Distribution of funding by firm size

Percentages

Firm size	2002	2003	2004	2005	2006
Micro	17.4	1.2	10.1	2.4	27.5
Small	24.2	17.6	27.8	26.7	48.7
Medium	40.8	12.9	27.9	31.3	14.6
Large	17.6	68.5	34.2	39.7	9.2
Total	100	100	100	100	100

Source: Based on information from CONACYT.

3.4.2.2. Other direct support programmes

In contrast with the sectoral and mixed funds, the Mexican administration has developed other means of direct support of R&D, innovative activities or technological development, which have proved more efficient in terms of management and co-ordination, and probably more successful in terms of outcomes. Prominent among these are the PROSOFT programme and the SME Fund financed and managed by the Ministry of Economy, and the AVANCE programme developed by CONACYT.

Table 3.6. Projects in co-operation supported by the Economy/CONACYT Fund, 2002-05

Percentages

	2002	2003	2004	2005
Projects with linkages (%)	48.2	49.2	89.1	86.9
Public research centres	44.4	41.9	29.8	30.1
Federal higher education institutions	51.9	12.9	31.6	24.7
State higher education institutions	3.7	38.7	35.1	34.2
Firms	0.0	3.2	0.0	0.0
Others	0.0	0.0	3.5	11.0
Projects without linkages	51.8	50.8	10.9	13.1
Total	100	100	100	100
Total number of projects	56	63	64	84

Source: Based on information from CONACYT.

The PROSOFT programme, which was introduced in 2002, does not specifically aim at fostering R&D or technology capacity building. Its role is to provide support for the development of enterprises in the ICT sector. PROSOFT manages funds from three sources: the federal government,[42] the state government and the companies that submit projects to the programme through "promoting organisations" that facilitate the review and management processes. It is praised by its beneficiaries for the simplicity of its management and the swiftness of its decision and disbursement procedures. Unlike several instruments to support innovation managed by CONACYT, PROSOFT has enjoyed a relatively important and sustained flow of resources.43 Its economic impact is quite positive in terms of job creation, firm creation, technological infrastructure, spillovers and cluster formation, and productivity. The shared interests among stakeholders, their joint participation in the financing of projects and a more "participatory" approach to decision making have probably facilitated the programme's success. A further step would probably be to build upon this success to develop similar initiatives in other priority sectors and use this type of programme as one way to promote regional technological clusters and build linkages with the regional research base.

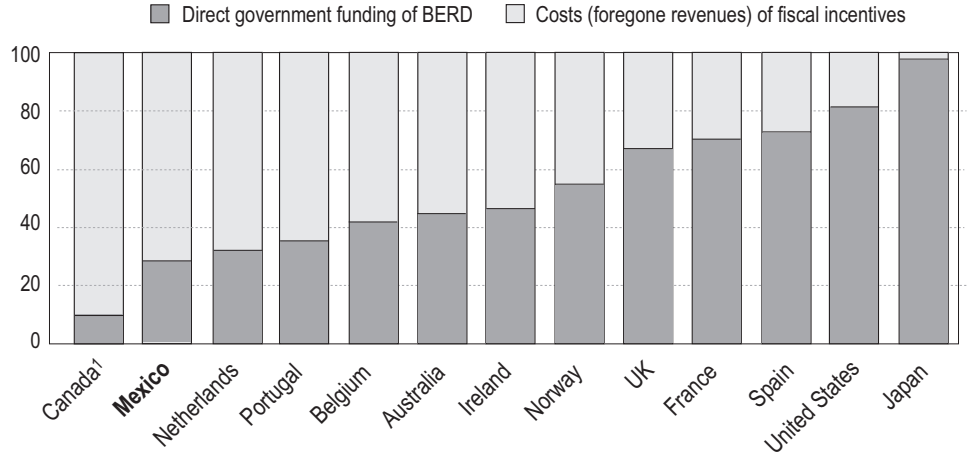
The *SME Fund* of the Ministry of Economy is another notable example of a successful bottom-up initiative by entrepreneurial stakeholders. Although not primarily focused on fostering innovation and technological development, it does have a line of action in this area. It has supported valuable initiatives owing to the role played by intermediary institutions in the design and submission of projects for funding, with matching resources from state and local governments and enterprises. Initiatives supported by FUMEC (the Mexico-United States Foundation for Science) for the development abroad of high-technology Mexican SMEs and the technological upgrading of supplier networks of firms in high-technology sectors dominated by multinationals are particularly noteworthy. The Monterrey Technological Institute for Higher Education (IESTM) and the State of Jalisco have developed high-technology clusters. In spite of limited resources, their leverage and economic impact have been quite high. These examples show that a key to successful support programmes aimed at enhancing the innovation capacity of SMEs in Mexico or at expanding their internal and external markets is reliance on dedicated intermediary institutions, often at the local level, which can efficiently manage projects and channel resources for their implementation. It also shows the importance of decentralised design and implementation of innovation support programmes.

The *AVANCE programme* managed by CONACYT is another example of a well-designed initiative to help technology-based innovative firms (or other entities) to bring new products, processes or services derived from research results to the market in priority areas defined by the PECYT. Well-defined eligibility criteria and operating rules have been developed in consultation with beneficiary stakeholders, decision procedures are clear and disbursement is swift. Unfortunately, the programme has been poorly endowed and the bulk of its resources go to relatively mature projects that are in the later stages of development. The financial components of AVANCE – the provision of risk capital and guarantee funds – are in principle co-financed by NAFIN in the framework of joint trust funds with CONACYT. These funds are new and their endowment is limited. Start-ups are therefore generally excluded from this programme.

3.4.3. The fiscal incentive system

Mexico's use of a fiscal incentive to support business R&D is not an exception among OECD countries. This incentive, introduced in 2001 and amended in 2002 at CONACYT's initiative, was a tax credit amounting to 30% of R&D expenditures to be deducted from corporate tax liability up to an annual ceiling on total credits which is determined each year by law. Over time this ceiling has been raised from MXN 500 million in 2001 to MXN 4.5 billion in 2007. Until it was suppressed in the 2009 S&T budget (see section 3.4.3.1 below) this fiscal incentive was by far the best endowed financial instrument in support of R&D and innovation. In 2006 it represented more than 75% of government support to business R&D. In this regard, Mexico's generosity stood out among OECD countries.[44]

Figure 3.1. Shares (%) of fiscal incentives and direct funding in total support to business R&D, 2005



1. Canada's fiscal incentive is much less generous than Mexico's. Direct support provided by provincial governments can be quite substantial but is not included.

As shown in Table 3.7, the design, management, scope of expenditures covered and "subsidy rates"[45] of R&D incentives vary widely across countries. However, the features of Mexico's system, as well as its weight in the overall public support of business R&D, were quite unusual by international standards.

Global ceiling for fiscal expenditures. Along with Hungary, Mexico was the only OECD country for which an annual global ceiling for total fiscal expenditure associated with the incentive was determined by the Ministry of Finance and voted into law. Apparent reasons for the ceiling may have included the perceived weakness of the tax collection system and the possible magnitude of fiscal fraud or evasion, as well as bad past experience with a multiplicity of tax incentives or loopholes granted to vested interests or to reduce the impact of price adjustments for disadvantaged social groups.[46]

Discretionary management of the incentive. Setting a global ceiling on foregone tax revenues induced by fiscal incentives leads automatically to a selection among project proposals submitted by firms seeking to benefit from the incentives during the year in which the ceiling applies. In Mexico this procedure was managed by an inter-ministerial committee, which included CONACYT and the Ministries of Finance, of Economy and of Education, on the basis of recommendations of panels composed of scientists and technology experts.[47]

Table 3.7. R&D fiscal incentives in OECD countries, 2006

	Volume of R&D	Increment of R&D	SMEs	Extended eligibility or additional incentive	Limitations
Tax credits					
Canada	20%		35%[5]	Extended carry forward	Ceiling of USD 2 million for SMEs
France	10%	40% over past two years	Tax exempt. for young science-based firms	Patents (incl. protection); immediate refund for new firms; double offset for wages of new Ph.D. recruit (1 year)	Ceiling of EUR 16 million a year
Ireland	20%	20%			
Italy	10%		30%	Wages of returning scientists	
Japan	10%		12%		Ceiling of 20% of taxable income
Korea	7%[1]	40%	15 and 50% on increment over four years		10% tax credit for R&D facilities
Mexico	30%			Patents and software	Ceiling of total amount of incentives (USD 450 million in 2007); granting of incentive by project.
Netherlands	4%		42%		Tax credit covers wages of R&D personnel, ceiling of EUR 110 000; subcontracting restrictions.
New Zealand[2]	15%				
Norway	8%		20%		Ceiling of USD 660 000
Poland	30%		50%		
Spain	30%	50% over past two years		Patents and software	Ceiling of 35% of corporate tax
Turkey	40%				
United States		20%		Patents for own research	Ceiling of 25% of tax liability over USD 25 000
Tax allowance					
Australia[3]	125%	175% over past three years		Patents and software	Floor of USD 16 000
Austria	125%	135% over past three years			Ceiling of EUR 100 000 for extramural R&D
Belgium	113.5%		118.5%	50% on wages in public/private collaboration	
Czech Rep.	200%				
Denmark	150% for sponsored R&D at PRI		150% (additional)		Limited to collaborative R&D
Hungary	200 to 400%[4]			Patents and software	Ceiling of USD 260 000; subcontracting restrictions
United Kingdom	125%		150%[5]		Subcontracting restrictions

1. On facilities.
2. Introduced in 2007.
3. Small firms in tax loss position can claim R&D tax refund equal to tax concession.
4. Depending on institution.
5. Small firms in tax loss position can claim R&D tax refund equal to a fraction of cash cost of qualifying R&D (25% in the United Kingdom, 35% in Canada under certain conditions).

The procedure had a number of negative aspects. It was a *de facto* "rationing" that favoured projects presented early in the year, irrespective of their quality; furthermore a disproportionate number of projects were submitted close to the submission deadline; the resulting overcrowding effect reduced the quality of evaluation of latecomers. The rationing effect may also have resulted in the allocation of an incentive lower than the requested amount. This uncertainty may have affected firms' strategic decisions or may have led them to inflate the costs of the R&D expenditures in the project(s) they submitted.

Finally, given the number and the variety of projects submitted for tax credits (3 155 in 2006), it may be asked whether the pool of experts used to evaluate them was sufficient in number and always had the necessary expertise.

These shortcomings were compounded by the fact that, by law, the global amount of fiscal incentives that could be awarded in a given year had to be allocated according to a predetermined quota and certain stated priorities.[48] While it is legitimate to determine priorities for the allocation of public support to industry, a selection process involving more than 3 000 proposals can be difficult, especially since, as is likely, firms tend to design their proposals so as to reflect these priorities. Prioritisation is therefore likely to be counter-productive and to hinder the evaluation process.

