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TECHNOLOGY, FINANCING AND POLICY SHIFTS IN MEXICO: CHALLENGES FOR SMALL FIRMS IN A NEWLY OPENED ECONOMY

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ABSTRACT

The thesis argues that as technology and the economy are closely related, one factor undermining Mexico's economic performance may be the lack of a coordinated technology and innovation policy. It examines the relationships between three main participants in the national system of innovation: government, firms and financial institutions. Indigenous technology development in Mexico has become a more relevant debate since the country evolved from a protected to an open economy. Therefore, the period of study starts with the background of the 1970s, while the core of the thesis covers the mid-1980s onwards. It is argued that the economic crises of this period justify the need for, and hence the assessment of, government participation.

Among the different government policy tools, this work focuses on the financing of private firms' technology projects. Small and medium-size enterprises (SMEs) are the subgroup of firms analysed through both quantitative and qualitative methods. Empirical evidence was gathered mainly from primary sources, including documents, in-depth interviews and a national survey of SMEs that have sought support from government agencies for undertaking technology projects.

Even if Mexico has the main elements that, by international standards, any national system of innovation should have, this research shows that the short-termism of the government policies to promote the development of technology clashes with the long-term nature of technology projects. The lack of effective coordination between participants within the system undermines the creation of national technology capabilities. Designers and users of technology promotion programmes are isolated from each other, and bridging institutions, like business chambers, are not bringing them closer overcoming divide. Small firms do not have internal resources for research and development (R&D) activities, and banks have been reluctant to fund technology projects. Therefore, this thesis makes the case for government intervention, while suggesting more suitable actions for change.

'Emulate rather than imitate'

Balthasar Gracián, 1637

To my father, Joaquín Xavier

To my mother, María Concepción

To my brother, Joaquín Ulises

To Francesca, my wife, my love,

my endurance. . .

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ACRONYMS AND ABBREVIATIONS

- AMB - Mexican Bankers Association / *Asociación Mexicana de Banqueros*
- ADIAT - Mexican Association of Directors of Applied Research and Technology Development / *Asociación Mexicana de Directores de Investigación Aplicada y Desarrollo Tecnológico*
- Banrural - Rural Development Bank / *Banco Rural*
- BdeM - Central Bank of Mexico / *Banco de México*
- CANACINTRA - Chamber of the Transformation Industry / *Cámara Nacional de la Industria de la Transformación*
- CCC - Presidential Science Advisory Council / *Consejo Consultivo de Ciencias*
- CCE - Businessmen Coordinating Council / *Consejo Coordinador Empresarial*
- CFE - Federal Electricity Commission / *Comisión Federal de Electricidad*
- CMHN - Mexican Council of Businessmen / *Consejo Mexicano de Hombres de Negocios*
- COECE - Coordinating Body of Foreign Trade Business Associations / *Consejo de Organizaciones Empresariales para el Comercio Exterior*
- Conacyt - National Council for Science and Technology / *Consejo Nacional de Ciencia y Tecnología*
- CONCAMIN - Confederation of Industrial Chambers / *Confederación de Cámaras Industriales*
- CONCANACO - National Council of Chambers of Commerce / *Consejo Nacional de Cámaras de Comercio*
- CONCERTEC - National Coordinating Committee for Technological Modernisation / *Comité Nacional de Concertación para la Modernización Tecnológica*
- COPARMEX - Employer's Confederation of Mexico / *Confederación Patronal de la República Mexicana*
- CPP - Average Percentage of Banks' Capture Costs / *Costo Porcentual Promedio*
- DF - Federal District / *Distrito Federal*

- EPA - Environmental Protection Agency
- FDI - Foreign Direct Investment
- FIDETEC - Research and Development Fund for Technological Modernisation / *Fondo de Investigación y Desarrollo para la Modernización Tecnológica*
- FOBAPROA - Fund for the Protection of Bank Savings / *Fondo Bancario para la Protección al Ahorro*
- FONEI - National Trust for Industrial Equipment / *Fondo Nacional para el Equipamiento Industrial*
- FORCCYTEC - Fund for the Strengthening of Firms' Scientific and Technological Capacities / *Fondo para el Fortalecimiento de las Capacidades Científicas y Tecnológicas Estratégicas*
- FUNTEC - Mexican Foundation for Innovation and Technology Transfer in Small and Medium-sized Firms / *Fundación Mexicana para la Innovación y Transferencia Tecnológica para la Pequeña y Mediana Empresa*
- GATT - General Agreement on Trade and Tariffs
- IIE - Institute for Electrical Research / *Instituto de Investigaciones Eléctricas*
- IMF - International Monetary Fund
- IMP - Mexican Petroleum Institute / *Instituto Mexicano del Petróleo*
- IMPI - Mexican Institute of Industrial Property - *Instituto Mexicano para la Protección Industrial*
- IMSS - Institute for Social Security / *Instituto Mexicano de Seguridad Social*
- INC - National Institute of Cardiology / *Instituto Nacional de Cardiología*
- INEGI - National Institute of Statistics, Geography and Information / *Instituto Nacional de Estadística, Geografía e Información*
- INIC - National Institute for Scientific Research / *Instituto Nacional para la Investigación Científica*
- INIFAR - National Institute for Agricultural and Forestry Research / *Instituto Nacional de Investigación Forestal y Agrícola*
- INN - National Institute for Nutrition / *Instituto Nacional de Nutrición*

- INO - National Oceanography Institute / *Instituto Nacional de Oceaongrafía*
- IPN - National Polytechnic Institute / *Instituto Politécnico Nacional*
- IRL - World Bank's Industrial Recovery Loan
- ISI - Import Substitution Industrialisation
- ITESM - Monterrey's Institute of Technology / *Instituto Tecnológico y de Estudios Superiores de Monterrey*
- LANFI - National Laboratories for Industrial Development / *Laboratorios Nacionales de Fomento Industrial*
- LDCs - Less Developed Countries
- LOAPF - Federal Public Administration Law / *Ley Orgánica de la Administración Pública Federal*
- MSI - Mexican System of Innovation
- Nafin - National Development Bank / *Nacional Financiera*
- NAFTA - North American Free Trade Agreement
- NICs - Newly Industrialised Countries
- NSI - National System of Innovation
- NTBF - New Technology Based Firms
- OECD - Organisation for Economic Co-operation and Development
- PCT - Patent Cooperation Treaty
- PDT - Technology Development Plan / *Plan de Desarrollo Tecnológico*
- Pemex - Mexican Petroleum Company / *Petróleos Mexicanos*
- PND - National Development Plan / *Plan Nacional de Desarrollo*
- PROMIN - Programme for the Financing of Industrial Modernisation / *Programa Unico de Financiamiento a la Modernización Industrial*
- PRONACYMT - National Programme for Scientific and Technological Modernisation / *Programa Nacional para la Ciencia y Modernización Tecnológica*
- PRONDETYC - National Programme for Technological and Scientific Development / *Programa Nacional de Desarrollo Tecnológico y Científico*
- RCM - Shared Risk Scheme / *Riesgo Compartido Multimodal*
- R&D - Research and Development

- ROTT - Registry of Technology Transfer / *Registro Oficial para la Transferencia Tecnológica*
- SARH - Ministry of Agriculture / *Secretaría de Agricultura y Recursos Hidráulicos*
- S&T - Science and Technology
- SCT - Ministry of Communications and Transport / *Secretaría de Comunicaciones y Transportes*
- SE - Ministry of Energy / *Secretaría de Energía*
- Secofi - Ministry of Trade and Industry - *Secretaría de Comercio y Fomento Industrial*
- SEDESOL - Ministry of Social Development / *Secretaría de Desarrollo Social*
- SEP - Ministry of Education / *Secretaría de Educación Pública*
- SHCP - Ministry of Finance / *Secretaría de Hacienda y Crédito Público*
- SMEs - Small and Medium-sized Enterprises
- SNI - National System of Investigators / *Sistema Nacional de Investigadores*
- SPP - Ministry of Budget and Programming / *Secretaría de Programación y Presupuesto*
- TIPP - Programme of Industrial Production Technology / *Tecnología Industrial para la Producción*
- UDI - Reference Indexed Unit of Account / *Unidades de Inversión*
- UNAM - National Autonomous University of Mexico / *Universidad Nacional Autónoma de México*
- UTT - Technology Transfer Unit / *Unidad de Transferencia Tecnológica*
- WTO - World Trade Organisation

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Joaquin Joaquin
The London School of Economics and Political Science, England
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Chapter 1
INTRODUCTION

'A company which wants to survive must innovate... The innovative performance of a company is affected by the conditions of the economy in which it operates. These in return are largely affected by the actions of the government.'

David Budworth, 1996

1.1 - THE ARGUMENT

Current economic debate on growth theories emphasises the importance of technology as a determinant of growth. Moreover, the dispute with main-stream opposing theories lies precisely there, on whether technology should be treated as an exogenous or endogenous factor.[1] Furthermore, the most recent studies of economic performance of nations are giving an increased weight to the role played by technology and innovation as an explanation of the different levels of competitiveness among countries (World Economic Forum and Harvard-CID 2000). Even though both the theorists and the empirical studies centre their attention on technology, the complex interactions of the processes and players involved in innovation systems have not been given the required attention as determinants of the innovative behaviour of a country.

The driving force behind this research is the underperformance of the Mexican economy over the last thirty years and the apparent

[1] For a review of the evolution of the theoretical discussion see Chapter 2.

relationship this has to a prolonged period of under-investment in technology and innovation. Within this context, the aim of this thesis is to understand why, despite many advantageous reforms in the economic climate of Mexico since the mid-1980s, there is little evidence of an improved position in innovation and technology. As Budworth argues, innovation is critical to companies' survival, but furthermore, the application of new technologies at the micro-level is the critical link between innovation as an isolated process and the performance of the national economy (Budworth 1996).

This research is timely, therefore, since after almost two decades of liberal reform, recent evidence suggests that during the period 1990–99, Mexico lagged far behind comparable countries such as Chile and Argentina, and even less-developed economies such as Bolivia, in terms of real growth in GDP *per capita* (World Economic Forum and Harvard-CID 2000). Indeed, over the comparable period during which this research has been formulated, Mexico has been outstripped in terms of growth by previously less-developed nations, thus the lack of investment in technology and innovation has come under increasing scrutiny as one critical factor.[2]

Given this underperformance by Mexico, it is necessary to reassess what appeared to be a promising climate for fostering innovation, and to ask what factors in the case of Mexico's economic and governmental reforms have inhibited, rather than stimulated, the development of the country's innovative capability. The economic factors are addressed first, before turning to the influence of government policy.

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[2] For instance, the most recent Global Competitiveness Report has introduced new measures of technical innovation and diffusion as key indicators of national competitiveness, after their tests based on the growth experience of the 1990s suggested that sustained high rates of economic growth depend on the ability of a national economy to upgrade technology, either through innovation at home or through the rapid and extensive adoption of technologies developed abroad (Sachs and Warner 2000).

The Mexican economic context for innovative performance

Since the mid-1980s there have been many changes to the macroeconomic environment of Mexico which ostensibly should have favoured such capability. The preceding period was characterised by an import substitution industrialisation (ISI) model, implemented following the Second World War, which, while encouraging industrial development, also led to favoured protection, regulation over open markets and to foreign investment inflows unaccompanied by technology transfer (Alcorta and Peres 1998; OECD 1994). The deficiencies of this model were highlighted by the first external crisis in 1976. As a result of protection and over-regulation in all sectors of the economy, companies had been sheltered from the need to upgrade their technological resources. Furthermore, links between industry and science and technology (S&T) centres were virtually non-existent, and industry grew in sectors not necessarily tied to Mexico's comparative advantages (Alcorta and Peres 1998; OECD 1994; OECD 1997).

By the mid-1980s, Mexican government policy had changed dramatically, reorientating towards liberalisation. The change was extremely rapid, Mexico evolving from a highly protected environment into an open economy in a period of less than a decade. In 1986 it became a member of the General Agreement on Trade and Tariffs (GATT) and by a 1995 had reduced significantly the average of trade barriers, had become part of the North American Free Trade Agreement (NAFTA), and a member of the Organisation of Economic Cooperation and Development (OECD). This sudden exposure to competition revealed the level of Mexico's technological deficit. Indeed, the situation mirrors the definition of 'technological backwardness', understood as the insufficient development of the set of social practices through which information is expected to become knowledge applied to production (Wionczek and Márquez 1993).

Paradoxically, it was hoped that this liberalisation would also provide the favourable context for this deficit to be ameliorated. Larger markets supposedly bring about more incentives for innovation, since the fixed costs of research and development for a particular product are recompensed by more extensive sales in foreign markets. Thus, free trade reforms are expected naturally to expand world markets and provide a major boost to growth (Sachs and Warner 2000). Furthermore, if open trade and economic deregulation increase exposure to competition, in a competitive market environment, business opportunities are gained primarily by efficiency, technology development and innovation. This is as important for the defence of domestic markets as for capturing external market share. Therefore, managers need to promote technological modernisation as a core component of their business strategy.

This heightened awareness of the importance of technology coincided with the widespread reform of the financial system, principally the privatisation of the banking sector in 1991 following a period of state ownership in the 1980s. This would be expected to open up sources of funding to facilitate the necessary technological investment.

However, the Mexican experience indicates that this favourable environment was not capitalised upon. The 1999 figures show that just 0.33 percent of GDP was spent on research and development (R&D), unchanged since 1991. In such terms, Mexico ranks 45th of the 59 countries detailed by the World Economic Forum despite ranking 12th in terms of GNP. Moreover, the total R&D personnel per thousand in the labour force remains around 0.9 percent for the same period. A benchmark measure such as technological sophistication shows Mexico to rank below comparable countries such as Brazil and Chile (44th, 41st and 26th respectively), and far behind key competitors: the US ranked 1st and Canada 13th (Conacyt 1996b; World Economic Forum and Harvard-CID 2000).

This contributes to Mexico's continued low levels of economic growth. Even as this introduction is being written, press comment surrounding the World Economic Forum 2001 Davos Summit points to Mexico's poor growth over the preceding decade, averaging 1.2 percent per annum, and the critical role played by technological retardation (World Economic Forum and Harvard-CID 2000). Referring to such a context, *La Jornada*, a major national newspaper in Mexico, likened Mexico to a failing student who, despite having every opportunity, nonetheless never seems to improve his grade (Zúñiga 2001).

The reasons for this failure lie firstly in the particular economic situation of Mexico. For while the opportunities outlined above represent an idealised model for growth, they do not reflect adequately the Mexican situation. A suitable economic environment, identified by Budworth (1996) as a determinant of innovative performance of companies (and by extension, nations) is not alone enough to guarantee a positive outcome. In the case of Mexico there are three main economic factors which have negated the potential released by the reforms of the recent years.

Firstly, there has been continued macroeconomic instability for a period of almost 30 years. The rapid restructuring during the 1980s, which allowed companies little time to adjust, was itself overlaid by a series of crises and consequent remedial policy initiatives. These repeated and ongoing fluctuations make even medium-term strategic planning futile. Furthermore, these crises compounded difficulties in the financial sector, already straining to readjust to private ownership.

Secondly, such volatility impacts most heavily upon small and medium-sized enterprises (SMEs) which have few resources to allocate to R&D, which is perceived to be too risky, costly and slow to return investment. Without a historical legacy of innovation accumulated in a context of competition and stability, SMEs exposed to an aggressive and volatile environment are unable to engage in long-term technological development. The profile of the Mexican private sector is weighted heavily towards such SMEs, which make up 90 percent of private Mexican businesses.

Finally, alternative sources of funding usually available to SMEs are absent in the Mexican scenario, where there is a very poorly developed venture capital market. This reflects in Mexico's ranking 50th of 59[3] in respect of the availability of venture capital to entrepreneurs with innovative but risky projects (World Economic Forum and Harvard-CID 2000).

In such an environment it is imperative that the government participates directly in fostering the innovative process. It is appropriate, therefore, to assess the policies of the Mexican government relating directly to technology in the light of the failures identified above.

Government policy and problems

To counteract this economic instability and successfully stimulate indigenous innovation growth, the Mexican government needs to provide a coherent policy framework. Two elements are essential; the approach must be holistic, integrating education and legal, financial and industrial policy; and this coherent framework must remain stable over a sufficient period of time to allow firms to formulate effective strategy.

Both these elements can be shown to be missing in the Mexican case. There has been a lack of coordination both within and between

[3] Countries ranking higher include Argentina 43, Brazil 45, Canada 17, Chile 34, Greece 25, India 30, Japan 26, Korea 11, Singapore 14, Thailand 42, Turkey 40, the UK 4 and the US 1. Bolivia and Ecuador ranked 58 and 59 respectively (World Economic Forum and Harvard-CID 2000). This basket of countries will form the basis of more detailed comparisons later in the thesis.

government departments and external agencies which has undermined the effectiveness of individual policy initiatives. Also, these initiatives have been predominantly responsive, determined by the volatile macroeconomic context. For reasons of political convenience, policies have targeted short-term goals, and without a credible system of accountability there has been little pressure to address long-term aims. This causes problems not only for companies, but also for the government itself, as the implementation of shifting programmes leads to bureaucratic confusion and inefficiency.

There is, therefore, an inherent conflict between the short-term political cycle and the R&D, innovation and technology cycle which by its nature takes a longer period of time to reach maturity and to realise commercial return. Even if the economic environment in Mexico had been stable, there is a case for government participation to overcome the long-term and risky nature of the innovation process, particularly for SMEs and at the early R&D stages. However, in Mexico's volatile situation, rapid changes in government policy have often proven at best ineffective and at worst counterproductive.

For example, during the period of liberal reforms, as we shall see later in this work, the government favoured a similar privatisation strategy in technology policy. The private sector was encouraged to take over responsibility for R&D and there was a simultaneous change in funding approach from direct state support through a system of grants to the use of the newly privatised banking sector as a credit intermediary. However, this policy failed because it was based on a naïve understanding of the Mexican situation. As was outlined above, there was no history of private sector investment in R&D, and without any experience in evaluating innovative investment proposals, the banking sector was reluctant to release government funds. Furthermore, as this policy change was followed by a severe financial crisis, the seed-funding from the government was not matched by the banks' own investment.

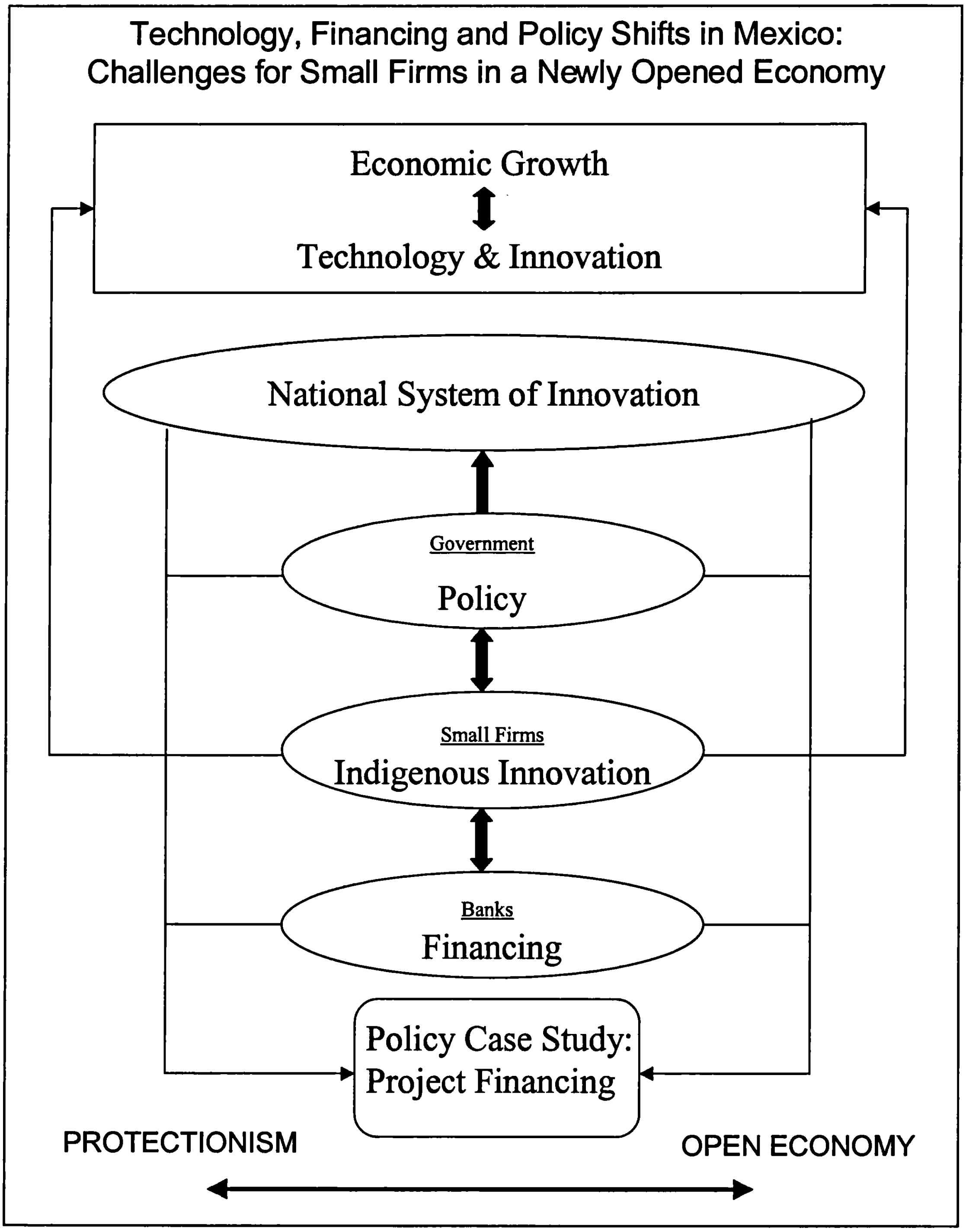
This transition from a grant-based to a credit-based system brings together all the elements introduced above, which cumulatively can explain the underperformance of the Mexican economy and the relationship that this has to technology and innovation, which formed the starting point of this introduction. It captures the inherent weaknesses of SMEs, the insufficiency of funding, and the impact of inappropriate policy design within the overall context of a rapid adjustment from a protectionist to a liberal economy. However, this context is not, in itself, the root of the problem. Neither regime has allowed a robust national system of innovation to develop, and so research must focus instead upon the nature of the central actors in the system and the dynamic relationships between them. A more detailed understanding of this complex interaction, thus far unresolved by existing research, may provide the key to breaking the vicious cycle of underinvestment in technology innovation and poor economic performance which has characterised the Mexican economy in the past 30 years.

1.2 - THE RESEARCH APPROACH AND STRUCTURE OF THE THESIS

The description advanced above can be condensed into a clear research hypothesis: that the poor performance of the innovative system in Mexico can be explained not by headline policy shifts, such as stabilisation and liberalisation, but rather by political economy deficits - notably conflicting interests - within the national innovation system.

This core idea can also be represented graphically. Figure 1.A illustrates how the elements presented in the argument interrelate and thereby provides a natural structure for the thesis. The umbrella relationship between economic growth, technology and innovation will form the subject of the next chapter, while the evolution of the national system of innovation and the key processes of policy, indigenous innovation and financing, are the focus of subsequent chapters. These themes are shown to overlap the transition between economic systems, and will be unified through a case study presented in the penultimate chapter.

Figure 1.A. Interrelations among the processes affecting the performance of Mexico's System of Innovation.



Running through this structure is the central question of why, if technology is acknowledged as vital for economic development in any country, has Mexico not formulated an adequate long-term policy? This will be addressed in relation to the main actors in each one of the processes that make up the national system of innovation. The analysis of government policy will examine the role of policy makers and implementers within public sector institutions such as the National Council for Science and Technology (Conacyt); the National Development Bank (Nafin), the Ministry of Finance (SHCP), the Ministry of Trade and Industry (Secofi), the Mexican Institute of Industrial Property (IMPI), and successive Presidents.

Governments can use a wide range of policy tools to promote and support innovation and technology-related activities including, amongst others, fiscal incentives, education, support for basic science, funding for universities and their link with the private sector, funding for the creation of R&D centres, and direct project financing. The importance, implementation and consequences of each could be the subject of a thesis in itself. For the purpose of this study, the government's financial instruments are the core policy under review.

The analysis of the private sector will focus upon the uptake of technology by small and medium-sized firms. This restricted focus can be justified for two reasons. Firstly, as detailed above, 90 percent of Mexican businesses fall into this category. Secondly, large firms generally have access to credit and capital (both domestic and foreign), and have traditionally allocated part of their budget to technology-related activites. The classification of firms for this study is related to their size and not to specific industrial sectors.

The leading national business associations like the Confederation of Industrial Chambers (CONCAMIN) and the Chamber of the

Transformation Industry (CANACINTRA) are also subjects of analysis because they form a bridge between private enterprise and the state.

Finally, the financing process will be investigated through an analysis of the role of privatised banks in the credit system as whole, and particularly the responsibility they were given for channeling the credits funded by public development banks and agencies (like Nafin and Conacyt) to the firms who required them.

Methodology framework

Given the different natures of the processes and actors to be examined in the research project, a cross-examination of several sources of data (primary and secondary/qualitative and quantitative) was needed, which in turn necesitated a multi-method approach.[4] The analysis of the government institutions was based upon archive documents, including statistics, publications, policy outlines, internal documents, programme operation guides, and both official and internal material. This was supported by semi-structured and in-depth interviews of officials of different levels at the agencies involved in the policy network.[5] This latter method was also used for the private sector, where it was applied to leaders of business associations and entrepreneurs of specific importance, and also to the banking sector, where credit executives were interviewed.[6] The core of the empirical work was based on an analytical survey,[7] conducted at a national level, which questioned[8] executives from a group of SMEs that had expressed an interest in

[4] For a detailed account of the sources, tools and methodology used, see Appendix 1.
[5] For the reference numbers of interviews and the detailed list of interviewees see Appendix 3. For the summary of topics used in the guides for interviews see Appendix 4.
[6] Ibid.
[7] For a detailed description of the methodology used for the design, testing, sampling application, processing and analysis of the survey's data, see Appendix 1.

technological development over the period 1980–98. This group was identified as being those firms that had approached government agencies for assistance since the first assistance programme was established in 1980, at the earliest stages of liberal reform.[9]

From this national-scale analysis of SMEs, three particularly interesting cases emerged and became the subject for deeper study. This involved a mixture of qualitative methods including visits to the firm for observation and open discussion with different people within the organisation. A reconstruction of the firms' experiences was possible and this helped to shed light on the problems that they faced when developing a technology project within the wider context described above.[10]

This marks a distinct change in approach from previous work, conceived within the context of protectionism, which focused on the analysis of the formal scientific and R&D communities and their relationship with government and business interests. However, in the new market-oriented economy, the centre of gravity in the system has shifted, revolving around the takeup of innovation by businesses. In consequence, this thesis will consider the scientific and academic sectors as providers of technology services to private businesses and will not, therefore, be concerned with the direct funding of R&D *per se.*

Structure of the thesis

Following the structure of Figure 1.A, the argument proceeds as follows:

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[8] For the survey questions and reference numbers see Appendixes 6 (Spanish) or Appendix 7 (English).
[9] The list including the name and location of the firms whose owner or director-general responded to the survey's questionnaire is detailed in Appendix 5.
[10] A summary of the case studies is presented in Appendix 2.

