

CSIS REPORT

NATIONAL POLICIES FOR INNOVATION AND GROWTH IN MEXICO

Author
James A. Lewis

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Preface

The following report is the product of a larger effort on “Science and Technology in 21st Century North America,” conducted by Mexico’s National Science and Technology Council (CONACYT) and the Center for Strategic and International Studies (CSIS). CSIS, led by the director of its Mexico Project, Armand Peschard-Sverdrup, worked with CONACYT to examine the concept of a cooperative science and technology area in North America. The goal was to identify areas of mutual interest among the three North American economies in the area of science and technology, examine specific means for strengthening cooperation, and develop concrete strategies.

As one part of this effort, CSIS and CONACYT focused on national policies to strengthen innovation and, by extension, broader regional growth in North America. The basic assumption is that a prosperous economic future for Mexico depends on increasing its innovative capabilities. CONACYT has already focused on these challenges, as part of the work on economic reform undertaken by the Mexican government. Mexico is at a transitional moment (albeit a moment that may take several years), as it faces new competitors and must find new kinds of economic activities to continue and accelerate its growth. CSIS and CONACYT held a day-long joint seminar on June 24, 2005, with speakers from the World Bank, the Inter-American Development Bank, the National Science Foundation, from leading high-tech companies, and from the Mexican, Canadian, and U.S. governments. The discussion examined innovation policies in each of the three countries, and this document attempts to reflect the comments and ideas provided during the seminar.

This report blends research on policies to promote innovation with an examination of Mexico’s policies and capabilities for high-tech innovation in order to provide recommendations, both for Mexico and for the NAFTA partner countries, on how to move forward. The recommendations address Mexico’s unique challenges and opportunities, but we hope to have made a small contribution to solving the larger problem of expanding innovation that all nations share and must solve.

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Executive Summary

Global economic integration, expanded trade, and rapid technological change challenge societies to find new ways to generate wealth. These challenges, which are not going to go away, are shared by the three nations of North America. In response, each nation has identified the creation of stronger innovative capabilities in their economies as the best response to global economic transition.

Innovation can take many forms. It includes the creation of new technologies and knowledge to improve existing processes and products and to create new goods and services. It also includes the adoption of technologies and knowledge created elsewhere to improve domestic economic performance. Innovation is the most important source of economic growth, and in an increasingly integrated and competitive global economy, the ability to innovate will be a key determinant for national success.

This topic is particularly important for Mexico. Mexico faces strong competition from Asia—competition not only from countries like Vietnam that offer low-wage manufacturing, but from those like China that possess an increasingly skilled, high-tech workforce. This is not competition that can be ignored without risking serious economic damage. Judging by the traditional measures used to determine an economy's innovative strength (the number of patents issued, the number of higher degrees in science and engineering, or public- and private-sector spending on R&D), Mexico lags behind other OECD countries. But Mexico also has significant strengths and advantages, including its access to resources and markets across North America.

Innovation requires change. To become more innovative, countries will need to change their policies and national systems for education, finance, and regulation. There are many obstacles to success in pursuing these changes. Chief among them for Mexico is the need for progress in its larger efforts at economic reform. These reforms are important for creating an economic environment that is supportive of innovation, and to some extent, national policies and actions for economic reform will determine the pace and scope of any effort to build a more high-tech, innovative economy in Mexico. The necessary steps will include adjusting regulatory, legal, and financial systems to enable new approaches to growth and development; restructuring ministries and reallocating resources; and creating the institutions that can generate core competencies for innovation. Mexico's economy is in transition, and the duration and success of this transition will be determined in large measure by the governmental response.

Our assessment is that Mexico has begun to put in place a strong policy framework for promoting innovation. Since the 1990s, Mexico has sought to advance its science and technology base by launching a series of programs and initiatives. Many are sponsored by the Mexico's National Science and Technology Council (CONACYT). These CONACYT projects aim to make significant improvements in the way that science and technology is conducted within the public sector; in the level of government support for private-sector research and development (R&D); in the collaboration among public and private organizations; and in the availability of human resources for technology R&D. Mexico has a small but well-qualified core of researchers upon which to build an expanded national innovation effort. CONACYT has also, working with the United

States and other nations, created a structure for scientific cooperation that can be expanded to meet the needs of a high-tech, innovation-driven economy.

This report assesses the state of innovation in Mexico and identifies “best practices” that are drawn from the experience of other nations that could help guide future Mexican efforts. It identifies a policy framework to guide Mexico’s continued national and trilateral efforts to support and promote innovation, and it makes recommendations as to how Mexico can build on these initiatives to promote and expand technological innovation in Mexico. Mexico’s development will increasingly depend on its ability to promote innovation in its domestic economy. To this end, the report makes a number of recommendations, including:

- Develop a national consensus among political leaders, labor, and business to “depoliticize” policies and programs that promote innovation. Judging from the experience of other nations that, in the last few decades, have transformed themselves into high-tech economies (such as Ireland with its national advisory board, Forfas), this agreement on a sustained, depoliticized commitment to promote innovation is crucial for success. It can involve the development of a national strategy that all political actors endorse, dedicated funding, or the creation of quasi-governmental bodies or agencies to promote innovation. Mexico has already undertaken some of these steps.
- Pursue “soft infrastructure” improvements to help create a supportive economic environment. The importance of “hard” infrastructure (telecommunications and electricity, roads, airports, and harbors) for economic growth is obvious. There is now substantial evidence that a country’s soft infrastructure (adequate business laws and regulations, protections for intellectual property, effective courts and enforcement structures, and a flexible financial system) is equally important. Success in building and maintaining this soft infrastructure is crucial for progress in increasing innovative capacity and will be a key ingredient for success in global competition.
- Build and expand regional “innovation clusters.” Research has shown that it is the location of a variety of necessary technological and business skills and services in close proximity to each other, often anchored on a university or transportation hub, that provides the basis for growth and development. Clusters can be reinforced by localized incentives and by focused investment on supporting infrastructure. Mexico already has a number of cities and regions that have strong research bases and good international connections. It can build upon and reinforce their success and seek to duplicate it in other areas.
- Create incentives and remove regulatory obstacles for linking business entrepreneurs and companies to university research. University research provides the new knowledge that drives innovation, but strong universities do not guarantee economic success. There must be processes in place that can take university research and transform it into commercial products and services if the larger economy is to gain the full benefit from research. The best incentives are those that allow universities and faculty to profit from commercializing research.
- Increase the number of graduate researchers, the amount of funding for R&D, and the private-sector share in R&D spending. This recommendation is straightforward.

Mexico's underinvestment in R&D and higher education damages its economic performance. Creating incentives for private companies to invest in R&D (a key weakness in Mexico, and an area of strength in other economies) is as important for long-term success as is government spending on education and research, but it requires a different set of policies to achieve—improvements in soft infrastructure and economic reforms that create incentives for private-sector investment.

- Create new initiatives to promote foreign direct investment (FDI), cross-border partnerships, and technology transfers, such as a Science and Technology Working Group in the U.S.-Mexico Binational Commission. Bilateral relations have been reenergized in the last few years, and a large number of groups have been created under the umbrella of the commission. Most of these groups focus on problems—law enforcement, narcotics, border security, pollution. We recommend that there be at least one group that focuses on opportunities—the opportunity for increased innovative capabilities in Mexico to benefit all the economies of North America. There is an underused 1972 Science and Technology Agreement between Mexico and the United States that can provide a framework for this expanded cooperation.

Our recommendations include several proposals to look at promoting innovation in the North American context. Expanding cooperation in science and technology to build an innovative North American economy could make an important contribution to the prosperity and strength of all three countries.

This report begins with two hypotheses: innovation is essential for economic growth; and government policies can accelerate innovation. Mexico already has, of course, a range of policies and programs to stimulate economic growth. Success in this endeavor, accompanied by the creation of new avenues of cooperation to build an innovative economy would benefit all of North America.

National Policies for Innovation and Growth in Mexico

James A. Lewis

In 2003, Mexico had the 10th-largest economy in the world. In 2004, it moved to 11th place, behind South Korea. In 2005, it fell to 12th place, after India. We should not ascribe too much weight to a country's relative economic position, but the trend is troublesome and perhaps telling. Whether Mexico is 10th or 5th or 15th is less important than whether it is taking the steps needed to let its economy meet a new level of competition in an intense and changing global market.

Mexico competes against both developed and developing economies. Trade liberalization and falling costs for communications and transportation reinforce strong international trends that spread economic activity among many countries and make it easier to move production facilities to locations that offer the greatest cost advantage.