Scope and eligibility. Although the eligibility criteria for R&D expenditures were in principle those defined in the OECD's *Frascati Manual* (OECD, 2002), expenditures that have benefited from the incentives encompassed other innovation-related expenditures, technological upgrading and even acquisition of capital equipment for production rather than for research. In fact the selection criteria (which included attraction of foreign investment) have distorted the pursuit of the primary objective of the scheme which was to raise investment in R&D.[49]

Table 3.8. Mexico's programme of R&D fiscal incentives

Number of approved projects and share of amount granted by size of firm, 2001-06

Firm size	2001		2002		2003		2004		2005		2006	
	A	B	A	B	A	B	A	B	A	B	A	B
Large	346	69.6	577	69.9	698	70.1	939	79.7	1 374	80.8	1 058	78.5
Medium-sized	250	26.5	322	22.1	323	20.7	423	14.9	576	12.6	351	14.9
Small	58	3.0	109	6.4	141	8.4	141	3.8	239	4.9	131	5.2
Micro	25	0.9	59	1.6	35	0.8	104	1.5	172	1.8	76	1.4
Total	679	100	1067	100	1197	100	1607	100	2 361	100	1 616	100

A: number of approved projects; B: share of amount granted (%).

Source: CONACYT.

The fiscal incentive system has undoubtedly contributed to the growth of business R&D and the technological upgrading of Mexico's capital-intensive manufacturing industry over the last seven years and in this respect has achieved some of its objectives. However, in addition to the limitations related to its design and management highlighted above, several others call into question its efficiency in addressing the R&D and innovation challenges faced by Mexican enterprises:

- Fiscal incentives are generally used by firms already engaged in R&D and innovation activities in order to develop incremental innovations. Therefore, a disproportionate share of the benefit of the scheme accrued to large enterprises and, to a lesser extent, to smaller ones with experience in R&D management. As illustrated in Table 3.8, in 2006 close to 80% of fiscal incentives went to large

enterprises in a few sectors.[50] Moreover, there was no ceiling on the benefits that could accrue to a single enterprise. SMEs were also disadvantaged by a lack of experience and the cost involved in submitting tax credit requests.

- There is reason to doubt whether there was much "additionality" in terms of investment in R&D that would not have taken place in the absence of the scheme. There was therefore some danger that the system gives rise to windfall profits and rent-seeking behaviour. Since the Mexican system was based on the volume of R&D rather than on its increment over the preceding year(s), the procedure tended to favour projects evaluated positively in the preceding year whether or not they include new R&D and innovation investment. This primarily concerns larger enterprises, often affiliates of multinational enterprises in sectors such as automobiles, chemicals, ICT and metallurgy (Lopez Martinez and Fernández Zayas, 2008).
- By design, the system could not efficiently support the vast majority of SMEs which face risks different from those associated with R&D investment and whose innovation projects do not necessarily involve R&D expenditures. In such cases, matching grants that support innovative ventures seem much more appropriate.

It can be argued that the rationale for and usefulness of fiscal incentives nonetheless exists in Mexico. Moreover, its elimination would send negative signals regarding policy continuity to the business community engaged in innovative activities. However, the re-introduction of fiscal incentives as a specific support scheme should not be envisaged without major design, financing and management reforms. It should be compatible, for tax credit rates, with the recently instituted "Single Rate Corporate Tax" system or IETU *(Impuesto Empresarial a Tasa Única)*. Possible reforms emulating best practices in OECD countries are detailed in Box 3.1.

3.4.3.1. A new package of R&D and innovation support programmes

In the context of the preparation of the 2009 S&T budget, it was decided to suppress the fiscal incentive and replace it by a new package of direct support programmes aimed at fostering R&D and innovation in the framework of the PECITI.[51] This package is endowed with MXN 2.5 billion for 2009 and is funded and managed by CONACYT. A strong component to protect intellectual property rights is built into this initiative which gives a bonus to co-operative projects. The package consists of three support programmes:

- INNOVAPYME supports R&D and innovation activities in projects of micro, small and medium size enterprises (MSMEs) with high value added, preferably undertaken in co-operation with other firms or public research institutions.
- INNOVATEC supports technological innovation projects aimed at raising the competitiveness of enterprises, preferably in co-operation with other firms or public research institutions. It also supports the development of S&T private infrastructure and the creation of private R&D centres.
- PROINNOVA supports R&D and innovation projects in "frontier technologies" undertaken in the framework of public/private co-operation, including public research institutions and SMEs.

All projects supported by these programmes can benefit from additional support for the inclusion of highly qualified personnel in the form of scholarships to holders of master's and doctorate degrees participating in the project for a period of up to 18 months.

Box 3.1. Fiscal incentives: possible reforms

1. Type of fiscal incentive

- *Maintain the tax credit* to be claimed against corporate tax liability as the form of fiscal incentive. Decrease the rate of benefits for volume-based R&D expenditures if an increment-based tax credit is instituted (see below).

2. Design

The system should be designed so as to ensure clarity, stability and low administrative costs of compliance with the rules that govern it. It should not discriminate against any type of firm that qualifies for eligibility, *notably as regards the incidence of the tax reform.*

- *Ceiling of total tax expenditures*. Abolish the ceiling of total tax expenditures as of the next fiscal year.
- *Ceiling of tax credit benefits for eligible enterprises.* Set a maximum tax credit benefit an enterprise can receive (presently large enterprises that benefit from the scheme get an average of USD 950 000 in tax credits).
- *Eligibility criteria.* Adhere strictly to the OECD *Frascati Manual* definition of R&D for tax benefit purposes. Ensure the wide dissemination of eligibility criteria by CONACYT.
- *Eligibility of enterprises.* As is currently the case, all qualifying enterprises subject to corporate taxation should be eligible, irrespective of type of activity. "Anti-fragmentation" rules should be applied to prevent enterprises from artificially splitting R&D expenditure claims among affiliates in order to maximise benefits.
- *Volume-based* vs. *increment-based tax credits.* Introduce a *mixed system with a higher rate for incremental expenditures* with a reference period of three years.[1] Given the costs incurred, the introduction of a mixed system would likely lead to reducing the present rate of tax credit for volume-based R&D expenditures. It is premature to propose tax credit rates for a mixed system but they could be between 15 and 20% for volume-based and between 45 and 50% for increment-based.
- *Targeted incentives.* Innovative SMEs and science-based start-ups face more financing problems than large enterprises, especially in a country like Mexico which lacks an active venture capital market. As in many OECD countries *extra (volume-based) incentives for SMEs seem to be justified* with a carry-forward provision. Similarly an extra incentive could be granted to *R&D expenditures incurred in co-operation with or contracted to public research institutions.* To maintain the neutrality of the fiscal incentive system and avoid duplication with sectoral priority programmes *no particular sector of activity should benefit from preferential tax credits.* Eventually Mexico could also emulate other OECD countries that use their fiscal incentive system to facilitate employment of highly qualified S&T personnel in enterprises, for instance by discounting social security costs or applying a multiplying factor to these personnel wages in the calculation of eligible R&D expenditures.

3. Management

- *Management responsibility.* CONACYT and the Ministry of Finance should jointly manage the fiscal incentive system.
- *Automatic* vs. *discretionary decisions*. The proposed elimination of the ceiling of total tax expenditures and *the institution of a ceiling for beneficiary enterprises* renders the cumbersome and bureaucratic discretionary decision process obsolete. It is recommended to adopt the lighter procedure used in most OECD countries, *i.e. automatic granting of the tax credit* to qualifying firms whose claims satisfy the eligibility criteria. Automatic granting should reduce management costs.
- *Compliance control*. *Develop* ex post *control procedures similar to those applied in other OECD countries.* The main responsibility for conducting these controls, and if needed determining penalties for firms guilty of tax evasion, would obviously be that of the Ministry of Finance but, as in other OECD countries, the institution in charge of S&T policy, CONACYT, should be involved in control procedures or at least be called on to provide advice.
- *Compliance costs.* Good management of the fiscal incentives system implies that all firms that are in a position to qualify for eligibility can actually do so. As mentioned above, compliance costs for submitting tax claims can be particularly high for smaller firms. CONACYT could eventually develop advisory programmes for first-time and smaller claimants.
- *Evaluation.* Introduce a regular evaluation system to monitor the impact of the fiscal incentive on firms' innovation strategy and performance. Link this system with innovation surveys.

1. Increment calculated over the average annual R&D expenditures during the last three fiscal years.

Table 3.9. R&D and innovation stimulus package, 2009

Level of support by programme

Programme (2009 budget)	Enterprise size	Percentage of funding over eligible expenditures			Ceiling of public funding per enterprise (MXN millions)
		Individual project	Consortium project (Enterprises in collaboration with research institutions)		
		% enterprise expenditures	% enterprise expenditures	% consortium expenditures	
INNOVAPYME (MXN 600 million)	MSME*	Up to 35%	Up to 50%	Up to 75%	18
PROINNOVA (MXN 700 million)	MSME Large enterprise	--	Up to 75% Up to 50%	Up to 75%	21
INNOVATEC (MXN 1.6 billion)	MSME and large enterprise	Up to 22%	Up to 30%	Up to 75%	36

* Micro, small and medium-sized enterprises.

Source: CONACYT, *www.conacyt.mx/Estimulos/Index_Estimulos.html*

The annual call for projects under these programmes and the evaluation modalities are the responsibility of an inter-ministerial committee composed of CONACYT and the Ministries of Finance, Economy and Education. CONACYT manages the programmes and the selection of projects in collaboration with the Mexican Association of Economic Development State Secretaries (AMSDE) and the Science & Technology State Councils. Projects are selected on a discretionary basis following consultation with technical committees. Here again, as in the case for sectoral and mixed funds, it may be feared that co-ordination problems associated with programme management and the "valuation" of projects which underpins their assessment and selection will limit the efficacy of the new programmes.

The new stimulus package has a relatively strong emphasis on SMEs and apparently recognises their diversity and the inadequacy of a "one-size-fits-all" approach. This is welcome given the bias against SMEs in the fiscal incentive system. Nevertheless, the package raises the question of the coherence and complementarity (or possible overlap) of the various programmes that support the strengthening of SMEs' technological and innovation potential, in particular between INNOVAPYME, the SME Fund of the Ministry of Economy and the Economia/CONACYT Technological Innovation Fund, on the one hand, and PROINNOVA and the AVANCE programme as regards the support to technology-based firms, on the other.

Before the creation of the new package, support to technology-based firms, in particular new ones, was a weak point in Mexico's policy mix. Only AVANCE and, to a lesser extent, the business accelerators initiative funded by the Ministry of Economy supported the development of research-based innovation activities in high-technology firms. These programmes fulfilled an important mission but were also under-funded and provided few opportunities for researchers from public research institutions to create high-technology firms or spinoffs. In this regard, beyond the stimulus package, more attention and support should be given to access to financial markets and the development of financial products (*e.g.* seed and venture capital) adapted to the creation of this category of firms.