Chapter 2 presents a review of the literature concerning technology and its links to economic growth and government intervention. The main concepts of technology and innovation are defined and the key relationships between technology and economic growth under different theoretical approaches discussed. Then the arguments are presented for and against state intervention as a crucial promoter of the building of national technological capability. The experiences of some East Asian and Latin American countries are described to show how important the interaction of states and markets can be in the technological development of a country. While more specifc theoretical discussions are introduced for each individual chapter, this chapter defines the overall theoretical approach towards political economy that is to be kept in mind throughout the thesis.

Chapter 3 sets out the theory behind a national system of innovation (NSI) as a context for the analysis of the Mexican case. The evolution of the Mexican system is described, from the era of the protected economy to the recent economic liberalisation. The participants of the system and their roles are presented, and special emphasis is placed on the aspects of legal industrial protection. In order to evaluate the status and performance of the system in relation to a sample of other countries, some comparative measurements –such as patents and expenditure – are introduced, leading to the question of why Mexico does not have a support package similar to those that exist in the countries against which it is competing.

The next three chapters take a closer look at the three specific players that influence the performance of the system: government, private firms and financial institutions:

Chapter 4 shows how technology policy is created in Mexico, focusing on the political forces and bureaucratic system that affect the manner in which decisions concerning innovation and technology policies are adopted and implemented. A brief description of the Mexican political system introduces the basic notions of the theory of the State, and provides the background to a historical account of the evolution of technology policy and the government institutions involved. Key questions addressed in this chapter include why the government is now in favour of using the free market to dictate the national technology system, and whether this results in the efficient performance of the resulting basket of policy instruments. Furthermore, the importance placed upon technology policy by politicians will be questioned, as will their inability to avoid mistakes of previous administrations. These questions emerge through the experiences of firms that have interacted with those agencies and the obstacles and limitations they have encountered.

Chapter 5 follows this by looking at the other side of technology policy: the private firms, or in other words, the 'clients' of the policy. The role of firms and businessmen is central in any analysis of innovation and technology development, as companies are the ultimate users of technological advances. This chapter analyses the capability of small firms that operate under free trade in a developing country like Mexico to both engage in innovation activities and develop indigenous technology, rather than acquiring it from abroad. In the context of the evolution of Mexico's private sector, together with its relationship with the government, the role of business associations in helping their members to engage in such activities is evaluated. This provokes the questions as to why these private sector representatives have not appealed more strongly for support in technology-related matters, and why there has been such a limited uptake of such government support as is available.

Chapter 6 brings a third actor into the dynamics of technology development: financial institutions. Any innovation or technology project has costs associated with it, thus financing is a crucial input for its development. This chapter assesses the role of national systems for financing innovation and the dramatic shifts experienced by banks in Mexico in the past 20 years. The attitude of commercial banks towards investment in technology underpins the viability of firms to develop their projects. We must question, therefore, why the financial sector in Mexico does not recognise the importance and potential profitability of participating in technology development projects. When banks and firms do not understand each other's needs, and in consequence the technology efforts of the country are hampered, the question arises: should the government participate in the financing of private firms' technology projects? That is the subject of the final chapter.

Chapter 7 has two main objectives: first, to understand and define the government's place as an important player in the financing of innovation; and second, using the analysis of programmes for direct project financing, to present a technology policy case study that reconstructs the interactions between the system of innovation and the technology policy network. This case study illustrates, within the theoretical framework of the thesis, how Mexico's historical background and economic, political and social culture have important effects on the development and strengthening of the technology capabilities of small firms. The programmes of Banco de Mexico, Nafin and Conacyt, with an emphasis on FIDETEC, are the centre of analysis, examined from the perspective of their users, designers, operators and intermediaries. Important conclusions are drawn and can be extrapolated as supportive of the thesis' general conclusions.

The final chapter will review the evidence presented in support of the central hypothesis, and suggest that this innovative approach towards the issue of technology may open future opportunities for overcoming the obstacles to technological investment, not only in Mexico, but also in other developing countries experiencing similar problems in achieving indigenous technology-driven growth.

Chapter 2

A REVIEW OF THE LITERATURE CONCERNING TECHNOLOGY, ITS LINK TO THE ECONOMY AND GOVERNMENT INTERVENTION

> 'Technical change is one of the most important sources of long-term economic growth...Classical, neo-classical, Keynesian and Schumpeterian economists alike would accept this assertion of the key role which technical change plays in fostering economic growth.'
>
> Daniele Archibugi and Jonathan Michie, 1998

INTRODUCTION

Technology is a word that has become part of our everyday vocabulary. We find the concept of technology as part of our lifestyles from dawn until dusk. Moreover, technology is embedded in the economy of nations and of the world as a whole (Turner and Hodges 1992), and the full range of players and events that surround technological innovation is vast. But this thesis is not about technologies as ends in themselves, rather the fact that they are widely considered central to economic growth. As governments of nations are concerned with the promotion of growth, they cannot afford to ignore the processes of innovation and technology development. It is, then, technology *as a tool for the promotion of economic growth* which is the main interest of this work. The topic is by nature complex and can be dealt with in many different ways. The approach of this discussion is political and economic, in the sense that it explores the dynamics of the interaction between the public and the private sector in the field of innovation and technology generation, and the impacts on the economy.

In Section 1 of this chapter the sometimes confusing or overlapping main concepts surrounding technology and innovation are differentiated. The meaning of technology and systems of innovation as well as the introduction of the suppliers, users and intermediaries in the process of technology development are presented. Section 2 reviews the theories regarding the relationship between technology and economic growth. It describes various approaches, including classical, Schumpeterian, neo-classical, new growth, and evolutionary.

The interaction of the government and markets in the study of technology capability building is discussed in Section 3. The approach is a political and economic one: arguments for and against state intervention are discussed. Section 4 proceeds to present some important aspects of technology and the economic performance of developing countries in East Asia and Latin America, to set the context for the core chapters of the thesis which centre around the case of Mexico.

2.1 – CONCEPTS AND DEFINITIONS

Technology, R&D and innovation

Perhaps the simplest way to describe the elements that revolve around this field of study is to start with definitions of concepts. The relationships between these concepts and their impact on economic performance will be assessed in the following section.

The dividing line between the meaning of *technology* and the meaning of *innovation* is virtually impossible to draw. Both concepts are directly linked with production of goods, and one cannot be understood without the other. A conventional definition of technology considers it 'the branch of knowledge dealing with scientific and industrial methods and their practical use in industry' (Longman Group Ltd. 1978). To put it more succinctly, it is the practical use of science. On the other hand, a series of authors define innovation as the initial introduction of a new product and/or the first use of a new product process. An innovation always rests upon an invention, that is, on new knowledge which is transformed by the innovator into economic activity. *Research and development* (R&D) is generally defined as investigative and experimental work carried out to acquire new scientific and technical knowledge, to devise and develop new products and processes or to apply newly-acquired knowledge in making technically significant improvements to existing products or processes (Christy and Ironside 1987).

A more elaborate set of definitions has been compiled by Lundvall (1992b) and he starts with the fact that in the models of standard economics, innovations appear as extraordinary events, coming from the outside, which temporarily disturb the general equilibrium. After a process of adjustment, reflecting the work of the price mechanism, a new state of equilibrium is established. This approach might have been adequate in pre-industrial societies where innovations seemed to occur as rare and exogenous events. Nowadays, however, innovation is a fundamental and inherent phenomenon; the long-term competitiveness of firms, and of national economies, reflect their innovative capability and firms must engage in activities which aim at innovation merely in order to hold their ground. An innovation may be regarded as a new use of pre-existing possibilities and components. Almost all innovations reflect knowledge already in existence, but combined in new ways. Sometimes, the process of innovation results in radical breaks with the past, making a substantial part of accumulated knowledge obsolete. Schumpeter's concept of creative destruction points to this discontinuity and might be applied not only to the structure of production, but also to the structure of knowledge. Innovation appears not primarily as a single event, but rather as a process (Schumpeter 1934; Schumpeter 1943).

The following threefold taxonomy distinguishes between incremental and basic (or radical) innovations while also looking at clusters of related innovations (Freeman 1987a):

- Incremental Innovation. This is a relatively smooth continuous process leading to steady improvement in the array of existing products and services and the ways in which they are produced. The rate of incremental change varies greatly between different industries.
- Radical Innovations. These are discontinuous events. They may lead to serious dislocations, economic perturbations and adjustments for the firms in a particular sector. Examples would be the introduction of the television or of an entirely new material in the textile industry.
- Technological Revolutions. These are the gales of creative destruction which are at the heart of Schumpeter's long wave theory. The introduction of railways or electric power are examples. To justify the description of a technological revolution, a change must not only lead to the emergence of new leading branches of the economy and a whole range of new product groups, it must also have fundamental effects on many other branches of the economy by transforming their methods of production and their input cost structure.

Moreover, innovations take two forms: product innovations and process innovations. The innovation process involves both, creating new knowledge and drawing on the knowledge pool to generate new products and processes. Further, it extends beyond the initial introduction of a new product to its diffusion among potential consumers and/or users, and includes the responses of producers to market feedback from buyers of new and existing products (Hall 1986).

Whether product or process innovation, the innovation line itself has three parts: invention–innovation–diffusion.

The great diversity which characterises innovative activity implies that no one channel or institutional form could be expected to provide an ideal framework for innovation; there is a variety of sources distinguishing between the roles of external and internal learning in the innovation process (Freeman 1995; Jewkes, Sawers, and Stillerman 1969; Metcalfe and Diliso 1996). Different inventories can be found throughout the related literature defining the crucial factors that encourage innovation. A comprehensive account would include (Dodgson and Bessant 1996):

- A thriving science base
- An educated and highly skilled workforce
- A range of intermediary organisations interlinking science base and industry
- Effective government policies and programmes designed to promote university/industry linkages
- Effective government policies towards technology-based joint ventures and offsets
- Legal protection of intellectual property rights
- A regulatory regime that encourages objective rather than *de facto* standards
- Strong managerial competence within firms
- Receptivity towards external know-how within firms
- Intermediaries between users and suppliers, providing a set of bridging institutions
- Availability of seed, venture and risk investment capital
- Firms experienced in linkages with other firms: customers, suppliers, competitors in long-term, trust-based relationships
- A number of progressive, leading firms in key sectors prepared to act as demonstrators to the rest of the industry

- Employee mobility between and within firms, and between firms and the science base
- Supportive local and regional environments
- Good information and communications technology infrastructure.

Given the increasingly scientific character of technology it is difficult to separate many of the elements of science policy from those of technology or innovation policy (Gonsen 1998). This work refers to 'science and technology (S&T) policy' but the emphasis is on the aspects most closely related to technology development and innovation.

Innovation systems

Perhaps the most popular contribution concerning innovation systems[1] is that of Lundvall. He talks about the fact that in the real world the state and the public sector are rooted in national states and their geographical sphere of influence is defined by national borders. The focus upon national systems of innovation reflects the fact that national economies differ regarding the structure of the production system and the general institutional setup. It is assumed that basic differences in historical experience, language and culture will be reflected in national idiosyncrasies in internal organisation of firms, inter-firm relationships, the role of the public sector, institutional setup of the financial sector, R&D intensity and R&D organisation, all of which together constitute the elements of the system (Lundvall 1992b). The relationships between the elements are just as important. In this respect, Nelson focuses the analysis upon the combined public and private character of technology and the role of, respectively, private firms, government and universities in the production of new technology (Nelson 1987; Nelson 1988). Furthermore, Freeman focuses upon the interaction between the

[1] For a detailed review of the concept of National Systems of Innovation see Chapter 3.

production system and the process of innovation and applies a combination of organisation and innovation theory (Freeman 1987b).

Bo Carlsson (1994) makes a further distinction about technological systems, which are not the same as national systems of innovations. They have been defined as networks of agents interacting in each specific technology area under a particular institutional infrastructure for the purpose of generating, diffusing, and utilizing technology. Technological systems differ from national systems of innovation in several important dimensions (Carlsson and Eliasson 1991, 111):

1. Technological systems are defined by technology rather than national boundaries. They are not necessarily bounded by national borders, although they are certainly influenced by cultural, linguistic and other circumstances which facilitate or impede contacts among units within the system. An important dimension in which technological systems may differ from one another is the degree to which they are international in character.
2. Technology systems vary in character and extent from one technology area to another within any given country. A country may be strong in one technology and weak in another.
3. A further difference concerns the degree of emphasis on diffusion and utilisation as distinct from creation of new technology. As a result, technological systems tend to place more emphasis on the microeconomic (as distinct from macro-oriented public policy) aspects of technology diffusion and utilisation. The creation of new technology pushes out the production possibility frontier or opportunity set. But it cannot be simply assumed that just because a technology exists, it is also known and used effectively. Unless the expanded opportunity set is converted into economic-entrepreneurial activity, it has no economic impact.

Private businesses can make their contribution to strengthening the technological system of which they are a part, while at the same time enhancing the chances of their own success, by increasing their economic competence in all areas, by increasing their R&D efforts, by initiating and building new bridging institutions while strengthening existing ones, by articulating the requirements to which the academic sector can respond, and by broadening their technological base (Carlsson and Eliasson 1991). Apart from private firms, other participants include financial institutions, the legal institutions that offer protection to intellectual property, science and technology institutions and educational institutions.

Suppliers and users in the innovation process and their limitations

The suppliers and users of the innovation process are presented in the tables below, showing the limitations that each of them present (Dodgson and Bessant, 1996). Table 2.1 first displays the list of the main providers of innovation together with their unique limiting factors. Table 2.2 refers to the users or demanders of innovation. The following section deals with the bridging institutions that act as the intermediaries between the two.

Table 2.1. Suppliers in the innovation process.

Supplier	*Limitations*
Lone inventor	Lacking in networks and contacts within user firms, marketing skills and experience, understanding of user needs, and project management experience.
University laboratory	Lacking in industrial perspective, project management experience, marketing skills and experience. Has a long-term focus, advances in knowledge rather than in application. Technology-push emphasis.
New technology-based firms	Limited in size and resources to manage the innovation process. Limited understanding of user needs. Lack of networks. Technology-push emphasis.
Commercial R&D laboratory	Lacking in long-term experience and resources to pursue advanced experimental work. Bias towards larger clients.
Government R&D laboratory	Over-reliant on the technology-push model. Insulated from awareness of commercial needs and real cost pressures. Different time horizons from users.
Technology institute	Technology-push orientation. Lack of marketing awareness or skills. Designed on university model but lack of long-term technology strength
Large industrial firm	Danger of resources being concentrated on the short-term. Lack of breadth coverage.
Consultancy	Very short-term emphasis. Limited capacity.
Regional technology centre	May lack technological depth, depends on the strength of its supply-side network.
Overseas supplier	Problems of arm's length transactions.

Table 2.2. Users in the innovation process.

User	*Limitations*
Small firm	Lack of awareness. Limited search behaviour. Lack of understanding of needs or ability to articulate them. Lack of network/access to suppliers.
New technology-based small firm	Lack of marketing awareness. Strong technology push, problems of risk finance.
Medium-sized firm	Deploys limited innovation resources to best ends. Lack of strategic perspective on technology/market.
Large organisation	Over-dependence on internal technical resources. Insular networks and relationships. Limited search behaviour.

Intermediaries in the innovation process

It is the overall system and the quality of interconnections within it that affect successful innovation. In particular, intermediaries in the process are important. Examples of such intermediaries include technology brokers, advisory and consultancy firms, university departments, regional technology centres, research and technology organisations, innovation agencies, and cross-national networks. Effective innovation policy requires a whole range of contributing factors: particularly important targets are the development of innovative capabilities within firms and the sensitive construction of 'bridges' via intermediaries to reach the suppliers (Dodgson and Bessant 1996).

Finance in the national systems of innovation[2]

Schumpeter was one of the first to discuss the importance of credit in the process of innovation. According to him, the entrepreneur is the driving force in the process of innovation, but he must be able to convince the banks to provide him with credit to finance the innovation (Schumpeter 1934, 69). He considers the lender's judgment of the borrower to set the limit of credit expansion, and his contribution is still enlightening. The key characteristic of innovation in this context is its requirement for finance, since it involves a number of different categories of investment – broadly defined as a sacrifice of cash flow in the present or near future with a view to improved cash flow later.

Although the government is not, strictly speaking, a financial institution, it does allocate resources for both private and public R&D and innovation.[3] The financial burden of research is often the most important obstacle to innovation, particularly in the case of smaller firms, and also for projects which require a good deal of development work. Thus, direct financing from governments of R&D activities in these cases can be one of the major, and most effective, policy tools used by governments.

2.2 – VIEWS ON TECHNOLOGY, INNOVATION AND THE ECONOMIC PERFORMANCE OF NATIONS

Overview of the traditional approaches to technology and growth

As stated at the start of the chapter, the importance of the study of technological innovation in this case is related to its impact on economic

[2] For a detailed discussion of the role of finance in national systems of innovation see Chapter 6.
[3] See Chapter 7.

growth and development. Whether growth derives predominantly from quantity changes in inputs or from technological change has always been a matter of great controversy, although the causal link between technical change on the one hand and growth on the other is undisputed - even though its calculation depends to a large extent upon definitions and measurement methods used. However, classical, neo-classical, Keynesian, Schumpeterian and institutionalist economists alike, from Adam Smith to Robert Solow via Ricardo and Marx, would accept the assertion of the key role which R&D and technical change play in fostering long-term economic growth. Such growth cannot occur to any significant extent in the absence of such technical change (OECD 1992; Usher 1980). New processes allow an increase in output per unit of input while new products create new markets and provide scope for output growth. Nevertheless, this proposition that investment in R&D and technological progress are essential for future growth has not yet been conclusively empirically demonstrated (Archibugi and Michie 1998; OECD 1992).

Marx in the 19th century and Schumpeter in the 20th placed innovation at the very centre of their growth theories. Paradoxically, Marx, although a powerful critic of capitalist society, admired it as far as innovation was concerned, as capitalism depends for its very existence on a constant drive to introduce new products and processes. In Marx's approach, when an individual capitalist doubles the productivity of labour whilst the value of the means of production remains the same, the articles produced have cost less labour time than the rest of the same article produced under average conditions. However, as the real value of a commodity is its social value, the capitalist who applies the new method sells his commodity at its social value and realises an extra surplus value as he has lower production costs. On the other hand, this surplus value vanishes as soon as the new method becomes generally used, and dissipates the difference between the individual value and the social value (Marx 1858, 312-317).

The microeconomic processes involved in the adoption of innovations, which today are commonly described as Schumpeterian, were clearly recognised by Classical economists (Cooper 1992). For instance, David Ricardo wrote: '...He...who made the discovery of the machine, or who first usefully applied it, would enjoy an additional advantage, by making great profits for a time...' (Ricardo 1830, 378-379). In both Ricardo's and Marx's view, the conclusion is that innovations in general leave the 'rate of surplus value' unaffected because of the re-assertion of equilibrium; but innovations in the wage goods sector reduce the costs of labour time in all other sectors.

In Schumpeter's theory, the ability and initiative of entrepreneurs, drawing upon the discoveries of scientists and inventors, create entirely new opportunities for investment, growth and employment. Schumpeter's analysis in its early form places considerable emphasis on the tendency of the industry to return to equilibrium. He suggests the idea that a re-organisation of the industry takes place in the re-establishment of equilibrium. Subsequently, Schumpeter's thinking moved toward the notion of continual change as a result of a succession of innovations, leading to a continual reorganisation of the economic system in which the re-establishment of equilibrium is pre-empted by further rounds of innovation (Schumpeter 1934, 156). Later he wrote that the capitalist economy is incessantly being revolutionised from within and that existing structures and all the conditions of doing business are constantly in the process of change (Schumpeter 1943).

Recent theoretical approaches to innovation have been based primarily on empirical observation of firms' behaviour and have been informed by the Schumpeterian concept of how competition takes place in the industrial sector.

In the late 1950s, Abramovitz (1956) and Solow (1957) attempted to account for economic growth in the United States, finding it to be not fully explained by the increase in productive inputs such as labour and capital alone. The largest part of growth was thus attributed to a residual, which was labelled 'technical change' (Abramovitz 1956; Solow 1957). In subsequent international comparative research studies it was shown that growth theories varied considerably across nations and that differences in technological competences played a significant role. Technology was treated as a public good, meaning that it was viewed as freely available to all economic agents, costly to generate but able to be assimilated with nil or negligible costs.

The basic prediction of the neo-classical theory, based on the notion that the main engine of growth - technology - was a freely available good, was that in the long run all countries should converge towards a similar income level (providing that they were experiencing the same rates of capital accumulation). This assumption has been challenged as unrealistic (Nelson and Wright 1992; Rosenberg 1972). This is due in large measure to the fact that in conventional neo-classical (comparative static) analysis, technological change is treated as an exogenous factor.

Neo-classical growth models since the pioneering work of Solow have also pointed to the crucial importance of technical and institutional change as expressed in the relatively large residual factor. Classical economic analysis envisaged that *per capita* output would be stationary as the rate of profit declined with diminishing improvements in productivity. The neo-classical tradition also incorporated the idea of falling marginal product of inputs, so that sustained growth was possible only through exogenous technological change (Solow 1957). If countries have access to the same technology, therefore, growth rates would be expected to converge across countries. Records of industrial countries offer support for convergence (World Bank 1991).

The growth rates of developing countries, however, have diverged. At first glance, this seems to be at odds with the expectation of convergence. But in practice, technological change has neither been equal nor has it been exogenously transmitted in most developing countries, because of import and other restrictions. Furthermore, even if all economies have access to the same technology, national growth rates can differ if human capital and the incentives to adopt new technology differ across countries. The new growth theories note that technological change is endogenous, and that education and knowledge produce positive externalities or increasing returns (Lucas 1988; Romer 1986).

In order to understand the relationship between technological change and economic growth more fully, we need to take an approach in which technological change is at least to some extent endogenised. In a theory in which technological change is endogenous, the existence of a variety of products, processes, economic agents, and institutions that exist in the economy must be recognised. The interdependence among these various entities, must similarly be recognised: it must deal with systems rather than with individual units. And it must be dynamic, recognising economic growth as a continuous process in which technologies and institutions co-evolve over time rather than as an end result at a moment in time (Carlsson 1994). New growth theory attempts to incorporate some measures of technological learning (Aghion and Howitt 1989; Aghion and Howitt 1992; Grossman and Helpman 1989; Lucas 1988; Romer 1986).

Despite its limitations, the 'new growth theory' highlights the interaction between growth and technology-related tangible and intangible investment. If the increasing returns associated with the features of technological change can be successfully introduced into macro-economic growth analysis and modelling, the results may show more satisfactorily (OECD 1992).

Even if emerging countries may benefit from technology developed by more advanced nations, the institutional theory suggested that the attainment of equal income is neither automatic nor easy to accomplish. Institutional factors such as social rigidity, class structure, or an unwillingness to provide incentives for the innovators can seriously hamper the attainment (or 'catch-up') potential of a nation (Gerschenkron 1962; Olson 1982; Rosenberg and Birdzell 1986).

These arguments were supported by a large body of evidence, more of a historical than an econometric nature. The history of economic growth shows that growth patterns tend to be related to specific economic, institutional, social and cultural differences across countries (Archibugi and Michie 1998). Economists and economic historians within both the neo-Schumpeterian evolutionary school and the more traditional approaches to the international political economy have shown considerable interest in the 'catch-up' process in economic development. They have stressed the role of technological and institutional change, and have pointed to the dynamic interaction between trade performance and growth performance (Freeman 1996). Partly as a result of historical accidents and partly as a result of deliberate policies and institutional changes, some countries have proved more adept in exploiting the potential of these new technologies, both in world trade and in domestic growth.[4]

Generalising from these discussions it would seem that to close a gap in income, backward or developing nations need to catch up with technologically-advanced nations in terms of technological competence. A successful strategy for economic development will therefore be associated with the ability of the country in question to create their own endogenous know-how (Archibugi and Michie 1998). Thus, investment policies that encourage externality-generating activities (improvements

[4] A qualitative analysis can attempt to capture some of those aspects of institutional change (Fagerberg 1988).

in education) or introduce increasing returns (improvements in physical infrastructure) can be good for growth. Also important are complementary policies that facilitate the spread of knowledge and that permit free entry and exit of firms and free mobility of people, capital and technology (World Bank 1991).

Technology and growth in developing countries: the evolutionary approach

It is possible to say that much of the traditional literature presented up to now has neglected the need for, and production of, technological activity in developing countries. Neo-classical theory simply assumes the problem will go away. Firms in a given industry are all on the same production function and select their technologies with reference to the relative factor price ratio, shifting costlessly along the function as this ratio changes. Moreover, in the highly simplified models used in trade theory, technology is taken to be freely available to all countries, and within countries to all firms. Developing countries are presumed to receive all relevant improvements from developed country innovators. There is no problem in assimilating the transferred technology in the developing country, and no adaptations are required, since alternatives are available for all factor prices. In the traditional approaches, developing countries select and, at no cost, apply those innovations that are useful or appropriate. The role of technological activity in developing countries is minimised, as well as the need for policies to support, protect and induce such activity (Lall 1992a).

Neo-classical approaches to development thus tend to confine themselves to cutting back government intervention in firms' technological activity, and also public S&T technology infrastructure. Where they admit the need for interventions in industry, they favour neutral rather than selective interventions (Lall 1991).