The export-led development model that worked well for Mexico in the past is increasingly less effective. The basis for investment in Mexico is changing as wages rise and low-skill manufacturing activities move to locations where costs are lower. Even China, sometimes called "the world's factory" and a recipient of many of the jobs and factories shed by Mexico, has seen its overall employment in manufacturing decline. Manufacturing (along with agriculture and extraction industries like oil) remains important for economies, but it will no longer be the principal driver of economic growth. Mexico's future economic development will increasingly depend on the effective creation and use of knowledge. To achieve this, Mexico must build its own science and technology assets, and it can also benefit from strengthening the scientific and technological interfaces it has with its neighbors in North America and other regions.

National policies for economic growth and development will need to adjust to the new global economy. Governments will need to pay greater attention to the ability of their economies to innovate. National policies can help countries adjust

to these global economic changes, accelerate innovation, and as a result, increase wealth and economic growth.

This reorientation of economic policy is particularly important for Mexico, which is entering a new phase in its economic development. Like many other nations, Mexico must move from competing on the basis of low labor costs to competing on the basis of knowledge, value, and innovation. This transition requires different kinds of policies and investments by both government and the private sector. The new goals for economic policy are to create the environment and competencies that promote knowledge creation.

Innovation in knowledge and technology is becoming a central factor in determining economic success. In response to this innovation imperative, economic activity around the globe is being restructured to take advantage of new technologies that accelerate knowledge creation and innovation. As a result, the pace of innovation in science, technology, and services is increasing in many countries, and the ability to create and take advantage of innovation will help determine the success of companies, industry sectors, and national economies. New technologies can create opportunities for entrepreneurial businesses, but countries that do not find ways to streamline and accelerate their national efforts risk falling behind.

Future economic growth in Mexico and in other nations will depend on the ability to innovate. Innovation is the development of new products, services, or methods of production through the application of scientific research or invention to commercial or government activities. Innovation is particularly important as economies become mature and can no longer expand by simply increasing the supply of resources devoted to production. Instead, these nations must find new ways to use resources more efficiently.

Mexico has begun to take steps to put these kinds of new policies in place. It is laying the foundation for an innovative economy. Beginning in the 1990s, Mexico launched a series of programs and initiatives administered by Mexico's Science and Technology Council (CONACYT) to advance the country's science and technology base. The recommendations in this report build on that by drawing on the experience of other nations and by examining the policies they have used to accelerate innovation and growth.

Mexico is building the foundations for a strong base in science, engineering, and technology. But our analysis shows that Mexico's innovation and technological capabilities need to be expanded and accelerated through both national efforts and international cooperation. Mexico must harness its resources more effectively to promote technological innovation. This report discusses the elements of an innovative economy, reviews successful programs in other nations to encourage innovation, and describes existing national initiatives already under way in Mexico. The report concludes with several recommendations and options for Mexican policy both nationally and within the larger North American context.

Elements of Innovation

A decade ago, discussions of economic policy revolved around the need to increase “competitiveness.” Competitiveness had an international connotation—the ability of national economies to maintain their position during an earlier phase

Elements of Innovation

- Human capital
 - Research universities
 - Skill/resource clusters
 - Entrepreneurial culture
- Knowledge Acquisition
 - R&D/IT
 - Technology transfers
- Commercialization of new knowledge
- Venture capital
- Supporting infrastructures
 - “Hard” (transportation, electricity, communications)
 - “Soft” (legal system, regulations, financial system)
- Openness to global competition

of globalization, particularly against new Asian economic powers like Japan.

Competitiveness and innovation are closely linked, but they measure different things. Competitiveness measures a nation’s capabilities to sell goods and services in comparison with other countries’ ability to do so. Innovation measures the ability of the participants in a national economy to produce new goods and services for domestic and international markets.

Innovation is closely linked to high-tech industries. The most successful high-tech companies are those that are best at innovation. High-tech industries develop and apply new tools and processes to meet existing needs or to create new opportunities. They transform scientific knowledge and engineering expertise into products and services. A high-tech economy must innovate if it is to remain high tech, and an innovative high-tech economy is more likely to be competitive internationally.

Beyond high technology, innovation is increasingly the focus of economic activity for both developed and developing economies. Innovation in new products, processes, and services has become a fundamental part of economic competition, because it is the best response to the pressures created by globalization and international economic integration. Even though innovation ultimately depends on a nation’s knowledge, skills, and creativity, government policies play an important role in creating the conditions and the resources required for innovation. Given the role governments have played for decades in shaping and controlling economic activity, if they do not reshape their policies and regulations in ways that will promote innovation, the result will be slow economic growth.

As innovation has become a central element in economic activity, there have been many efforts to conceptualize and describe it. Some efforts to capture the complex interactions that lead to innovation describe the process as a “national innovation system.” The simplest description of a national innovation system is that it is the collection of processes and skills that create new knowledge and then turn this knowledge into commercial activity. The idea of a single “system”

dramatically oversimplifies the complex series of interactions that lead to innovation in an economy. However, we can draw on the many descriptions of a national innovation system to identify factors that make up a nation's technological capabilities and determine the rate and scope of innovation.

Five important factors shape a nation's capabilities for innovation:

1. the stock and production of human capital,
2. processes for knowledge acquisition,
3. the ability to commercialize new knowledge,
4. the presence of supporting infrastructures, and
5. a country's openness to competition.

Understanding these factors can help provide both a way to measure national innovative capabilities and a guide for policy. Government policies that positively affect these factors can accelerate the pace of innovation and improve national prospects for long-term economic growth.

Human Capital

Human capital is the skills and knowledge possessed by individuals. Human capital is created through education and experience. Both are important for the development of high technology, but advanced education plays a particularly important role. Economies with a greater supply of human capital will do better in the new global economic environment, and increasing the stock of human capital is an important goal for national policies. Many policy recommendations for building human capital focus on strengthening the entire education system, and a literate workforce is essential for a high-tech economy. However, if the goal is to increase innovative capabilities in the near term, government education policies and resources should make strengthening graduate research programs their primary goal.

Research Institutions

Strong research institutions, particularly universities, are a crucial element for an innovative, high-tech economy. Graduate programs produce scientific knowledge and expertise. Graduate programs at universities are the source of new human capital. They produce both the workforce and also the ideas needed for technological innovation. A lack of strong research universities and graduate research programs will significantly hamper any nation's effort to expand technological innovation. Governments can accelerate the creation of human capital and speed its transition to high-tech economies by strengthening their research universities.

The emphasis on research universities is particularly important because of changes in the way that science is conducted. These institutions have become the core component of one of the most productive approaches to innovation. In the

past, large central laboratories were the primary source for innovation. Now, the most dynamic element of the innovation process combines university research, start-up firms, and financial support (from venture capital, corporations, or governments). A number of conditions are required for this blend of business and academics to produce economic benefits, including: (1) the presence of advanced graduate research programs, (2) a willingness by universities to tolerate entrepreneurship among faculty and students and to permit a flow of intellectual property to the private sector, and (3) effective mechanisms to link ideas with capital and business experience. Well-known examples of this process include North Carolina's Research Triangle, California's Silicon Valley, and the high-tech corridor area around the Massachusetts Institute of Technology (MIT). These areas now serve as models for other regions in the United States and for other countries.

Skill-and-Resource Clusters

Research universities provide ideas and workers, but to turn these ideas into economically valuable activities requires many other skills. These additional skills include legal and financial services, and business and managerial expertise. Clustering these skills—locating them in close geographical proximity to one another—maximizes the economic benefits they provide. The development of these skill-and-resource clusters around research universities can provide substantial economic benefits to a region and to a nation. Such clusters create a community of interlocking expertise that lowers the costs and risks associated with innovation by ensuring that a range of needed skills can be easily found and is readily accessible.

Entrepreneurial Culture

Innovation works best when it occurs in the context of an entrepreneurial culture. An entrepreneurial culture accepts risk and failure and empowers individuals to conceptualize how research can be turned into marketable ideas. Entrepreneurship reflects the larger social and cultural preferences found in different societies, but there is some evidence that entrepreneurship can be learned. A legal and regulatory framework that supports risk-taking and does not penalize honest failures will also encourage and expand entrepreneurship. The ability to see potential opportunities in the ideas created by university research and the willingness to take the risks entailed in turning this knowledge into a business are crucial for making scientific research a contributor to economic growth.