Support to pre-competitive R&D projects undertaken in partnership by industrial firms and public research institutions (see section 3.4.4), including academic research centres, can also play an important role in the development of high-technology firms and academic spinoffs, as demonstrated by the experience of many OECD and non-member countries. In this context, the Israeli MAGNET programme is particularly interesting owing to the simplicity of its management (see Box 3.2).

Box 3.2. Israel's MAGNET programme

The objective of the MAGNET programme,[1] launched in 1994 and managed by the Office of the Chief Scientist of the Israeli Ministry of Industry, Trade and Employment, is to strengthen industrial companies' capacity to draw from a vast and varied research and technological pool, giving them the capability to develop innovative, high value-added products with important export potential. It has contributed significantly to the creation and initial growth of new technology-based firms, a process which has been particularly dynamic in Israel. [2]

The programme provides financial support to "pre-competitive" R&D projects developed jointly by enterprises and academic research institutes organised in the framework of a consortium specifically dedicated to the project and governed by "collaborative agreements" among parties. The intellectual property rights derived from technologies developed by a consortium belong to the members that developed it; however other members receive at no charge a licence to use the technology for further development of their own products.

Eligibility, management and selection criteria

- Every Israeli industrial entity can apply; consortia must be formed as legal entities with non-profit status. There is no limit on the number of companies participating in the consortium. There is no sectoral criterion.
- Projects presented by consortia are selected by the MAGNET Committee headed by the Chief Scientist, Ministry of Industry, Trade and Employment. The majority of members are external to his/her office.
- Projects are selected on the basis of: *i)* expected innovation output; *ii)* expected returns (benchmark is USD 10 in expected sales for USD 1 of R&D investment); *iii)* potential exports; and *iv)* academic contribution and partnership contributions. The MAGNET Committee checks if the consortium has the financial and human resources to carry out its proposed project.
- Outcomes are evaluated on a yearly basis with an impact on the following year's financing; a more in-depth evaluation is undertaken after three years. A comprehensive evaluation of the programme is carried out every seven years or so.

Funding

- The annual budget of the MAGNET programme is around USD 60 million to be disbursed as grants to the selected consortia (about 20% of total direct support to industrial R&D in Israel).
- Project expenses eligible for financing by the MAGNET programme are: salaries to the direct employees of the consortium plus overhead; research equipment and materials; patent- and licence-related costs.
- MAGNET grants to enterprises can amount to 66% of the approved budget. The consortium adds the rest, with the breakdown determined by the members of the consortium.

1. MAGNET is the Hebrew acronym for "Generic Pre-competitive Technologies and R&D".
2. Most of the approved consortia are in the areas of ICT, mechatronics, pharmaceuticals, and health and biotechnology.

3.4.4. Strengthening collaboration and linkages between public research and industry

3.4.4.1. Collaboration and partnerships

In Mexico, policies and support programmes focusing explicitly, as their primary objective, on fostering collaboration between enterprises and public research institutions for R&D and innovation activities have been weak. In this area, most current policy instruments support collaboration indirectly, to the extent that they include collaboration as a criterion of project selection in programmes with other priority objectives. This is particularly true for the former fiscal incentive system, the mixed funds and most of the sectoral funds. It also applies to the stimulus package introduced in 2009. Unfortunately, and probably in part owing to the low level of financing of the funds, the preferential treatment supposed to be given to collaborative projects has not yielded the expected results, with the exception of the Economy/CONACYT Fund (Table 3.5). The much better endowed fiscal incentive scheme did not effectively contribute to collaboration with public research institutions (Lopez Martinez and Fernández Zayas, 2008).

This highlights a principle that is particularly relevant in the Mexican case: support instruments should focus on the priority issue they are designed to address and not seek to meet a multiplicity of objectives. At the same time, however, those specifically designed to promote collaboration between public and private institutions, such as the competitive "Consorcios" programme launched in 2003 in the framework of the PECYT, have been rather unsuccessful. Factors in this relative failure include the lack of medium-term commitment, weak involvement of public and private stakeholders in the design of the programme, and, as elsewhere, poor funding. Industry-science relationships would be more efficiently fostered in the framework of well-funded dedicated programmes or instruments designed with the involvement of stakeholders.

Among such programmes public/private partnerships for research and innovation (P/PPs) figure prominently (see Box 3.3). These have a strong leverage effect on both public and private investment in R&D and their share in total public support to R&D and innovation has generally increased over time. This approach was emulated in Mexico in 2007 with the launch of the Strategic Alliances for Research and Innovation programme (AERIs) under which CONACYT awards competitive grants to projects jointly presented by at least two enterprises and two public research institutions.

With its strong focus on collaborative projects and its substantial endowment, the new PROINNOVA programme signals a renewed emphasis on public/private partnerships in Mexico's S&T policy. It is to be hoped that the efforts undertaken will not be compromised by co-ordination and management failures, as several government bodies are once again involved in the selection and implementation of projects. It also remains to be seen how the complementarity between the PROINNOVA and the AERIs programme will be managed.

Other actions rely on incentives provided by institutional reforms such as those on the mobility of researchers and the development of technology transfer or licensing offices (TTOs and TLOs) in research institutions receiving public funding.

Box 3.3. Public/private partnerships for research and innovation: a high-leverage public support instrument

An important conclusion of recent OECD work on the role of government in fostering knowledge-based growth is that greater use of public/private partnerships (P/PPs) can enhance the contribution of science, technology and innovation policy to economic performance. P/PPs for research and innovation offer a framework for the public and private sectors to join forces in areas in which they have complementary interests but cannot act as efficiently alone (risk sharing and mutual leveraging effects). They can fill some gaps in innovation systems more effectively than other policy instruments.

P/PPs are unique tools to promote collaborative research in areas where innovation is deeply rooted in science:

- Major programmes to promote strategic R&D co-operation among universities, public research institutes and private firms have been launched or reinforced in many OECD countries since the late 1990s, following the pioneering examples of the Australian CRC and Swedish Competence Centre programmes (*e.g.* Kplus and Kind/Knet in Austria, the Innovation Consortiums in Denmark, the National Technological Research and Innovation Networks in France, the Technology Leading Institutes in the Netherlands, and the CENIT programme in Spain).

- P/PP is the best approach to building innovative networks in new multidisciplinary research fields, either as stand-alone initiatives (*e.g.* Genomics in the Netherlands) or as part of broader P/PP programmes (*e.g.* nanotechnology, Gehomme and Genoplante networks in France, and the Kplus centre on bio-molecular therapeutics in Austria).

In addition to providing effective springboards for frontier and pre-competitive R&D in areas of strategic importance, P/PPs can contribute to other objectives and yield broad benefits:

- *Input, output and behavioural additionality*. Cost-sharing arrangements and industry leadership within P/PPs (as in the case of Spain's CENIT programme) translate into high leverage of public support on business R&D and innovation. P/PPs have also a lasting effect on the behaviour of public and private researchers, by contributing to build trust and personal networks that facilitate further formal and informal co-operation.

- *New avenues for commercial spillovers from public research*. P/PPs provide participating firms with easier access to public research outputs and facilitate the creation of new technology-based firms, especially spinoffs from public research, as well as the mobility of human resources between the public and private sectors (*e.g.* Israel's MAGNET programme, see Box 3.2).

- *Linking SMEs with scientific research*. Most innovative SMEs find it difficult to establish direct contacts with universities and public labs. P/PPs can play the role of effective bridging institutions (*e.g.* ProInno in Germany).

- *Increased synergies within and between regional innovation systems* (*e.g.* Korea's Regional Innovation Centre programme). National P/PP programmes can enhance co-operation between local innovative clusters in order to ensure critical mass and better exploit complementarities.

Whereas P/PPs can potentially achieve what other policy instruments cannot, handling them is a delicate matter since the partners must engage in sustained co-operation with partners from different managerial cultures and partly conflicting goals. OECD work points to the following critical factors for success:

- Long-term commitment from both government and industry, based on a shared vision.

- Critical mass but also depth of the national and regional innovation systems. P/PPs should not create "high-technology islands" but be embedded in local and regional innovative clusters, and benefit innovative SMEs as well as large firms. Programmes to promote large P/PPs can be complemented by measures to support smaller P/P research teams (*e.g.* Austria's CDL programme, Australia's ARC Linkage Grants and Fellowships programme).

- Building on existing networks without neglecting areas in which potential actors are still dispersed (*e.g.* multidisciplinary research) and/or inexperienced in accessing government support.

- Efficient steering mechanisms that ensure a sustainable balance between public and private interests, especially: *i)* competitive selection of projects and participants; *ii)* optimal financing; *iii)* efficient organisation and management; and *iv)* rigorous evaluation.

As compared with more advanced countries and major emerging economies (*e.g.* Brazil[52] and China) the development of such offices is slow in Mexico and the rules that govern the management of IPRs by public research institutions and the appropriation or allocation of the proceeds should be clarified. In this respect, the recently created IMPI/CONACYT Fund is a welcome initiative that should facilitate the development of TTOs and TLOs in, or attached to, Mexico's public research institutions.

3.4.4.2. Linkages and intermediation

For the overwhelming majority of firms, notably SMEs, the benefits to be gained from interaction with public research institutions cannot be derived from collaborative R&D and innovation activities. Expected benefits come from technology diffusion and transfer activities. In Mexico these activities are mainly developed by:

- CONACYT and sectoral ministries' research centres. The broader management autonomy granted to these centres (see below) has led them to develop more actively their activities related to the provision of technological services;
- intermediary institutions financially supported by sectoral ministries, such as the System for Technological Assistance to Enterprises (SATE), the Technological Accelerators initiative (TECHBA), the Centres for Productive Articulation (CAP) supported by the Ministry of Economy, or the PRODUCE and COFUPRO Foundations in the agricultural sector.

While there is certainly a rationale for supporting the supply of technological services by PRCs and subsidised intermediary institutions, it can be argued that this hinders the emergence of more open technology markets in which certified private brokers could compete with – or complement the action of – public or publicly supported institutions. In Mexico, as in many countries, this raises the question of the right balance between the support of supply and of demand for the provision of technological services.

3.4.5. Emergence of technological and sectoral innovative clusters

Although Mexico does not have an explicit technological cluster policy, policy initiatives at the federal, but perhaps more importantly at the state or municipal levels, have facilitated the emergence of technological and/or sectoral clusters in states such as Jalisco (electronics and high value added food and agro-industries), Guanajuato (biotechnology for agriculture and traditional industries), Nuevo Leon (software and electronics), Queretaro (machinery) and Baja California Norte (micro-electronics and biotechnology).

These clusters have benefited from support measures jointly funded at the federal (CONACYT and the Ministry of Economy) and state levels, often with matching funds from industry. However, a prerequisite for their success appears to have been strong participation of concerned business associations and intermediary organisations. Together with state and municipal authorities, these have fostered the development of technological infrastructure, human capital and knowledge transfers in collaboration with local higher education institutions and public research centres.