In contrast to the analyses just mentioned, new approaches to the issues of technology in developing countries have recently appeared. These have assigned a central role to indigenous technological effort in mastering new production processes, adapting them to local conditions, improving upon them within the economy and exploiting them overseas by manufactured export growth and diversification, and by exporting the technologies themselves (Lall 1992a). These factors can be considered separately at the firm and the national levels.[5]

Firm-level technological capabilities

The micro-level analysis of technology in developing countries has drawn a great deal of inspiration from the 'evolutionary theories' developed by Nelson and Winter (1982), and explained in Nelson (1981) and Dosi (1988). The starting point of these theories is that firms differ in terms of the production function. Technological knowledge is not shared equally among firms, nor is it easily imitated by or transferred across firms. Transfer necessarily requires learning because technologies are tacit, and their underlying principles may not always be clearly understood (Dosi 1988; Nelson 1981; Nelson and Winter 1982). As a description of reality, in both developed or less-developed countries, the evolutionary approach is more believable than the production function theories. As Dosi puts it, evolutionary theories can explain the 'permanent existence of asymmetries among firms, in terms of their process technologies and quality of output' (Dosi 1988, 1155). Once firm-level technological change is understood as a continuous process involving the absorption or creation of technical knowledge, determined partly by external inputs and partly by past accumulation of skills and knowledge, it is evident that 'innovation' can be defined much more broadly to cover all types of search and improvement efforts.

[5] For a more detailed discussion see Chapter 5 .

National technological capabilities

Countries differ in their ability to exploit technologies or bring forth technological innovation. The technological competence of a country's industrial sector may be manifested in a number of variables such as its dynamism, competitiveness, diversification, productivity growth or export performance (Lall 1990; Lall 1991; Lall 1992a). There is no theory that brings together all the factors that may influence these variables, as different studies analyse different influences. Moreover, national capabilities are not simply the sum of thousands of individual firm-level capabilities developed in isolation. Aggregated firm-level capabilities are affected by a series of policy variables and institutions which produce the technological competitiveness of a country's economy as a whole (Lall 1992b). Therefore, over the long-term, economic growth arises from the interactions of capabilities and incentives operating in an institutional framework: institutions set the rules of the game and act to alter capabilities and change incentives (OECD 1987). Moreover, it can be argued that the emergence of advantage depends on a complex evolution of competitive and cooperative ties among local firms, on government policies and on a host of other social and political institutions (Porter 1990).

In developing countries, just as for developed ones, given the skills and incentives to engage in technology activities, performance would still differ depending on the ability of institutions and government policies to overcome market failures and protect innovative activities. Therefore, the next section discusses how government intervention affects all aspects of technology development.

2.3 – THE POLITICAL ECONOMY OF INNOVATION: THE INTERACTION OF STATES AND MARKETS

Important efforts are made by companies and governments to create, enhance and diffuse technology. In this interaction, states and markets show a clear case of political economy (Dodgson and Bessant 1996). Technology-based products account for the highest and fastest growing proportion of world trade, which explains much of the corporate and public policy interest in technological innovation. Firms use technology as a fundamental driver of competitiveness, and in a wide variety of ways governments support corporate technological activities as the primary agents of technical advance within an economy.

Although it is essential for firms to stay in business, technological innovation is a lengthy and frequently uncertain process. Firms' preparedness to invest valuable resources in something so costly, disruptive and unpredictable derives from confidence in the potential comparative competitive advantage it can offer. There are ways in which public policies can assist firms to improve awareness of why and how to invest in technology, and to overcome the complexities and uncertainties of innovation so as to enhance their own and their nations' competitiveness and ability to pay their way in the world (Dodgson and Bessant 1996).

Governments face information and incentive problems no less than the private market. Therefore, good policy requires the identification of market failures and the differentiation between those causes of failure that can be directly attacked by making markets work more effectively and those that cannot. It is important to identify which market failures can be ameliorated through non-market institutions. It is important to recognise both the limits and strengths of the markets, as well as the limits and strengths of government intervention aimed at correcting market failures (Stiglitz 1989).

When there is a call, in some countries at least, for less government involvement (interference) in industry, it is becoming increasingly evident that consideration of the threats and opportunities posed by radical innovations need to be an important component of government policy (Rothwell and Zegveld 1981). Since it implies greater government involvement with industry, this could pose a dilemma. Involvement of industry in policy formulation and implementation processes might go some way towards resolving this dilemma; it should also result in policies of greater relevance to the needs of industry. Moreover, world economic crisis can be structural, and bound to a significant extent with the mode of evolution of industries and of technologies, implying that the changes necessary to overcome them are difficult and rather long-term in perspective (Rothwell and Zegveld 1981).

On a more general level, some economists, businessmen and politicians are seriously worried by the proliferation of government controls and regulation of all kinds, which take up a great deal of management time and effort. Others, on the other hand, argue that the costs, complexities and risk-taking of technical innovation in many branches of industry are now becoming so great that an even higher degree of government involvement at all levels is quite inevitable. Moreover, it is argued that government-backed international competition is becoming so universal that economic survival dictates state involvement here too. Government participation in new product development, new plant investment, procurement, overseas marketing, and other aspects of innovation would lead logically to a strategy of total state involvement (Evans 1995).

Arguments against state intervention

Simply stating that R&D is risky or that industry's R&D cycle times are too long does not automatically lead to the need for an R&D policy. If a market failure is identified, its severity must be assessed to determine industry's capacity for removing it through collective action or some other private sector strategy (Tassey 1997).

If the firm is the social agency that specialises in innovation, the firm should be left to manage the precise form of the technology-market match and the uncertainty of success in innovation. The same simple point leads to a natural policy concern with both the firm's ability and incentive to innovate. Nor is this policy a version of 'laissez innover' (Mowery and Rosenberg, 1979), of leaving innovation to the market, since this usually implies not only non-interference in the technology-market match but also non-interference in the producers' abilities and incentives. A less radical position is that there should be room for institutional policies, like those related to providing the framework rather than directly interfering in the process of resource allocation: policies on competition, financial[6] and legal institutions[7], for these more obviously shape the firm's incentive to innovate, as well as its ability (Howells 1997).

Industry's investments in the various elements of the typical industrial technology suffer from a number of partial market failures, and government's role is therefore more difficult to define and implement. These barriers to adequate investment in technology R&D affect both the aggregate amount of R&D spending by industry and the composition of this R&D (Tassey 1997).

[6] See Chapter 6.
[7] See Chapter 3.

The main anti-interventionist arguments can be summarised and classified as follows:

1. The evolutionary argument. There is a scepticism towards prediction and manageability of processes of change inherent in evolutionary thinking. Evolution is fundamentally an open process ruled partly by contingency, and partly by unforeseeable and accidental generation of new knowledge. The importance of unexpected novelty and survival of the luckiest tends to make forecasting and planning for the future rather uncertain and seems to leave little room for effective innovation policies (Dalum, Johnson, and Lundvall 1992).
2. The Austrian argument. The market mechanism is a very effective discovery process. Its results cannot be improved by policy-makers through selective intervention in resource allocation (Hayek 1975).
3. The political failure/rent-seeking argument. Much depends, however, on the competence, honesty and political strength of the policy-makers.[8] Where governments are so weak or corruptible that selective intervention leads to the hijacking of policy by entrenched interests, it may be better to suffer market failure than pervasive government failure (Biggs and Levy 1990).
4. The knowledge/information argument. Governments do not necessarily have the requisite information of present and future market trends in order to effectively intervene selectively. The market turns out to be a more efficient mechanism for digesting dispersed information than any man can design (Hayek 1975).
5. The general equilibrium argument. The selective allocation of resources via selective intervention may affect the rest of the economy operating under market forces.

Some other economists, however, use a more targeted approach and have questions about usefulness and the need for subsidy, especially of

[8] See Chapter 4.

full-scale commercial development. Eads and Nelson (1971) have argued that, while governments should continue to finance the development of basic skills and knowledge (including engineering skills and knowledge), industrial firms still do have the capacity to finance even very large-scale development projects. The latter provided that both the technology and the market conditions are right (Eads and Nelson 1971). Government-financed projects of full-scale commercial development will be one result of pressures from government and industrial lobbies committed to a particular technology, without sufficiently cool appreciation of its commercial prospects. In other words, governments are running the risk of commercially financing second-best projects, which, once given governmental financial and political involvement, will also be more difficult to stop than regular commercial projects.

The experience of developing countries is overburdened with instances of misguided intervention. Yet the existence of relatively few cases of very successful selective intervention suggests that, in the presence of market failures, improved forms of intervention may well be worth striving for.

The justification of state intervention

The arguments against state intervention presented above mainly centred around the capacity of markets in successfully leading the process of innovation, and a scepticism of government's ability to intervene effectively in markets when going beyond framework policies. Nevertheless, those who do not trust the market blindly would neglect three important and interrelated problems (Eads and Nelson 1971):

- Market imperfections. These exist particularly in the high technology sectors, where there is considerable monopoly power and barriers to entry, and where lead times for the development of new technologies are long.

- Infant industries. There is a problem regarding how to sustain infant industries in an internationally free trade world where mature industries have stronger technological positions.
- Adjustment. In an open world with rapid technical, competitive and political change, it is the government's responsibility to tackle the social costs of transition.

Taking into account these three problems, the notion of government responsibility cannot simply be banished. In such a context the institutional setup can also be very important. To a greater or lesser extent, all authors involved with the study of innovation give important attention to the role of governments. Even those who oppose state intervention have to defend their 'no participation' position in order to support the natural flow of technological innovation under perfect markets. Perhaps a better division would be between those in favour of an active selective intervention on the one hand, and on the other those who find that intervention limited to providing the appropriate framework or public goods policy is more effective. Therefore, the debate of government participation becomes relevant under any approach.

If governments are interested at all in growth, they have to be interested in the nature of the path it takes as well as its pace. So, what effort, if any, should government make to promote growth through encouraging the workings of innovation? One answer to this question would be to leave it to the market, but there are good reasons in this area to expect the market to generate welfare sub-optimal solutions. Why intervene? A first answer could then be that the market is unreliable (Hall 1986). An equally important matter is whether governments can do better than the (imperfect) market, and here is an aspect that is more difficult to resolve.

It could be said that appropriate intervention calls for an understanding of how the innovation process works and what its effects will be. So another answer to 'why intervene?' would include these aspects:

- To devise some way of rewarding inventive activity to overcome the inappropriability problem
- R&D uncertainty
- Size of investment or the length of project gestation discourages all but the most risk-loving inventors to buy or retain an interest in the company.

Given that the creation of new knowledge has 'public good' characteristics, governments intervene in the creation and reinforcement of S&T infrastructure. This includes the system of education and training of a country, its public and private research laboratories and its network of S&T associations (Ergas 1986).

The imperfections (fragmentation, gaps and externalities) that characterise the markets for finance for technology development, for the creation of new skills and for the generation and diffusion of technical information are considered to be larger in less developed countries (LDCs) than in developed countries, and may therefore create a case for government intervention (Lall 1991; Lall 1992b).

In practice, governments may lack the skills, knowledge, objectivity and/or autonomy to intervene efficiently, leading to the higher costs of government failures than the costs of market failure itself (OED 1992). However, alongside the ill-advised and inefficient government actions in the past in import-substituting economies, successful interventionist industrialisation strategies have also been recorded in export-oriented countries. In this respect, Moreira (1995) contrasts the cases of Brazil and Korea in terms of government intervention. Intervention in Brazil was not properly designed to overcome market failures, and lacked the guidance and discipline of an open economy. The Korean government's intervention was both decisive and selective, and reduced the risk of failure by subjecting actions to the objective of achieving export growth. Apart from the increasingly accepted advantage of outward-orientation, Moreira's analysis shows that government intervention may be a powerful instrument of industrialisation when it is used within the discipline of an outward-oriented economy, and with selective and clear objectives of remedying specific market failures. In short, well-designed policies can increase the quality and pace of industrialisation (Moreira 1995).

A government or nation can become involved in economic transformation in two different ways: becoming implicated in the process of capital accumulation and involvement in conflicts over distribution and welfare. Wealth creation is no longer considered just a function of nature and markets: effective state-craft is needed.

What kind of intervention?

Under the reindustrialisation[9] approach, public policy must simultaneously tackle three main factors determining overall national innovative performance: technological opportunity; structure of the industrial sector; and the size and structure of market demand. An important factor influencing national technological opportunity is the size and orientation of the scientific and technological infrastructure (universities, government laboratories and collective industrial research institutes). Moreover, governments must provide a suitable regulatory framework in which all three elements can develop effectively, and the three remaining main government policy instruments - finance, procurement and technical infrastructure (including technical education)

[9] When there is structural transformation of industry into higher value-added, more knowledge-intensive sectors and product groups, and the creation of

- should be directed at these elements in a balanced way (Rothwell and Zegveld 1985).

Regarding the structure and dynamics of the industrial sector, public policies generally have swung from supporting industrial agglomeration to a bias in favour of small firms and have largely ignored the dynamic complementarities that exist between the two. While the balance between the large and the small might vary over the industry cycle, it should be a prime aim of public policy to redress any major imbalances that occur. With respect to the size and structure of market demand, it is possible to say that they are key elements in determining innovative performance. For a large variety of products, governments can provide substantial markets and are hence in a position to exercise their market power in influencing the direction of supply towards higher value-added, technologically more innovative products. Thus, public procurement policy can be considered, potentially at least, to be an effective instrument in influencing both the rate and direction of supplier innovations. Other forms of state intervention include state control exercised over foreign technology agreements, restrictions on the import of technology, and technology decisions through the state ownership and control of technology-using and -generating firms and institutions (Fransman 1986).

For Evans, the main argument is that state involvement is a given, so the appropriate question is not 'how much' but 'what kind'. First of all he starts by constructing two historically-grounded ideal types of states: predatory and developmental (Evans 1995). Predatory states extract at the expense of society, undercutting development. Developmental states have not only presided over industrial transformation but, it can be argued, played a role in making it happen. They are embedded in a concrete set of social ties that binds the state

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major new technology-based sectors and products serving new markets, it is called 'reindustrialisation' (Rothwell 1986; Rothwell and Zegveld 1985).

to society and provides institutional channels for the continual negotiation of goals and policies. They have the structural basis for successful state involvement in industrial transformation. Structures confer potential for involvement, but potential has to be translated into action to have an effect, so there are patterns or roles of the states, and Evans uses a new terminology – to go back to the question of 'what kind' – to define state involvement:

- The 'custodian' role (a variation of the more conventional 'regulator') identifies regulatory efforts that privilege policing over promotion, restricting the initiatives of private actors.
- 'Demiurge' is a specific way of playing the more generic role of 'producer'. This role is based on a strong assumption about the limitations of private capital, which is considered incapable of successfully sustaining development of commodity production. The state establishes enterprises that compete in markets for normal private goods.
- The role of 'midwife' occurs where, instead of substituting itself for private producers, the state tries to assist in the emergence of new entrepreneurial groups or to induce existing groups to venture into more challenging kinds of production: promotion over policing (i.e. infant sector protection, subsidies, incentives, etc.).
- 'Husbandry' consists of assisting private groups in meeting global challenges that continually affect local firms. The techniques of husbandry overlap with those of midwifery.

His prediction is that combining midwifery and husbandry should work better than combinations that rely more heavily on custodian or demiurge (Evans 1995).

The empirical evidence for the effectiveness of state intervention through technology policy does not allow clear generalisations, either for developed or for less developed countries. However, the Korean case shows that imports of technology should complement rather than substitute for indigenous technological development (World Bank 1993). The effects of technology policy on the building up of technology capacities are widely different from country to country. Ergas states that the effect of technology policies depends on the environment in which they operate (Ergas 1986). If the environment promotes the broad diffusion of new ideas and the rapid adoption of new technologies, then policies aimed at encouraging innovation can yield spin-offs across a broad range of economic activities. Conversely, in an environment characterised by low mobility of human and capital resources, the results of government-sponsored innovation will remain trapped in their originating sector or firm.

The impact of S&T policies is also modified by a number of other factors, such as sociocultural and historical backgrounds, the forms of state intervention, the ways in which the state makes its decisions about the matter, the timing of such decisions, the interests involved in the decision-making process, and the degree of consistency among different S&T policy instruments (Gonsen 1998).

Even in 1963, the OECD was already reporting the fact that a science policy aimed at promoting economic growth is by no means limited to the direct or indirect aid which the government can provide for financing research and development by business enterprises. The Organisation was pointing at other factors which affect more or less directly and profoundly the R&D activities designed to promote economic growth; and these must also be integrated into a comprehensive science policy aimed at economic growth (Freeman, Poignant, and Svennilson 1963).

In a world where economic, social and political institutions – the state among them – shape international specialisation, state involvement must be taken as one of the sociopolitical determinants of which niche a country ends up occupying in the international division of labour.

2.4 - TECHNOLOGY AND ECONOMIC PERFORMANCE IN 'CATCHING UP' COUNTRIES: THE CONTEXT FOR THE CASE OF MEXICO

Many historical accounts point to the importance of institutional innovations in both Germany and the United States which facilitated their 'catching up' with and 'forging ahead' of Britain in economic terms. Particularly important were specialised institutions for vocational education and later for the education of graduate engineers. In the early stages of 'catching up', the import of technology from Britain through migration of skilled workers and reverse engineering was of crucial importance. But in the later stage of 'forging ahead' the social innovation of in-house industrial R&D departments in the chemical and electrical industries from the 1870s onwards was also of major importance in the introduction, exploitation and diffusion of the new technologies (Ashby 1969; Fox and Guagnini 1993; Freeman 1989; Maddison 1982; Maddison 1991).

Carlota Perez and Luc Soete have suggested that times of change in techno-economic paradigm could create especially favourable windows of opportunity for catching-up countries (Perez and Soete 1988). But these opportunities could be seized only if they had made the necessary infrastructural investments and institutional changes over a long period, so that an intensive and fruitful learning process could take place in the new and in older technologies. The import of the technologies is very far from the costless diffusion of perfect information assumed in pure versions of neo-classical theory. It involves very active involvement in learning activities at enterprise level (Bell 1991). Technologies cannot simply be taken off the shelf and put into use anywhere. Moreover, without infrastructural investment in education, training, R&D and other scientific and technical activities, very little can be accomplished by way of acquisition of imported technologies.

Starting as low-income economies in the 1960s, a few economies in East Asia managed, in a few decades, to bridge all or nearly all of the income gap that separated them from the high-income economies of the OECD. Meanwhile many other developing countries stagnated (World Bank 1999).

Amsden and Wade argue that active policies were needed to import and learn to use new technologies, as well as intensive learning at the enterprise level (Amsden 1991; Amsden 1992; Wade 1990). At this level, there are many channels of technological learning and all have been important in the experience of the East Asian countries over the past 40 to 50 years, but three channels have been exceptionally important:

- Education of large numbers of qualified engineers and especially of electronic engineers
- Promotion of a wide range of technical and scientific activities within an individual industry and within commerce itself
- Investment in physical equipment, in new and second-hand plant and machinery.

It is important to mention that these channels could not have been effective had there not been an export-oriented strategy, together with tight fiscal and monetary policies.

Among the economies that are most successfully closing the knowledge gap with the global technological leaders, several featured active government participation, including Japan, Korea and Taiwan, China. Korea followed a strongly interventionist and nationalist route, keeping foreign direct investment (FDI) to a minimum and relying on other modes of technology transfer and a concerted domestic technological effort (World Bank 1999). Although the government of Taiwan, China, was also actively involved in promoting industry, its policies differed in many ways from those of Korea. The Taiwanese based their growth strategy on small and medium-sized enterprises, rather than supporting a few large enterprises that were particularly successful at developing exports. Although Taiwan did not erect the barriers to FDI that Korea did, neither did they it base its development on the massive recruitment of FDI as some other economies have done (World Bank 1999).

It is often forgotten today that in the 1950s the prospects for growth in Latin America seemed far more favourable than those in Asia. US investment was substantial and the levels of industrialisation were well above those in Asia. Argentina was regarded as already being almost developed or industrialised and *per capita* incomes generally were much higher in Latin America than in Asia (Freeman 1996).

However, by the 1970s, despite this lower starting point in terms of industrialisation, the four 'Tigers' of East Asia were generally being bracketed with Brazil, Mexico and Venezuela as NICs (newly industrialised countries). They all enjoyed growth rates well above those of the US and Europe for quite a long period, so that catching up seemed a feasible prospect for them, if not yet for the great majority of less developed countries (Freeman 1996).

But in the 1980s there was a sharp process of differentiation between Latin American NICs and the East Asian NICs. Whereas the East Asian countries continued their rapid growth and even accelerated it, the Latin American countries slowed down or declined. The high growth rates achieved by the East Asian countries were associated with an even more impressive achievement in export performance. All four 'tigers' surpassed the leading Latin American countries (Brazil and Mexico[10]) in their share of world merchandise exports and far surpassed them in world manufacturing exports; the combined exports of the four 'tigers' in 1989 were greater than those of the USA in the commodities group and nearly as large as those of Japan, although in 1980 they still had been producing only about half the export levels of either of those countries (Amsden 1989; Amsden 1991; Freeman 1996; World Bank 1999).

In a recent review of science and technology policy indicators in Latin America, it is concluded that overall science and technology budgets are modest and even declining, there is a low patent activity, and a shortage of scientific and engineering personnel engaged in R&D (Correa 1995).[11]

Within the alternative tradition of evolutionary, neo-Schumpeterian economics, Fagerberg (1988) was the first to offer a reasonably plausible and consistent model of the 'catching up' and 'forging ahead' processes. He was also the first systematically to compare national innovative performance for Asian and Latin American as well as OECD countries (27 countries altogether). His work demonstrated a much better performance in all respects by Asian NICs than by Latin American for the period of 1973 to 1983. Nevertheless, it has little or nothing to say on how to achieve higher growth in innovative activity or other efforts related to the exploitation of innovation and diffusion, and the relation between these changes and similar changes in the institutional system are ignored.

Summing up the discussion on 'catching up' in new technology, the basis of the East Asian success and the relative failure of Latin America

[10] Between 1977-1989, Mexico was the country in the region with the most registered patents, but was continuously overtaken by the Asian Tigers towards the end of the 1980s (World Bank 1999).

in the 1980s lies in a combination of institutional and social changes promoted by active policies (Amsden, 1989, 1991; Wade, 1990), as in the earlier case of Japan (Freeman 1987b). It still remains to be seen whether the major policy changes and new industrial initiatives which are taking place in some Latin American countries, like Mexico, will enable them to evolve into the new international political economy.

Thus, as will be discussed further in the following chapter, the national system of innovation is a crucial factor in facilitating the acquisition and exploitation of new technologies. But in its broadest sense this national system also involves and interacts with other features of the social and political system that are covered in the rest of the thesis for the case of Mexico.

So for the specific case of Mexico, some of the aspects reported by the OECD link the latter discussion of the region with the single performance of the country: Mexico's main challenge regarding economic and social development requires an extraordinary effort of educational, structural, institutional, technological and managerial upgrading. Science and technology policy must become a central agent of Mexico's structural change: the country needs many more professional engineers, scientists and technicians; it needs a much larger technological infrastructure to support the modernisation of industry, services, and public administration; and it needs a much wider base of enterprises with high technical standards able to compete on the international markets on the basis of product quality rather than low labour costs, which at the moment is still fundamental to Mexico's comparative advantage (OECD 1994).

[11] Mexico's indicators are presented in Chapter 3.

SUMMARY

To summarize, we could say that most current streams of thought commonly accept that technological change is one of the primary forces generating economic growth. Nevertheless, the causal linkages between innovation and economic growth are not too well understood.

A starting point is the understanding of the concepts, players and roles of innovative or technological activity. A system of innovation is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge, and a national system encompasses elements and relationships either located within or rooted inside the borders of a nation state.

Countries differ both in their degree of cultural homogeneity and in their degree of political centralisation. Both globalisation and regionalisation could be interpreted as processes that weaken the coherence and importance of national systems. National systems play an important role in supporting and directing processes of innovation and learning. The concept of national systems of innovation may also be useful when it comes to inspiring public policies at the national and international level. Public policies must derive first from the assumption that there is an important role for the state to play in the fostering and promotion of technology-related activities in its productive sector; in the correction of given market failures; and in the pursuit of economic growth.

As far as the generators and users in the innovation process are concerned, there is clearly no such thing as a standard or typical supplier or user in any industry, and thus any policy designed to close gaps in resources or capabilities on the way to developing technological competence must first find ways of dealing with the diversity of the client population. No single policy measure is capable of meeting the wide range of needs; instead some combination is required (Dodgson and Bessant 1996). The issue of what kind of government participation rather than how much of it is central to the understanding of the relationships between technology, economic environment and economic performance.

Chapter 3
EVOLUTION AND INSTITUTIONAL FRAMEWORK OF MEXICO'S NATIONAL SYSTEM OF INNOVATION

> 'Science and technology institutions are not fully performing an enabling role: links and interactions between support organisations, business and academia are tenuous; investment in intangibles and human capital is low; and public policy is only partially effective.'
>
> Ludovico Alcorta and Wilson Peres, 1998

INTRODUCTION

For anything that reflects some kind of technology it can be argued that it started sometime in the past with an idea, which led to an invention, then to an innovation, which in the end created a new product, process of production or service. Whose idea was it? Who believed in it? How and by whom was it developed? Who paid for the first prototypes? How was the intellectual property protected from imitators? Who was it intended for and who benefited from it?

The introduction of new advanced products and processes, both locally and internationally, is generally seen as the result of the functioning and interactions of the institutions, organisations, investments and policies of a national system of innovation (Alcorta and Peres 1998). This chapter discusses Mexico's national system of innovation and the way in which it functions to provide the country with the capacities to develop technologically.

Section 1 presents the main concepts and elements of a national system of innovation, from its definition to its performance measurements. Section 2 covers the origins and historical background of the Mexican system of innovation, assessing its evolution under the protected economy. This includes the origins of the country's science and technology institutions, as well as the main aspects of technology policy planning, design and implementation at the time. An hypothesis that prevails throughout this analysis is that, in Mexico, the lack of concern for technology development issues can be attributed to the inward development policy in place during that period (1950s-mid 1980s). This policy not only reduced vital incentives, but also hid the real dimension of the changes needed (Nacional Financiera and Comisión Económica para América Latina 1974). The first results of the system are presented. Section 3 continues the analysis of the system in Mexico but now looks at more recent times, when the country began operating under the framework of an open economy. The stages of opening up the economy are described, and the institutional configuration analysed. The participants of the Mexican system of innovation are presented, together with their roles and infrastructure. Section 4 introduces the framework of technology policy within the context of an open economy and its impacts on the Mexican system of innovation. Policy issues include taxation and legal aspects. The final section presents some performance measurements, such as patents and expenditure, used within the Mexican system of innovation since the opening up of the economy, and compares them with other countries.