Funding for Research and Development

Research and development (R&D) consists of systematic creative work that is performed to increase the stock of knowledge and to devise new applications using this knowledge. There are three broad categories of R&D activities: basic research, applied research, and development. In many instances, the private sector will contribute significantly to research and development activities, particularly

for the development of new products or services. Government programs that encourage private-sector investment in R&D can increase and accelerate this contribution.

Other aspects of R&D, however, are unlikely to attract private-sector funding even with government incentives. Basic research is experimental or theoretical work undertaken to acquire new knowledge of underlying phenomena without any particular application or use in view, and the knowledge created by basic research is the ultimate source of innovation. Because basic research produces general knowledge that is widely disseminated, a company that invests in basic research would not see an adequate return. Consequently, funding for basic research must usually come from the public sector. This is an important government activity, however, as basic research provides the new knowledge that leads to innovation. A country could compensate for a lack of basic research by acquiring knowledge from external sources, but it might find itself at a disadvantage compared to nations with strong research capabilities.

Commercialization of New Knowledge

Government support for research and development can be a crucial determinant for a nation's ability to acquire new knowledge. However, research by itself does not create wealth. There are many examples of nations that spent heavily on R&D without producing economic benefit. The Soviet Union had a strong science and technology base yet grew poorer every year. A straightforward increase in R&D funding will not produce economic benefits if the result of increased research cannot be turned into commercial activities. The failure to effectively commercialize research has been a major handicap for many innovation policies.

The key to capturing the economic benefit that comes from investments in R&D lies in the ability to turn research into commerce. The new knowledge must be effectively commercialized if a country is to capture the full benefit of its investment in R&D activities. This aspect is what makes innovation different from research. The classic view of innovation is that it is entrepreneurs who are primarily responsible for the commercialization of scientific research. The process has become increasingly complex as a growing range of actors use different approaches to getting financial returns from research. Universities license the products of their researchers. Large corporations use a range of strategies (licensing, codevelopment, or outright acquisition of innovative start-up firms) to obtain new knowledge for commercial use. One key element for success is the configuration of rules that apply to the licensing of publicly funded research to commercial entities. The experience of the United States with the 1980 Bayh-Dole Act is that technology-transfer rules that encourage commercial use of research provide benefits for economic growth.¹

¹ The U.S. Congress passed the Bayh-Dole Act in 1980 to encourage greater commercial use of research and inventions produced with government funding. Before Bayh-Dole, much of the research at universities was not turned into commercial products, limiting the value of university research to the economy. Bayh-Dole promotes the participation of universities in the development and commercialization process. It allows universities to retain title to inventions created in a

Information Technology

For a few years at the beginning of the Internet revolution, there was considerable debate among economists as to whether companies' investments in information technology (IT) actually produced any tangible benefits. It now appears that there was a lag between the acquisition of information technologies and the ability of individuals and companies to use IT to increase their productivity, primarily because people had to learn how to use the new equipment. Greater use of information technology makes knowledge acquisition easier, because IT has lowered the cost of finding information. The Internet creates an immense online resource that is immediately accessible to researchers and entrepreneurs. Information is easier to locate, store, and transfer. Expertise is easier to locate. Collaboration is easier within the same firm. The improvement of telecommunications services and the promotion of access to and use of the Internet to increase knowledge acquisition is one strategy the government can adopt in order to obtain both immediate and long-term benefits.

Private-sector Financing and Venture Capital

The financial process to support innovation is more complex and requires specialized financial services that support innovation along all the phases of the path from research to marketable product. The financial system needs venture capital to allow entrepreneurs to take the ideas from research and turn them into products. These venture capital firms have special skills and a tolerance for risk that are not usually found among traditional banks. Continued financing is required once the firm is established to allow the new company to continue to operate until it can depend on revenue from sales. Along with financial support, the new company can also benefit from access to business skills and advice that are provided in tandem with private-sector financing.

Venture capitalists make high-risk investments that offer the promise of equally high returns. Venture capital is crucial for companies that seek to exploit new ideas from research, because these firms are usually new, unproven, small, and private, and thus unable to obtain traditional financing such as that provided by banks or equity markets. The benefits of venture capital are widely recognized. Many governments try to foster venture capital by creating governmental entities that mimic the activities of venture capitalists or by offering incentives that will attract venture capital to their region or country.

Supporting Infrastructures

Governments can increase innovation and attract investment by developing the public infrastructures needed for commercial activity. These include both the "hard" infrastructure (transportation, electricity, communications) and the intangible or "soft" infrastructure (the legal system, regulations, the financial system) that provide the conditions for economic growth. In many cases—

federally funded program and to sell or transfer that invention to the marketplace. The government gets a royalty-free, nonexclusive license to use the invention for government purposes.

particularly with soft infrastructure—these are goods and services that only a government can supply.

- *“Hard” Infrastructure.* The quality of a country’s physical infrastructure is one key determinant for attracting investment and for productivity. The creation of physical infrastructure is a traditional development tool. Physical infrastructure for transportation and communications is important—an isolated cluster that is poorly linked to the global economy will not perform well. Adequate telecommunications services and a reliable supply of electrical power are critical components for high-tech industries. The experience of countries in the process of development, such as China, suggests that a strategy for building a high-tech economy works best if governments concentrate the scarce funding available for physical infrastructure on a few geographical areas. In the short term, this investment strategy will be inequitable, as some areas will receive less funding; in the long term, it will produce faster economic growth. Governments also need a strategy for the eventual privatization of infrastructures.
- *“Soft” Infrastructure.* Even though a country’s physical infrastructure—which includes transportation systems (roads, bridges, harbors, and airports), telecommunications services, and electrical power generation—is essential for economic activity, soft infrastructure is just as important. Soft infrastructure—the laws, capital markets, and culture that enable commercial activities to take place and turn research into innovation and innovation into economic activity—is best provided by governments. Economics once treated the quality of a nation’s soft infrastructure as an external factor for growth, but these intangible factors are as important as physical infrastructure is for growth. Legislation, policy, and government performance are the primary determinants of a nation’s soft infrastructure.

Improvement in soft infrastructure is closely tied to a government’s ability to implement administrative reforms and to the adoption of best practices from other nations’ experience. The development of an adequate corpus of laws and regulations for the protection of intellectual property, bankruptcy, competition, and other business practices forms the basis of a country’s soft infrastructure. Regulatory agencies and courts must enforce these laws in a way that is transparent and equitable. Because laws and rules that make it possible for capital markets to prosper will increase the supply of investment for economic development, effective administration of a financial system is closely tied to the regulatory framework, as laws and rules that enable capital markets will increase the supply of investment for economic development. Countries with a better soft infrastructure have a long-term advantage, and governments can improve soft infrastructure by undertaking a series of reforms to improve governance. Weaknesses in soft infrastructure form an unappreciated barrier to economic growth that will impede the most well-supported development strategy.

Technology Transfer

Technology transfer provides skills and intellectual property that allow businesses and individuals to become more productive and competitive. These transfers are closely tied to foreign direct investment (FDI), which the former head of the World Trade Organization (WTO) called the “best mechanism” in the world for transferring technology. Criticisms of foreign ownership of national assets ignore the increases in productivity, technological resources, and innovative capacity that foreign participation brings to a country’s economy. Even though many worry about the depredations that come from economic globalization, countries that are more open to the global economy grow faster and become more competitive—in part because of their increased access to technology and know-how.

Openness to Competition

There is a correlation between long-term success in building an innovative economy and the government’s openness to competition. Over the long term, competition leads to a more efficient use of resources and creates incentives for companies to bring new products to market more quickly than competitors can. This correlation can seem counterintuitive, and an engineering model for economic growth where investment and production decisions are made by fiat can superficially seem more efficient. The latter approach substitutes administrative and political processes for broadly distributed private-sector decisionmaking and market forces.

Openness to competition has implications for both domestic policy and foreign trade. Domestically, privatizing state monopolies improves economic performance. Laws that block anticompetitive practices also enhance economic performance.

Deregulation to ease the burden of opening a new business seems far from science and technology policy, but it is an important element for enabling the national ability to innovate, by making it easier to create the small firms that can commercialize research and push forward with new ideas.

One important reform involves trade policies. Countries that are open to foreign trade and foreign investment grow faster. The import substitution model used by many countries to promote industry ultimately works against economic growth. By sheltering national industries from competition, particularly foreign competition, the import substitution model creates inefficient and uncompetitive industries. Open economies have greater access to resources, including knowledge and financing, and their national companies learn to compete in the global market. In the same way that a football player who plays in the First Division will become faster and quicker than if he played in a local league, companies that participate in the larger global market will become more efficient. There is an element of risk in opening up an economy, particularly if a national financial system is poorly administered, but there is even greater risk in remaining closed.