The consolidation of technological clusters is particularly important for strengthening regional innovative capacity and necessitates further action. Indeed, experience with cluster development highlights the catalyst role that government policy can play in promoting regional innovation when:

- there is strong commitment and involvement of local public and private stakeholders who put investment in knowledge at the centre of their social and economic development strategies;
- decentralised bodies lead the management of jointly funded programmes;
- attention is given in priority to technological infrastructure, in particular ICT, metrology, standards and managerial capacities, and to the organisation of knowledge spillovers and transfers between public research and industry and among enterprises participating in the cluster.

Building upon the experience and achievements of the cluster approach, the opportunity should now be seized to integrate it into a broader vision of regional innovation systems. This implies strengthening endogenous innovation capacities at local and regional levels through co-ordinated and complementary investment by the municipal, state and federal levels in S&T infrastructure for well-defined technological or sectoral priorities. This also requires removing constitutional or legal obstacles that impede co-operation among states or between municipalities in different states, such as the Federal Planning Law.

3.4.6. Public research

Mexico has a well-developed and diversified public research sector. It is geographically highly concentrated and its performance in terms of its contribution to S&T development and innovation is hindered by important management rigidities, overall resources constraints and research funding allocation procedures. However, institutions such as CINVESTAV, IPN and laboratories of some larger universities demonstrate that when these rigidities and constraints are overcome, achievements in scientific production, collaboration with industry and contribution to innovation can be remarkable.

Some reforms of the public research sector have occurred in recent years. They mainly concern the governance of CONACYT research centres and the development of S&T infrastructure in the context of efforts to decentralise higher education institutions. More need to be undertaken, notably as regards financing patterns and, eventually, the SNI.

3.4.6.1. Governance of public research centres: an unfinished process

CONACYT's and sectoral ministries' public research centres remain institutionally under presidential authority and are governed by the S&T Law and the Law on Para-public Entities. In recent years several changes in the governance and financing of these centres have led them to take a more proactive approach.

PRCs can now co-operate with public and private firms, realise joint projects with them, form technology-based firms and use resources obtained from the provision of S&T services, proceeds from collaboration projects with industry, and donations for scientific research and technological development. Most PRCs have increased the share of self-financing in their overall budget.[53] PRC researchers may participate in research projects with other (private) entities and receive income for their participation.[54] Legal modifications introduced in 2006 empower PRCs' governing organisms to establish the conditions of use and appropriation of their researchers' results and to set rules of confidentiality when profitable knowledge is generated in the framework of collaborative projects with industry or in technology-based firms created by PRCs. Further reforms are

needed, in particular in the regulatory framework that makes investment in equipment and personnel management still largely subject to centralised control, as this tends to adversely affect contractual arrangements with private enterprises and the management of intellectual property.

The institution of "performance agreements" established a governance mechanism which includes appraisals and accountability to increase transparency and induces the centres to give priority to research and technological activities or programmes with acknowledged social or economic relevance.[55]

The missions, governance and modes of financing of PRCs should evolve as the innovation system matures. Some should forge stronger links with the academic sector in their research and training activities and others with industrial associations more interested in applied research and the training of engineers and technicians that the centres can provide. However, the diversity of PRCs' missions means that greater management autonomy must be predicated upon the implementation of performance evaluation mechanisms and the generalisation of common governance structures or charters. In this regard, public research institutes co-ordinated by sectoral ministries should be subject to the same type of performance agreements as those of CONACYT centres. This would probably help increase transparency in S&T activities funded by the sectoral ministry responsible for their management and ensure greater efficiency in terms of research productivity and expected social benefits.

3.4.6.2. Patterns of financing, evaluation and accountability

The financing of public research come mainly from CONACYT's and sectoral ministries' funding allocation to public research centres, the Education/CONACYT Basic Science Fund, institutional funding of higher education institutions (HEI) by the Ministry of Education, and complementary income for SNI researchers.

Over the PECYT period the total budget for public research stagnated (except for the financing of the SNI). While resources devoted to problem-oriented research in PRCs have grown slightly, especially if proceeds from technological services offered by PRCs are included, those allocated to the Basic Research Fund have been on a downward trend since 2002, when CONACYT was separated from the Ministry of Education.[56] However, if problem-oriented research remains a priority, this should not adversely affect curiosity-driven research. In a virtuous circle, the latter nurtures the former at the same time as its agenda is increasingly driven by the former. The modalities of financing should strengthen this virtuous circle. The policy mix and the governance structure that support public research institutions have to evolve accordingly.

The volume of resources devoted to public research should increase and its allocation should ensure that funded research activities make an efficient contribution to the generation of knowledge, the training of highly skilled personnel, the solution of collective problems, and the strengthening of the innovation capacity of the productive sector. To this end, a better balance should be struck between institutional funding, competitive funding and other sources of funding. A growing share and volume of resources should be devoted to competitive funding through the restructuring of sectoral funds that support basic and applied research, which are presently financed and managed by CONACYT in co-ordination with the Ministry of Education and other sectoral ministries.

Institutional funding of public research is too limited, as it essentially only covers salaries and other current costs. Institutional funding[57] should probably continue to evolve according to traditional quantitative criteria (*e.g.* size of institution, salaries, training activities and current costs), but a non-negligible share should help finance discretionary research (including research infrastructure) in areas of specialisation defined by the institutions. Following best practices in other countries, the magnitude of institutional funding should be based on the results of periodic evaluations, with emphasis on the quality of research according to academic standards, as well as criteria pertaining to the contribution of researchers and other highly qualified S&T resources to innovation performance (*e.g.* patents and relationships with industry).[58] Moreover, increases in institutional funding should continue to be examined in light of the need to further decentralise research activities. Endowed with the appropriate resources, the Ministry of Education should continue to be responsible for the management of institutional funding of academic institutions.

Like large public institutions responsible for research funding in other countries, such as the US National Science Foundation, CONACYT would be responsible for the *competitive financing* of two categories of research projects:

- One covers the so-called "blank" projects that are selected on the basis of criteria of research excellence irrespective of scientific discipline, with an emphasis on collaborative projects. The source of finance would be the Education/CONACYT Fund for basic research, and its budget should increase in line with the country's evolving scientific potential.[59] Management should be entrusted to Conacyt to avoid delays in disbursement. The competitive selection of projects should give a clear premium to collaborative ones[60] and consideration should be given to an extension of the time horizon of funded projects.

- The second covers research projects submitted in the framework of research and innovation priority programmes defined in the PECITI. The source of finance for such projects would be a consolidated fund encompassing the resources previously available under the sectoral funds. This fund could be under the main responsibility of CONACYT in order to reduce the problems of co-ordination and dilution of responsibility that presently hamper the efficient management of the sectoral funds. The fund would finance medium-term research and innovation programmes[61] with emphasis on public/private partnerships such as those launched in the framework of the AERIs. Their management would be entrusted to a consortium of partners. Other countries that have funded such schemes with sufficient resources have found that they give public research institutions a strong incentive to reorient their scientific activities towards problem-solving research more closely related to innovation. An added benefit is a resource multiplier effect due to mutual leveraging of public and private resources. However, as emphasised above, the successful implementation of such programmes and of other forms of co-operation with the private sector requires a lessening of the stringent constraints on the hiring and mobility of research personnel and the purchase of equipment as well as less bureaucratic monitoring of implementation.

- Other sources of finance for public research should be more actively sought, in particular those stemming from international co-operation as part of CONACYT agreements. Public research institutions should also be encouraged to develop their own international collaboration networks and regulatory obstacles that hinder such developments should be removed or lessened.

Box 3.4. CINVESTAV's National Laboratory of Genomics for Biodiversity – LANGEBIO

Mexico is one of the world's countries with the highest degree of biodiversity. This genetic diversity represents an invaluable asset and a strategic advantage for crop improvement and biotechnological developments. The development of new technological platforms in the last 15 years, such as genomics, proteomics and metabolic profiling, has tremendously facilitated gene discovery, the identification of active compounds for medicine and the development of biotechnology-based industrial processes. To exploit the potential of Mexico's biodiversity it was necessary to create the human and physical infrastructure to carry out complex functional genomics projects. In this context the Mexican government decided to create a research unit to exploit functional genomics for the sustainable management of the country's biodiversity.

The creation of this unit, the National Laboratory of Genomics for Biodiversity (LANGEBIO), was proposed by internationally recognised scientists with experience in genomics[1] from the Irapuato Unit of Mexico's Centre for Research and Advanced Studies (CINVESTAV) in the State of Guanajuato. A formal proposal was submitted to the Mexican federal government.

It had the following major objectives: the development of a research unit capable of carrying out world-class research on the biotechnological utilisation of Mexican biodiversity, the provision of genomic services to national research organisations and enterprises, an effective programme for intellectual property protection and technology transfer and a solid programme of public awareness of biotechnology. The proposal included the acquisition of state-of-the-art scientific equipment, the creation of 70 permanent positions, including 18 principal investigators, technicians and support staff and the construction of new buildings.

In 2005, in an unprecedented action for Mexican science, three federal departments (CONACYT and the Ministries of Education and Agriculture) together with the Government of the State of Guanajuato signed an agreement to provide the USD 50 million required for construction, acquisition of all required equipment and creation of the new positions needed for the activities of LANGEBIO.

In spite of the difficulties imposed by Mexico's legal and regulatory framework for public spending and acquisitions, at the beginning of 2006 a state-of-the-art genome sequencing facility, undoubtedly the best in Latin America, was established in provisional laboratories provided by the Irapuato Unit of CINVESTAV. In parallel, Enrique Norten, one of Mexico's most prestigious architects, was chosen for the construction of LANGEBIO´s new buildings. An international search to hire new staff members was initiated in 2006.

The scientific challenges also began early on with a request by the Minister of Agriculture for the sequencing of the gene encoding regions of the maize genome. Gene enrichment techniques, high-throughput Sanger and pyrosequencing strategies and efficient bioinformatics platforms for assembly and gene annotation had to be established. Over 7 billion bases of whole and gene-enriched maize genome were sequenced and approximately 50 000 maize genes (excluding those encoded by transposable elements) were characterised. More recent projects include the sequencing of the transcriptome of chilli peppers, the fungus *Trichoderma atroviridae,* agave and avocado, as well as LANGEBIO's participation in an international programme for sequencing and annotation of the complete genome of *Trichoderma viridae* and *Trichoderma atroviridae*. Global gene expression analysis of drought-tolerant and fertiliser-use-efficient maize varieties is also under way.

The LANGEBIO initiative has so far been a success. The federal and the Guanajuato state governments have responded positively to a bottom-up initiative. An impressive scientific infrastructure has been developed and a world-class research team assembled. It has created new knowledge with important patented applications in the health, agriculture and industrial areas. This infrastructure is also contributing to the provision of technological services to enterprises and facilitating the development of a biotechnology cluster in Guanajuato. However, owing to budgetary constraints, the investment in facilities, equipment and human resources is progressing at a slower pace than anticipated. Longer-term financial commitment has to be secured to support the priority given by Mexico to biotechnology as an important component of economic and technological development in the PECITI.