3.1 – NATIONAL SYSTEMS OF INNOVATION: CONCEPTUAL FRAMEWORK

Before the Mexican system of innovation can be analysed, it is important to be acquainted with the main concepts related to all national systems of innovation. The following brief review introduces the definitions, components, interactions and performance measures of national systems of innovation.

Definition

The concept of national systems of innovation (NSI) was first posited by Freeman (1987), who defined the NSI as the 'network of institutions of private and public sectors, whose activities and interactions initiate, import, modify and diffuse new technologies' (Freeman 1987b, 1). It has since been widely disseminated by several authors and organisations (Edquist 1997; Lundvall 1992a; Niosi et al. 1993; OECD 1992). Lundvall, for example, defined the NSI in terms of the 'elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge...either located within or rooted inside the borders of a nation state' (Lundvall 1992a, 2).

Elements

National systems of innovation involve both *institutions* and *organisations* (Edquist and Johnson 1997; Galli and Teubal 1997; Smith 1997).

Institutions are the rules and laws, established practices, common habits and routines that govern the behaviour of organisations and the individuals that comprise them. Their main functions are to reduce uncertainty, regulate interaction and provide incentives. Thus the importance of the intellectual property protection regime (Watanabe 1985).

Organisations are the formalised structures or bodies that operate the NSI. They are the players with predetermined roles within the innovation process, including basic and applied research; knowledge dissemination; invention; product and process research, design, experimentation and development; and new product commercialisation. Such organisations include: schools and universities; industrial and government research laboratories; information-providing and regulatory agencies or knowledge infrastructure agencies; and private and public firms. Within organisations, however, as firms are responsible for innovating, they play a central role in the NSI (Alcorta and Peres 1998).

Each organisation provides the NSI with different kinds of knowledge necessary for successful innovative performance. For instance: universities provide scientific theory and engineering principles; laboratories bring in specifications on products, components and materials; firms supply knowledge on how components interact; and user firms provide information on emerging technological opportunities and the performance of products (Carlsson 1994). These interactions involve not only markets but important personal and professional acquaintances and institutional relations (Alcorta and Peres 1998).

It is generally accepted that governments must support basic research that is socially useful yet would not have been undertaken by the market because it is considered too high-risk. Public policy, therefore, provides direction and coordination to the NSI (Dalum, Johnson, and Lundvall 1992; Freeman and Soete 1997; Galli and Teubal 1997; Nelson 1993). But public policy's role goes well beyond that.[1] Because of the number and variety of institutions and organisations and of

[1] Chapter 4 discusses the role of the public sector in the design, implementation and evaluation of technology policy in Mexico.

possible interactions, both market and non-market, it is necessary to introduce mechanisms that will coordinate them. Moreover, apart from their role in establishing and enforcing institutions, governments can set priorities and provide incentives. Two of the main mechanisms for public policy are related to funding - either of university or government research - or programmes for directly supporting different aspects of the innovation process.[2]

Industrial and intellectual property protection systems

An extensive discussion of the nature of intellectual property systems - institutional aspects, regulations, behaviour and policies - is beyond the scope of this thesis, but some issues need to be recalled here as they affect firms' innovative activities within a national system of innovation.

Intellectual property is a term used to describe the wide range of rights that are conferred by the legal system in relation to discrete items of information that have resulted from intellectual activity e.g. inventions, scientific discoveries, literary and artistic works, trade marks and industrial designs (Lamberton 1994; Rickeston 1992). National intellectual property systems have the following basic requirements (Archibugi and Pianta 1996):

- a balance between providing adequate incentives to generate invention and innovation and ensuring rapid diffusion of new technologies.
- a balance between the private interest of the inventor and society's interest in creating a stable system conducive to both invention and diffusion, with due attention to welfare considerations.

[2] The thesis concentrates on the aspects of public financing for firms' technology projects, see Chapter 7.

- a balance between the temporary monopoly power granted to inventors by patent protection and the norms for the protection of competition (such as anti-trust laws, industry regulations, etc.).

NSI's performance measurements

The output of the NSI can be measured in terms of indicators such as numbers of new products or patents, share of sales derived from new products, or a combination of these. However, it should be assessed not simply through the use of quantitative changes but also through the analysis of the distribution of technological activities or specialisation across different sectors (Archibugi and Pianta 1992).

The most relevant performance indicators of NSI should reflect the efficiency and effectiveness in producing, diffusing and exploiting economically-useful knowledge. Such indicators are not well developed today. One of the classical measures for comparing different NSI is R&D expenditure as a proportion of GDP. This is considered an input measure. The output measures used include patents, the proportion of new products in sales, and the proportion of high-technology products in foreign trade (Lundvall 1992a). Each input or output measure has its own specific weaknesses and it is wise to combine them in order to get a more satisfactory picture of the performance of a NSI.

The patent system in the broader sense is probably the most conventional and also one of the most powerful policy instruments that have been used for the development and diffusion of new technologies. History indicates that the patent system can work as an effective tool to stimulate people's interest in inventive activity. Third world nations' frustration about the system appears to accrue partly from their patent offices' failure to provide adequate information services and the absence of complementary policy instruments (Watanabe 1985). Furthermore, patent indicators are only partial indicators of innovative performance, as not all inventions or innovations are patented, nor are all patents innovations. There is a propensity to patenting variations across sectors and firm size classes. Moreover, many patents are never transferred into commercially viable products and the economic impact of individual patents may differ considerably (Kleinknecht 1996).

Other measures can be used in combination with other indicators, including (Patel and Pavitt 1995):

- the technological balance of payments (data for patent and know-how licenses)
- exports of high- and medium-technology products
- direct measurement of innovations and their diffusion (total costs of innovation)
- surveys of technical experts
- technometrics (measurement and comparison of various dimensions of technical performance of a product or production process)
- statistics on citations contained in patents
- scientific papers and citations.

The rest of this chapter discusses the way in which the Mexican National System of Innovation has evolved. With the above-mentioned concepts in mind, it analyses the system's institutions, organisations, interactions and results, firstly in the context of protectionism and secondly in the context of an open economy.

3.2 – HISTORICAL BACKGROUND OF THE MEXICAN SYSTEM OF INNOVATION

Origins and background (1950s–1970s)

In Mexico, scientific and technological organisations have been established since the 19th century, although it was not until 1950 that a coordinating organisation, the National Institute for Scientific Research, INIC (Instituto Nacional para la Investigación Científica), was created. INIC did not cover applied research or technology, and did not have technical personnel (INIC 1970). It was the precursor of the National Council for Science and Technology, Conacyt (Consejo Nacional de Ciencia y Tecnología), which is today in charge of defining Mexico's national policy for science and technology (Alcorta and Peres 1998; Nadal Egea 1995).

Historically, both science and technology have followed the overall course of external dependence which characterises the Mexican economy and society (Wionczek and Márquez 1993). The impetus given to economic development via import substitution in the 1930s coincided with the emergence of incipient scientific and technological activities. However, they did not receive support either from the state of from the productive sectors. While measures to promote industrialisation were accompanied by increased spending on higher education, which contributed to the advancement of certain areas of scientific research, no similar effort took place in the field of technology. This general lack of interest in technological development could have been related to the fact that technology could be acquired from outside, mostly from the United States, at costs easily transferable to the final consumer in a heavily protected economy. Moreover, little technical know-how was needed in the initial import substitution stages (Alcorta and Peres 1998). Consequently, foreign capital goods, know-how and technical assistance were imported massively, and technological dependence increased progressively as a result.

Such dependence was considered inevitable by the country's economic policy-makers and highly profitable by both the foreign technology sellers and the local buyers and users. The issue of choosing technologies appropriate to the local endowment of other production factors was not yet perceived, while at the enterprise level no risks of importing proven technology seemed to exist. The result was that as late as in the early 1970s no Mexican technology policies existed, little if any technology was created nationally, and the meaningful absorption of imported technology - including management capacity - into the economy and society was hampered by the absence of local technological capability (Alcorta and Peres 1998; Vergara Reyes 1993; Wionczek 1973). The efforts favouring technological development consisted of regulating the transfer of technology processes. Thus their impact was limited and reduced to some areas and enterprises, mostly those publicly-owned.

Not until the early 1970s did the state start considering the need for R&D policies. Some ambitious efforts were made, including: the establishment of policy guidelines for science and technology; provision of additional financing for R&D at university and technical education levels; and the linking of local scientific and technological output with the productive sectors, through supporting legislation, in respect to technology transfer from abroad and the country's access to the international patent system. But given the overall technological dependence and the heavy presence of transnationals in Mexico, not much was achieved in these fields. At the highest political level, what was absent was the understanding that no economic and social development was possible in the face of the persistent weakness of scientific and technological efforts which were largely divorced from the productive sector (Ramírez and Unger 1998; Wionczek and Márquez 1993).

In retrospect, Mexico has lagged scientifically and technologically behind other countries which entered into the industrialisation *cum* modernisation process post World War II, and the country condemned itself to dependent development patterns. It could not be otherwise while overall policies were largely improvised and industrial, fiscal and monetary policies continued unconnected with science and technology support policy proposals (Alcorta and Peres 1998; Metcalfe 1997) .

The Mexican System of Innovation during the protected era (1970s–mid 1980s)

Context

Under the protected environment that prevailed in the country until the mid-1980s, the chances of reducing Mexico's high technological dependence were very slim because most domestic and foreign enterprises lacked incentives to innovate (Bazdresch and Márquez 1999; Elizondo Mayer-Serra 1999; Vergara Reyes 1993). The large presence of transnational enterprises in Mexico was significant, especially as they use mostly foreign technologies in their productive activities. Historically, only a minority of technological problems have been resolved locally (Wionczek and Márquez 1993).

The evaluation of the role played by foreign technology in Mexico's industrialisation is difficult because of the limited availability of data. It is particularly true for the period prior to the early 1970s, in which, on one hand, the government regarded the contribution of technological progress to the development process as relatively unimportant, and, on the other, most enterprises, whether public or private, domestic or foreign, refused to collect and make public information related to technological aspects of their operations (Wionczek 1973; Wionczek and Márquez 1993).

The situation improved in the 1970s, thanks to new laws implemented in the first half of the decade. An official policy regarding technology transfer was defined in November 1972, when a law providing for the approval of technology transfer contracts and another on patents and trademarks were drafted at the then Ministry of Trade and Industry with the full support of the Presidency. Previously, technology transfer had been taken care of by various measures included in industrial development legislation (Wionczek, Bueno, and Navarrete 1974). Therefore, it can be argued that until late 1972, the Mexican government confined its participation to monitoring the costs of acquiring technology abroad using foreign currency. It did not seem to be concerned with what these technologies really were and how they would function within Mexico's particular development characteristics. Nor did it offer to help the manufacture and capital goods production of the private sector to adapt imported technology to local conditions (Wionczek and Márquez 1993).

In the period 1950–80, under a protected scheme, manufacturing production grew fast and generated a constant demand for technology (available mainly from industrialised countries). However, small adaptations were carried out within firms. The existence of such demand stimulated the formation of technical human resources for both the adjustment of imported technologies to local conditions, and the production of some equipment and machinery (Mercado García 1980). It seems as if demand for technology had stimulated the initial growth and evolution of an internal offer of scientific and technological knowledge. Nevertheless, the persistent weakness of close and permanent links between the education system, R&D and its users was made obvious during the Mexican oil boom that started in the mid-1970s. At that time, urgently needed equipment, technology, and high-level technicians had to be brought from abroad because the local productive apparatus failed to respond to growing demand (Alcorta and Peres 1998; Ramírez and Unger 1998).

Origins of technology policy institutions

Mexico's continued lack of awareness and understanding of the role of scientific research can be traced back to the beginning of the first formal attempts to design policy for science and technology. By the end of the 1960s, it was still not accepted openly that an explicit science and technology policy was needed in Mexico (Urquidi and Lajous V. 1967).

Agencies established during the first half of the 20th century had already been replaced by INIC, founded in 1950 under the Ministry of Education's budget. Most of INIC's resources had been channeled to support basic scientific research in universities (INIC 1970). Nevertheless, the scientific community in Mexico has been characterised by the weakness of its institutions and by being dependent on a small group of people.

It was not until the mid-1960s that public opinion in Mexico indicated some concern about the country's scientific and technological underdevelopment, and the high dependence on knowledge generated abroad. It was also realised that practically all technological processes and design for industrial plant came from abroad, at prices that were seen as over-inflated. In 1966–67 groups started to argue in favour of a restructuring of INIC, specifically to include the technology-related aspects of R&D (Urquidi and Lajous V. 1967; Wionczek, Bueno, and Navarrete 1974). It is commonly mentioned that the recommendations of UNESCO during the 1960s to create bodies for the formulation and implementation of science and technology policy was the direct precedent for the establishment of science councils in Latin America, and of Conacyt in Mexico (Nadal Egea 1995).

During the first quarter of 1969, the Ministry of the Presidency convened a series of meetings with the directors and top staff of the main research institutions in Mexico. The outcome of this process was an executive order to INIC, charging it with the task of carrying out the necessary steps to establish an institutional base for the development and implementation of S&T policy in Mexico. Towards the end of 1970, INIC produced a final report with a series of recommendations. On 23rd December 1970, the Federal Congress approved a law creating Conacyt. Since 1971, Conacyt has been the focus of dialogue and communication between government and the scientific community (Márquez 1982). However, its creation did not offer clear signs of improving the problems mentioned before, as it had the characteristics of a typical heavy bureaucratic machine (Nadal Egea 1977; Wionczek 1973). Moreover, according to Alzati, former Director of Conacyt, due to the political reasons surrounding the creation of Conacyt, the institution was more a presidential tool to control the country's academic community than a true concern for science and technology.[3]

Conacyt was formally set up as a decentralised body responsible for the design and implementation of S&T policy in Mexico. Nevertheless, it has had difficulty in influencing the substance of S&T decisions in Mexico. One of the main reasons for this difficulty is precisely that it *is* a decentralised body and not a ministry. In Mexico's public sector, where decision-making is heavily centralised, the relative weight of a decentralised body is almost negligible when confronted with monster state-owned firms or state-controlled entities such as the Mexican petroleum company, Pemex (Petróleos Mexicanos), the Federal Electricity Commission, CFE (Comisión Federal de Electricidad) or the Institute of Social Security, IMSS (Instituto Mexicano de Seguridad Social). And *vis-a-vis* giant ministries, Conacyt was, and still is, dwarfed and thus could not influence science and technology decisions as it

[3] Interview #10.

should (Nadal Egea 1995). Conacyt is an agency employing currently approximately 1,500 people and exercising an annual budget of 300 million US dollars.[4]

Technology policy

As became clear in the last sub-section, the need for an integrated science and technology policy consistent with the country's economic, social and cultural requirements started being perceived in Mexico only in the late 1960s. In spite of some progress made in this respect by the state and scientific community during the 1970s, one can hardly talk about the emergence of a long-term policy in that field even though some components of such a policy did exist.

When talking about the various planning exercises in respect of science and technology policy, Wionczek and Marquez consider that the most serious was the first one, Plan Nacional Indicativo de Ciencia y Tecnologia (Wionczek and Márquez 1993, 44-49). This plan, elaborated by Conacyt and made public in 1976, was based on a thorough evaluation of the existing scientific and technological systems. Some 300 scientists and technologists participated in its elaboration (Aboites 1994). It was based on two premises. First, recognising the increasing importance of science and technology in economic and social development, it considered it imperative to systematically organise and institutionalise R&D activities. Second, in view of underdevelopment, the relative shortage of financial resources and the magnitude of the needs of vast sectors of the population, it embraced the idea of long-term science and technology planning and of establishing R&D priorities. The plan's basic goals were scientific development, cultural autonomy and technological self-determination (Conacyt 1976).

[4] Interview #15.

In addition to establishing overall goals and policy guidelines, the plan addressed itself in detail to all aspects of the science and technology infrastructure problems, from manpower training, producing and maintaining R&D equipment and scientific instruments, to the advisable patterns of international cooperation. Goals and guidelines for action in this respect were set for the incoming six-year presidential term (1977–82).[5] Furthermore, the plan quantified the expenditure needed to meet the outlined targets, indicating that by 1982 it should rise to slightly over one percent of GDP. The state's participation in funding R&D would be reduced and the private sector's share would increase (Conacyt 1976). The plan proposed institutional changes in the management of science and technology activities. The National Science and Technology Planning Commission was to be established with high-level participants from the government, major public enterprises, higher education institutions, and users of science and technology in the productive sector.[6] It had the responsibility of the permanent planning process.

The plan further proposed that the state designed fiscal, financial and other incentives for private enterprises that would help them to develop their own R&D capability, increasing the use of domestic R&D. Scientific and technological policy was to be incorporated into the overall development strategy. However, the results of the planning exercises were not necessarily spectacular, due to the sharp changes which characterise the six-year political cycle in Mexico.[7] Moreover, the complex interplay of power groups seeking their own short-term political and economic interests prevented the initial efforts of technology policy to render the expected achievements (Márquez 1982; Wionczek and Márquez 1993).

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[5] A similar attempt was made at the end of 1994 in respect to proposed adjustments to Fidetec to better meet the needs of users of the programme. The change of administration and the economic crisis of 1995 prevented any effort at continuity. See Chapter 7.

[6] If the financial sector had been included, this Commission could be a predecessor of 1992's CONCERTEC. See Section 3 (page 27) of this chapter.

[7] The political aspects are discussed in a more detailed way in Chapter 4.

The subsequent presidential administration (1977–82) saw the appearance of the new National Science and Technology Programme for 1978–82. It was not only unrelated to the earlier Conacyt planning work but took the form of a disorganised directory of thousands of isolated research projects submitted by the scientific and technological community members (Conacyt 1978; Wionczek and Márquez 1993).

Legal aspects

Regarding the legal aspects that prevailed in this first era of technology policy in Mexico, it should be noted that in 1972 the Mexican government enacted a law requiring all contracts on transfer of technology to be registered with a special office in the Ministry of Industry. The law covered agreements on patents, trade marks, unpatented know-how, technical assistance, engineering services (basic and detailed), training of technical personnel and management services. The parties to these agreements had 60 days to register their contracts in the Registry of Transfer of Technology, ROTT (Registro Oficial para la Transferencia Tecnológica). The purpose of this requirement was to make licensing agreements available for scrutiny by government experts, in order to verify that restrictive clauses harmful for the economy would not be included as part of these agreements. Mexican firms perceived this instrument as an obstacle to their access to foreign sources of technology, and it was seen as one step within a sequence of highly regulatory policies. With ROTT, between 1973–84, the private sector had to endure what it considered an invasion of its prerogatives (Nadal Egea 1995).

In 1976 a new law for patents and trade marks was enacted by the federal Congress. Patents were restricted in a number of sectors, terms were shorter than those available internationally and lapsed if not used locally early on, or faced compulsory licensing. Penalties for infringement of property protection laws were small (Sherwood 1990).

Results and performance

Faced with a general lack of understanding, and in the absence of criteria for scientific and technological policy, the academic and research institutions' budgets are usually determined by treasury authorities on the basis of the amount approved for the previous year. These disadvantages increase, particularly when the budget is subject to restrictive policies, since the amount allocated for science and technology is usually the first to be reduced due to a lack of awareness of its importance on the part of both treasury administrators and the rest of the state bureaucracy, not to mention a large segment of the university bureaucracy.

According to the 1976 Plan, it was necessary that total national spending on science and technology continued to grow during the next administration at a real annual average rate of about 20 percent. Only in this way would the proportion of national spending of science and technology increase from 0.52 percent of GDP in 1976 to something more than 1 percent in 1982, the minimum considered necessary for developing countries (Conacyt 1976). Nevertheless, due to the cyclical political process of forgetting earlier attempts to establish the bases for a long-term national policy on science and technology,[8] the goals of the 1976 Plan vanished (Wionczek 1981).

According to the data presented by Conacyt's reports, domestic spending on science and technology did increase considerably, even if not to the expected levels: from 772 million pesos in 1970 to 4,729 million pesos in 1985 (at constant prices). Its share of total federal expenditure budget rose from 0.15 percent in 1970 to 0.51 percent in 1985. Private expenditure on these activities continued to be very small. Funds assigned to Conacyt grew slowly but steadily from 41

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[8] See Chapter 4 .

million pesos in 1971 to 505 million in 1985. In 1985 these resources represented a 0.006 percent share in GDP, a 10.68 percent share in total domestic spending and an 11.21 percent share in total government expenditure for science and technology. Until 1985 almost 95 percent of all spending in the scientific and technological areas was made by the state (Conacyt 1976; Conacyt 1978; Márquez 1982; Wionczek and Márquez 1993).

3.3 - THE MEXICAN SYSTEM OF INNOVATION SINCE THE OPENING OF THE ECONOMY

From protectionism to economic opening

A common criticism of the protectionist framework that dominated the Mexican economy since the 1940s is that possibilities for deepening the import-substitution strategy became exhausted by the late 1970s and that this was not recognised by the relevant government officials. Thus, Mexico was slow to change gear, open its economy and move to an export-promotion strategy (Casalet 2000; Lustig 1992; Nadal Egea 1995).[9]

Following the debt crisis of the early and mid-1980s, the 1990s featured a considerable reduction of state involvement in technological development. Sectoral priorities were no longer established by the state and are now left instead to the market, comparative advantage and profitability. S&T institutions have been streamlined or eliminated, previous attempts to develop indigenous technologies through public enterprises have ceased and most state firms have been privatised. Intellectual property protection laws have been strengthened by expanding the scope of patents to previously excluded products and increasing their duration, and by introducing tougher penalties (Braga

[9] It could be argued though, that by Latin American standards it was not slower than other countries like Brazil.

1993). Controls and regulations on technology transfer have been eliminated, including provisions that discriminate in favour of local firms, set domestic content requirements or limit the acquisition of foreign capital goods (Nadal Egea 1995; Vaistos 1990). More emphasis has been given to the technology side of research and development, correcting the historical higher importance of science over technology.[10]

Facing the 1982 crisis, Mexico had to defend against the negative impact of the crisis on its emerging scientific and technological development in three ways: the effort to regain levels of federal budget allocations for science and technology; the more rational resources allocation in this field; and the design of a set of incentives to encourage investment in technological innovation by private enterprises (Aboites 1994).

In December 1984, the Science and Technology Development Act was enacted to establish administrative and legal procedures for promoting and developing a national science and technology system. Its main objectives were:

- to coordinate, promote, develop, disseminate and apply the scientific and technical knowledge required for national development;
- to establish guidelines for the federal public administration in the planning of scientific and technological activities;
- to establish a framework for the President of the Republic to coordinate efforts with state and local governments, according to their level of scientific and technical development;
- to promote the participation of the public and private sectors in the development, use and dissemination of scientific and technological knowledge.

[10] Interviews #10, 11 and 20.

To a large extent, these provisions were ineffective. The Planning Committee created by this Law did not succeed in implementing the criteria and guidelines needed to coordinate the efforts of the institutions involved in R&D. The content of the National Science and Technology Development Programme for 1984–88 confirmed the persistence of serious problems in Mexico, arising from the lack of a long-term approach to science and technology policy and making impossible self-reliant technological advancement. The programme stated at its outset that it was based on a long-term outlook but would take effect at least explicitly and on a compulsory basis during that administration only (Wionczek and Márquez 1993). It was hard to believe that, if no progress had been made in respect of science and technology policy in Mexico when the economy was growing rapidly, progress could be expected at the time of the serious crisis of 1982, and when the country was set to start a radical shift in economic policy to open up to international competition.

By 1983–84, the private sector was pressing hard for economic reform in Mexico. From 1983–88 the regulatory environment started to change gradually. In 1983–1984, import permits for 35 percent of the categories of the Import Tariff Schedule were eliminated. In 1986, Mexico became a member of GATT (now the World Trade Organisation, WTO). In 1986, it implemented an accelerated programme to reduce the level of remaining tariffs and eliminate official prices on commercial goods (OECD 1994).

In the first months of 1990, Mexico began negotiations with the United States on the North American Free Trade Agreement (NAFTA). Formal negotiations amongst Canada, the US and Mexico began in June 1991, and the Agreement was signed on 17 December 1992. Following ratification by the US Congress in November 1993, NAFTA became effective in January 1994. Mexico also engaged in several other regional free trade initiatives that include Chile, Costa Rica, and the Group of

Three (Mexico, Venezuela and Colombia). On 18 May 1994 Mexico became a member of the OECD (OECD 1994). Furthermore, an Agreement has been signed with the European Union to promote trade and investment.

The participants of the Mexican System of Innovation

The Mexican System of Innovation is composed of the following elements (Casalet 2000; Casas 2000; Márquez 1982; Phillips Greene 1995):

- almost all of the federal government's ministries;
- a national organisation in charge of the coordination (Conacyt);
- private and public universities, higher education institutions, and technical education institutions;
- R&D centres that provide service to industry;
- laboratories of certification, quality control and metrology;
- technical information centres;
- financial institutions with funding programmes;
- technology consultancy firms;
- R&D units within private and public enterprises;
- the legal framework regarding science and technology;
- skilled R&D human resources; and
- foundations, academies and associations related to R&D activities

Historically the private sector plays a limited role in Mexico's R&D system (Ramírez and Unger 1998). Therefore, this section concentrates on the public sector institutions/organisations that provide the infrastructure of the Mexican System of Innovation (MSI).

According to Cimoli, the governmental institutional players in Mexico's system of innovation can be classified in four types (Cimoli 2000):

1. Fostering institutions that provide incentives to technological and innovation activities (i.e. Conacyt, Nafin, FIDETEC, Secofi)
2. Bridging institutions that provide information and reduce uncertainty (i.e. the Mexican Institue of Industrial Property, IMPI)
3. Highly specialised R&D institutions that develop specific sectors' projects (i.e. the Mexican Petroleum Institute, IMP)
4. R&D institutions that develop technology and innovation projects in different sectors and regions of the country (i.e. SEP–Conacyt Centres).