Debates over the benefits of competition versus more interventionist economic policies date back to the onset of industrialization. In the global depression of the 1930s, the market orthodoxy of classic economics failed as a guide to policy, and many economists and policymakers concluded that market economies would not produce positive social outcomes. They believed that government management of the economy could avoid the wastefulness of private markets. This technocratic approach remains attractive to many countries today. In the initial stage of development, this engineering can speed growth, but once economies mature, it may become an obstacle.

The government-directed model becomes increasingly inefficient as economies become more developed, and the issue is no longer to create or organize new productive assets but to find better ways to use existing assets. In the United States, for example, private initiatives provide most of the impetus and direction for growth in the American economy. U.S. policies have emphasized less intrusive government, fewer regulations, privatization, and increased reliance on markets and competition among private entities. This emphasis on privatization and markets reflects the demise of the Keynesian-inspired macroeconomic management that had shaped government policy from the 1940s through the end of the 1970s. Some analysts attribute the U.S. success in innovation and economic growth to the absence of explicit, centrally directed growth policies, but many question the application of these policies to other countries.

The U.S. approach stands in contrast to the strategy adopted in European countries, China, or Japan, where the government plays a prominent role in investment decisions for both government and private-sector efforts. Other countries have relied on heavy public investment in infrastructure, human capital, and low-cost financing for companies and entrepreneurs to expand their productive capabilities. Some have also used financial incentives to attract foreign investment in industrial capacity to expand research. This approach substitutes administrative and political processes for private-sector decisionmaking and market disciplines. These “statist” policies appear to work best in developing economies where resources are underutilized and markets are inefficient. As economies mature and the need for innovation and flexibility increases, the statist approach becomes progressively more inefficient. One crucial challenge for developing nations is to create transition strategies for moving to a market-driven economy that is supported by the “soft infrastructure” of financial markets, laws, and courts.

International Experience

The problems that Mexico confronts are not unique. All countries must respond to the challenge of globalization and the need for a transition to an economy based on information. In the last decade, a number of countries have developed policies and programs to increase economic growth and create innovative, technology-oriented economies. While there are unique national aspects determined by environment, culture, and history that shape innovation and

growth in a nation, the innovation systems of different countries have many similarities and common elements. Mexico can draw useful lessons from the experience of these other nations, both those that, like the United States, emphasize a market-oriented approach, and those that have given government a greater role.

Ireland

Ireland has been one of Europe’s chief success stories. Exports, foreign investment, support from the European Union, and a national consensus on economic policy produced an average 7 percent increase in GDP every year for most of the last decade. Ireland had long been a sluggish agricultural economy

Ireland

- Political consensus on a high-tech economic agenda
1987 agreement by political parties, unions, and business leaders to the Programme for National Recovery
- Long-term commitment
Four additional national programs since 1987
- Programs combined fiscal stability, tax reform, and targeted development to accelerate growth
Ireland’s 10 percent corporate tax is a powerful incentive for foreign investors.

whose young people fled to other nations for opportunities. As a result of policies that created opportunities, it has become a magnet for investment and employment. Foreign job seekers now come to Ireland rather than the other way around. Ireland now enjoys faster growth and a higher a per capita GDP than many of the larger European countries that were once more advanced.

Ireland depends on trade for its economic well-being, and the pace of global recovery and changes in the pattern of investment will determine the shape of its economy. Exports are the primary engine for growth, but the Irish economy now also benefits from increased consumer spending, construction, and business investment at home. For the future, Ireland’s Industrial Development Authority (IDA) has targeted the IT industry, biotech, financial services, and international services as four key areas for specialization.

Ireland has been a beneficiary of globalization. The chief concern among Irish politicians today is that global economic change may now be a source of risk and that the Irish economy may suffer. Ireland’s attractiveness as a low-cost center will no longer be as effective in attracting jobs and investments. In this, Ireland faces the not unusual problem of having to move to producing higher-value goods and services. It appears to be having some success in this area.

The Irish are concerned that European expansion and the growth of global competition will slow their progress. After years of rapid growth, Ireland faces the more difficult challenge of remaining competitive in the global knowledge economy. Their response has been to emphasize the policies that promote innovation and competitiveness.

One key element of the Irish experience involves political consensus on a high-tech economic agenda, beginning with the agreement by political parties, unions, and business leaders in 1987 to the Programme for National Recovery. The consensus on the need for a new approach to economic policy effectively depoliticized key aspects of the new approach. The program was a combination of fiscal stability, tax reform, and targeted development. The Irish government created a national board, Forfas, to coordinate the development and implementation of national plans for technological development and innovation.

The Programme for National Recovery was followed by four additional national programs that targeted foreign investment and adopted rules to enhance competitiveness, the most recent being the Programme for Prosperity and Fairness. The series of national programs sent a positive signal to investors that Ireland had made a long-term commitment to improving economic conditions. The programs' goals are long-term increases in both labor productivity and in employment by targeting foreign investment and by adopting rules that enhance competitiveness. Ireland's decision to fix corporate taxes at 10 percent has been a powerful incentive. And Ireland's access to the larger European market and its ability to draw on European community resources has helped to accelerate its development.

Part of Ireland's success is explained by its embrace of the IT industry. In 2002, Ireland had over 800 foreign and domestic software companies, and software is a leading economic sector. The industry is export-oriented and has done well in the global market. But the Irish are deeply concerned that China and India could displace them completely from the market. Many of the indigenous firms are too small to be competitive globally. Irish firms are considering, in partnership with the government, a strategy of consolidation and a focus on software products where they retain a comparative strength.

Ireland confronts more serious problems than the size of its firms as it faces new competitors for investment. Multinational firms dominate Ireland's manufacturing sector. The attractiveness for these multinationals of China's large and fast-growing domestic consumer market alone will lead companies to shift some investment from Ireland to Asia. India is a particular challenge to Ireland, as it has some of the advantages Ireland had when it began its period of rapid growth—a well-trained, English-speaking workforce and a reasonably effective government. Ireland's membership in the EU provided advantages, but membership may be less important if the focus of EU subsidies shifts east as the importance of the European market declines. Ireland still offers greater institutional and labor stability than any of these new competitors, but it is not clear if the policy formula that has worked so well for it since the 1990s can continue to produce a competitive advantage.

This is not a crisis for Ireland. Unemployment remains low at 4.5 percent (below the EU average and well below Ireland's 15 percent unemployment in the 1980s). Shifts in foreign investment and in European aid would have to continue to decline for several more years to inflict serious damage, and it is likely that the Irish will be able to develop a fifth consensus program to overcome these

challenges. Future national program will emphasize Ireland's human capital advantages, which are significant. Ireland's "soft infrastructure"—its legal, financial, and educational systems; its democratic government; and its links to the United States and the European Union—give it some real advantages over Asian competitors.

It is interesting to compare Ireland's efforts to the experience of the Netherlands. The experiences of both nations have common features that appear to contribute to economic success and offer suggestions for successful national policies. In both countries, growing concern over economic stagnation drove a political solution. Like Ireland, the Netherlands confronted a period of economic malaise, and the country experienced high unemployment and unsustainable budget deficits. Beginning with the 1982 Wassenaar agreement, unions, companies, and the government agreed on fiscal and economic policies to promote growth. The outcome was a change in the political process in the Netherlands to emphasize consensus among labor, industry, and political parties in developing national economic policies. Part of the success in the Netherlands and in Ireland lies in the successful efforts to "depoliticize" their national efforts to improve economic competitiveness and become knowledge-based economies. Despite very real challenges from Asia and Eastern Europe, the Netherlands appears to be following a trajectory that, like Ireland, will allow it to remain a strong economy well positioned to benefit from globalization.

China

China also began its efforts to develop a high-tech economy that would produce rapid economic growth with a series of political decisions. In contrast to Ireland or the Netherlands, however, China can still be seen as a command economy where the need to build consensus on policy was limited to a very small group of senior political leaders. China's rulers, beginning with Deng Xiaoping, were able to gain the support of other party leaders and move ahead with plans to open China's economy and build a strong science and engineering base. This centrally

driven development model is not unique to China; some variant of it has been used by a number of other nations, including Korea, Malaysia, and of course, Japan, to build modern economies.