1. Drs. Luis Herrera, Jean Philippe Vielle, Alfredo Herrera and Octavio Martínez.

In Mexico, with the exception of the SNI and projects funded by the Education/ CONACYT Fund, *ex post evaluation* of the results of research activities is rare. Too often it merely involves checking that the operating rules have been respected and budgetary control. Evaluation needs to be developed in line with best practices in other OECD countries. The counterpart of autonomy and increased resources is greater *social and economic accountability*. *Ex ante* evaluations of project submissions should follow best practices of peer review involving international experts, and *ex post* assessments of outcomes should affect future funding patterns.

3.4.6.3. S&T infrastructure and decentralisation

The development and maintenance of advanced scientific and technological infrastructure has long suffered from low priority and limited sources of funding, in part owing to severe budgetary restrictions. Only recently has this situation begun to change, with a doubling of federal investment between 2002 and 2006. This has helped to facilitate the decentralisation of S&T capacities. The current trend to link the granting of increased institutional resources to PRCs and HEIs, at least in part, to a regionalisation of their facilities should be maintained if not reinforced. The financing of S&T infrastructure should be an integral part of planning and budgeting public investment in S&T, especially when a larger part of resources for research projects is to be allocated through competitive funding processes.

More account should also be taken of the possibility of states' contributions to physical infrastructure and to the value added by other scientific facilities when developing local centres of excellence. The respective efforts of the federal and state levels will of course differ depending on the states' levels of development. As state governments receive larger budgets under the recently implemented fiscal reform, their participation in the financing of S&T infrastructure and projects should probably increase, at least in the most developed states. In a number of instances, state governments have indeed contributed funding in addition to the federal resources endowments. An emblematic case is the CINVESTAV National Laboratory of Genomics for Biodiversity (LANGEBIO) established in 2005 in the State of Guanajuato with joint funding from the state, CONACYT and the Ministries of Education and Agriculture (Box 3.4).

3.4.6.4. Reforming the SNI: a long-term challenge

As noted earlier, without the creation of the SNI in 1984, centrally managed by CONACYT and financed on its budget since 2002, the level of excellence of Mexico's research activities and the number and diversity of internationally recognised researchers would not be what they are today. However, if it remains unchanged, this unusual system, which absorbs a third of CONACYT's budget, may present long-term risks. While its role in developing a high-quality research base and ensuring the attractiveness of research careers should be preserved, reforms are needed to address the nature of the evaluation criteria used, the management and funding of the system, and the dangers of an ageing research community. In the longer term, the reform process could lead to the adoption by research institutions of remuneration patterns based on nationally defined standards:

- First, the *criteria of excellence* should not be restricted to scientific publications but should include contributions to research-based innovation developed either in research institutions or in collaboration with the private sector.[62] There are welcome initiatives in that direction. More credit might be given to research work

carried out in international teams or networks, and the links between collective research and individual rewards could be reconsidered.[63]

- Second, *financial rewards* in the form of a non-taxable complement to remuneration should eventually become part of researchers' regular salary once they have been confirmed at the same SNI level over a certain period. This is obviously a delicate issue with important budgetary consequences in terms of pension provisions and would require changes in labour laws governing public servants as they apply to SNI members.[64] It would change the salary scales of researchers in public research institutions and help deal with the pension issues that contribute to the ageing of the researcher community. It would also be in line with a reform that would give researchers teaching responsibilities beyond those related to the training of postgraduates. While the obstacles are daunting and such changes would be difficult to implement in the short to medium term, there is no reason why Mexico's practices should be so different from those of other countries with a strong scientific base.
- Third, while *selection procedures* might continue to be centrally managed to avoid moral hazards, evaluation committees should increasingly include members of the international scientific community. The increased costs could be compensated by reducing the frequency of evaluations relating to promotion to higher SNI levels. The inclusion of expatriate Mexican scientists in evaluation panels is a good move in this respect.
- Finally, in a longer-term perspective, the possibility of moving towards a more decentralised system in which the management of rewards would increasingly be devolved to the research institutions themselves, which have an incentive to promote the quality and relevance of their research, should not be excluded. The management of the system would remain with the institution with oversight responsibility for a research base defined by its excellence and social relevance. Funding, however, would come from government bodies with responsibility for personnel. In this case, the Ministry of Education would eventually incur most of the costs and would either transfer resources to CONACYT or make disbursements according to the results of evaluation procedures overseen by CONACYT.

3.4.7. Development of human resources

In spite of the instability of its STI policy over the last two decades, Mexico has maintained its efforts to develop skilled human capital. As illustrated in Table 3.3, this is the area that receives by far the largest amount of funding in CONACYT's budget. These efforts have paid off in some respects even if the achievements need to be put in perspective given the small percentage of students enrolling in tertiary education. Mexico's share of science and engineering graduates in all newly awarded tertiary degrees is above the OECD average; the number of doctorates awarded, while quite small by international standards, has doubled since 2000 and more than trebled in engineering and technology.

These efforts need to be maintained and expanded, but the attention to supply needs to be complemented by efforts on the demand side, as envisaged by the PECITI.

3.4.7.1. The postgraduate scholarship programme is bearing fruit

In one form or another, this programme has been in existence since the early 1980s and, through a continuous learning process, its operation and administration have gradually improved. To date it has benefited more than 150 000 students[65] and it is currently the most important source of funding for Mexicans interested in pursuing postgraduate studies either in Mexico or abroad. In recent years the number of scholarships has increased and they have been more regionally balanced. In the current budgetary context, however, the number is levelling off, particularly as concerns scholarships for postgraduate studies abroad.[66]

This programme has demonstrated its usefulness but may nevertheless call for improvements in terms of its financing modes, selection criteria in terms of scientific disciplines, and likely imbalances in the labour market for scientists and engineers. The introduction of a greater degree of selectivity in CONACYT's scholarships may be in order. Some states have developed similar programmes and tend to award scholarships in disciplines related to their areas of comparative advantage or to areas they wish to strengthen. This approach should be emulated at the federal level. With the use of improved prospective methods, an effort should be made to anticipate possible imbalances in supply and demand for human resources for S&T, notably in strategic areas that benefit from R&D and innovation support programmes. Concurrently, information surveys on the professional trajectories of scholarship beneficiaries should be developed to provide indicators which can be included in the existing National System of Evaluation of Quality of Postgraduate Studies.

3.4.7.2. The Excellence Postgraduate Programme[67]

In a context of rapid growth of enrolment in postgraduate studies in a country with a strong tradition of autonomous HEIs, quality control of training is of utmost importance. In 1991, under the aegis of the Ministry of Education, CONACYT launched the National Postgraduate Programme to ensure and enhance the quality of postgraduate studies. HEIs' postgraduate programmes were assessed with a view to organise a Register of Excellence, and scholarships are granted to all students enrolled in registered programmes. In 2006 of the 183 HEIs offering 614 doctoral programmes only 37% (214) were registered in the Excellence Postgraduate Programme.

It can be argued that to ensure a better link between academic training in S&T disciplines and the needs of the labour market for highly skilled personnel, industry representatives could participate in evaluation of postgraduate programmes. Surveys could also be regularly undertaken to monitor the career paths of students who received scholarships.

3.4.7.3. New initiatives in support of the mobility and insertion of HRST

The recently introduced IDEA programme fosters the insertion of highly skilled S&T personnel (at master's and doctorate levels) in enterprises. It lowers hiring costs by granting scholarships to participating personnel and is a sound initiative. It is however too soon to evaluate its results and to determine whether the chosen mode of financing

(scholarship) is the most appropriate for ensuring the sustainability of S&T employment in the private sector, as compared to instruments used in other countries.[68]

CONACYT and some state governments also provide continuous training stipends to allow enterprises' skilled personnel to update and develop their qualifications by taking a leave of absence from their employers to take training courses in HEIs or public research centres. More flexibility should be introduced in these programmes to better adapt the training periods and curricula to the needs of the candidates and the requirements of the enterprises.

Mobility from public research institutions to the private sector, even for relatively short periods, is still hindered by regulatory or legal obstacles related to the civil servant status of these institutions' personnel.

3.4.7.4. Attraction and retention of expatriates and foreign talent

Unlike countries such as India or China, portrayed as able to benefit from the inflows of former expatriates, mostly from the United States, Mexico's capacity to do so seems rather modest; similar conclusions would apply regarding attraction of foreign highly skilled workers to the country.

The Programme in Support of Science in Mexico (PACIME)[69] launched in 1991and financed by a World Bank loan matched by the Mexican government included a facility to invite Mexican doctoral graduates from foreign institutions and interested Mexican and foreign scientists working abroad for permanent or medium-term stays in Mexico.[70] This facility was very successful in the 1990s. Not only did it attract a significant number of Mexican and foreign doctoral degree holders (mainly from the Soviet bloc), it also encouraged national state universities desiring to enhance their research capacities to enlist the services of these repatriates and foreigners. Unfortunately, this apparent success was short-lived.[71]

In 2003 CONACYT set up the Institutional Consolidation Programme (PCI)[72] which included support for postdoctoral stays, repatriation and retention, and some mobility for Mexican scientists abroad. However, budget constraints and the priority given by CONACYT to other human resource development programmes have resulted in extremely slow progress. Yet, there is little doubt that in light of the rapid internationalisation of science and innovation networks Mexico should step up its efforts to attract foreign scientists to its public research institutions beyond current actions in the framework of bilateral scientific co-operation agreements.

3.4.8. Policy fragmentation and co-ordination failures

Well-meant efforts under the PECYT to make STI policy more coherent through better adapted institutional set-ups and support programmes suffered from problems of *co-ordination, dilution of responsibilities and fragmentation* of often underfunded programmes, especially those jointly funded and managed by CONACYT and sectoral ministries. The roots of the problem are many:

- A main problem is the fact that support programmes were designed and implemented less according to policy objectives based on a sound diagnosis than as a result of compromises regarding management and funding responsibilities between CONACYT and sectoral ministries and/or state governments. Such a situation is bound to generate significant inefficiencies due to transaction costs,

administrative rivalries and bureaucratic obstacles, with the programme beneficiaries as the ultimate victims.

- Necessary compromises between government bodies that jointly fund and manage support programmes often lead to the definition of operating rules or selection criteria that reflect a multiplicity of objectives, some open, some hidden.[73] A one-to-one correspondence between objective and programme or financial instrument is generally preferable for efficiency and effectiveness reasons.
- Many support programmes lack the critical mass needed to be effective. When resources are scarce and there is an objective need to reach compromises among agencies or ministries jointly involved in policy design, funding and management, as was and still is the case in Mexico, compromise leads to fragmentation and underfunding of individual programmes supporting STI activities, with many eligibility criteria and very cumbersome decision-making procedures.
- Discretionary procedures that govern the selection of projects and the absence of transparency as regards administrative and technical decision criteria often lead to lack of visibility of support programmes and opportunistic behaviour of stakeholders applying for support.
- Finally, there is confusion between the different functions of policy design, programme funding and programme or financial instrument management. These distinct functions call for different types of political, administrative or technical responsibilities but are too often concentrated in the same government bodies in Mexico.