Nevertheless, a broader spectrum of institutions and organisations participate in different ways in the MSI, and may fall outside Cimoli's classification. For instance, the Mexican Constitution gives the legislative branch the power to issue laws regarding the promotion of scientific and technological development,[11] and the President has the power to send legislative initiatives to the Congress.[12] According to the most recent amendments to the Federal Public Administration Law, LOAPF (Ley Orgánica de la Administración Pública Federal) since 1992, the Ministry of Education, SEP (Secretaría de Educación Pública), is now in charge of science and technology policy and the coordination and promotion of scientific and technological development. These duties were formerly carried out by the Ministry of Budget and Programming, SPP (Secretaría de Programación y Presupuesto), whose other responsibilities have been largely taken over by the Ministry of Finance, SHCP (Secretaría de Hacienda y Crédito Público).

While SEP is responsible for scientific and technological policy, Conacyt must be consulted concerning all activities and programmes in this area. Its General Director is a member of the extended cabinet. SEP oversees the operation and evaluation of Conacyt, as well as its programming and budget decisions.

[11] Article 73 of the Mexican Constitution.
[12] Article 89 of the Mexican Constitution.

SEP and Conacyt are not the only federal agencies involved in scientific and technological development: LOAPF also confers responsibilities of this nature on other ministries and public agencies. Some of the most important bodies of the Mexican government working in the S&T field are:

- The Science and Technology Committee within Congress (Chamber of Deputies), which specialises in the formulation and the analysis of legislative initiatives.
- The Presidential Science Advisory Council, CCC (Consejo Consultivo de Ciencias) which keeps the President informed and advised regarding science matters.
- The Ministry of Education (SEP) is the highest authority for science and technology policy and the coordination and promotion of scientific and technological development.
- The National Council for Science and Technology (Conacyt) is the primary agency responsible for defining and implementing science and technology policy.
- Other ministries which work in S&T areas related to their fields. The most active are the Ministry of Energy, SE (Secretaría de Energía), the Ministry of Trade and Industry, Secofi (Secretaría de Comercio y Fomento Industrial), the Ministry of Agriculture, SARH (Secretaría de Agricultura y Recursos Hidráulicos), the Ministry of Communications, SCT (Secretaría de Comunicaciones y Transportes), and the Ministry of Social Development, SEDESOL (*Secretaría de Desarrollo Social*).
- The National R&D centres concentrated within public universities, higher education institutes, the system of SEP-Conacyt centres, and research centres dependent on other ministries.

The infrastructure of the MSI

Within the spectrum of private and public institutions and organisations that comprise the MSI, some are specifically devoted to R&D activities and these are the ones commonly known as the infrastructure of a national system of innovation. In the case of Mexico, the main participants are (Alzati and Teubal 1992; Bazdresch and Márquez 1999; Casalet 2000; Casas 2000; Concheiro 1987):

- Government R&D centres: in this category are the SEP-Conacyt Centres, Sectoral R&D Centres and activities of other ministries. The SEP-Conacyt Centres System is a group of 28 research centres specialising in a range of fields including natural sciences, social sciences, humanities, and technology development (Phillips Greene 1995). The entire system has over 4500 active personnel, of which almost 2500 are directly involved in research. Traditionally, these centres have developed in isolation from industry, with little attention to market demands for technology diffusion or innovation (Casalet 2000).
- The National System of Investigators, SNI (Sistema Nacional de Investigadores): system based on peer review by distinguished Mexican scientists, offering tax-free income to its members.
- Higher education centres: public universities generate a large share of national R&D output, and almost 95 percent of papers published are produced by researchers working at public universities. The leading university in R&D is Mexico's National Autonomous University, UNAM (Universidad Nacional Autónoma de México), which has about 2960 researchers. In its R&D system UNAM has 25 institutes, 16 centres and 6 programmes. The second institution is the National Polytechnic Institute, IPN (Instituto Politécnico Nacional) which has 536 researchers. Apart from Monterrey's Institute of Technology, ITESM (Instituto Tecnológico y de Estudios Superiores de Monterrey) which is strongly committed to R&D, maintaining important links with local and national industry, private universities are little involved in R&D. According to the surveyed firms, educational institutions play a very important role in the

promotion and support of the country's technology development. 91.7 percent of the respondents consider them most responsible.[13]

The following Sectoral Centres and activities of other ministries play an important role due to their size and quality of their research (although there are others):

- the Institute for Electrical Research, IIE (Instituto de Investigaciones Eléctricas)
- the Mexican Petroleum Institute, IMP (Instituto Mexicano del Petróleo)
- the National Institute for Agricultural and Forestry Research, INIFAR (Instituto Nacional de Investigación Forestal y Agrícola)
- the Biomedical Centres of the Mexican Institute for Social Security (IMSS)
- the National Oceanography Institute, INO (Instituto Nacional de Oceaongrafía)
- the former National Laboratories for Industrial Development, LANFI (Laboratorios Nacionales de Fomento Industrial)
- the National Institute of Cardiology, INC (Instituto Nacional de Cardiología)
- the National Institute for Nutrition, INN (Instituto Nacional de Nutrición)

When asked about their perception of the centres, the former Technology Director of one of the largest business associations said that in his experience, 'the centres have skilled personnel, but they are not focused to their region's needs'.[14] Moreover, Conacyt's former Director General talked about the centres' potential to serve either their region or a specific industrial sector, otherwise, according to him, if they

[13] Author's Survey: Question #12.
[14] Interview #3.

cannot find a clientele, they should be closed or transferred to a university to concentrate on basic research.[15]

In recent years, industrial support organisations like the SEP-Conacyt centres, which offer R&D services, have been facing severe financial restrictions as a result of fiscal retrenchment. In those organisations that have successfully moved towards self-financing, this has been done at the expense of eliminating what little independent long-term research projects they had. Less successful ones are struggling to make ends meet and are being forced to reduce personnel and to sell equipment. The reduction of personnel involved in R&D worsens the problem of the non-availability of technologically-skilled human resources (Alcorta and Peres 1998).

According to the surveyed firms, R&D centres play a very important role in the promotion and support of the country's technology development. 94.4 percent of the respondents consider them most responsible.[16]

3.4 - THE TECHNOLOGY POLICY FRAMEWORK FOR A NATIONAL SYSTEM OF INNOVATION UNDER AN OPEN ECONOMY

Chapter 4 analyses the way in which technology policy is created in the context of the Mexican political system. In contrast, this section examines the way technology policy evolved to set the new framework for the operation of the MSI under the opened economy.

Under President Salinas' administration, the National Development Plan 1989–94, PND (Plan Nacional de Desarrollo) placed great emphasis on the promotion of scientific and technological activity. The Plan established the general criteria for national S&T policy through the National Programme for Scientific and Technological Modernisation

[15] Interview #10.
[16] Author's Survey: Question #13.

(PRONCYMT). PRONCYMT, based on PND, was elaborated by SEP under the guidance of Conacyt, the Planning Committee, and the rest of the institutions involved in this field (Conacyt 1990).

One of the main challenges stated in the programme was to increase private sector participation in financing scientific and technological training and in clearly defining the objectives of science and technology policy. In the field of technology its objectives were to encourage private participation in R&D; to support human resource development in areas related to industrial activities; and to support, through the acquisition and development of up-to-date technologies, the increased efficiency of health, education and housing services, as well as the protection and improvement of the environment (Conacyt 1990).

In the light of the new economic environment that has prevailed in Mexico during recent years, the main technology policies can be classified as follows:

Fiscal policies for R&D

As in most OECD countries, an active fiscal policy constitutes an important complement to the government's effort to promote technological innovation. Common benefits are deductions for current expenditures in R&D, accelerated depreciation, tax credits, and exemptions.

In Mexico, the Income Tax Law provides for deductions of up to 1 percent of total sales for investments in R&D and an additional 0.5 percent if projects meet certain criteria set by Conacyt. To obtain this benefit, the firm must deposit these resources in special trust funds designated for this specific purpose. The law also permits accelerated depreciation of equipment, at a rate of up to 35 percent, when it is linked to domestic product and process R&D. On the other hand, the 2 percent Assets Tax directly affects those sectors absorbing technology embodied in capital goods (OECD 1994, 129).

According to the examination of science and technology in Mexico carried out by the OECD in 1994, existing tax schemes in favour of industrial R&D appear to be insufficient given the challenges faced by Mexico. The examiners considered it necessary to introduce temporarily - for a period of three to five years - tax measures that can act as catalysts for technological investment. They also suggested the elimination of the 2 percent tax on assets.

It is worth mentioning that countries with which Mexico's firms compete can offer up to 100 percent immediate tax deductions for current and capital expenditure on R&D (Canada, USA, Japan, France, Italy), not to mention the rest of the incentives that are by far broader and stronger than in Mexico (Mercado 1996). The 1997 amendment to the income tax law provides for fiscal credit of up to 20 percent for expenditure on technology research and development.[17] This is an improvement on the incentives but still does not match international standards.

Linkages between universities, R&D centres and firms

The evidence regarding the way that parts of the system of innovation interact with each other is limited and fragmented. Historically, many research centres and technology institutions determined their programmes on the basis of what the government or individual researchers wanted and not as a result of a study of what industry needed. Their emphasis has been more towards basic science than to applied and productive technology development.[18] There was little consultation with the private sector and they operated largely in

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[17] Article 27-A of the Income Tax Law, as appears on the federal government's official diary of the 29th of December 1997 (Diario Oficial 1997, 34).
[18] Interviews #3, 4, 11,15 and 20.

isolation from real demand conditions, resulting in a poor system of technological linkages within the country (Alcorta and Peres 1998; Casas 2000; Ramírez and Unger 1998). Research centres have the 'optimum human resources to provide the services to industry; what is lacking is the link between them'.[19]

The problem dates back to the import substitution period when there was little incentive for universities and firms to cooperate with one another, because the protected market conditions did not require firms to innovate and universities depended financially on the state, rather than on the business sector (Peres 1997; Plonsky 1993). They had no need to sell their services to generate their own funding and be self-sufficient.[20] Hence, the choice of research was independent of business needs. More recently, there have been attempts at commercialising the output of industrial R&D institutes. Since the 1990s a number of modes of cooperation such as transfer offices, university companies, joint programmes and projects to promote integration between university and industry have emerged. Most programmes have had limited success (Alcorta and Peres 1998; Casas 2000).

When interviewed, entrepreneurs who have recently developed technology projects reported that when they approached academic and research institutions, they found good technical advice but were disadvantaged by the poor commercial vision of the academic institutions to help them thoroughly.[21] Another problem was that the institutions were not able to clearly develop a proposal with its associated costs. Some of them 'could not give an estimate of their costs, some were too expensive, some too cheap and that did not give us confidence'.[22]

[19] Interview #20.
[20] Interviews #3, 11 15 and 20.
[21] Interviews #2 and 8.

The results of the survey conducted for this thesis show some interesting evidence of the way in which firms interact with academic and research organisations. Out of the firms that developed a technology project, 54.7 percent did so on their own, and the remaining 45.3 percent used some kind of service from an R&D agency.[23] Figure 3.A shows the type of institution used by the latter firms, and evidences the weight of public universities and R&D centres compared to private and foreign ones. Public universities' services were used by 51.7 percent of the firms, while 37.9 percent hired public R&D services.[24] Respondents were asked to rate the service provided by these agencies. Figure 3.B shows that most of them were satisfied as 82.7 percent rated the service from adequate to very good, and only 17.2 percent complained about a bad or poor service.[25]

There is a need to bring closer together all the players involved in the technology development process to overcome the historical lack of communication between them. In order to foster such interactions, Conacyt has the Industry-Academy Linkage Programme, established since 1991. It provides firms with grants of up to 50 percent of project costs and covers expenditures for personnel training, joint research, and joint commercialisation. Moreover, one attempt to find agreed solutions to the problems of technology modernisation and innovation in the country was launched in 1992. Conacyt's authorities considered that it was required to bring issues to the top of the economic, social and political agenda. In June of that year by an agreement with the Ministries of Public Education (SEP), of Finance (SHCP), of Trade and Industrial Development (Secofi), Conacyt established the National Coordinating Committee for Technological Modernisation, CONCERTEC (Comité Nacional de Concertación para la Modernización Tecnológica). Its main objectives were (Conacyt 1992):

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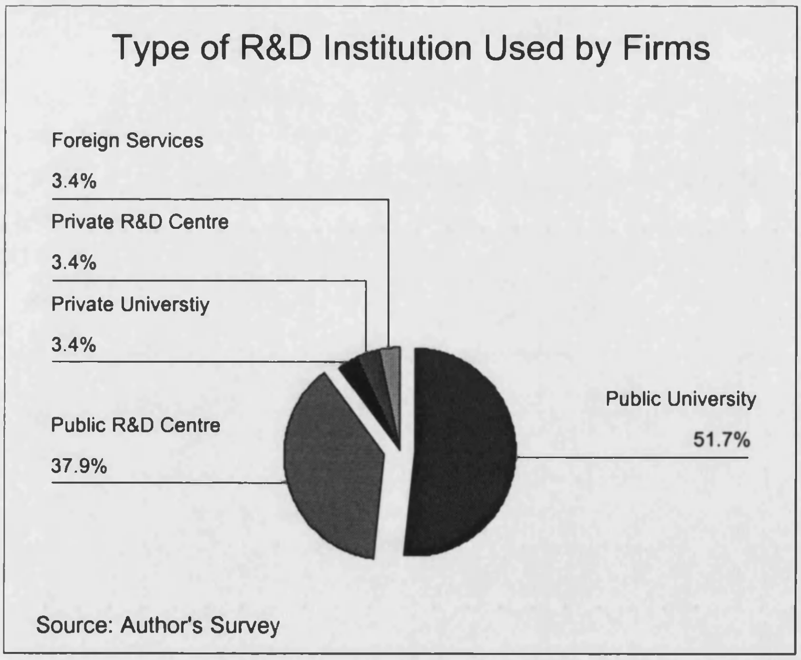
[22] Interview #8.
[23] Author's Survey: Question #27.
[24] Author's Survey: Question #27, part 2.

1. To facilitate the linkage between Mexican firms in need of technology and the country's research and educational institutions which can supply technology related services.
2. To intensify communication and coordination amongst the public agencies which share responsibilities and challenges in the technology sector, as well as between them and private firms and academic institutions.
3. To establish an integral financial scheme to cover effectively all stages of the process of technological modernisation, with special emphasis to address the needs of SMEs struggling to compete and survive in a global environment.

Figure 3.A. Respondents' answer to the question: What type of R&D institution did you use to develop your project?



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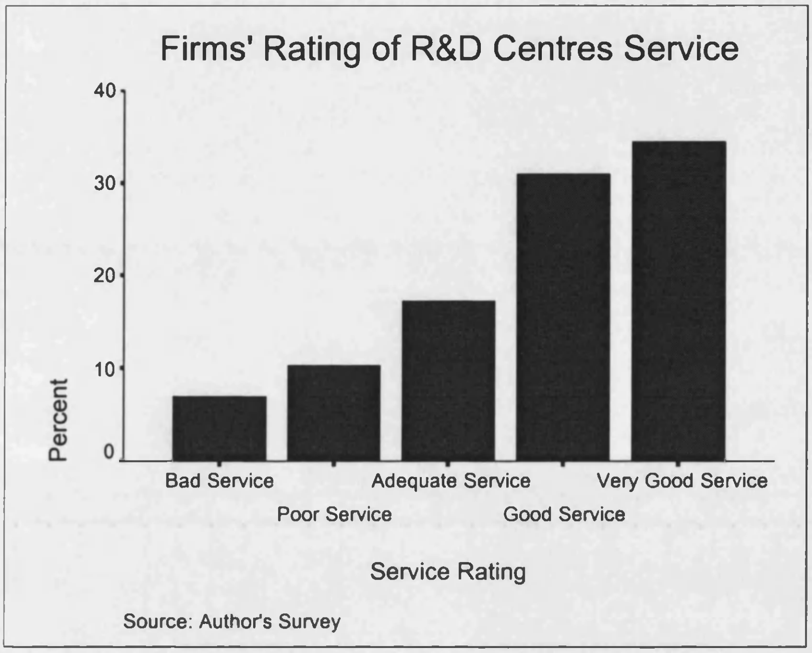
[25] Author's Survey: Question #28.

Figure 3.B. Respondents' answer to the question: How do you rate the service of the R&D centre that you used for your project?



The Committee was formed by high-level representatives from the public, private, financial and academic sectors. Chaired by the Minister of Education, it comprised 60 members of the above-mentioned groups, including members of Congress and labour leaders, as well as the Ministers of SHCP and Secofi who co-chaired the committee (Conacyt 1994d; OECD 1994). During his intervention at the inauguration session of the Committee, Fausto Alzati, Director General of Conacyt, recognised the need to create 'the institutions to facilitate the formation of a complex and dynamic network' so that users and providers of technology, government and financial institutions can meet the goals established by CONCERTEC (Conacyt 1992, 9).

Present at the same session, the Minister of Education and Chairman of CONCERTEC, Ernesto Zedillo, addressed the Committee and highlighted the importance of CONCERTEC, which in his own words was 'embedded in the lines established by the National Programme of Science and Technological Modernisation...and will be a forum where the needs and opinions of the productive apparatus, of the financial services institutions, and of the research and education centres will converge' (Conacyt 1992, 22).

Regardless of its importance, there was a visible decline in the attendance of the high-ranking representatives from the different sectors. There were only two sessions following the inauguration one for the rest of the Salinas' administration. There were some attempts to reconvene the Committee, but it has not got back together.

Financing of industrial R&D

As discussed thoroughly in Chapter 7, there are two basic programmes for financing R&D within private firms: the Research and Development Fund for Technological Modernisation, FIDETEC (Fondo de Investigación y Desarrollo para la Modernización Tecnológica) managed by Conacyt, and the Technology Development Programme, managed by the National Development Bank, Nafin (Nacional Financiera). FIDETEC provides loans and risk-sharing guarantees to those commercial banks which lend to firms engaging into pre-commercial technology development and innovation efforts. The Nafin programme deals with the commercialisation or scaling-up of product or process development and it complements FIDETEC.[26]

The legal protection of industrial property

Another important aspect of technology policy, if not sometimes classified directly within its lines, concerns the legal and protective schemes for technology, R&D and innovation. Under the Salinas administration and in the NAFTA negotiations environment, the patent and trade mark legislation was radically transformed in June 1991 with

[26] Chapter 7 examines the policies and programmes for direct project financing.

the Law to Protect Industrial Property Rights (Aboites 1994). The law was an important step forward in the Government's efforts to provide industry with an adequate legal framework for promoting technological modernisation and industrial innovation. It is comparable to those of industrialised countries. It clearly defines and establishes protection for diverse industrial property instruments, ranging from patents and trade marks to industrial secrets and design. With the new law, there are no excluded areas for patenting, it is equal to that of any industrialised country.[27]

The new law included the creation of the Mexican Institute of Industrial Property, IMPI (Instituto Mexicano de la Propiedad Industrial), responsible for the entire system, which became operational at the beginning of 1994 (OECD 1994; Phillips Greene 1995). IMPI is a decentralised governmental organisation, responsible for providing advice and technical assistance on industrial property-based issues, developing and updating databanks on patents and trade marks, both national and international, and disseminating information on current international technology. IMPI has specific areas in charge of the following: issuing trade mark registrations and property titles, repression of unfair competition and provision of technological information services (IMPI 1997). According to its Director General, the institute is not only self-financing, but gives back money to the Ministry of Finance every year.[28]

Another important development is the new metrology and normalisation law issued in June 1992. Its main objective is to encourage higher-quality standards among Mexican firms and, in consequence, enhance their competitive capabilities (OECD 1994). The most recent issue regarding the protection framework is that Mexico adopted the Patent Cooperation Treaty (PCT) in January 1995 (IMPI 1997).

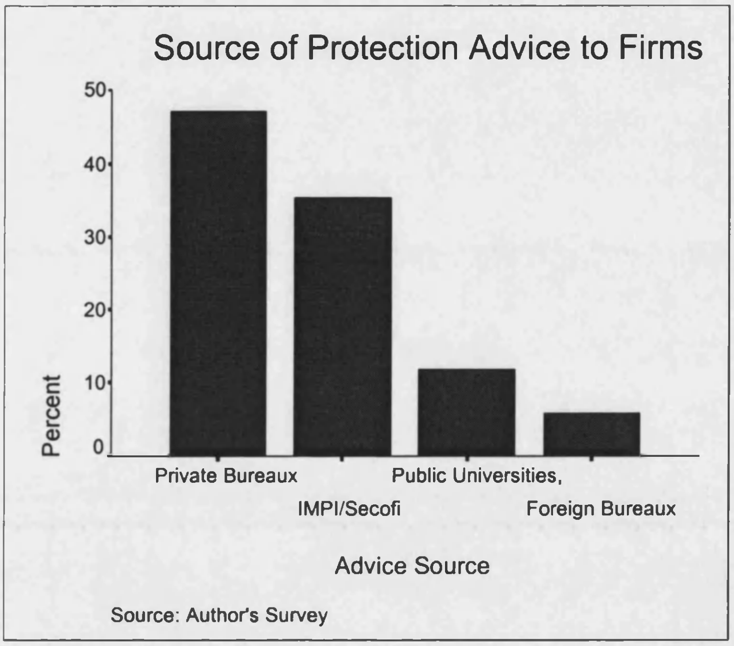
[27] Interview #11.
[28] Ibid.

In different forums towards the end of the Salinas administration, top officials of the Ministry of Trade and Industry were emphasising the importance of technology aspects within industrial policy(Clavijo Quiroga and Casar 1994a; Clavijo Quiroga and Casar 1994b). When Jaime Serra Puche, former Minister of Trade and Industry, addressed the Assembly of the Confederation of Industrial Chambers, CONCAMIN (Confederación de Cámaras Industriales) in March 1994, he said that the legal framework changes responded to the new promotion spirit of the Mexican government and referred to the creation of the IMPI (Serra Puche 1994). Nevertheless, the experiences of entrepreneurs still highlight that the mechanisms are not fast enough compared to those in other countries like the US; though they do acknowledge the improvements in the legal framework, and the importance of Mexico's adherence to the Paris Convention which results in lower costs for patenting.[29]

Answers to the Author's Survey questions regarding the protection of the respondents' technology projects reflect further the way in which Mexican entrepreneurs see the legal framework and the procedures to protect industrial property. Only 26.6 percent of the firms with a technology project had received some sort of protection advice, while the remaining 71.9 percent had none at the time the survey was conducted.[30] From those that had been advised, 47.1 percent referred to private bureaux as their source of information, followed by 35.3 percent that mentioned IMPI or Secofi. 11.8 percent had been advised by public universities or R&D centres, and the remaining 5.9 percent by foreign patent bureaux. See Figure 3.C.[31]

[29] Interviews #1, 4, and 9.
[30] Author's Survey: Question #66.

Figure 3.C. Respondents' answers to the question: From which agencies did you receive protection advice for your project?



What is most striking is that only 32.8 percent said they had started their protection procedure[32] but almost half of those were not able to rate the procedure as yet; and 60 percent of those who could rate it considered it adequate or good, 9 percent very good, while 39 percent found it bad or very bad.[33] It seems as though the new legislation is of international standards, but Mexican firms still need to learn to use it in their favour.

3.5 - SOME INDICATORS OF THE PERFORMANCE OF THE MEXICAN SYSTEM OF INNOVATION

Using some of the most conventional indicators for the performance of a national system of innovation, this section shows results of the Mexican system for recent years, and compares them with different countries such as Argentina, Bolivia, Brazil, Canada, Chile, Ecuador,

[31] Author's Survey: Question #67.
[32] Author's Survey: Question #68.
[33] Author's Survey: Question #69.

Greece, India, Japan, Korea, Mexico, Singapore, Thailand, Turkey, the UK and the US.[34]

Patents

As a result of the new legislation, there were 6961 patent applications in 1992, a 32 percent increase over the previous year. Total patent applications rose from 4251 in 1990 to almost 11,000 by the end of 1997. Patents granted totalled 3186 by the end of 1996, while in 1987 only 1156 were given. Regarding applications by Mexican nationals, there has been a decrease from 742 in 1987 to 420 by the end of 1997. In 1996, only 116 patents presented by Mexicans were given registration (IMPI 1997; OECD 1994). In 1996, applications filed by residents in other countries were as follows: 3,316 in Canada; 189 in Chile; 434 in Greece; 340,861 in Japan; 68,446 in Korea; 203 in Thailand; 367 in Turkey; 25, 269 in the UK; and 111,883 in the US (World Bank 2000).

Expenditure and investment

In 1999, Mexico's total spending in R&D as a percentage of GNP was 0.33, ranking 45 out of 59 in the Global Competitiveness Report 2000. Thailand (0.13 percent) and Ecuador (0.02 percent) are the only ones out of those used for the comparisons which spent less than Mexico. For instance the percentage spent by Korea was 2.82 , Japan 2.80, the US 2.63, the UK 1.95, Bolivia 1.67, Canada 1.66, Singapore 1.13, Brazil 0.81, India 0.73, Chile 0.68, Greece 0.47, Turkey 0.45 and Argentina 0.38 (World Economic Forum and Harvard-CID 2000).

[34] The sample of countries was chosen to include examples from different geographical regions, different levels of industrialisation, and Mexico's most important trading partners.

Public expenditure and investment

One of the main characteristics of the MSI is the very low level of aggregate expenditure in R&D. In 1995, almost 80 percent of total R&D expenditure was funded by the government, most of which went to universities (Conacyt 1996b). The equivalent average figure for OECD countries is 43 percent, for Asian 'tigers' 36 percent, and for European NICs 44 percent (CEPAL and UNESCO 1992; UNESCO 1996). Not only do most of the public resources go to the public education sector, but most of those go to Conacyt, the SEP-Conacyt Centres System and UNAM, which together received 42 percent of the total federal expenditure (Alcorta and Peres 1998).

Total federal expenditure in science and technology as a percentage of GDP rose from 0.28 percent in 1990 to 0.35 percent in 1995, being among the lowest in OECD countries. For instance, in the US, S&T expenditure accounts for 2.58 percent of GDP, in Japan 2.64 percent and in Canada 2.27 percent. Mexico's is lower than Greece (0.49 percent) and Turkey (0.39 percent) (Conacyt 1996b).