Since 1986, China has put substantial effort into building a high-tech economy, driven by a desire to increase security, international competitiveness, and national prestige. In retrospect, the most important decisions were to open China's

China

- High-level political decisions to create a high-tech economy allow private control of resources and open economy to foreign participation
- Targeted subsidies, including tax and tariff concessions, land grants, investment in public infrastructure, and government support for graduate education and research and development
- Trade policies to provide incentives to locate and manufacture in China
- A strategy to trade market access for technology with Western companies
- The attraction of a giant market

economy to foreign participation; to develop national programs to build human capital and to support research and development in key areas of science; and to allow the decentralization of economic decisionmaking and move from reliance on a national plan for growth to a process that has many aspects of a market economy.

China's government used a set of complementary policies to develop its high-tech sectors. It provided tax and tariff concessions to attract foreign investors, including land grants, investment in public infrastructure, and subsidizing the development of a skilled workforce. China's national and regional governments wooed foreign companies with a broad range of incentives that would be familiar to any nation, state, or city that has tried to attract a plant or company. These include low-cost or no-cost financing, land grants in the form of long-term leases, construction loans, tax and trade credits or rebates, the creation of special export zones, and investments in electrical power and other utilities, communications, and transportation infrastructures. Regional governments compete with each other to attract foreign investment and were probably a larger source of direct subsidies than national programs.

China reinforced these incentives with targeted trade restrictions—at least until it joined the WTO—that provided incentives for high-tech investment in China. Companies that located and manufactured in China paid a lower tariff rate than companies that imported goods from factories outside of China. China's regional governments exercise a degree of control over export and import restrictions not usually found in other nations. These regional governments use this control to offer exemptions and credit that form a part of their competition with other Chinese regions to win foreign investment.

Chinese policies before WTO accession gave an advantage to firms that had a presence in China. The attraction of these incentives for foreign companies was magnified by the benefit of being able to be located in a gigantic and fast-growing market. The attraction for foreign investors is not only the access to lower-cost labor and resources, but also access to a new talent pool created by its investment in university education and in research. Finally, partnership with a Chinese firm or institution can be an important tool for successfully navigating the many formal and informal requirements imposed by Beijing.

China aggressively sought technology transfer from foreign investors, with a strategy to obtain technology from Western companies in exchange for market access, but in exchange, it used its trade policies to provide incentives to locate and manufacture in China. Technology transfer has also played a central role, and winning technology transfer concessions from foreign firms is a part of every Chinese negotiation with foreign partners. This reflects a national strategy to acquire advanced foreign technology but also a natural business reaction by Chinese entrepreneurs. China regulates technology transfers by foreign companies. These regulations limit the ability of the foreign company to require confidentiality from its Chinese partner or restrict sales and require the approval of the Ministry of Foreign Trade and Economic Cooperation. These regulations can skew technology transfers in favor of Chinese firms.

Continued growth in China faces a number of challenges. China has unappreciated weaknesses, particularly in its legal, financial, and political system. Weaknesses in the financial system and political interference in investment decisions constrain China’s domestic capital market, and there is still a strong element of central planning that hinders growth. Weak enforcement of intellectual property rules will work against an easy transition to an information economy. China’s rapid development in recent years may be difficult to sustain absent further reform. In this sense, it is easy to overstate the advantages that China has as a competitor when compared to Mexico or other nations.

International Best Practices

Ireland and China provide two leading examples of successful efforts to transform economies. Many countries have used similar policies to pursue this goal with greater or lesser degrees of success. From the experience of these nations, we can suggest a series of “international best practices” that can help to guide Mexico’s efforts.

- *Develop political consensus on policies for high-tech innovation and growth.* Agreement by political parties, unions, and business leaders to place innovation and growth policies outside of politics provides an essential boost and a guarantee of long-term support. Since improvements in the innovation process may require several years before they produce results, agreement to depoliticize these policies can provide the time needed for real results.
- *Create targeted incentives and subsidies.* Incentives and subsidies should have two goals: to provide adequate resources where markets and the private sector do not; and (to the extent possible) skew economic activity in the direction of creating or acquiring new knowledge, building human capital, and attracting foreign participation in business and research. By targeting government support for infrastructure, human capital, and research on nascent innovation clusters, governments may be able to achieve a higher return for their spending than would be the case with broadly diffused national programs.

Best Practices

- Develop political consensus on policies for high-tech innovation and growth
- Create targeted incentives and subsidies
- Integrate with the global economy
- Open up to foreign participation/competition
- Build supporting infrastructures
- Decentralize commercial decisionmaking
- Adjust legal and financial systems to accelerate innovation
- Strengthen or create institutions that produce core competencies for innovation

- *Integrate with the global economy.* Economies that do not adopt open policies find themselves increasingly at a disadvantage. To succeed, open economies need strong fiscal and monetary policies, because they can be the source of the technological, informational, and financial resources needed for development.
- *Open up to foreign participation/competition.* Globalization places real stress on economies as companies adjust to new and more intense competition, but integration with the global economy is a primary source of the technological, informational, and financial resources needed for development. Openness to increased foreign collaboration in technology can make significant contributions to development.
- *Build supporting infrastructures.* Using focused regional investment programs to put in place and maintain roads, modern telecommunications and airports will help attract foreign investment and make efforts at knowledge creation more efficient. No country can do this in every location. The most successful programs have selected a few locations and invested heavily in them: Shanghai is among the most modern cities in the world, but neighboring provinces to the east remain (for now) impoverished.
- *Decentralize economic decisionmaking.* Reforms and policies that result in less-intrusive governments, fewer regulations, privatization, and greater reliance on markets and competition among private entities are in general more likely to achieve economic growth. Governments can speed the large initial investments needed in infrastructure or human capital creation, but individual initiative remains the better path to success. Some analysts attribute the U.S. success in technological innovation and economic growth to its reliance on a market-oriented approach that emphasizes private investment and decisionmaking. Finding the right balance between government and private action can be difficult. The broad issue is to determine where government intervention offers benefits and when to transition to a private-sector lead.
- *Adjust legal and financial systems to accelerate innovation.* Adjusting legal and financial systems to support innovation requires attention to laws and regulations governing competition, intellectual property, bankruptcy, financing, and foreign investment and to the rules governing the establishment and setting up of new companies. The goal is a flexible system that places as few possible impediments in the path of turning ideas into commercial activity. A strong court system that can enforce rules (particularly for intellectual property) is an asset in the emerging global economy. Developing these legal and financial systems may require an iterative process that draws upon best practices from leading economies around the world.
- *Strengthen or create institutions that produce core competencies for innovation.* High-tech innovation requires centers that generate and exploit new ideas. These can be public institutions, such as universities and government-funded research centers, but they can also include research and development activities at private firms. University graduate programs are crucial, in that they generate not only new ideas but also produce the science

and engineering workforce needed for innovation. Core competencies include more than science and engineering, and the educational system also needs to produce legal, business, and financial service skills to support innovative activities.

Mexico: Metrics for High-Tech Economies

These are the prerequisites for the new international economic environment in which Mexico and other countries must operate. It is an environment where knowledge creation and innovation are becoming more important than agriculture or heavy industry for creating wealth. Mexico has laid the foundation for a strong science, engineering, and technology base, but analyses using several different measures show several areas where the Mexican economy needs additional growth if it is to be competitive.

The customary metrics for determining an economy's strength in technological innovation include the number of patents and advanced degrees issued; the percentage of advanced degrees in the workforce; the percentage of GDP devoted to R&D by government and by private-sector sources; and the share of high technology in manufacturing and in exports. Indirect measures include the degree of integration into the global economy, such as trade and FDI; and the penetration of IT services into an economy (measured by the access to the Internet and broadband access). The statistics collected by the Organization for Economic Cooperation and Development (OECD) and the OECD average provide a useful set of benchmarks for assessing a nation's innovative capabilities in comparison with other economies.

Currently, one important area of strength for Mexico in terms of its innovative capabilities lies in its integration with the global economy. It outpaces the OECD average in key areas. FDI remains relatively high, at \$10.8 billion. This amount is somewhat smaller than FDI inflows in the 1990s (which averaged between \$12 billion and \$13 billion), reflecting the more competitive environment Mexico faces, particularly from Asian economies like China and Vietnam, which contend with Mexico for the global market for low-cost manufactured goods. This competition is most noticeable in the *maquiladora* sector, assembly-for-export plants that popped up along Mexico's northern border after passage of the North American Free Trade Agreement. A significant proportion of the *maquiladoras* have immigrated to Asia.

Mexican companies have specialized in the assembly and manufacture of medium- and high-tech goods for export. This specialization is reflected in the composition of its exports. The share of high-tech exports averages around 30 percent, in comparison to an OECD average of 26 percent. The concern for Mexico is that these high-tech exports are the result of production from low-wage assembly and are vulnerable to increasing foreign competition.