3.4.9. An unbalanced policy mix

In most countries the governance structure of STI policy and the relative power of major stakeholders (*e.g.* government agencies, research institutions, academic and business sectors) influence the mix of financing instruments and funding programmes designed to enhance the performance of the innovation system. This influence has been, and continues to be, particularly strong in Mexico. Against the general background of limited budgetary resources for S&T, governance issues concerning the respective roles of CONACYT and other ministries and their co-ordination in the design and implementation of STI policy have strongly affected the mix of programmes and instruments in support of STI and resulted in imbalances. Some of these imbalances are being corrected in the framework of the PECITI, others may call for governance reforms.

As seen in Section 3.3, the allocation of the S&T budget among main policy areas reflects these imbalances which also reveal the difficulties for better orienting these resources to meet the challenges faced by the STI system, in terms not only of relative amounts of resources but also of the choice of support instruments and the criteria attached to the granting of public funding.

The development of human resources for S&T, mainly funded by the Ministry of Education and CONACYT, remains the major component of the policy mix in quantitative terms. This certainly corresponds to an objective and well-founded priority. Through purely mechanical effects, the financing of the SNI is bound to absorb a larger share of resources devoted to this area. As highlighted above, a reform of the present financing scheme should eventually be considered.

The policy mix in support of public research raises questions of level and delivery of support. Overall resources devoted to basic research have been stagnating and should increase, but the increase should be subject to changes in allocation procedures both for institutional and competitive funding to reflect performance criteria for the former and excellence and an emphasis on collaboration for the latter. Support to problem-oriented research is relatively better endowed and, through the establishment of performance agreements and increased management autonomy, efficiency improvements have been achieved. However, despite the orientations of the PECYT and maintained in the PECITI, the financing of public research suffers from a lack of dedicated programmes with credible critical mass focused on strategic technologies.

It is in the area of *support to business R&D and innovation* that the policy mix imbalances are the most striking. Taking the budgetary costs of fiscal incentives into account, this is the area in which the amount of support has increased fastest but also where the policy mix has been most distorted *vis-à-vis* the types of market or systemic failures that public support was intended to address.

The most important bias was until recently the disproportionate share of indirect support in the form of fiscal incentives. It is clear, for the reasons given in Section 3.4.3, that a better balance should be struck between direct and indirect support. The introduction of the new R&D and innovation stimulus package is therefore a welcome move, even if as presently organised it may suffer implementation problems. If a new fiscal scheme compatible with the IETU is to be introduced its design and management should be substantially improved along the lines presented in Box 3.1.

Other biases relate to the absence of dedicated programmes in areas in which business S&T and innovation capacity and/or its contribution to the performance of the STI system are weak. The most noteworthy deficiencies in terms of funding and/or design are in the following areas:

- Support to medium-term collaboration in R&D and innovation activities between enterprises and public research institutions, notably if public/private partnerships are insufficiently used to strengthen linkages between science and industry. AERIs programmes should be stepped up and consideration given to their complementarity with PROINNOVA.
- Support to new technology-based firms does not get the policy attention and support it deserves. As mentioned, support to science-based innovation activities is available through existing schemes such as AVANCE, and possibly now INNOVAPYME. But, in the absence of effective seed and venture capital markets, a specific support scheme should explicitly foster the creation and/or development of high-technology firms or spinoffs from public research institutions.
- Many OECD countries or regions pursue active public procurement policies as a way to encourage enterprises' innovative capacity and better respond to pressing social needs in areas such as health, environment, energy, education and transport. In Mexico, such policies are essentially inexistent, and this is rather surprising. As the experience of other countries illustrates, active public procurement policy at both national and regional levels, compatible with international trade rules, can be a potent driver of innovation and strengthen public/private collaboration in submissions to public tenders for social infrastructure, and goods and services with a high technological content.

3.5. Moving towards more efficient innovation policy

"As the economic crisis continues to unfold around the globe …innovation will be one of the keys to emerging from the downturn and putting countries back on a path to sustainable – and smarter – growth" (OECD, 2009). This message from the OECD Innovation Strategy project takes on particular relevance for countries which, like Mexico, have lagged in harnessing the benefits of science and technology to foster productivity growth, maintain their international competitiveness and meet social challenges. Governments are likely to assume a larger role in steering economies out of the crisis in the coming years through stepped-up public investment, support measures and incentives that aim at compensating for more risk-adverse behaviour by private actors by leveraging business investment in innovation-related activities. STI policy is thus an integral component of a strategy to deal with the crisis and lay the foundation for recovery. As public resources get scarcer, policy efficiency becomes more crucial. It should be underpinned by inter-ministerial co-ordination across areas that impinge upon innovation performance, sound governance, effective delivery and evaluation processes.

3.5.1. Guiding principles

3.5.1.1. Political commitment

Reaping the economic and social benefits of investment in science and technology takes time. Therefore, sustained political commitment and the social visibility of the benefits to the economy and society as a whole are essential to a successful S&T and innovation policy. There are no examples of developed or emerging countries that have succeeded in putting knowledge and innovation at the core of their development strategy without such a long-term commitment.

In Mexico, this commitment has too often not been sustained. The objective of a ratio of R&D to GDP of 1%, to be achieved by the end of the previous administration, was not reached. It may have been unrealistic, but for the main stakeholders it was at best a missed opportunity, at worst a lack of political commitment. The present administration has made a similar commitment in the PECITI, and in 2008, the S&T budget was increased significantly. This commitment needs to be maintained over time by the executive and legislative branches of government, and the scientific, economic and social outcomes of increased public investment should be highlighted in due course in the public debate.

Political commitment also involves consensus building when determining national priorities and setting oversight processes to ensure that these priorities are effectively addressed in the design of innovation policies and reflected both in budgetary appropriations and institutional arrangements for policy implementation.

3.5.1.2. Policy efficiency: guiding principles

Efficient use of public funds to meet economic and social challenges is an element of sound budgetary management. Public resources for scientific and technological development compete with other current or investment expenditures in areas that are often perceived as having higher or more immediate priority. Resources for the alleviation of poverty and the development of social and economic infrastructure put strong pressure on the budget. While fiscal reform can open new margins of manoeuvre,

budgetary constraints are becoming more stringent due to the economic downturn and the fall in oil prices. The opportunity costs of public resources devoted to S&T policies and their legitimacy for addressing market and systemic failures must therefore be fully justified by appropriate accounting of expected economic and social returns and *ex post* evaluations.

The strategic orientations of the 2001-06 PECYT responded to a sound diagnosis of the main weaknesses of the Mexican STI system. However expectations raised by this programme remained largely unfulfilled. They highlight failures, as well as partial successes, from which lessons can be drawn to formulate guiding principles for the design, governance, funding and implementation of STI policies in the framework of the PECITI. These principles are inspired by best practices in more advanced countries, taking into account the specificities of the Mexican situation and the transition out of the current economic downturn that calls for more innovation-based growth patterns.

- *Effective governance*. A prerequisite is political commitment at the highest executive levels of government regarding adequate budgetary appropriations in support of STI activities. This commitment should also be reflected in the operation of the governance structure entrusted with the preparation of the S&T budget in accordance with the Federal Budgetary Law, the steering of STI policy and its co-ordination with major stakeholders, including relevant ministerial departments whose actions impinge on the framework conditions that affect the performance of the STI system. Congressional committees on competitiveness, S&T and budgetary appropriations should also play a more important role in the monitoring and funding of S&T policy.
- *Effective and transparent priority setting* should be achieved through the involvement of all major stakeholders, including the scientific and business communities and the civil sector. Outcomes should be reflected in planning and budgeting documents submitted by the government to the legislative branch and widely disseminated to the public upon approval.
- *Dynamic balance between public and private resources devoted to R&D and innovation.* A condition for improved innovation performance by the private sector is access to and collaboration with the public research system funded on the basis of criteria of excellence and relevance of research activities.
- *Clarification of functional responsibilities.* Following international best practices the political bodies responsible for defining priorities and for policy design should be distinct from agencies in charge of policy implementation, the latter being accountable to the former.
- *Single agent management.* While co-ordination of various government bodies or different levels of government is necessary for policy design and/or programme funding, single body management of implementation is generally preferable to arrangements involving joint management and funding. These usually entail high transaction costs and complicated or even antagonistic decision-making processes.
- *Critical mass and lean procedures in the delivery of government support.* Multiplication of programmes should be avoided. This often reflects opacity in policy design, response to vested interests and/or overlapping responsibilities among government agencies. Moreover it often involves high administrative costs, inefficiencies in delivery and can lead to fragmentation and programmes of less

than critical mass. The devolution of management responsibility for mixed funds to states addresses this issue. Sectoral funds that reflect strategic priorities should, to the extent possible, be funded and managed according to unified operating procedures.

- *Balanced policy mix.* The policy mix should reflect the importance of various policy priorities and the critical mass necessary for effective programmes. For support to business R&D and innovation, the policy mix should strike an appropriate balance between direct (e.g. matching funds) and indirect support measures and sectoral support and take better account of the types of market or systemic failures these measures can address. In the case of support to public research institutions, it should strike an appropriate balance between institutional and competitive funding while encouraging access to external resources.
- *Balance between top-down and bottom-up approaches.* Stakeholders such as intermediary institutions and state bodies can contribute more to the definition and implementation of programmes that benefit their constituencies. Good practices already adopted (e.g. technological infrastructure, technological clusters, AERIs) should be generalised when appropriate.
- *Evaluation and accountability.* Regular evaluation of support programmes and institutions receiving public support should become the norm, with practical consequences for further rounds of support. However, a balance must be struck between the need for periodic adjustments based on evaluations and the stability of support programmes to ensure their long-term impact on the behaviour of beneficiaries. Regular audits should also check that budgetary appropriations earmarked for S&T are effectively spent in that area.

3.5.2. Improving governance structures

Throughout this chapter it has been emphasised that, in spite of CONACYT's authority with respect to the objectives of the PECYT, the low levels of resources devoted to S&T/R&D during the preceding administration, together with the dispersion of budgetary and management responsibilities, resulted in ineffective governance and a distorted policy mix of a large number of often under-funded support programmes. Measures to strengthen Mexico's innovation system will only succeed if they are part of an effective overall governance system that adheres to the principles detailed above.

Given Mexico's institutions and the principles that apply to its government structure, flexibility is limited and there is no silver bullet to improve the governance of the STI system.

The creation of a Ministry of Science and Technology (or of Higher Education, Science and Technology), a common practice in OECD countries, would in principle be worth considering. Such a ministry would be in charge of policy design and entrusted with the power to co-ordinate the whole of the S&T budget and oversee government agencies responsible for policy implementation. CONACYT legitimately aspired to fulfil that function[74] but was not given the means and was not in an institutional position to do so.