Private expenditure and investment

The small participation of the private sector in aggregate R&D expenditure financing discussed above is the first indication of such conduct. There is no technological culture among Mexican firms (Alcorta and Peres 1998). Firms invest little in innovation. Privately-funded R&D expenditure is around 25 percent, half of what the private sector finances in other countries of the region (CEPAL and UNESCO 1992). The private sector is mostly composed of small and medium-sized firms with limited R&D capabilities, so large firms finance R&D areas and may spend most of the private business expenditure in R&D. Moreover, Mexico's private sector is spending only 0.06 percent of GDP on R&D, compared with 2.15 percent in Japan (1991), 1.81 percent in the US (1992), and 1.32 percent in the EU (1991) (OECD 1994). Furthermore and contrary to public universities and higher education centres, R&D

activities in private universities are funded primarily by non-government sources. According to the Global Competitiveness Report, Mexico's private sector spending in R&D ranked 48 out of 59, while countries ranking above are Argentina 44, Brazil 32, Canada 18, Chile 39, Greece 43, India 42, Japan 4, Korea 14, Singapore 13, Thailand 45, Turkey 38, the UK 15 and the US 3; and countries ranking below are Bolivia 59 and Ecuador 49 (World Economic Forum and Harvard-CID 2000).

Human capital formation

Education and human training play a pivotal role in technological change and growth of the NSI (Alcorta and Peres 1998). Nevertheless, human resources dedicated to science and technology are scarce. In 1995, only nine in every 10,000 inhabitants were involved in these activities. This level is inferior to other OECD members. In Japan the figure is 125, and in Canada 86. Regarding the number of scientists and engineers, in Mexico there are five in every 10,000 inhabitants, while in the US there are 74. The only country comparable in this regard with Mexico is Turkey, with seven in every 10,000 inhabitants (Conacyt 1996b). Furthermore, scientists and engineers (per million people) involved in R&D activities between 1985-1995 amounted to 213. In contrast, the numbers for Argentina were 671, for Bolivia 250, for Brazil 168, for Canada 2,656, for Greece 774, for Japan 6,309, for Korea 2,636, for Singapore 2,728, for Turkey 261, for the UK 2,417, and for the US 3,732 (World Bank 2000).

Science and technology publications

As described in Section 1, apart from the traditional performance measures of a NSI, there are other complementary or alternative indicators that can be used to evaluate the functioning of an system of innovation. In the case of Mexico, some attempts to include these measures have been made by Conacyt, and include science- and technology-related publications. The average number of such publications in Mexico between 1993 and 1995 was 2258. For the same period in Argentina there were 2,430, in Brazil 4,577, in Canada 31,116, in Chile 1,261, in Japan 54,536, in the UK 52,871 and in the US 257,414. Nevertheless, in Mexico the number of such publications has increased by 97 percent from 1980 to 1995 (Conacyt 1996b; Robles de la Rosa 2001).

CONCLUSIONS

One of the main reasons why the Mexican System of Innovation lags behind other comparable countries is that for a long period the economy was not exposed to competition. Businessmen did not have incentives to adopt strategies based on technology and innovation The former government policies regarding protected markets and public ownership encouraged the growth of many enterprises, but they also encouraged inefficiency and a lack of attention to technological innovation. Mexican industry had no need to exploit its own technologies to compete. At most, the manufacturing of undifferentiated goods needed only process innovation, which could be acquired by embodied technology in plant and equipment. Foreign subsidiaries received manufacturing know-how directly from multinational enterprises.

Mexico's system of innovation developed into a weak entity. Although emerging in an institutionalised way at the end of the 1950s and 1960s, and expanding considerably during the 1970s, it has since proved unable to consolidate into an effective promoter of technological upgrading and innovation. There have been significant specific accomplishments in policy-making, institutional development, education and training but it has not been possible to replicate such advances throughout the whole system.

During the 1990s, and in response to the major changes in the country's economic environment, Mexico underwent important modifications in its science and technology system. However, the system is still not well articulated in its decision-making processes and the interactions between its players are not yet well coordinated, not just within the public sector, but between the pubic sector and the rest of the participants of the system.

Mexico's government has played a central role in the shape and orientation of the technology and innovations system, but has been unable to establish and implement a long-term, coherent technology policy which would be required for a more successful outcome, as shown by the performance measures presented in the chapter. Almost 30 years ago the country saw the birth of the first formal institution in charge of technology policy, Conacyt, but despite its longevity, its programmes have not yet given high impact results, undermining the development of a strong technology community in Mexico.

It can be said that the 1984–89 Programme for Science and Technology and its successor, the National Programme for Science and Technological Modernisation 1990-94, traced a fundamental difference between scientific endeavour and technological activity: science is for the academic sector and technology is for economic activities. Therefore, the importance of technology for the country's growth has been recognised and the spirit of the new vision is that technology development is to be pursued through linkages of university research with private industry, and federally-supported R&D to be carried out directly by private firms. Thus, as this chapter has discussed, links between academy and firms are still loose. On one hand, enhancing the operation of the national system is the major route to increasing the creativity of firms. On the other, private businesses can make their contribution to strengthening the technological system of which they are a part – while at the same time enhancing the chances of their own success – by increasing their economic competence in all areas, increasing their R&D efforts, initiating, building and strengthening linkages with academic institutions, articulating the requirements to which the academic sector can respond, and broadening their technological base.

While firms are the primary actors in the generation of technology, their activities are supported by the accumulation of knowledge and skills in a complex milieu of other research and training institutions. Technology policy cannot be concerned with innovative activities of firms alone, it must encompass the broader context: the whole of the Mexican national system of innovation. Chapter 4 deals with the way in which the government promotes the country's technology development and the way in which the political and bureaucratic systems may affect technology policy.

Chapter 4
CREATING TECHNOLOGY POLICY IN MEXICO

> 'Few would disagree that in all countries the state plays a central role in shaping, stimulating and inhibiting various forms of technical change.'
>
> Martin Fransman, 1986

INTRODUCTION

This chapter is concerned with how the forces of the Mexican political and bureaucratic system condition the manner in which decisions concerning science and technology are adopted and implemented. Decisions governing the allocation of resources for the acquisition of technologies, whether through domestic R&D or licensing agreements, emanate from a political process. And the choice of the array of specific policy instruments through which these decisions are actually implemented is dependent on the political forces acting in this environment.

As policy-makers struggle to improve the performance of their innovation systems, and in particular to help firms in their countries become more innovative and more able to draw upon science and technology in the enhancement of their competitiveness, it is not surprising that there is a strong desire to know what works and how to make it work better.

The history of policy to stimulate innovation has been outlined by several authors discussing the experience in different countries (Johnston and Gummett 1979; Pavitt and Walker 1976; Ronayne 1984). Policy tools available to policy-makers include: direct government participation in research; attempts to stimulate private research by placing government contracts with innovators; all manner of subsidies, tax reliefs, loans, and investment allowances; centralised coordination of research activity; the patent system; attempts to reduce market imperfections; honours and awards; general economic management aimed at providing the most attractive climate for innovation; and educational and training schemes (Hall 1986).

In the case of Mexico, most of the technology policy literature dates from the period of import substitution. There is much less written which expressly addresses the questions of technology policy under the aegis of trade liberalisation, and this chapter presents empirical evidence of the experience in recent years.

Section 1 introduces the Mexican political system under the main conceptual framework of the notions of the State, institutions, politicians, bureaucracy and policy networks. Section 2 then describes the origins of technology policy in Mexico during the protected economy era, from 1970 to the mid-1980s. The evolution of the technology policy context since the 1980s is presented in Section 3. Section 4 focuses on the importance of technology policy *per se* and provides an evaluation of the way the government in Mexico has used the array of technology policy tools to promote technology and innovation activities in the country. Section 5 uses the experiences of firms that have interacted with public agencies as an example of the obstacles and limitations of the political system when designing and implementing technology-oriented programmes.

4.1 – THE STATE, INSTITUTIONS, POLITICIANS, BUREAUCRACY AND POLICY NETWORKS: THE CONTEXT OF MEXICO'S POLITICAL SYSTEM

Mexico is a federal republic with a written constitution, promulgated in 1917. The Mexican territory is divided into 31 states and a Federal District, DF (Distrito Federal), where the national government and federal administration are located. The federal government consists of three equal but separate organs, the executive, legislative and judiciary branches. The executive function is vested in a single individual, the president, who is selected by universal suffrage every six years. The political system in Mexico allows for party competition and there are several political parties. The Revolutionary Institutional Party (PRI) remained in power from 1929 to 2000.[1] The National Action Party (PAN) represents right-wing political groups: it has been growing over the past 15 years, participates in state and municipal governments, and has won the presidency for the 2000-06 administration. The Democratic Revolution Party (PRD) is formed of a broad coalition of left-wing groups and parties and has grown in some states and regions. The other national parties represent smaller constituencies (OECD 1994).

In order to better understand the context in which Mexico's government operates, and the way in which it designs and implements technology policy, it is important to briefly review some of the most relevant concepts related to the State and the inherent characteristics for the case of Mexico.

Institutions

During the last few decades, economists have given increasing attention to the role of institutions in the functioning and change of

[1] On December 1st 2000, the first President from an opposition party (PAN) was inaugurated, ending the long-ruling regime of the PRI.

economic systems. Institutions have also become increasingly important in innovation theory. Their role is also emphasised in all versions of the system of innovation approach (Edquist and Johnson 1997, 41). Institutions are sets of habits, routines, rules, norms and laws which regulate the relations between people and shape human interaction.

Different nations have developed different institutions, formal and informal, for making political decisions. The formal institutions of government as defined by constitutions are critical to these decisions. But equally important to public policy are the informal practices that have developed around these institutions as interest groups, political parties, individual politicians and bureaucrats have struggled to bend these institutions to their wills. These 'rules of the game' define a different political logic for each nation. This is a logic that public policy, no matter how technical the subject matter, cannot escape (Immergut 1992, 3).

Mexico is experiencing a profound transition. Long operating under a semi-authoritarian political system based on a tight structure of economic as well as political controls, the country has been dramatically changed by recent and ongoing reforms. Many of the old institutions – economic, political and social – still exist, but most are mere shells of what they used to be. Rapidly emerging new institutions are gradually transforming the political landscape of Mexico (Rubio 1995).

The State

One conception of politics makes it essentially equivalent to government. By *government* we mean the formal political machinery of the country as a whole: its institutions, laws, public policies, and key actors. Politics then refers to the activities, processes, and structures of government (Caporaso and Levine 1992). According to Smith, the state[2] is 'a collection of institutions and rules' (1993, 49). Moreover, 'state action' is shorthand for individuals acting within particular agencies or institutions (Smith 1993, 49). Officials and politicians behave in ways that result in state autonomy when it serves their own career interests to do so, and the content of their decisions will reflect their interests (Geddes 1994, 7-8). According to Philip, the Mexican system is a set of arrangements in constant redefinition 'around its only fixed element - which is the presidency... A strong presidency can survive a weakening of elite institutions such as the PRI. What any president will need is to create new political institutions to replace the old declining ones' (Philip 1992, 183).

Judging from the relative political stability of Mexico during times of prosperity as well as during times of crisis, one would presume that the state has been quite effective at relieving social and political pressures. Yet the presence of a highly centralised state, practically unlimited powers of the subsequent presidents and a one-party political system have accounted for corruption, disruptions, bureaucratic and technical inefficiencies (Lustig 1992, 243-251; Wionczek and Márquez 1993).

State autonomy and interest groups

Governments can and often do act independently of underlying socioeconomic forces (Evans 1995, 39-40; Geddes 1994, 1-5). Governments sometimes effect radical shifts in economic policy without the support of important interest groups: in other words, autonomously. In consequence, there is a need to understand the state's role in bringing about change. The notion of state autonomy maintains that the state and state actors have interests of their own and, in certain circumstances, the ability to transform these interests into policy (Smith 1993). As previously mentioned, in order to

[2] The concept of the 'state' is used in the thesis as synonymous with 'government', though differences in their definitions exist.

understand state behaviour one must understand the behaviour of the individuals, as shaped by the political institutions that determine the costs and benefits of the different actions they can choose (Geddes 1994, 182-196; Schneider 1991, 202).

State officials sometimes have policy preferences independent of those of major social and economic groups in society, and these officials can sometimes, by virtue of their positions in government, use state power and resources to pursue their own ideas and interests. Government policies often reflect the economic ideologies of state officials rather than those of domestic groups. These policies in turn create the incentives that shape the choices of individuals in society. And these choices then affect the rate of growth, the distribution of the benefits of growth, and, in sum, the way political, economic and social systems work (Geddes 1994; Reis 1994).

State and society are not just linked together: each helps constitute the other. Most of the independent institutions – chambers of commerce and industry, research centres, universities, the media, political parties – that exist in Mexican society today were originally shaped under a monopolistic political system organised around a given party line. Although the party line changed every six years, all allegedly independent entities were expected to conform to, and be disciplined by, the system. Mexico's State has been moderately semi-authoritarian but highly participatory. The regime has not been repressive or monolithic but it has demanded discipline and conformity (Rubio 1995).

Despite the economic strength of business, it often has great difficulty in establishing stable and well-integrated relations with government which often limits its political impact. The instability of business policy communities derives from the unwillingness of business to encourage state intervention, the large number of actors involved, the conflicts of interests between actors, the political nature of many of the areas where business is involved and the organisation of the state (Smith 1993, 160). Thus, if the existence of an autonomous Mexican state is accepted, certain consequences in its relationship to the private sector can be identified. Many recent analysts admit to the existence of Mexican state autonomy, but considerable disagreement exists as to its extent and limits. Some believe that the state has relative autonomy from short-term business interests but acts in the long-term interests of Mexico's private sector. Others believe that the state is not the instrument of the private sector even though the state has favoured the latter's interests (Camp 1989, 222-252).

Bennett and Sharpe (1980) suggest that there are three principal explanations of Mexico's state autonomy. First, the weak condition of the private sector itself explains state intervention. Second, state intervention institutionalised a larger, visible role for the state in the economy. Finally, they believe that each presidential administration alters state orientations. Carried to an extreme, one can argue that state autonomy might be extremely weak if not for the fact that Mexicans expect an activist state, thus giving political actors more room to make policy choices (Bell 1991).

Policy networks

The notions of the state, its autonomy and its organisation through its bureaucracy[3] are not enough to explain the dynamics of the way policies are designed, implemented and evaluated. Even the most bureaucratically coherent state cannot effect transformation without a network of ties to social groups and classes with which it shares a project. Connectedness is as important as coherence (Evans 1995, 249). Thus, the theories of policy communities and policy networks[4]

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[3] For the purpose of this study, 'bureaucracy' is used as a generic term, equivalent to the organisational apparatus of the state (Evans 1995).
[4] The literature on networks has been developed primarily in Europe, although there have been several important contributions from North America (Atkinson

serve to know more about the politics of the decision-making process within organisations.

These theories deal with how individual governmental and non-governmental actors (or dominant coalitions) decide to use and exploit their resources of authority, money, expertise, information and organisation: in sum, how their strategies are formulated and converted into policies. Public policy instruments are the set of techniques by which government authorities wield their power in attempting to ensure support and to effect or prevent social change (Vedung 1998, 21)

Policy network and the related notion of policy community refer to actors and relationships in the policy process that take us beyond political-bureaucratic relationships. Political scientists use the term *policy network* to refer to interdependent relationships that emerge between both organisations and individuals who are in frequent contact with one another in particular policy areas The *community* refers to the actors and the *network* refers to the relationships (Benson 1982, 148) among actors.

The membership of a community is defined by a common identity or interest: members share a direct or indirect, actual or potential interest in the public policy issues and problems which arise for their community. They possess resources of authority, money, information, expertise and organisation, with the potential for their use at some stage in the policy process. The actors of the community will transact with each other, exchanging resources in order to balance and optimise their mutual relationships. So, *network* is the linking process, the outcome of those exchanges, within a policy community or between a

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and Coleman 1992; Heclo 1978; Peters 1998; Sabatier 1991). Rhodes and Marsh argue that the American literature served as a foundation for this body of research and served as a precursor of attention to concepts such as corporatism, networks and communities (Rhodes and Marsh 1992).

number of policy communities (Atkinson and Coleman 1992). A policy network may evolve or be constituted around a discrete policy issue or problem, a set of related issues or around a policy process. The members of a network may be drawn from one policy community or several. Policy issues and problems provide the occasion for a policy network (Hay 1998; Wright 1988).

Fragmented policy processes are a significant obstacle to the generation of a coherent body of knowledge. It is common that within the same political system, things work differently in agriculture, transportation, monetary policy, and so on (Atkinson and Coleman 1992). For Dowding (1995, 142) the explanation of the outcomes lies in the characteristics of the actors. They explain both the nature of the network and the nature of the policy process (Dowding 1995, 142; Marsh 1998)

The concepts of state autonomy and policy network demonstrate that in order to understand both how policy is made and the role of groups in its development, it is important to understand the interests of the state and the type of relationships that exist between groups and the state (Smith 1993). In order to complete a general frame of reference of the technology policy network in Mexico, the lack of a democratic government for several decades and of a juridical institutional framework must be emphasised. This has made policy design and implementation extremely vulnerable to manipulation by government and private interest groups. Manipulation is thus far removed from the public eye and there is almost no accountability for the actions of public officials, nor for the actions of interest groups. (Nadal Egea 1995). With these concepts and its related aspects of the Mexican political system in mind, the next section introduces the history of technology policy in Mexico since the 1970s.

4.2 - OUTLINE OF THE ORIGINS OF TECHNOLOGY POLICY IN MEXICO (1970-mid 1980s)

Background

The 1970s saw a growing consensus about the importance of market-oriented policies, but the increasing importance of liberalism was not as widely accepted as it would prove to be later.[5] Mexico, among other countries, experienced this conflict during the Echeverria and Lopez Portillo governments. From 1970 to 1982, under these administrations, state intervention was characterised by attempts to strengthen the weight of government in the economic process rather than to mitigate it. The essence of state intervention during that period lay in its refusal to give up the import-substitution model (ISI) (Valdés-Ugalde 1996).

Arguably, before 1970, the federal government had not perceived the fundamental need of a modern state to develop a national scientific and technological capacity (Flores 1982). With the start of the process for presidential succession in 1969–70, the National Institute for Scientific Research (INIC)[6], a body created in 1950 and dependent on the Ministry of Education, was charged with the task of carrying out a series of studies in order to define the main lines of a national policy for science and technology. A committee was created for the study and promotion of science and technology, integrated by the Rector of UNAM, the Director of IPN and the Secretary-General of INIC (Nadal Egea 1995). The committee's work centred on the preparation of a draft law designed to reorganise INIC but its work was interrupted by a serious political students' movement in 1968. After that year, politicians were highly concerned about the lack of a firm grasp or political control over scientists and researchers. Thus, the creation of Conacyt had

[5] For a more detailed discussion of the growing importance of neo-liberal policies in Latin America see Calvert (1994, 32-34).
[6] See Chapter 3.

important political considerations during the first year of President Echeverria's mandate (Casas and Ponce 1986).

During the first quarter of 1969, the Ministry of the Presidency convened a series of meetings with the directors and top staff of the main research institutions in Mexico. The outcome of this process was an executive order to INIC, charging this institute with the task of carrying out the necessary steps to establish the institutional base for the development and implementation of S&T policy in Mexico (Nadal Egea 1995).

1970–1976

By the end of 1970, INIC produced a final report with a series of recommendations. In December of the same year, President Echeverria created the National Council for Science and Technology (Conacyt) as one of his first government acts. Since that year, Conacyt has been the focus of dialogue and communication between government and the scientific community (Márquez 1982). It was set up as a decentralised body responsible for the design and implementation of S&T policy in Mexico. In its capacity as obligatory adviser to the public sector on all matters regarding science and technology, Conacyt has not been able to influence the substance of S&T decisions mainly because, as discussed in Chapter 3, it is a decentralised body and not a ministry.

The President's benevolent attitude during Conacyt's formative phase permitted the agency, between 1971 and 1976, to undertake a number of activities not limited to the attempt to develop a national policy for science and technology. They included a significant number of initiatives and measures that, on the one hand, tended to strengthen the science and technology infrastructure of the country with regard to diffusion, information, statistics, equipment and instrument imports, and technical norms, but on the other tended toward the establishment of permanent links between science and technology and the educational and production systems, such as the creation of new research centres, without the interference of the federal bureaucracy (Nadal Egea 1977).

Ministers of state and all members of the board of directors were well acquainted with the President's attitude, and adopted a position of extreme tolerance towards Conacyt. However, in retrospect it is clear that this situation was both circumstantial and temporary. Thus, between 1971 and 1976, the council lived largely as a result of being viewed favourably by Mexico's president who, at the same time and in contrast to his particular style of government,[7] intervened very little in its activities (Márquez 1982; Wionczek 1981).

During the National Conference on Education, Science and Technology, held in June 1976 as part of the political campaign just prior to the change of administration, the spokesman for Conacyt stated in the presence of the incoming president of Mexico that for science and technology to give results, its strategies must be designed not for six years, but for 20–25 years, considering the gestation period of science and technology; therefore a national plan for science and technology that lacks a long-term perspective runs the risk of being a meaningless exercise.[8]

On the basis of these criteria, Conacyt presented the National Plan for Science and Technology to both the outgoing president of Mexico and the president-elect in November 1976. Representatives of the private, public and scientific sector collaborated in the elaboration of the plan (Amadeo 1978), but after the new government took office, nothing more was heard of it. Concern became widespread about the lack of

[7] According to Centeno, President Luis Echeverria began the process through which the Mexican presidential office came to completely dominate the bureaucracy without checks and balances from other powerful institutions. He centralised power in the already dominant presidency (Centeno 1994).
[8] See Wionczek (1981).

continuity that had led to the failure of scientific research and technological development programmes that had been financed and encouraged by the federal government (Nadal Egea 1977; Wionczek 1981).

1977–1982

According to the 1976 Plan, it was necessary that national spending on science and technology continue to grow during the next administration at a real annual average rate of about 20 percent. Nevertheless, due to the economic/financial crisis of the end of 1976 and to the cyclical political process of forgetting the earlier attempts to establish long-term national policies, the goals of the 1976 Plan vanished, including the need to increase the spending on science and technology to 1 percent of GDP.

Traditionally, plans inherited by a new President from a previous administration are not implemented: in fact, they are substituted as soon as possible (Conacyt 1978; OECD 1997). By the end of 1978 there were negative feelings within the Federal Government towards Conacyt's performance. It seems as if it were impossible to isolate science and technology policy from the institutional aberrations and discontinuities that result from the Mexican six-year political cycle (Wionczek 1981). Conacyt's lack of real social and political support under the new presidential administration showed how a bureaucratic change exposed the fragility of Conacyt and its functions (Amadeo 1978).

In June, 1977, President Lopez Portillo[9] summoned fifty members of the scientific community and high-level officials of Conacyt to discuss before the President and members of his Cabinet the problems of science and

[9] President Jose Lopez Portillo shared Echeverria's desire to maintain control over government policy (Centeno 1994).

research in Mexico. The President asked Conacyt to detail a National Programme of Science and Technology. In the process, Conacyt consulted members of the scientific and technological communities, the different public agencies related to the subject, and representatives of the private sector.

As a result, in October 1978 the National Programme of Science and Technology 1978–82 (PRONCYT) was presented. Most of the document was concerned with previous results and new goals in the areas of basic research and science. PRONCYT dedicated its pages of technology policy mainly to the concept of technology transfer. The Programme was also concerned with specific sectors of industry and of the economy and established particular goals for each of those priority sectors. During those years Conacyt concentrated on a big scholarship programme designed to form human resources in foreign universities (Amadeo 1978; OECD 1997).

4.3 – TECHNOLOGY POLICY IN MEXICO SINCE THE MID-1980s

1983–1988

In his presentation of the National Programme for Technological and Scientific Development 1984-88, PRONDETYC (Programa Nacional de Desarrollo Tecnológico y Científico), President de la Madrid[10] declared that the state's actions in the science and technology fields had to be coordinated among different agencies of the government to make federal expenditure more efficient and to avoid duplicity of functions. PRONDETYC established that state intervention in the planning of science and technology is justified because more than 90 percent of national expenditure on those activities came from the public sector (Hodara 1985; Poder Ejecutivo Federal 1984). Nevertheless, the plan

[10] The de la Madrid administration in some ways represented a return to a balance of power between the president and his ministers (Centeno 1994).

promoted communication by the government with the productive sector in order to link politicians, scientists, researchers, technology developers and the users of technology. PRONDETYC recognised that in the past there had not been proper scientific and technological planning as those activities had not been integrated with the country's national planning. Therefore, the science and technology policy had been merely an institutional policy and a public expenditure policy, without considering the complex interrelation of science and technology with economic and social development.

In PRONDETYC's diagnosis of the technology development promotion activities, until the early 1980s, it explicitly mentioned that they did not emphasise the direct participation of the industrial plant in R&D activities. This left productive processes dependent on imported technology with very little assimilation into the local processes. Excessive protectionism led to low competition and lack of incentives to incorporate technological innovation into the industrial plant of the country. The government's efforts had been limited with regard to the promotion of indigenous technology. The programmes designed to support technology development in SMEs imposed non-favourable conditions for those kinds of firms. In particular, the operation of federal programmes to finance technology activities of firms did not flow as it was supposed to, because the funds had to be given via commercial banks which stopped the process for months. Based on the diagnosis, PRONDETYC set the new goals to promote technology progress as a means of improving national production and competition in foreign markets (Hodara 1985; Poder Ejecutivo Federal 1984).

As outlined in the previous chapter, the 1984–89 Programme and its successor for the 1989-1994 administration, the National Programme for Science and Technological Modernisation 1990–94, drew the line between scientific endeavour and technological activities, leaving science to the academic sector and technology to economic related activities. Therefore, technology development is reckoned as linkages of university research with private industry, and federally-supported R&D to be carried out directly by private firms.

1989–1994

During his presidential campaign, Carlos Salinas[11] talked about the importance of giving science and technology a top place in the development of Mexico. In one of his speeches, he set the lines on which his administration would base its technology policy when he declared that 'the state has to support research in all its areas, but for technology development to be efficient, it has to be financed preferably by the productive sector' (SPP and Conacyt 1990, vii).