Other metrics are not positive. If research and development is one of the foundations for a knowledge economy, Mexico lags behind other economies. The OECD average for investment in R&D is 2.2 percent of GDP. Mexico invests

0.39 percent of GDP. The composition of R&D investment in Mexico also differs substantially from what is found in other nations. In many OECD countries, the private sector contributes more to R&D than does the government. While private-sector funding tends to be concentrated on the development of new products or services for the market (rather than fundamental research), in Mexico it is the government that provides the bulk of the funding: perhaps two-thirds of the national R&D investment comes from public funds. The World Bank estimates private-sector R&D investment in Mexico to be 0.1 percent of GDP, while the OECD average is 1.5 percent. Mexican R&D funds are concentrated in higher education and public-sector research institutions, with little private-sector spending on R&D. This means that Mexican companies are not developing new products and services at the same rate as other OECD economies.

The decisions by Mexican firms to underinvest in R&D create a serious economic problem, but it is one shared by many nations in Latin America. A number of factors lead companies to make this decision not to invest. These factors are related to Mexico's soft infrastructure. One of the most important factors is companies' concerns over intellectual property. Companies will not invest in R&D if they fear that they cannot capture the benefits of that investment. In an economy with weak intellectual property protection, investing in R&D could actually put a company at a competitive disadvantage, as they would pay for innovations that their competitors could use without paying. A good system for intellectual property protection includes not only effective laws but also an effective enforcement system, where companies can be confident that courts will punish intellectual property theft and compensate them for losses.

An absence of competition also decreases companies' incentives to invest in R&D. If markets are closed (either through restrictions on foreign investment, nontariff barriers to trade, or by bureaucratic obstacles that deter domestic entrepreneurs from opening new firms), a company will not feel the same pressure to create new products or find new ways to produce more efficiently. The end result makes these closed sectors of the economy out-of-date and uncompetitive. A World Bank study estimated that it takes 58 days to open a new business in Mexico, compared with 27 days in Chile or 3 days in Canada. Reducing the impediments to the creation of new businesses would help spur innovation.

The availability of human capital is another important factor for building a high-tech economy, particularly for the private sector. An economy that does not produce a sufficient number of scientists and engineers must attract its high-tech workforce from outside to compensate. This is becoming increasingly difficult as many governments and companies now compete for a scientific workforce. Singapore, for example, aggressively recruits scientific talent through a national program that provides research funding, housing, and other amenities. China and India are also making successful efforts to attract their nationals working in other countries to come back. Even the United States is facing serious competition for foreign talent. An undersupply of science and engineering graduates raises the cost of R&D for firms in Mexico.

Mexico could benefit if it improved its performance in the creation of human capital. From 1994 to 2003, the number of science Ph.D.'s awarded in Mexico was a little over 4,600. While the trend has been for the number of science Ph.D.'s to increase every year, this number is insufficient for a strong high-tech base. Perhaps as a result, the number of researchers per 1,000 people in Mexico is 0.6. The OECD average is 7.8. Mexico had (in 2001) a total of 22,000 researchers in its economy. It will need to accelerate the creation of human capital to remain competitive in a high-tech market.

The number of patents issues in Mexico has been consistently less than the OECD average for a nation of its size and wealth. In 2004, according to the World Intellectual Property Organization (WIPO), innovators in Mexico received only 162 patents. This number suggests that innovation, even by Mexican researchers, may be more likely to occur outside of the Mexican economy.

Assessment

Mexico has several advantages for building a more innovative economy. One advantage comes from the federal government's recognition of the need to make the transition to a knowledge-based, high-tech economy. Even though

governments in many countries have come to a similar conclusion, Mexico has begun to put into place the policies needed for this transition. The question is how well and how rapidly these plans can be implemented and how they can be reinforced.

Mexico has strengths that can bolster its efforts to adopt new economic policies. The legislative and policy programs enacted in 2000 and 2001 provide a good framework for moving ahead, and

the government has made the promotion of innovation a central part of its plans for economic development. Mexico has a small—but well-qualified—core of researchers who form the basis for expansion and for building a knowledge-based economy. CONACYT (the *Consejo Nacional de Ciencia y Tecnología*) has created an effective structure that makes it possible for Mexico to cooperate on science programs with international bodies, other governments, and other countries' research institutions.

Nevertheless, there are many areas for improvement at both the national and international levels. The key problem is the low level of investment in R&D (as a percentage of GDP). This is far below other OECD nations, and the problem is exacerbated by the very low level of private-sector investment in R&D. Low private-sector investment in R&D is reflected in the small number of start-up technology firms, the limited linkages between business and the research

Assessment

- Good policy framework
 - Mexico incorporates innovation in its economic plans
- Small but well-qualified core group of researchers
- Structure for international scientific cooperation among institutions
- Progress in structural reforms a key determinant of success

community, and the generally slow pace of innovation in many industry sectors. Also, the transition to an innovative high-tech economy is slowed by the lack of a strong science and engineering workforce. Investment in human capital to begin building a skilled workforce is also essential.

The strong programs to increase Mexico's science and technology base will also be affected by the pace and scope of larger economic reforms. Better fiscal performance, deregulation, and further privatization are needed to take advantage of increases in science and technological capabilities.

Mexico: Initiatives for High-Tech Innovation

The metrics used to measure innovation show that Mexico's technological infrastructure lags behind many OECD countries. To its credit, the government of Mexico has recognized this problem and, beginning in the 1990s, sought to develop a range of policies to address it. These government policies provide the framework for innovation and growth.

In 2001, the Fox administration unveiled its National Program for Science and Technology 2001–2006. The National Program highlighted the role of science

Key Initiatives

- Structural Reform Agenda 2002–2006
- Special Program for Science and Technology 2001–2006
- 2002 Ley de Ciencia y Tecnología and CONACYT's Organic Law
- Other key initiatives

FUMEC: Fundación México-Estados Unidos para la Ciencia

Innovation for Competitiveness: World Bank

U.C. MEXUS: University of California

AVANCE: High Value-Added Businesses Linking Knowledge with Entrepreneurs

Compite: Comité Nacional de Productividad e Innovación Tecnológica

SISTEC: Sistema de Información sobre Servicios Tecnológicos

and technology for Mexico's development. It was an integral part of the 2001–2006 National Development Plan. The program set strategic priorities for science and technology (S&T) and identified broad objectives, such as creating a coherent policy framework for S&T, increasing Mexico's S&T capacity, and finding ways to use S&T to increase innovation in the private sector.

In 2002, Mexico revised its legal framework for science and technology when it passed the *Ley de Ciencia y Tecnología* (Science and Technology Law). The law created new mechanisms to support scientific research and technology. These include:

- Making CONACYT a separate agency that reports directly to the president instead of the Ministry of Education;
- Establishing several new coordinating bodies, including the General Council on Scientific Research and Technological Development (chaired by the president), which develops and coordinates policy; the

Intersecretarial Committee to Integrate the Science and Technology Federal Budget; and the Scientific and Technological Consulting Forum, which provides advice to the General Council and to CONACYT;

- Establishing a separate budget function for CONACYT and creating new funding mechanisms for federal and mixed (combined federal, state, and local) funding;²
- Launching a National Conference on Science and Technology to bring together the 31 Mexican states (and the federal district) on science and technology issues³ and a Science and Technology Advisory Forum to provide CONACYT with policy advice from the private sector.
- Creating tax incentives to subsidize private R&D for approved companies (a tax credit equal to 30 percent of the annual research spending).

Congress approved CONACYT's Organic Law in 2002 and modified CONACYT authorities to allow it to better carry out the requirements of the *Ley de Ciencia y Tecnología*. The responsibilities of the strengthened CONACYT are to:

- Promote the use of mixed and sectoral funds (from different federal agencies, state governments, and the private sector) for scientific and technological research. Sectoral funds are provided by the different federal ministries. There are 14 sectoral funds for basic research and for applied research and technological development in health, communications, environment, agriculture, and other areas.
- Establish and strengthen links with international organizations and expand collaboration between Mexican and foreign institutions.
- Administer Mexico's postgraduate scholarship system. These programs support around 1,500 postgraduate students working outside of Mexico and have, as one goal, the repatriation of researchers, where students get economic support in exchange for returning to Mexico once their studies are complete.
- Coordinate the activities of the 27 CONACYT Research Centers that are located around the country. Each center concentrates its work in a few areas of research.
- Administer the National Researchers System (SNI) that provides support to research in institutions of higher learning, public-sector research centers, and to researchers in private institutions.