However, the creation of a new ministry seems unrealistic at the present time. Furthermore, it is politically unlikely that the power that was denied to CONACYT for the PECYT would now be ensured by granting it ministerial status, especially since it was recently decided to make the Minister of Economy the chairman of CONACYT's Board.

The creation of a new ministry should nevertheless remain an option for future consideration. In the near term the most feasible option is an inter-ministerial council chaired by the president and including ministers with management and budgetary responsibility for S&T programmes or institutions.

3.5.2.1. An effective S&T inter-ministerial council

The General Council of Scientific Research and Technology Development established in the framework of the 2002 S&T Law and chaired by the President of the Republic met only three times in the past six years. To be effective an inter-ministerial council should not only be formally entrusted with defining national priorities and ensuring inter-departmental co-ordination of S&T policy orientation and national support programmes: it should exert these responsibilities and be involved in the preparation of the S&T budget. The General Council, whose existence was maintained in the current revision of the S&T Law, could assume these responsibilities if there is a political commitment for it to do so at the highest level, that of the Presidency. In particular, the Council:

- Should have real influence – or at least a consultative say – regarding resource appropriations (including all S&T resources beyond those of Chapter 38), and possibly resource transfers between the federal and state levels. Its oversight responsibilities should also encompass regulatory policies that impinge upon the performance of the STI system, via legislative proposals or a consultative role regarding the impact on innovation of key framework conditions such as competition policy or labour regulations. In this respect it would seem important for the Council be in a position to review the provisions of existing laws and regulations (*e.g.* the Law on Parapublic Entities, the Law on Public Procurement and the Labour Law) that may presently hinder the efficiency of public research institutions and, more generally, may adversely affect the performance of the S&T and innovation system. In fact, for the new law on science, technology and innovation to have a real and lasting impact would require other legislative or regulatory changes as well.
- Could be assisted by a tripartite S&T consultative board composed of representatives of the scientific and business communities and intermediary institutions. The existing Advisory Forum for Science and Technology (FCCyT) instituted by the S&T Law could in principle perform the functions of such a body, but its role and composition should be reconsidered. One the one hand, its membership should be better balanced between representatives of the academic and the industrial sectors;[75] on the other, it should better manage its dual role of advocacy for S&T and innovation and consensus building among the stakeholders it represents.
- Would be expected to meet at ministerial level at least twice a year to address strategic issues concerning S&T policy and their consequences in terms of budgetary appropriations and legislative or regulatory action. More frequent meetings at lower levels would be devoted to inter-ministerial co-ordination and monitoring of policy implementation.

In addition, and in order to acknowledge and enhance the role of S&T and innovation in Mexico's social and economic development, CONACYT could also become a full member of the Government's Restricted Cabinet which deals with economic matters and competitiveness.

In this institutional setting, S&T planning and budgeting would be distinguished from financing and implementation of competitive programmes, with the latter performed by "means" or financing agencies. However, non-competitive forms of financing would continue to be assured by sectoral ministries, for example mission-oriented STI programmes or projects executed in the research institutions under their authority, or the institutional funding of basic research by the Ministry of Education.

CONACYT and the Ministry of Economy would be entrusted with particular responsibilities not only as the main government bodies responsible for policy implementation and programme funding, but also because of the complementarity of their actions in support of R&D and innovation at the interface of scientific and technological development. The question of their respective roles is therefore important for the governance of the STI system.

A clarification of the roles of the various bodies, ministries or specialised agencies, endowed with S&T budgetary resources would facilitate the necessary streamlining of support programmes and simplify the criteria for support allocation.

3.5.2.2. An evolving role for CONACYT

In order to ensure stability and avoid the disruptions associated with the current practice of rotating chairmanships, the Minister of Economy should chair the CONACYT Board on a more permanent basis. In addition to its role in the overall co-ordination of S&T policy, which could be strengthened if its director general reported directly to the president, CONACYT would evolve into a "means agency" with the following main responsibilities:

- Management of competitive funds to finance R&D-intensive projects or programmes:
  - The *Basic Science Fund* for non-oriented research performed by public research institutions.
  - A limited number of *sectoral funds* in areas corresponding to national technological or sectoral STI priorities and devoted to the financing of medium-term applied R&D and innovation programmes submitted by public research institutions and/or industrial associations. While CONACYT would be responsible for the management of these funds, ministries with administrative responsibilities for the priority sectors would be involved in programme definition and evaluation of outcomes. Part of the resources allocated to these funds would be explicitly devoted to the medium-term financing of public/private research and innovation partnerships (consortia and AERIs). A condition of the effective management of these funds would be a streamlining of the bureaucratic decision and disbursement procedures.
  - The *AVANCE institutional fund*, whenever projects are presented in collaboration with public research institutions.
  - The new *R&D and innovation stimulus package.*

- Management of the interface with sub-federal entities for the development of STI capacities:
  - programming and co-financing of *mixed funds* according to national and regional priorities with particular attention to the development of S&T infrastructure for regional innovation systems and technological clusters, with increased devolution of project selection and management to the states.
- Public research centres:
  - CONACYT would continue to oversee and fund the institutional component of its research centres while encouraging their greater management autonomy (including further progress towards self-financing), closer links with HEIs, or even possible partial or total privatisation for those that primarily provide services.
- Human resources for S&T:
  - management of the National System of Researchers and of its reform and transition towards a mixed system of centralised evaluation and decentralised compensation;
  - management of the postgraduate scholarship and the IDEA programme.
- Fiscal incentives:
  - The re-establishment of an R&D fiscal incentives scheme with new modalities and consistent with the IETU should be considered in the future. In this case, CONACYT should jointly manage the reformed scheme with the Ministry of Finance, with particular responsibility for information dissemination, procedural support, *ex post* control and monitoring and evaluation.

Finally, CONACYT would also maintain its oversight and financing responsibilities for the programmes aimed at enhancing international scientific co-operation (FONCICYT).

3.5.2.3. The role of the Ministry of Economy in the promotion of innovation for competitiveness

The Ministry of Economy plays an important role in fostering competitiveness and, like ministries with similar responsibilities in most OECD countries, it should move towards increased emphasis on the promotion of enterprises' innovation capacity building and technological infrastructure. Its actions could be organised along the following lines:

- Technological Innovation Trust Fund:
  - This fund would cover the missions presently attributed to the Economia/ CONACYT Technological Innovation Fund and support innovation projects submitted by firms, essentially SMEs. Support would be granted through matching funds or grants. Eligible investment expenditures would include R&D costs and technological infrastructure (*e.g.* ICT, logistics, metrology, certification, IPRs). Projects should be assessed on the basis of expected returns and supported irrespective of sectors or technological area. The only conditions of eligibility should be related to a project's constraints[76] on developing economically viable innovative activities. The only discriminating

factor among projects could be preferential treatment for those carried out in co-operation with PRCs or HEIs.

  - The fund would develop links with the financial sector through its contribution to the development of venture and seed capital funds and guarantee funds in co-operation with NAFIN. Like innovation agencies in various OECD countries, it could also provide special incentives for the creation of new technology-based firms.[77]

- Technological infrastructure and diffusion:
  - In liaison with institutions such as INFOTEC, CENAM and IMPI, the Ministry of Economy should develop or strengthen its support for technological infrastructure and diffusion programmes submitted by intermediary institutions or industry associations, notably for the development of innovation clusters and productive networks. In this important area of promotion of regional innovation capacities, strong co-ordination with CONACYT would be required.

Finally, the Ministry of Economy should be endowed with adequate resources for emulating the PROSOFT programme in other priority technology areas, provided that the support is complemented by funding from other sources, including firms, intermediary institutions and local governments, and contributes to the development of sectoral and regional clusters.

3.5.2.4. Improving the articulation between the federal and state levels

Governance reforms should also concern the design, management and financing of policies and programmes that aim at strengthening STI capacities at state and local levels.[78] This raises several questions.

Co-ordination mechanisms between the federal and state levels which involve CONACYT and state S&T councils should be reinforced with a view to identifying projects that correspond to national priorities, and therefore call for a larger share of federal funding, and those that correspond to state priorities, and therefore imply differentiated shares of funding, especially in light of the fiscal reform that increases resource transfers. The more strategic approach currently adopted by CONACYT in the definition and design of projects selected for funding is a good step in that direction which deserves to be developed further.

As noted above, the management and effectiveness of mixed funds have quite often been impaired by lengthy selection and disbursement processes, and, in a number of states, by weak capacity to develop and submit adequate R&D and innovation proposals. The supply/demand balance of mixed funds should be modified to give states more management responsibility for funds allocated to institutions located in their territorial jurisdiction. Decentralisation of policy should be accompanied by decentralisation of management[79] and, to a larger extent than is now the case, by decentralisation of resources. This would greatly reduce the administrative burden borne by CONACYT, as mixed funds would eventually merge with, or contribute to, the state S&T budget for financing projects presented or led by local institutions. The shifting balance of management and financing responsibilities between the federal and state levels would obviously not be the same for all states.

As concerns the strengthening of S&T capacities of less developed states, a mechanism similar to the European Union's Structural Funds for overcoming regional disparities in terms of infrastructure would deserve consideration by the Congress.[80]

3.5.2.5. Evaluation

Finally, good governance implies regular evaluation exercises with feedback on policy design and financing. In Mexico an embryonic culture of evaluating outcomes has to be further developed, as too many policy assessments tend to be simply a description of resource allocation, a check that procedures have been respected, and sometimes consideration of the quality of management. Too often issues of the effectiveness of the policy instrument *vis-à-vis* its stated objectives and its cost effectiveness are not addressed. Following practices increasingly implemented in other countries, CONACYT and other ministries responsible for the funding of S&T and innovation programmes or projects should develop monitoring and assessment systems based on qualitative and quantitative information and indicators. The rationale of support programmes as well as the expected outputs and outcomes should be highlighted at the outset. Monitoring and *ex post* assessments should provide feedback on policy design and funding.

Notes

1. Mexico's relatively good record in the training of engineers can be traced back to the creation of IPN.
2. The Ministry of Planning and Budget was suppressed in 1992 and responsibility for CONACYT was transferred to the Ministry of Education.
3. In particular the Autonomous University of Mexico (UAM).
4. The National Programme for Technological and Scientific Development (1984-88); the National Programme for Science and Technological Modernization (1990-94): and the Science and Technology Programme (1995-2000).
5. The Ministry of Education with oversight of CONACYT and HEI, and sectoral ministries with oversight of research institutes in their areas of responsibilities.
6. FIDETEC's principal objective was to encourage private business to invest in R&D activities considered highly risky but promising. CONACYT funded these projects in their first stages (conception and prototype). FORCCYTEC was a fund to support the creation of private R&D centres to strengthen industry's technological and innovative capabilities. PREAEM promoted university-industry links which supported research projects of mutual interest. PIEBT's main aim was to support start-ups. CONACYT provided seed capital and space to incubate the start-up in its first stages, along with management advice and training.
7. Changes were only introduced in 2008. They concern the modification of evaluation criteria to take better account of innovation performance (not only scientific excellence) and the periodicity of the reviews to which researchers are submitted.
8. However, sectoral ministries such sat the Ministries of Economy, of Health and of Agriculture retained an important role in the funding and management of specific programmes as well as, for the latter two ministries, the oversight of public research centres.
9. With the exception of the fiscal incentive which became more important over time.