Therefore, it is not surprising that, in the orientation of most programmes of technology development, support for the different agencies involved shifted to the promotion of a more active participation of the private sector for the acquisition, assimilation, adaptation and diffusion of efficient technologies to strengthen the national productive apparatus (Poder Ejecutivo Federal 1989; Villarreal Gonda 1993). State reform, along with economic reform, was the key goal of Salinas' policies. It was meant to consolidate the modernisation project that was initiated by his predecessor Miguel de la Madrid. Salinas' reform reshaped state structure in order to reduce its economic intervention and to foster private investment as a substitute for the past role of public investment (Valdés-Ugalde 1996).

The government adopted a new technology policy in the 1990s. The National Programme for Scientific and Technological Modernisation 1990–94, PRONACYMT (Programa Nacional para la Ciencia y

[11] Salinas constructed an even more powerful presidency than had existed in the 1970s. By 1992 he had reestablished the predominance of the presidency

Modernización Tecnológica) established that there was an urgent need for private firms to participate in the financing of the technological modernisation of the country through shared funding with the public sector. Once again, PRONACYMT, as PRONDETYC before it, linked the lack of interest among the productive sector in participating in technology activities with the development model of the country in the previous decades. A closed economy, isolated from foreign competition and highly regulated, prompted most Mexican firms to operate without the worries of scientific and technological development, without the need for a skilled workforce, and without the need to offer quality goods and services to the protected market (SPP and Conacyt 1990). In order to comply with the requirements of the US while negotiating NAFTA, and to encourage the private sector's interest in technology, the government provided better protection of industrial property rights (Micheli 1996).[12]

PRONACYMT viewed the new macroeconomic strategy of opening and deregulating the country as a corrective tool for the distortions caused by the previous model. The programme considered that the new structure of incentives would encourage the productive sector to participate in science and technology activities. At the beginning of the new model, the state would have to broaden its support programmes and funds to help those firms wanting to develop technology projects. Eventually, the private productive sector would finance most of its own technology needs (Clavijo Quiroga et al. 1994; Micheli 1996; SPP and Conacyt 1990).

This new approach to technology policy was made within the context of trade liberalisation and NAFTA.[13] Even if the state was to leave private firms, of whatever size, to compete with foreign ones, President Salinas

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in practically every political sphere. The Salinas administration represented a technocratic revolution directed from above (Centeno 1994).
[12] See Chapter 3.

recognised that some form of governmental support could be justified for the smaller ones at the beginning of the economic opening process.[14] Therefore, Conacyt implemented programmes to support the technology activities of small and medium-sized firms with pre-commercial technology and innovation projects, giving emphasis to the agency's technology areas, and involving the private sector and academia to develop new linkage programmes. Secofi was in charge of the promotion of foreign direct investment which also contains important technology transfer elements.[15]

During the process of evaluating Mexico's request to become a member of the Organisation of Economic Cooperation and Development (OECD), an analysis of the national science and technology system was carried out by the organisation. The document presented in 1994 reflects some interesting aspects of the evolution of technology policy and the status of its institutions. Several observations and recommendations were made, including the following most important ones (OECD 1994):

- There is a need for a consistent S&T strategy across the functions of the secretariats and agencies, especially the relationship to economic objectives.
- Conacyt seems an innovative and disciplined agency for building up Mexican scientific and technological capacity. However, it is not well placed to play this role, because of its present location under SEP.
- Even if nominated by the President, and thus a member of the President's extended cabinet, the Director-General of Conacyt is perceived by all other members of the Government to be subordinated to SEP. Therefore, he lacks the power to advise them on science and technology matters.

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[13] Interview #10.
[14] Interview #19.
[15] Interviews #10 and 20.

- The lack of a robust, well-endowed agency or secretariat for providing policies and operational S&T programmes in pursuit of the economic and other missions of government is an anomaly in the governmental structure.
- The Ministry of Trade and Industry (Secofi) in its dedication to market principles, has not invested vigorously enough in S&T activities to compensate for market failures and to prepare the knowledge infrastructure for the coming competitive struggle.
- It is illogical to have a Ministry of Public Education with major activities in support of industry, yet little control over economic and industrial policy, while Secofi pays little attention to the technological capabilities that will determine whether Mexican firms can compete under NAFTA trade conditions.
- Mexico should be ready to invest one percent of GDP in S&T and technological innovation at the beginning of the next century, if it wishes to compete in a globalised economy.

The observations and recommendations outlined above, were severely affected by the economic and financial crisis that hit Mexico at the end of 1994-beginning of 1995. The new context shaped the way in which technology—related programmes were going to be carried out from then on.

The years after the 1995 crisis

In May 1995 the Mexican government launched the National Development Plan (1995–2000), which aimed to modernise the country's industry. The first Report on the State of the Nation (1995) expressed the government's intention to develop research and increase the number of researchers, improve the quality of research infrastructures, and decentralise science and technology activities. In 1995 new legislation was introduced making firms' R&D investment tax-deductible (OECD 1997). That same year, the Technology Development

Plan, PDT (Plan de Desarrollo Tecnológico) was formulated. In this plan, the government expected that investment in R&D activities would rise from 0.3 to 0.7 percent of GDP, and that the increase would come mainly from the private sector (Quintero 1999, 31).

The Plan stated that Secofi, in coordination with SEP and Conacyt, would foster a scientific and technology innovation culture in the Mexican society. Within the framework of the Education Development Programme 1995–2000, Secofi would collaborate with SEP to incorporate the subjects of innovation, experimentation, science and technology into the study plans of different education levels. In the context of the Science and Technology Programme 1995–2000, Secofi would aid Conacyt to increase the number of media programmes and printed documents about technology and innovation subjects. They would promote successful cases of technology developments of firms, the capacities of R&D centres; and those events related to S&T. Together, they would also establish a scholarship programme for those researchers who wished to spend a year working for a productive company developing technology projects. Moreover, Secofi and Conacyt would implement a system for financing quality programmes in small firms (Poder Ejecutivo Federal and Secofi 1995).

In August 2000, towards the end of President Zedillo's administration, Carlos Bazdresch, who had been Director-General of Conacyt for the whole of the presidential term, defined what he saw as some of the main obstacles for scientific and technological development in Mexico.

These were:

- the lack of infrastructure for R&D, as investment was stopped during the six years of the administration due to economic problems;
- the high dependency on government expenditure;
- the budget restrictions resulting from the 1995 economic crisis;

- the loose links between science and society; and
- the public expenditure figures, which remain at 1994 levels.

On the other side, he added that the goal of achieving an annual expenditure of 1 percent of GDP was not met, partly because Mexican entrepreneurs did not increase their investment in these activities, thus ending the presidential administration with an aggregated total expenditure of 3.5 percent of GDP over the six years. Moreover, he admitted that in the previous few years, the PRI did not worry much about the promotion of scientific and technological knowledge (Herrera Beltrán 2000).

Regarding the debate that started at the end of the Salinas' administration following the OECD's recommendation to establish a Ministry of Science and Technology in Mexico, Bazdresch assessed that during Zedillo's administration such a Ministry was not created because it was perceived that Conacyt should have a 'horizontal' character. He added that there are pros and cons of this situation, an advantage being that a Ministry will have greater weight as it would be closer to the President, a situation which, in Mexico, is very valuable. The transition team of the president-elect for the 2000–2006 period began to reconsider the division of the Ministry of Education to create a Ministry of Science and Technology, instead of maintaining Conacyt (Herrera Beltrán 2000). Nevertheless by the time President Fox announced the reforms to the executive and appointed his cabinet, no mention of the creation of a ministry of science and technology was made.

4.4 – TECHNOLOGY POLICY AND NETWORKS IN MEXICO

This section examines the way in which public policies can assist firms with becoming involved in technology-related activities, and with overcoming the complexities and uncertainties of innovation so as to enhance their own and their nation's competitiveness. It is important to try to specify the circumstances under which the public sector participates in innovation processes as a competent pacer stimulating long-term positive learning effects, internal as well as external to the public sector. This helps to understand the circumstances, presented in Section 4.5, where public sector activities seem to inhibit innovation capabilities.

The state as promoter of technology and innovative activities

A new breed of market-oriented theoretical ideas and policy proposals seems to be gaining ground throughout the economics profession. Protectionism, inward-orientedness and direct investment subsidies are increasingly identified as the main source of poor economic performance, all of them resulting from a high degree of government intervention in the economy (Katz 1995, 109). Nevertheless, it can also be argued that the character of state institutions helps determine whether and how countries change their position in the international division of labour (Evans 1995, 247). There can be little doubt as to the crucial role innovation and technological change play in the building up of international competitiveness.

It is precisely here that the role of governments in strengthening the workings of the national system of innovation,[16] in supporting the process of technical change and in promoting a greater degree of technological innovation at enterprise level can be conceptually defended, even under strict *laissez faire* rules (Fransman 1986). Many issues in relation to the generation, diffusion, and utilisation of technical knowledge, and to the functioning of the national system of innovation in supporting the process of technical advance in the production of

[16] The concept and dynamics of National Systems of Innovation are discussed in Chapter 3.

goods and services, are directly linked to the governmental role in developing economies (Katz 1995, 114).

In a period characterised by increasing internationalisation and transnational political regulation, the traditional role of national government in relation to industrial and technology policy is challenged. In this context it becomes important to understand which role the public sector plays in relation to innovation and technical change within nations (Gregersen 1992, 129-132). For the Mexican case, entrepreneurs consider the federal government as the main promoter of technology development, which is beneficial for the society as a whole and not simply for firms themselves, especially in the open-economy environment.[17] Moreover, according to the surveyed firms, the federal government plays a very important role in the promotion and support of the country's technological development. Figure 4.A shows that 80.6 percent of the respondents consider it most responsible (highest category). None responded 'not responsible'.[18] When asked whether the government should participate in the promotion of technology activities which are of benefit to individual firms, 98.4 percent of the respondents answered that it should.[19]

A nation's ability to undergo structural industrial transformation will depend to a large extent on the abilities and propensities of industrial managers, though there seems little doubt that public policies also have an important role to play in this process. Public policies can enhance the technological potential both of individual companies and public R&D institutions; they can promote an overall environment conducive to firm-based investment in techno-market activities, and public bodies can create an innovation demanding market through their procurement activities (Rothwell 1986, 65-83). Six basic principles may help policy-

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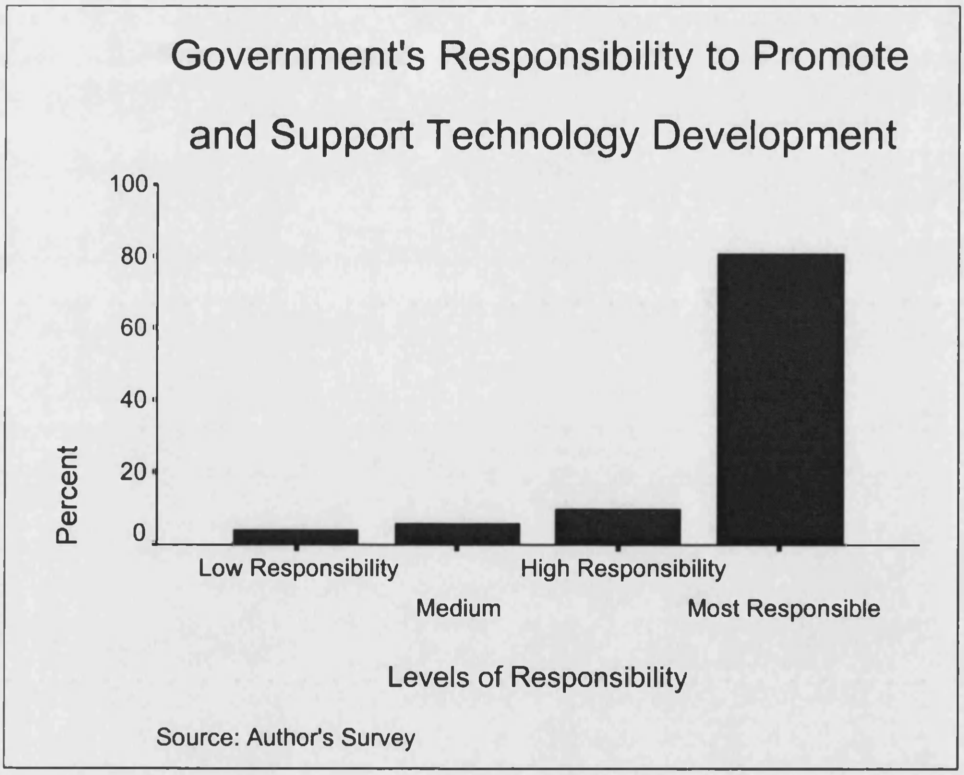
[17] Interviews #2, 3, 5 and 8.
[18] Author's Survey: Question #14.
[19] Author's Survey: Question #65.

makers determine useful answers to questions related to technology and innovation policy structure and purpose (Branscomb and Keller 1998, 463-464):

- encourage private innovation;
- emphasise basic technology research;
- facilitate access to new and old technologies;
- use all policy tools;
- leverage globalisation of innovation; and improve government effectiveness in policy development.

Figure 4.A. Respondents' answers to the question: How responsible is the federal government in the promotion and support of technology development in Mexico?



Technology policies and tools

There are considerable differences between the innovation policies adopted by different countries. Some opt largely for rather general policies designed to create the right environment for innovation. Others intervene more directly in the innovation process, promulgating some combination of technologically or industrially non-selective measures and measures of technology/industrial selection. The specific forms of public policies for innovation support are shown in Table 4.1.

As this thesis concentrates on finance-related policies[20], it is relevant to mention that for this case there are three levels of policy (Rothwell 1986, 65-83):

- Finance for R&D: this includes orienting finance of infrastructurally-based R&D towards stimulating developments in main priority areas and in facilitating transfers to industry. It includes also utilising government grants to orienting industrial R&D towards reindustrialisation projects.
- Finance and industrial structure: this involves influencing financing systems (both public and private) towards achieving the appropriate industrial structural dynamic; in general, it means increasing the availability of long-term money for restructuring programmes in firms and of venture capital for new technology-based startups.
- Overall fiscal climate: this involves establishing an overall climate conducive to private investment in technology projects; favourable tax regimes, directed public expenditures, moderate interest rates, and so on.

[20] See Chapter 6 and Chapter 7.

Table 4.1. Technology policies and tools for innovation support.

Policy	*Tools*
Direct financial support	Grants, subsidies, loans, provision of equipment or services, loan guarantees
Indirect financial support	Schemes encouraging investment in innovation, venture capital
Information	Networks, advisory centres, consultancy services, specialist libraries, databases
Scientific and technical infrastructure	Public laboratories, research associations, learned societies, research grants
Educational infrastructure	General education system, universities and polytechnics, technical education system, apprenticeship schemes, retraining system
Public procurement	Central or local government purchasing and contracts, R&D contracts
Taxation	Company, personal, indirect and payroll taxation, tax allowances
Regulations	Patents, regulations like environmental control, inspectorates, monopoly and anti-trust legislation
Public enterprise	Innovation by public-owned industries, use of these as pioneering facilities, establishment of new industries
Political	Planning, regional policies, honours and awards for innovation, encouragement of mergers or joint ventures
Public services	Procurement, maintenance, supervision and innovation in public services such as telecommunications, transport, health care
Trade	Trade, tariffs and currency regulations

Source: Braun (1994, 97), Dodgson and Bessant (1996, 48), Rothwell (1986, 65-83), Schienstock (1994, 12).

Technology policies, among other public policies, are a result of complex social and political processes which qualify the rationality of the choice of alternative options (Bastos and Cooper 1995). Whatever type or combination of policies is adopted, it can be stated that it should contain the following features (Rothwell 1986, 65-83):

- Coherence: the actions of the various institutions involved in policy formulation and implementation should be coordinated in order to avoid contradictory measures, especially between innovation and other policies: innovation policies and general macro-economic policies must pull together.
- Consistency: Innovation policies must be insulated from the dictates of the short-term political cycle. Innovation policy should not be manipulated by party dogma.
- Flexibility: Policies must be capable of responding to changing industrial needs, threats and opportunities. They should incorporate ongoing evaluation, with positive feedback to the policy system in order to continuously improve policy effectiveness.
- Complementarity: policies should not only complement each other, but should also complement the strategic interest of domestic companies. This means policy-makers should be aware of the long-term strategic thinking within national companies.
- Realism: policy-makers must recognise the inherent limitations of public policy and accept them. Over-optimistic expectations, unmet, might result in disillusionment and the termination of promising initiatives. Policies should thus be based on a realistic assessment of industrial potential. Public policy-makers should also recognise their own limitations and leave the choice of individual projects in the hands of industrial managers.

Above all, government policy should aim at creating a psychological climate favourable to research and innovation. Campaigns designed to inform and convince enterprises of the importance and profitability of research are often effective in converting managers to the idea that research is a paying proposition. However, even the most skilful propaganda will be of little effect without concrete and specific policy measures aimed directly at encouraging business enterprises to undertake or expand research activities (Freeman, Poignant, and Svennilson 1963).

Technology policy networks and interest groups

With the reduction of state protectionism, it is argued that science and technology will depend much more upon market criteria, owing to their close connections to industrial policy. For the case of science and technology, the immediate beneficiaries have much more bargaining power than the mass of those who are the targets of social policies. The academic–scientific community constitutes a very visible and articulate pressure group, if not a powerful one.[21] The big economic interests at stake on the technology front render the market much more relevant to decision-makers than in other areas of state action (Reis 1994, 131-137). Therefore, the agency responsible for advising the government in S&T policy matters has to be of high governmental level and closely linked, though not subordinated, to that in charge of economic planning (Comité Asesor de las Naciones Unidas sobre la Aplicación de la Ciencia y la Tecnología al Desarrollo 1973).

The manner in which science and technology policy initiatives are triggered and carried out is of critical importance. The study of how different actors play their roles in launching and implementing diverse policy initiatives, and the circumstances surrounding their actions, including the institutional framework, provides important insights for the design of viable science and technology policies. The viability and

[21] In Mexico, the 'scientific community' is considerably organised, while the 'technology community' is not. There are some leading entrepreneurs but a strong group can not be identified (Interview #20).

effectiveness of a particular S&T policy are heavily dependent upon the relative composition of political forces and coalitions encompassing these agents' actions. The decisions to establish effective links between science and technology on the one hand, and economic and social planning on the other, are of a political nature. They are a matter of consultation, cooperation, interaction and feedback amongst the participating agencies. The first step towards a national S&T policy is the government's decision to jointly consider S&T policy and economic and social policy when planning the development strategies for the country. In addition, the nature of the political regime and its proneness to manipulation by interest groups, its flexibility or its rigidities, and its capabilities for response to different demands from political and private actors and of international context are all determinant variables of the applicability of S&T policy (Comité Asesor de las Naciones Unidas sobre la Aplicación de la Ciencia y la Tecnología al Desarrollo 1973; Nadal Egea 1995, 110-112).

An example of the latter is the recent experience of an organised interest group, the Mexican Association of Directors of Applied Research and Technology Development, ADIAT (Asociación Mexicana de Directores de Investigación Aplicada y Desarrollo Tecnológico). This Association comprises more than 220 firms and institutions dedicated to research. ADIAT presented before the Chamber of Deputies of the legislative branch of government a proposal for the tax deductibility of R&D investments. The negotiations started in 1997 with a commission of the Chamber (Quintero 1999). The proposal mainly asked for fiscal incentives similar to those existing in countries trading with Mexico, including Canada, the US and Japan, among others. It consisted of three main points to approve:

- Fiscal credit for 35 percent of investment and expenditure in R&D
- Duty-free imports of equipment bought abroad with research purposes
- Non-accumulation for tax accountancy of revenue coming from the sales of Mexican technology abroad (royalty).

In December 1997, an initiative to promote R&D was approved, but it was quite different to the one presented by ADIAT. Of the three main lines negotiated by ADIAT, only the first was approved and that for a reduced credit, 20 percent. According to the information available, this result was negotiated between the officials of the Ministry of Finance and the representatives of the Chamber in charge of the science and technology commission. Later on, it was agreed with ADIAT that it would collaborate with the Ministry of Finance in the design and promotion of the operation rules of the new legal article. The rules were never implemented and at the end of 1998 a new initiative presented by the Executive was approved by Congress. This new fraction includes fiscal incentives similar to the previous article, but the 20 percent fiscal credit can not exceed 500 million pesos.[22] Moreover, those firms willing to claim the benefit have to present their projects for evaluation by an interinstitutional commission integrated only by public agencies: SHCP, Secofi, SEP, and Conacyt (Quintero 1999). Thus, not allowing the private sector to be involved in such a Commission shows more of the autonomy of the government to make decisions unilaterally.

4.5 - OBSTACLES AND LIMITATIONS OF TECHNOLOGY POLICY IN MEXICO

Successful policies are perceived by users to be consistent. Where general policy direction is clearly understood and particular initiatives are seen as contributing to these aims, confidence in the system and a

[22] Equivalent to US$ 55 million approximately.

willingness to participate build up. Government thus moves into the role of partner with the industry, rather than that of occasional benefactor or supporter. The effect is to articulate needs more clearly and to help focus policy-making more accurately towards meeting them. Therefore, the task of creating policy is highly problematic for governments. The uncertainties involved and amount of specialised information needed are daunting. Governments lack clear guidelines or institutions with well-defined routines to guide innovation policy (Peterson 1993). Before making decisions, policy-makers should examine existing institutional incentives and knowledge competences that affect retention and transmission and the generation of novelty (McKelvey 1997, 220). Otherwise, the following obstacles can obstruct the implementation and operation of effective policy:

Short-termism/long-term vision

The possibility of building infrastructures and innovation networks into effective national systems of innovation, such as the German, Swedish and Japanese systems, is improved with long-term consistency as opposed to short-term political shifting in industrial policy (Dodgson and Bessant 1996, 173-179; Rothwell and Zegveld 1982). In Mexico, short-term political shifts resulting in policy shifts have been a major problem in building a consistent and realistic long-term technology and innovation policy. There are no historical institutional bases, and policies are designed and implemented from scratch over and over again. Not only are there effects every six years with the ending of the presidential terms, there are also annual changes of public officials who bring their own teams of people and new ways of seeing things. The bureaucracy has to comply and put the new programmes into practice.[23]

[23] Interviews # 3, 5, 13, 15, 17, 20.

This in turn impacts on the way firms interact with the government agencies. For instance, 73.3 percent of the surveyed firms expressed the view that a presidential change had some kind of effect on their project.[24] Those effects range from redesign of main policies to the loss of interest from new officials due to a lack of civil service; the latter being the most relevant of the effects mentioned by the respondents of the survey (see Table 4.2).[25]

Long-term consistency of purpose, and the underlying financial commitment which that implies, are difficult to reconcile with political systems which are subject to short-term turbulence and wild swings in philosophy (Dodgson and Bessant 1996, 173-179). For instance, Mexico has gone through rapid changes in its economic policy, thus affecting specific areas like technology policy.

Table 4.2. Respondents' answers to the questions: Did the change of President affect your project? In which ways?

	Yes / percent	No / percent
General effect of presidential change	73.3	26.7
Policy and programme changes; Destroy the former; No continuity	40.9	59.1
Internal institutional disorganisation; Less follow-up; Slow procedures; Bad service	31.8	68.2
Lack of civil service; Change of attitude; Unexperienced personnel; Less interest	59.1	40.9
Source: Author's Survey		

Moreover, the fact that one party dominated the government for over 70 years made it easier to implement those changes. Additionally, there is a 'tradition' of abandoning whatever the former administration has done, and the main concerns are to show some kind of successful

[24] 66.7 percent of the surveyed firms confirmed that their project had started during one presidential term and continued during another (Survey Question #57).
[25] Author's Survey: Questions #58 and 59.

results within an administration even if the users of programmes are affected.[26] Fausto Alzati remembers that when the new administration began, the new team in charge of Conacyt 'questioned everything done by us, from the creation of the programmes to the giving of funds to firms' projects via FIDETEC...they did not understand what had been done and we were not given the opportunity to explain it...it became a relationship of adversaries'.[27]

Therefore, a critical policy question when examining less-developed countries (LDCs) that participate in an increasingly liberal economic order is how to effect the transformation from a regime of short-term defensive reactions to a pattern of strategic actions. In the case of a country like Mexico which has been dealing with macroeconomic crises so often, long-term strategic actions may be more difficult to achieve. Thus, short-termism, in the broadest sense, may continue to be a syndrome affecting all actors in the economy: firms, business associations, labour unions and government. In contrast, a policy that places LDCs on a sustained path of industrialisation must overcome short-termism at many levels simultaneously (Thomadakis 1998, 113). This means that policies being developed and introduced today will probably not begin to have a significant impact for five to ten years.

Governments should be prepared to adopt a strategic long-term approach to innovation policy, which should be largely divorced from the short-term, and often rather cynical, dictates of party politics. Policies based on a consensus between government, industry and society regarding long-term economic aims can help achieve such an approach (Rothwell and Zegveld 1981).

It is also important to recognise that some particular measures are relatively time-consuming to implement. This commitment over an

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[26] Interviews #3, 4, 10, 15 and 17.
[27] Interview #10.

extended period of time - years rather than months - may, however, have a much greater effect on user firms, since technology transfer becomes reinforced as a day-to-day process within the company and thus the capability for managing it effectively is developed (Dodgson and Bessant 1996, 173-179). Within a context of continuous crisis, there is a high degree of uncertainty for both private firms and public agencies involved in the technology activities and policies. For instance, if a technology project is expected to take ten years to reach its commercial phase, it is difficult for entrepreneurs to take the risks knowing that policies tend to change and crises likely to occur. On the side of the government, when crises happen, budgets are restricted and funds have often been cut for S&T activities, like in the case of the 1995 crisis.[28]

Stability/instability of the bureaucratic apparatus

Similarly, the ability to build close links with the user community depends upon a stable infrastructure and a policy platform which appears to those users to be clear, consistent and broadly supportive. According to the Global Competitiveness Report 2000, Mexico's institutional stability ranks 52nd out of 59, meaning that the legal and political institutions are perceived to be likely to change dramatically in the next five years (World Economic Forum and Harvard-CID 2000). Learning also requires some continuity of staff involved in policy design and implementation together with the time, resources and information necessary for effective review (Dodgson and Bessant 1996, 173-179). Mexico lacks a tradition of civil service and changes of personnel are a common practice, thus experience is not accumulated and is often lost.[29] Changes of personnel also disorient the users of the government's programmes, and bring about negative effects for

[28] Interviews #10, 13, 19, and 20.
[29] Interviews #4, 5, 8, and 13.

technology projects.[30] Following the Global Competitiveness Report 2000 ranking, the country is 42^{nd} out of 59 in time spent by entrepreneurs dealing with government bureaucracy (World Economic Forum and Harvard-CID 2000).