CONACYT and other agencies run specific programs to advance technological innovation in the private sector. The "High Value-Added Businesses Linking Knowledge with Visionary Entrepreneurs" works as a kind of

² Twenty-six mixed funds and one municipal fund have been put in place since 2002.

³ Twenty-three of the states have state councils on science and technology.

venture-capital effort and provides support for researchers, entrepreneurs, companies, and research institutions wishing to transform scientific and technological developments into commercial activities. The Ministry of Economics operates the National Committee on Productivity and Technological Innovation (Comité Nacional de Productividad e Innovación Tecnológica), which is designed to improve the competitive position of small and medium-sized enterprises by maximizing the use of their resources.

Bilateral initiatives include the Mexico-United States Foundation for Science (*Fundación México-Estados Unidos para la Ciencia*); the Innovation for Competitiveness Program funded by the World Bank; and U.C. MEXUS, a cooperative arrangement with the University of California system to expand collaboration between researchers and institutions in the United States and Mexico. CONACYT has successfully duplicated the U.C. MEXUS model with other U.S. research universities.

In reviewing these initiatives, it is important to put them in the context of the larger program of reforms that began during the last few years. The success of the larger reform program—whether it is the Structural Reform Agenda, 2002–2006, or some consequent reform effort—will be a crucial determinant for the pace of Mexico’s transition to a high-tech economy. These reforms contribute directly to strengthening the soft infrastructure needed for innovation. Deregulation, privatization, and more effective legal and financial services are crucial improvements that could accelerate the country’s economic transition.

Structural reform will free up resources and allow for greater investment in building innovative capacity. Fiscal reform can play a crucial role in shaping investment in science by both the government and the private sector. For example, tax breaks can incentivize private investment in R&D, but their value as an incentive is decreased when government collection of taxes is low. Mexico may collect as little as 12 percent of GDP in taxes (the average in OECD countries ranges between 25 percent and 45 percent). If companies evade their full tax burden, offering them a credit for R&D investment provides little incentive to do more.

Structural reform remains an important potential accelerator for Mexico’s economic transition. A slow pace for structural reform will slow the development of a high-tech economy. Mexico and CONACYT have put in place a legal and policy framework to promote high-tech innovation, but this effort to accelerate innovation will move slowly absent progress in economic and regulatory reform. Alternatively, even relatively modest progress in reform, if it is sustained, will send the right signal to investors and entrepreneurs and energize policies to promote science and technology.

Recommendations and Options for Policy

In all economies, the process of innovation is complex and nonlinear. This nonlinear aspect of innovation complicates policymaking. Building a high-tech economy is not a simple task, but the policies that Mexico has put in place in the

last few years, as well as the initiatives begun by CONACYT and other agencies, identify the areas in need of improvement and position Mexico to move toward a new kind of economy. The following recommendations suggest areas where Mexico could make progress in accelerating its economic transition.

Policymakers in Mexico understand the need to expand the existing programs to increase the number of researchers and to increase both funding for R&D and the private sector's share in R&D. These are areas where CONACYT has already begun to take steps to address shortfalls, but they remain crucial weaknesses. Additional programs that bring Mexico's science and technology workforce and R&D funding to levels equal to the OECD averages should be made national goals.

To a large extent, the transformation of Mexico's economy will depend on efforts taken by Mexico itself. It will take a national decision to reallocate government resources, find additional support from multilateral financial institutions, or expand federal spending (perhaps as a result of fiscal reforms) to fund these increases. Increased spending is a direct route to expanding capabilities for technological innovation, but many other priorities compete for funding. For this reason, Mexico will need to consider other national and multinational initiatives.

The two fundamental goals of a strategy to build an innovative, high-tech economy in Mexico should be to increase the supply of "inputs" needed for high-tech innovation and to remove obstacles and disincentives. This approach avoids the situation often found in Europe, where government officials, rather than scientists and entrepreneurs, direct national efforts at innovation. This is not because scientists and entrepreneurs are innately more skilled than officials, but because a decentralized approach allows a variety of efforts in different technology areas. An "industrial policy" approach decreases the likelihood of success. With this in mind, and drawing on the experiences of other nations, policymakers may wish to consider the following options for both national and multilateral initiatives.

National Options

- *Consensus on policies that affect the development of high technology and innovation.* The examples of Ireland or the Netherlands are useful guides for Mexico. These nations explicitly identified and agreed on policies to transform their economies and, in Ireland's case, to spur innovation. By insulating high-tech and innovation policies from their political contests, they obtained a number of

National Policy Options

- Build political consensus on high-tech/innovation policies
- Foster "innovation clusters"
- Increase incentives for entrepreneurs to work with universities and businesses
- "Soft Infrastructure" improvements
- Increase the number of researchers, funding for R&D, and the private-sector share in R&D

benefits. The consistent application of policies over a long period of time provided cumulative benefits to development. Depoliticization sends positive signals to investors and increases the chances for support from multilateral financial institutions. Many governments have plans for transforming their countries into high-tech information economies that pursue innovation, but few have made the political commitment needed for rapid progress. Mexico could gain an advantage over its competitors if it could reach internal political agreement on innovation policies.

- *Improve “soft infrastructure.”* Soft infrastructure is a prime determinant of growth. It is also an appealing area for action in that many (but not all) improvements can be made with a minimum commitment of resources. For Mexico, progress in improving soft infrastructure to increase innovation is closely tied to progress in larger reform efforts. Mexico’s Structural Reform Agenda included initiatives for the energy sector, telecommunications, labor and financial markets, and judicial reform. Progress in these areas is crucial for building a high-tech economy. Legal reform will help provide the rules and laws necessary for innovation. Legal reform should include the development of clear antitrust, bankruptcy, and intellectual property rules that encourage innovation. Telecommunications reform will accelerate the creation of a strong IT system that will speed knowledge acquisition and management. Financial reform will help provide the private sector with resources for entrepreneurial activities and increase government resources for investments in basic research, human capital, and infrastructures. Deregulation will make it easier to create new businesses to turn research into economic gain.
- *Create and expand “innovation clusters.”* The combination of science and engineering expertise with entrepreneurial skills, supported by legal, business, and financial skills, can be a principal source of innovation for Mexico. Government policies that encourage the development of these innovation clusters will help Mexico’s economic transitions. Building clusters is really an investment strategy, where the government concentrates resources on a specific area. CONACYT has already laid the foundation for a policy of building innovation clusters through its work with the 27 national research institutions it supports in states across Mexico. These research centers can form the core of a cluster strategy. Government spending on infrastructure investment (modern airport facilities, good roads, or other public services) can reinforce and accelerate these clusters and encourage additional private-sector investment from both Mexican and foreign sources. Mexico could also consider establishing special zones around these research centers where companies and investors would be eligible for exemptions from business regulations, land grants or low-cost leases, special financial programs, or tax exemptions.
- *Build human capital.* Successive Mexican governments have recognized the benefits of a better-educated workforce, and Mexico has been a pioneer in some areas, such as tele-education (the Telesecundaria program, for example). National policies to build a high-tech economy need to include a renewed

focus on education, especially advanced education in engineering and the sciences. The foundation for such an effort already exists. CONACYT has put in place a number of programs to increase graduate enrolment, including scholarships to Mexico's universities and cooperative arrangements with universities in the United States and other countries. These programs form a strong base for pursuing a new objective—generating a greater output of graduates. CONACYT may wish to follow the example of nations like China, which encourage and subsidize advanced study at foreign institutions. Again, the existing cooperative agreements provide the basis for expansion of the number of students studying at foreign institutions. The emphasis must be on a significant quantitative increase in Mexico's scientific and technical workforce from either domestic or foreign institutions. Previous reports have also noted the advantages to Mexico of building human capital.⁴

- *Offer new incentives for businesses and entrepreneurs to form partnerships with universities.* The lack of connections between research institutions and business remains a problem for Mexico's economic development and science policy, despite strong efforts by CONACYT to encourage these connections. CONACYT has focused on making research and researchers more accessible to the business community. This effort could be reinforced by tying it to financial incentives, perhaps as part of a larger cluster strategy, to increase collaboration between business and research. One set of incentives that has worked in other countries is to create financing facilities (through agencies or government banks) that provide low-cost or no-cost loans to researchers and entrepreneurs who are trying to commercialize research.