10. As emphasised by a panel of international experts entrusted with the evaluation of Mexico's R&D and innovation policy 2001-06: "While the PECYT represent an initiative that addresses Mexico's challenges in an appropriate manner, neither the global articulation of the strategy, nor the rhythm of implementation of new support instruments, not the portfolio of instruments at the disposal of CONACYT have been satisfactory…This situation compounded by the weaknesses of the institutional model of co-ordination and governance of the STI policy has generated difficulties to prioritise effectively the actions that would foster a better articulation of the whole system." ADIAT/CONACYT (2007).

11. The present review is part of this process. Its overall assessment and recommendations were made available to the Mexican authorities in the summer of 2008 and formally presented in Mexico by the OECD Secretary General on 26 September 2009 on the occasion of the approval of the PECITI by the General Council chaired by Mexico's President. These assessment and recommendations were presented to a wider public of STI stakeholders at the 1st Forum on Innovation organised by CONACYT and the ministry of Economy in January 2009. The FCCyT and the ADIAT/CONACYT studies have also contributed to the assessment process. See FCCyT (2007) and ADIAT/CONACYT (2007).

12. The degree of autonomy is determined to a significant extent by the President of the Republic. The appointment of CONACYT research centres' directors also remains a prerogative of the President. This generates credibility issues for firms and other entities in terms of engaging in co-operation projects and agreements with the centres.

13. To date, however, PRCs patent little. Only the Mexican Institute of Petroleum (IMP) and the Electrical Research Institute (IIE) have patented significantly over the last several years.

14. The Ministers of Education, Foreign Affairs, Economy, Health, Energy, Environment, Agriculture, and Communications and Transport.

15. This is an important issue in many countries, but probably more so in Mexico with its pyramidal structure of executive power.

16. The chair changes periodically and is presently held by the Minister of Economy.

17. Less than 20% if the financing of the PRCs is included. Around two-thirds of its budget goes for support to human resources in S&T (*e.g.* financing of the SNI and the scholarship system). In 2006 the total budget administered by CONACYT was USD 508 million, or 17% of total federal expenditures in science and technology.

18. Foregone revenues related to R&D fiscal incentives are not included in the federal S&T budget.

19. In particular UNAM, CINVESTAV, IPN and UAM. The greater share of institutional funding goes to the payment of salaries.

20. Formerly, the Ministry of Energy funded some research activities of PEMEX but no longer appears to do so.

21. Such as the National Institute of Public Health (INSP) and the National Institute of Cardiology.

22. Moreover, whereas CONACYT research centres are fully accountable and must enter performance agreements this is not the case for most other public research institutions under sectoral ministries.

23. From MXN 9 870 million in 2002 to MXN 10 282 million in 2006 (at 2006 prices), with small upwards and downwards variations in the intervening years. CONACYT's budget started growing again in real terms in 2008 with a 14.8% increase over 2007.

24. The number of SNI members almost doubled from around 7 500 in 2000 to over 14 500 in 2007.

25. In 2006, 72% of accepted projects involved only one researcher.

26. There are ten research centres in exact and natural sciences and eight in social sciences and humanities.

27. The Technological Innovation Fund, previously called the S&T Fund for Economic Development.

28. With a further increase to a ceiling of MXN 4.5 billion in 2007 and 2008.

29. Support for the development of innovative clusters provided by the Ministry of Economy is not included in the S&T budget.

30. In the Mexican government system, the term "sector" as it relates to sectoral funds refers to the area of a ministry's administrative responsibility, not to a field of economic activity.

31. 15 sectoral priorities for the Economia/CONACYT Fund.

32. Rejection rates were above 70% for the Education/CONACYT Fund and close to 90% for the Economy/CONACYT Fund in the last two years.

33. All sectoral funds except Education/CONACYT and Economy/CONACYT.

34. Between 2002 and 2006 CONACYT's share of total expenditures in mixed funds was 59% and the state share 40%, the rest being funded by municipal governments.

35. Between 2002 and 2006 research centres and HEIs received more than 60% of the grants.

36. However, funding increased in 2008 with MXN 350 million allocated to so-called "strategic projects", with MXN 30 million minimum per project.

37. Since 2001 the number of firms and institutions accredited by the RENIECYT, which entitles them to R&D and innovation-related support, has increased more than 15-fold.

38. As well as the Ministry of Finance through its role in the determination of the ceiling of fiscal incentives and the selection of beneficiaries.

39. Although fiscal incentives are not accounted as budgetary resources, the fact that a ceiling is set and selection criteria are applied creates at least the perception of financial support, the magnitude of which affects other instruments. The situation is very different in other OECD countries with a similar instrument which they apply without predetermined ceilings.

40. Under the name "Fund of S&T for Economic Development. The name was changed in 2007 and the terms of reference were slightly changed.

41. Projects presented by large firms must involve SMEs in their proposals.

42. Federal funds allocated to PROSOFT are not included in the S&T budget.

43. In 2004, the programme budget surpassed USD 13 million. In 2005 the amount distributed increased to more than USD 18 million, and the number of projects increased from 68 in 2004 to 181 in 2005. In 2006 the volume of resources allocated by PROSOFT to software development amounted to USD 40 million distributed to more than 300 projects.

44. Calculated for international comparisons as the amount of tax relief incurred by one currency unit of R&D expenditure, according to the following "B-index" formula: $B = (1-A)/(1-t)$, where A is the net present discounted value of depreciation allowances, tax credits and other R&D tax incentives available, and t is the corporate income tax rate. In Mexico, the level of generosity was 0.37%, second only to that of Spain at 0.39% (OECD, 2007g).

45. The tax subsidy rate of course depends on the rate of the corporate income tax, not only on the rate of the tax incentive.

46. Or to deal with structural budgetary problems as in the case of tax deductions for government-issued bonds (CETES).

47. Most of them belonging to the SNI.

48. In 2007 of the MXN 4.5 billion of fiscal incentives, MXN 1 billion was earmarked for "R&D projects for alternative sources of energy and R&D projects for micro and small enterprises"; another MXN 1 billion for the development of "specialised infrastructure of research centres devoted to projects focusing on the development of products, materials or production processes that constitute scientific or technological progress". The remaining MXN 2.5 billion could be allocated to other non-prioritised projects.

49. This distortion is also likely to have led to an overestimation of business R&D expenditures in statistical surveys.

50. While 81% of eligible expenditures submitted by large enterprises were supported, the figure for SMEs was 65%.

51. Outstanding tax credits awarded before 2009 can of course be claimed in 2009 and subsequent years.

52. In Brazil it is compulsory to have TTOs or TLOs in research institutions receiving public funding.

53. The share of self-financing by CONACYT centres reached 35% in 2006.

54. In principle there could also participate in the creation of spin-offs. The cases are very rare, however, and there seems to be high regulatory barriers.

55. All CONACYT's research centres, but not all sectoral ministries' centres, have underwritten performance agreements.

56. From 1995 to 2001 the Ministry of Education funded and managed the Programme of Support of Research, the predecessor of the Basic Research Fund. Over 2002-07 CONACYT's contribution to the fund was double that of the Ministry of Education.

57. Mainly provided by SEP for HEIs, and other ministries and CONACYT for their research centres.

58. In a number of more advanced countries the criteria attempt to reflect performance and excellence (*e.g.* scientific publications, number of doctoral students, research grants awards, patents, etc.)

59. It is likely that the current high rejection rate of projects highlights the scarcity of funds more than poor quality or lack of relevance. The Mexican science system has certainly a higher absorptive capacity for basic research than the resource ceiling of the fund.

60. In order to increase interactivity in the research system, CONACYT introduced in 2002 some changes in the call for proposals in order to give priority to applications involving groups and research networks. However the results were not conclusive as the share of individual projects only dropped from 78% in 2003-05 to 72.0% in 2006.

61. The difference with the sectoral programmes initially considered in the PECYT is that they would be managed by a "means agency" and not by the sectoral ministries.

62. In the context of a desirable reform of IPR management in public research institutions, part of the proceeds of IPRs should also go to individual researchers.

63. To avoid abuses, more weight could be given to international recognition in the credit given to individual researchers participating in collaborative work.

64. One possibility is that, upon retirement, SNI members would continue to receive a fraction of their last SNI premium in their pension.

65. Including scholarships funded by sectoral ministries, mainly Education and Health. Overall, CONACYT presently funds around two-thirds of postgraduate scholarships.

66. This levelling off contrasts with Chile's active promotion of studies abroad, under the Bicentennial System for the Formation of Specialised Human Capital Abroad, which foresees a threefold

increase in the number of scholarships available for study in the best overseas universities by 2010.

67. Programa de Fortalecimiento del Posgrado Nacional (PFPN).

68. Such as direct wage subsidies to lower the cost of newly hired S&T personnel with subsidy rates declining over time, or inclusion of such wages in the R&D expenditures eligible for fiscal incentives at a premium rate.

69. *Programa de Apoyo a la Ciencia en México*.

70. The amount of the loan was USD 150 million. The programme focused mainly on the development of S&T physical and human resources infrastructure.

71. Mexico received 299 foreign academics in 1994 and only 49 in 2002.

72. Programa de Consolidación Institucional.

73. Such as the use of R&D fiscal incentives to attract foreign investment.

74. Although policy design and co-ordination were not clearly distinguished from implementation.

75. At present it has 14 representatives of the academic sector and three industry members.

76. Such as access to finance, access to proprietary technology, availability of qualified personnel, etc.

77. Eventually, this fund could become an autonomous innovation agency able to participate financially in firms it supports. In this case, it would have to receive endowments from the public sector and financial institutions.

78. The recent study, *OECD Reviews of Regional Innovation: 15 Mexican States* (OECD, 2009), provides more detailed answers to the two following main questions: How should national innovation policy take into account the regional dimension of innovation systems? How can regional actors support innovation that is relevant for their specific regional context?

79. This, as well as federal/state co-ordination, would be facilitated by more homogeneous state administrative structures regarding the administrations responsible for S&T policy and programmes.

80. The Structural Funds clearly go beyond the S&T issue. In the European Union, they have played a significant role in the catching-up process of backward or peripheral regions and have demonstrated that resource transfers aimed at improving the infrastructure of such regions can yield global benefits for the EU as a whole.
See, for example, *http://ec.europa.eu/regional_policy/innovation/index_en.htm*.

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