Multilateral Options for North America

Mexico's transition to a high-tech economy should also be approached in the larger context of both the global and the North American economy. Since the adoption of the North American Free Trade Agreement (NAFTA), there have been strong integrative forces between Mexico and the United States and between the United States and Canada. Policies to strengthen economic growth and innovation can build on NAFTA's strong base of trade and investment. At the same time, each of the North American nations faces similar challenges from globalization and from economic transition. Improvements in one country can benefit all. Economic growth in Mexico would benefit the United States directly in a number of areas, by expanding markets and helping moderate immigration. Cooperative efforts, either bilaterally or trilaterally, hold real potential for growth across North America and to help address other problems, such as immigration.

Canada and Mexico face many of the same challenges from globalization. Some Canadian sources cite concern over emerging low-cost competitors, including China, India, Brazil, and (ironically) Mexico. Although Canada has a relatively strong technology sector, Canada's government and business

⁴ For example, Richard Jackson, *Building Human Capital in an Aging Mexico*, a report of the U.S.-Mexico Binational Council (Washington, D.C.: CSIS, July 2005).

community came to the conclusion in the late 1990s that by many measures, Canadian performance in innovation was below average in key areas, such as the growth of labor productivity. In response to the need for what government sources called “significant improvement,” Canada launched a series of programs to improve its innovative capabilities.

Canada’s efforts to build a more innovative economy contain a number of attractive elements that could serve as useful precedents for both Mexico and the United States. However, the central problem for accelerating innovation is different in each country. The problem in Mexico involves shortfalls in governance, investment, and human capital. In Canada, the issue is the need for a broad reorientation of economic policy. Canadian policies in some ways resemble European economic policies, which emphasize the delivery of social services. Perhaps the most important conclusion we can draw from the Canadian experience is that Canada, like Mexico and the United States, is focused on promoting innovation, and this shared focus provides a strong foundation for a cooperative North American effort.

To date, economic growth and technological cooperation have not been high on the bilateral or North American agenda. This is increasingly counterproductive and could make bilateral discussions irrelevant. The bilateral agenda needs to reflect the nature of the new global economy if it is to remain relevant. As science, technology, and innovation have become more important in determining the success of economies, the attention devoted by North American governments to these topics and to cooperation should increase.

- *Create new bilateral or trilateral initiatives.* The single most important step would be for both countries to move science and technology cooperation to a central place on the bilateral agenda. Both the United States and Mexico would benefit from developing additional mechanisms for cooperation outside of the existing structures. There are many existing bilateral mechanisms, but science and technology are strangely absent from their efforts. There are more than a dozen working groups under the umbrella of the U.S.-Mexico Binational Commission, focusing on security, trade, environment, and border issues—there is even a working group specifically for e-commerce. But there is no working group for science and technology cooperation. Adding an S&T working group to the binational commission is an easy first step. Its work could build on the existing (and underutilized) 1972 Science and Technology Agreement between the two countries.

Some have recommended that the best approach would be to amend NAFTA to include science and technology (including education). NAFTA would become the vehicle for cooperation in science and technology. The attraction of this idea is that it firmly links science and technology to the economic and commercial concerns at the heart of NAFTA. Creating a North American market has benefited the economies of all three NAFTA partners and attempting to duplicate this by creating a common ‘research space’ might produce similar benefits. Any effort to expand NAFTA would have to be carefully designed to avoid reopening the disputes over the benefit of free

trade that marked the NAFTA debate. The difficulty of designing this politically neutral approach and avoiding another round of criticism is a major obstacle to using NAFTA to strengthen research ties.

- *Expand government-to-government collaboration and partnerships.* One avenue that has not been explored fully can be found in the lack of discussion of science and technology issues in existing bilateral mechanisms. The United States has undertaken a series of science and technology assistance programs in many countries, designed to build and maintain research capacity. Many strategies have been employed over time. Activities like training and education, investments in centers of excellence, networking, support for scientists and institutions, and data sharing have helped move countries from being recipients to collaborators. While there are strong partnerships at the institutional level between the United States and Mexico, increased government-to-government collaboration would be useful. The objective should be to identify, in both governmental and nongovernmental sectors, where new efforts could provide a foundation for a more systematic and sustained approach to developing an architecture for strengthened North American cooperation in the realm of science and technology. These efforts could include new agreements to promote FDI, cross-border partnerships, and technology transfers. Under the Partnership for Prosperity created by the two countries in 2001, the United States and Mexico have recently announced a new series of partnerships between 10 U.S. universities and their Mexican counterparts. These initial partnerships (undertaken as part of the TIES program—Training, Internships, Exchanges, and Scholarships—created in 2004 to build human capital) do not focus on innovation and technology, but the effort provides a useful platform for expansion into high-tech areas.
- *Establish an innovation council for high technology.* One useful precedent that could be duplicated in the North American context is the recent creation of an Innovation Council for High Technology between the United States and Russia. The council was created in November 2004. It seeks to spur private-sector innovation, entrepreneurship, and partnerships by promoting cooperation in innovation, commercialization, and high technology. The members are drawn from government agencies, business, and the research community. The council works to expand interaction among government agencies and the business and scientific communities. Its goal is to commercialize the results of scientific and technical activities, including those developed through government funding. Creation of a similar council among the United States, Mexico, and Canada could spur cooperation in creating a North American innovation zone that could benefit all three countries.

Conclusion

In March 2005, in a joint statement, U.S. president George W. Bush, Mexican president Vicente Fox, and Canadian prime minister Paul Martin said, “In a rapidly changing world, we must develop new avenues of cooperation that will make our societies safer and more secure, our businesses more competitive and

our economies more resilient.” Expanding cooperation in science and technology to build an innovative North American economy is one of the better ways to do this in all three countries.

National economies grow at different rates, and national policies can either slow or accelerate these rates. In seeking to identify national policies that will accelerate growth, governments must take a number of factors into account. The most important of these factors are: the internationalization of economic activity; the effect of new technologies in changing the costs of economic activities; the increased importance of intellectual property in national wealth; and the role of innovation.

All countries face the challenge of globalization and need to increase innovation. These are global trends that reflect deep and long-term changes in international relations, technology, and economic behavior. How each nation responds will help determine its well-being and growth. Increasing the scope and rate of innovation in a national economy will improve its position in a global economic environment.

This report began with two hypotheses: innovation is essential for economic growth; and government policies can accelerate innovation. Mexico already has, of course, a range of policies and programs to stimulate economic growth. Mexico has sought to advance its science and technology base by launching a series of programs and initiatives administered by CONACYT.

These CONACYT projects have aimed to make significant improvements in: the way that science and technology is conducted within the public sector; the level of government support for private-sector R&D; the amount and quality of collaboration among public and private organizations; the availability of human resources for technology R&D; and Mexico’s participation in international technology-promoting endeavors.

The breadth and depth of CONACYT’s proposed and progressing work thus far is impressive and falls squarely within the strategic objectives of the Special Program of Science and Technology 2001–2006. Though the program is evaluated each year, being three-fourths of the way to completion provides a special opportunity to take a longer-range view of what has been done to date and what is yet to be done.

One key question for Mexican policy is to determine where additional government action can produce outcomes that advance economic transition. Markets are very effective at supplying goods and services in most situations, but in some instances, a reliance on the private sector will not produce the best outcome. Another question—for Mexico, the United States, and Canada—is how to build on existing cooperative efforts to accelerate growth and innovation in all three economies.

A cursory examination of many of the bilateral efforts that Mexico and the United States have undertaken might suggest that these efforts are oriented toward shared problems. Creating new initiatives for scientific and technological cooperation would be something different—a focus on creating shared

opportunities. In an increasingly challenging international environment, there could be many benefits beyond economic growth for North America if it takes this approach.

About the Author

James A. Lewis is a senior fellow and director of the CSIS Technology and Public Policy Program. Lewis, a former member of the U.S. Foreign Service and the Senior Executive Service, worked on foreign policy, national security, and technology-related issues at the Departments of State and Commerce. Since coming to CSIS, he has authored numerous publications, including *Globalization and National Security* (2004), *Spectrum Management for the 21st Century* (2003), *Perils and Prospects for Internet Self-Regulation* (2002), *Assessing the Risk of Cyber Terrorism, Cyber War, and Other Cyber Threats* (2002), *Strengthening Law Enforcement Capabilities for Counterterrorism* (2001), *Preserving America's Strength in Satellite Technology* (2001), and *China as a Military Space Competitor* (forthcoming). His current research involves innovation, military space, and the global information technology industry. He received his Ph.D. from the University of Chicago in 1984.