Isolation/consultation

Technology policy based on the logic of the beneficiaries should be more democratic and more open to the public (Tanaka and Hirasawa 1996). Nevertheless, in Mexico there is almost no consultation with the users or beneficiaries of the government's programmes. Only 33 percent of the surveyed entrepreneurs said they had been asked for some kind of feedback regarding their experience with the programmes they used, or had been asked for suggestions as to how to improve them.[31] And when they are consulted, their views and suggestions are rarely put into practice.[32] For instance, at the end of the 1989-1994 administration, Conacyt invited firms, clients of FIDETEC, technology evaluators, banks executives, and representatives from other government agencies involved in the operation of the programme to discuss its problems and potential solutions.[33] A document with recommendations endorsed by those third parties was given to the new directors of Conacyt and FIDETEC. Participants considered the exercise as a very important step towards the improvement of the programme based on the experiences of the users. Nevertheless, the recommendations were not taken into account by the new administration, and decisions were made isolated from the needs of the beneficiaries.[34]

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[30] See Chapter 7.
[31] Author's Survey: Question #56.
[32] Interviews # 4, 9, and 16.
[33] See also Chapter 7.
[34] Interviews #4, 9, 15 and 17.

Rigidity/flexibility

Another factor of innovation policy is the way it is operated, managed, controlled and tuned. The programmes must have rapid and flexible response systems, with a flexible structure which permits modification and development within the life of the programme, tailoring to and focusing on user needs; thus allowing for learning and further improvement (Dodgson and Bessant 1996, 173-179). Incentive programmes are in general too inflexible and too demanding in terms of required administrative details and liaison effects. In the administration of incentive programmes, governments are usually too slow and complex in their response to the needs of industry (Rothwell 1986). For instance, a Mexican entrepreneur complained about the fact that his firm's technology project had unexpected technical delays, common in projects of this nature, and the government agencies that were financing the project did not respond to their requests to restructure the plans, thus losing time and commercial opportunities: 'nobody had the criteria to make decisions', he explained.[35]

Fragmentation/coherence

Another of the main causes of the inflexibility of the government's programmes to respond to their users' problems is that responsibility is normally divided between several different government departments. Some have a direct responsibility for stimulating, encouraging and supporting invention and innovation in sectors like agriculture, industry and services. Others have responsibility for safety, employment, consumer protection, education, environmental conditions, international trade, health and so forth. The government departments involved are often imperfectly aware of the implications of their departmentalised

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[35] Interview #5.

policies for innovation elsewhere in the economy (Rothwell and Zegveld 1981).

In Mexico, public agencies tend to be individualistic and pursue their own and specific interests; there is very little coordination amongst them and they usually lack a common goal.[36] For instance, technology policy is partly designed by Conacyt, but the Ministry of Finance and the Ministry of Trade and Industry play an important role.[37] Sanchez Ugarte, former Vice-Minister of Industry at Secofi, recalls the ongoing debate of whether the instruments of technology promotion should be on the side of the industrial policy or on the side of human resources/education policy; at the time, they were more concentrated on the education side, resulting in weaker links between the agencies involved with industrial promotion and those promoting activities of universities and research centres.[38] According to Carlos Bazdresch, Director-General of Conacyt during Zedillo's administration, the government's expenditure on S&T is approximately 600 million US$ per year, but results are not evident due to their dispersion among small programmes of different state agencies, which are operated in isolation from each other, without rules and no integration (Herrera Beltrán 1999).

Centralised/decentralised operation

One last important consideration is the way policy is moving away from highly centralised administration and towards greater devolution to agencies closer to the target of the programmes. Several benefits flow from such decentralisation, including faster response time and opportunities for much closer contact with user firms than would be possible from a single, large bureaucratic centre. Nevertheless there

[36] Interviews #3, 4, 11, 12 and 20.
[37] Interview #10.
[38] Interview #20.

can be some disadvantages with decentralised policy. Good policy builds in some form of monitoring and evaluation in order to improve the design of subsequent programmes, but when the system is extended through decentralisation, there is a risk that much of the valuable feedback from implementation will be lost (Dodgson and Bessant 1996, 173-179).

In a highly centralised system like Mexico's the experience of entrepreneurs dealing with a federal government agency shows that even if there are regional and local representations, they have very little decision-making power to deal effectively with government, thus having to complete almost every procedure directly with the central offices in Mexico City.[39] Instead of encouraging regional offices to look for potential technology projects in firms, very little responsibility is delegated to the regional offices and that increases the costs of applying for support from the government.[40]

CONCLUSIONS

Mexico has gone through four economic crises in the last three decades (1976, 1982, 1987 and 1995) and the government has sacrificed resources previously allocated to science and technology activities to help resolve these crises. When in crisis, to stop implementing a comprehensive S&T policy can lead to obstruction of the long-term goals of increasing productivity and industrial development.

This chapter has suggested that Mexico's scientific and technological backwardness can be partly explained by the persistence of policies aimed at accelerating growth without structural change and by the subsequent lack of reasonably coherent long-term science and technology strategies. Successful policy-makers and programme teams

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[39] Interviews # 1, 2, 5 and 8.
[40] Interview #13.

retain what they have learned over time about the most effective form of policy formulation and delivery. When policies are short-term and frequently changed there is no opportunity to make this learning cumulative. Maintaining continuity, however, is a problem; with politicians ever eager to launch their new policies it is difficult not to succumb to the pressures of continual policy relaunches. Furthermore, the results of the rapid and forced rotation of the state bureaucracy at all levels are obviously lamentable in the case of science and technology policy. Another aspect that is important for a better performance of private innovation is the need for the government to make use of the full range of policy tools while sharing more decision-making with the private sector.

The cohesion of elites is also crucial. No programme can proceed if there are divisions regarding appropriate policies within the ruling circles. A lack of inter-departmental coordination and occasionally cooperation between the relevant organisations and agencies involved in the technology policy process can result in a complementarity problem between different initiatives, and might also lead to the propagation of contradictory measures. The more radical a reform, the more important such cohesion becomes. Precisely because of the often traumatic social costs involved, the state must speak with one voice and must remain committed to the programme, especially during the initial and most difficult stages. As former President Salinas confirmed, the need to continue with the macroeconomic policies and trade reform made it impossible for his government to allow for exceptions of intervention as in the case of technology policy. [41]

Furthermore, the state has to rely on a bureaucratic apparatus able to respond effectively to new policy directions. For instance, it can be said that the government's overloaded effort of free market reform and

[41] Interview # 19.

democratisation in the 1990s did not give time to implement an organisational/administrative reform as well. Thus, the rather patrimonial state has not been able to effectively carry out the project of modernisation.

A weak rule of law coupled with a lack of accountability and of a democratic political system have undermined the possibility of designing and implementing a sound and robust S&T policy which is not prone to manipulation. Technology policy can be present in strong authoritarian states, and it can be argued that Mexico is an authoritarian state, but this does not mean that authoritarianism is the perfect condition for a successful S&T policy, or even an advantage for it. Therefore, the Mexican government has the tasks ahead:

- to provide a favourable overall economic climate, e.g. less vulnerable to recurrent crises;
- to also provide a favourable social climate, e.g. stimulate the social acceptance of new technology and help overcome social and institutional rigidities and resistance to change;
- to establish a relatively stable political climate, as dramatic political swifts create uncertainty;
- and to *avoid* rapid policy changes, as stop-go policies can deter the adoption by firms of the necessary long-term development strategies.

The next chapter discusses the role of private firms, which ultimately are the ones affected by the prevailing environment - namely the economic context, the national system of innovation and the government's policies - in the way they engage or not in technology activities.

Chapter 5

SMALL FIRMS, BUSINESS ASSOCIATIONS AND INDIGENOUS TECHNOLOGY INNOVATION IN MEXICO

'...in the modern era of globalisation...the pace of technology change has been further accelerated, so in industry after industry, there is a sense of research or die.'

Louis Turner and Michael Hodges, 1992

INTRODUCTION

Commonly, studies of economic development in Mexico concentrate on the government, its policies, and its role in economic growth, ignoring the impact of the private sector and the entrepreneur. Yet businessmen and entrepreneurs contribute greatly to the evolution of new cultural values and the modernisation of structures essential to economic and political development. Entrepreneurship, defined broadly, embraces small firms, innovation, and regional and local development policy. In the long-term, innovation is the most important form of 'entrepreneurship'(Casson 1982, 391). In a study of technology as a central factor for a nation's development, a more complete picture of Mexico's private firms is needed.

The limited studies of the attitudes of firms and business associations towards technology transfer and autonomous or indigenous technology development can be related to the restricted information available. The following historical causes[1] contribute to this problem:

[1] For further details, see Wionczek, Bueno, and Navarrete (1974).

- The scarce and incipient research on firms and their attitudes
- The historical lack of interest in exploring the role of technology in the industrial development of the country
- The hermetic attitude and operation of firms regarding technology issues.

Therefore, this chapter aims to contribute to the study of firms and their capacity to innovate, both in Mexico and in similarly developing countries recently opened to global competition. Evidence from fieldwork will be presented along with theoretical issues and historical facts of Mexico's most recent events.

Section 1 presents the main theoretical discussion concerning the capability of developing countries to engage in innovation activities. The importance of indigenous technology is reviewed. The increasing role acquired in international markets by small and medium-sized companies, which through very different methods have extended their range of activity beyond national frontiers, shows that this possibility is not reserved simply for multinational units. SMEs are important actors in economic life and in technological progress (Alonso 1995; OECD 1982). The second half of this section discusses SMEs in relation to larger firms and their technology capabilities, with an emphasis on cases from the less developed countries. Section 2 presents an overview of the evolution of Mexico's private sector, its structure and the way Mexican firms have been involved in the creation of an innovation culture. Section 3 describes the role of business associations in helping the nation's industries achieve their goals, and whether in Mexico their participation has had an important effect. As this thesis is concerned with the way in which government and firms interact in the process of technology development for the country, Section 4 analyses the relations between private and public sector, from the protectionist era to the recent economic liberalisation in Mexico, under the understanding that rapid changes in the government's economic policy stimulated companies to export and generated a new interest in technology (Barrientos 1994). The impacts on small and medium-sized firms are also assessed.

5.1 - THE IMPORTANCE OF INDIGENOUS TECHNOLOGY FOR LESS DEVELOPED COUNTRIES AND FOR SMALL AND MEDIUM-SIZED FIRMS

Innovation and technology in less developed countries

As discussed in detail in Chapter 2, innovation is the initial introduction of a new product and/or the first use of a new product process. Innovation usually rests upon research, and following Schumpeter's ideas and his concept of 'creative destruction', innovation primarily appears not as a single event, but rather as a process (Schumpeter 1934).[2] Innovation or new knowledge about technology is critical for developing countries seeking to close the so-called technology gaps between poor and rich nations.

Developing countries have the option of acquiring technical knowledge already available in industrial countries, or creating their own. Due to the high costs of creating technical knowledge, much of it is created in industrial countries (World Bank 1999, 1-2). When discussing the importance of indigenous research and innovation, it could be argued that it may be a waste of time in view of discoveries already made by others. Technological knowledge and expertise is mainly acquired from abroad through an open trade regime, foreign direct investment, or licensing agreements. Openness to FDI[3] is important in itself as

[2] For a detailed discussion on the issues and concepts of innovation and its relation to economic development see Chapter 2.
[3] FDI is a very important source of acquiring technical knowledge and Mexico is amongst the top 12 developing countries that have attracted most foreign investment in the past three decades (World Bank 2000, 72). Nevertheless, as discussed in this section, the development of national technological capabilities is critical and no country can rely merely on imported technology.

multinational investors are global leaders in innovation and their activities in developing countries can be important in transmitting knowledge of best practices (World Bank 1999, 8; World Bank 2000, 72). But when talking of technology development, there is every likelihood that the end-results will be different, as different economic environments will influence the process of research and development.

Therefore, imported technology is rarely associated with the production of a wholly new product or process for the international markets (James 1979, 95-96). Even in manufacturing, knowledge produced in other countries has to be adapted to local conditions (such as weather, consumer tastes and availability of complementary inputs). Thus, indigenous science and research are evidently needed if less developed countries (LDCs) are going to be able to engage in true product innovation or even take advantage of the large global stock of knowledge, as they need competence to search for appropriate technologies and to 'select, absorb and adapt' imported technology (World Bank 1999, 8).

Thus, an indigenous process of technological development in such countries requires technological capabilities based on skills and knowledge. The accumulation of such capabilities is as important to economic development as the accumulation of capital. Thus the ability to make independent technological choices, to adapt and improve techniques and products, and eventually to innovate endogenously are essential aspects of the process of economic development (James 1979, 95-96; Romijn 1999, 1-8; Stewart 1981, 80).

According to the former Director of Conacyt in Mexico, 'the challenge lies on the ability to absorb and diffuse imported technologies, while simultaneously developing technology capabilities to engage in true innovation...if the productive apparatus is not updated, it is impossible to talk about innovation'.[4]

Since the 1970s, case studies of technological development by firms have been carried out in developing countries.[5] Until then, the prevailing notion was that developing countries could advance economically by importing ready-made technological improvements and their benefits from more technologically advanced countries. There was very little recognition of the existence of, or the need for, indigenous technological activities in LDCs. Hence, the technological problem faced by these countries was primarily seen as transferring appropriate technology by making the right choices from the available alternatives. This goes some way to explaining the preoccupation with issues such as capital intensity and the relative costs of different means of transfer (Romijn 1999, 1-8; Weiss 1988, 236-237).

The conceptual framework underlying this appreciation was predominantly neo-classical. Developing-country firms face a production function with a number of given alternative technologies, all of which they know fully. The key to the progress of firms lies in the selection of the most appropriate technique given local factor endowments and relative prices (Fransman 1985; Stewart and James 1982).

The assumptions required for this model to work were challenged on both theoretical and empirical grounds by a number of alternative, more dynamic and realistic approaches that began to emerge in the second half of the 1970s. These approaches are referred to as institutionalist, structuralist or evolutionary. They emphasise the importance of and need for technological change in developing countries themselves (Romijn 1999, 11-19). Such literature on

[4] Interview #10.

technology and development argues that imports alone are insufficient for improving efficiency and inducing a self-sustaining industrialisation process. This is because mere access to foreign technology does not imply mastery of it. FDI or technology licensing may be good ways to bring technology to a country, but mastery results from a process involving the local acquisition of technological skills and knowledge,[6] better known as technological capabilities (Dahlman and Westphal 1981). The technology transfer process therefore requires the commitment of time and both human and physical resources to activities that lead to technological learning. Imports of technology can be very useful or even necessary starting points for that local learning process, but they can never substitute it entirely (Stewart 1981). Hence there is no automatic link between technology imports and the development of local technological capability.

A number of empirical studies have been inspired by evolutionary approaches. They deal with the development of indigenous technological capability in LDCs, both within firms and within countries (Nelson and Winter, 1982; Bell and Pavitt 1992; Dosi, Pavitt, and Soete 1992; Katz 1987; Lall 1987; Lall et al. 1994). In the evolutionary view, technical change at the level of individual firms occurs as the result of a continuous learning process through activities to absorb, adapt and create technology, because 'simply producing a given set of products with a given technology will not enable a firm to survive for long' (Nelson 1991).[7] The growth and competitiveness of firms are functions of the organisational routines that they build up as a result of those

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[5] See Amsden 1989; Biggs, Shah, and Srivastava 1995; Fransman and King 1984; Hobday 1995; Katz 1987; Lall 1987; Lall et al. 1994; Stewart, Lall, and Wangwe 1992; Westphal, Kim, and Dahlman 1984.

[6] Two of the economies that have come a long way toward closing the technology gap with the global leaders are Korea and Taiwan. Neither based their development on the 'wholesale recruitment of FDI' (World Bank 1999, 32-33)

[7] An entrepreneur involved in technology projects in Mexico believes that 'it is for the firms to make their own technology...it is as important as living or dying' (Interview #7).

learning processes. Most of the learning requires a purposeful commitment and allocation of resources, as it is only through practice that it is possible to assimilate the technology (Lall 1992b).

For the evolutionary theorists on the one hand, the process of technological progress within firms is gradual, comprising a series of successive small changes and improvements which are built into an existing technology, product or structure of a firm. On the other hand, the traditional approach equates technical change with major innovation, an activity still concentrated in the technologically advanced countries (Nelson and Winter 1982).

Recent neo-classical work has shifted away from the static model in which technological change was treated as exogenous, and now aims at endogenising innovation (Fransman 1985; Stewart and James 1982). However, these works still focus exclusively on radical innovations that emanate from formal R&D. Such a framework is not particularly suitable for explaining technological change in developing countries, in which major innovations occur only rarely and most of the technological efforts undertaken by firms take the form of informal research and experimentation on the firm's premises (Romijn 1999).

Although evolutionary theory was developed with an industrialised context in mind, it appears to be a relevant framework for the understanding and interpretation of technological change within firms in developing countries as well. Significant technological capabilities emerged in the firms studied, particularly those in Latin American countries, Korea and India (Amsden 1989; Katz 1987; Lall 1987). The findings of these studies clearly undermined the notion that LDC firms were mere choosers and users of foreign technology. The potential of those firms is enhanced by the possibility of exporting new capital goods to other less developed countries with similar conditions, or new consumer goods to countries with similar tastes and incomes.

Yugoslavia, for instance, has been able to export technology to Egypt and Indonesia. Furthermore, a United Nations investigation recommended that Nigeria and other African nations make use of technology developed in Mexico and India (James 1979, 96-97).

Already the awareness of the importance of indigenous innovation can be detected in answers given by respondents to the Author's Surveys presented later on in the chapter. One of the most important results relevant to this section is that almost 60% of the firms surveyed considered innovation or adaptation as the best way to invest in modernisation of their technology. Less than 3% saw the purchase of national or foreign technologies as a good investment.[8]

Further results of the Author's Survey show some interesting points of view from Mexican SME firms which have engaged in technology projects themselves, on the following issues:[9]

- The importance of technology to the country's development: 90.4% responded 'Most Important' and 8.2% 'Very Important'.
- The importance of technology to their firm's development: 81.9% responded 'Most Important' and 16.7% 'Very Important'.
- The capacity of Mexican firms to develop their own technology: 88.9% answered 'Yes'.
- The type of technology project developed by their firm: 65.6% considered their projects to be innovations; 25% as adaptations of national or foreign technologies; and 9.4% as improvements.

If it can be argued that developing countries like Mexico can and should engage in innovative activities, it is important to go further to discuss in detail what kind of firms are able to develop technology.

[8] Author's Survey: Question # 4.
[9] Author's Survey: Questions #1, 2, 3 and 22.

Size of firms and technology development

Following the discussion of the previous section, under the evolutionary approach firms progress through research, but since it is a costly activity and the gains are uncertain they will tend to engage in it when they feel pressure to do so. Pressures can take the form of constraints that have to be overcome in order to avoid loss of market share or profit, or incentives that promise future gain. Pressures can arise from within the firm itself as well as from the firm's environment (Romijn 1999, 11-19). An example of such pressures can be drawn from a study commissioned by Conacyt in 1992 which evaluated Mexico's technology gap. The results showed that those sectors with a narrower gap were those which were less protected.[10] The correlation between tariffs and technology experience was inverse.

Furthermore, many factors operate in the environment of the firm which can help to explain the extent to which firms engage in technology-related activities. Among the most important are:

- the general economic climate
- the degree of competition and market structure
- the rate of change of the international technological frontier
- government policies aimed at regulating foreign trade and fiscal and monetary parameters
- government investments in a supportive science and technology infrastructure through public R&D and technical education of the labour force.

While important factors within the firm are (Romijn 1999, 11-19):

- the nature of the technology employed

[10] Interview # 10.

- ownership
- attitude or personal factors
- firm size

In 1998, respondents to the Author's Survey were asked which factors within the firm were essential for the technology capability[11] (see Table 5.1). Almost 80% considered skilled personnel as essential, followed by financial strength, seen as highly important by 63.9%. Long establishment in business was considered by 90.3% to be non-important, so it can be assumed that they believed newly-established firms to have technology capabilities. Attitude or personal factors were only mentioned by 9.7% of the respondents. 34% thought that a firm's internal infrastructure was an important element. In this question, the firm size factor was not listed as a category, and no respondent mentioned it as one of the 'other factors'.

Table 5.1. Respondents' answers to the question: Which factors are essential for a firm to develop technology capabilities?

ESSENTIAL FACTORS FOR FIRMS' TECHNOLOGY CAPABILITIES		
	Yes / percent	No / percent
Skilled Personnel	77.8	22.2
Financial Strength	63.9	36.1
Previous Experience	55.6	44.4
Infrastructure	34.7	65.3
Long Establishment	9.7	90.3
OTHER FACTORS*:		
Innovative Attitude	9.7	
Commercial Potential	4.2	
*Mentioned by respondents under the field of 'other' factors		
Source: Author's Survey		

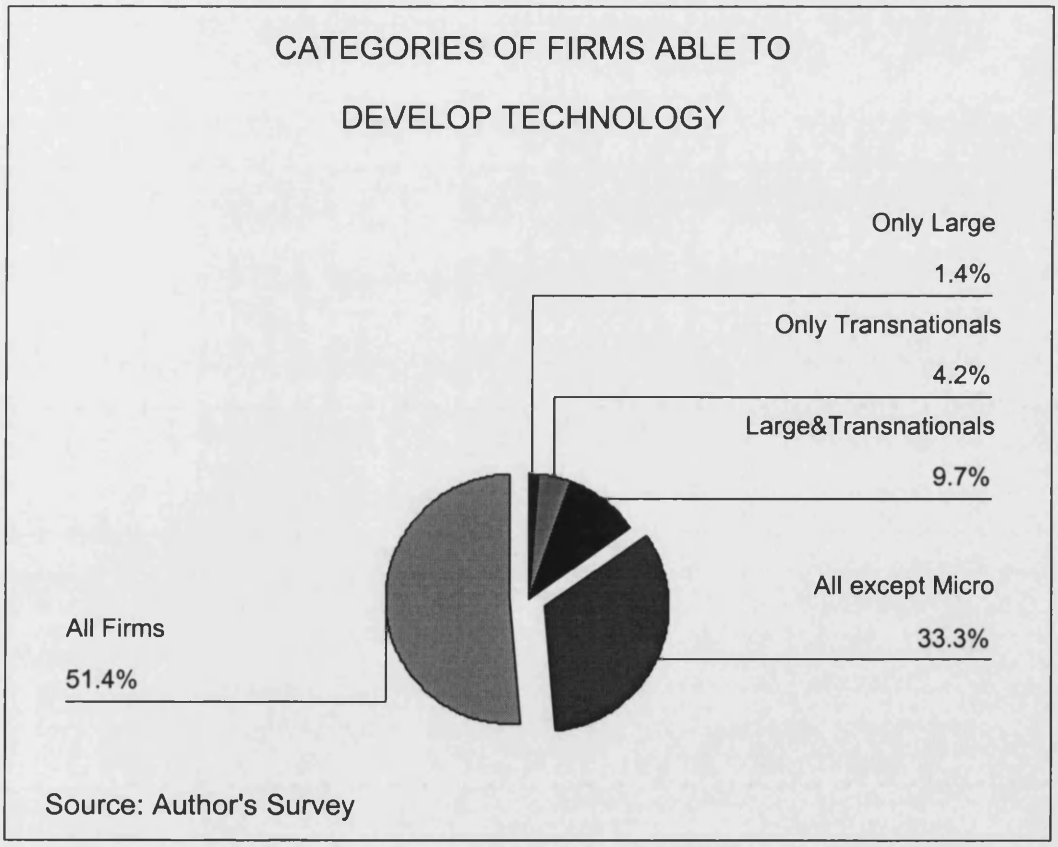
A separate question asked which categories of firms were able to develop technology[12] (see Figure 5.A). From their own experience,

[11] Author's Survey: Question #7.
[12] Author's Survey: Question #4.

51.4% of the surveyed entrepreneurs believe that all firms, from microenterprises to transnationals, could develop technology. 33.3% saw microfirms as the only category not fit to develop technology. It can be inferred that according to 84.7% of Mexican entrepreneurs, SMEs can develop technology projects.

In line with the central objectives of this thesis, the factor of firm size is going to be developed further, and a number of significant points concerning this issue are now presented.

Figure 5.A. Respondents' answers to the question: What categories of firms are able to develop technology in Mexico?



Discussion of the relative role played by small and large firms in innovation is controversial and sometimes contradictory, from the theoretical as well as the empirical point of view (Galhardi 1994). In 1943, Schumpeter argued that large, established corporations had become the most powerful engine of technological change and economic growth (Schumpeter 1943). Ten years later, Galbraith also argued that the high cost of industrial R&D activities meant that they could only be carried out by firms having the resources associated with considerable size (Galbraith 1952).

However, more recent authors maintain that small firms are an important participant in economic growth (Freeman 1982b; Rothwell and Zegveld 1981). According to their views, as well as supplying certain specific markets, small firms act as vehicles for the introduction of new technologies. These views have been accepted and acted upon by governments in their attempts to redirect government policies in favour of SMEs. In the United States, for example, measures to protect and assist small firms have been set up since 1953. In Europe, policies in favour of small firms have been strengthened since the early 1970s, demonstrating a growing belief in the innovative potential of small firms (Rothwell and Zegveld 1981).

A third position is based on the neo-Schumpeterian view that large and small firms are a necessary complement to each other, rather than alternatives. Utterback and Abernath argue that a small entrepreneurial organisation and a large one producing high volumes play different roles in relation to the different types of innovation (product or process) that occur during the product life cycle (Utterback and Abernath 1978).

With regard to the technological capability of developing countries, the focus of most literature has been on the more advanced large firms sector, but firms in this sector constitute only a segment of the total industrial structure in the great majority of developing countries. Small firms – typically much more influential than large, modern firms in the creation of employment and income in developing countries – are usually believed not to have a noteworthy role to play in the development of home-grown technological capability.

Considering the quantitative importance of small-scale enterprises in developing countries, it appears that they have been inadequately represented, especially in the studies focusing on Asian and Latin American countries. Productivity and incomes are lowest in small firms, and it is there that the acquisition of more advanced technological capabilities would therefore be most needed.

A recent study by Romjin shows that there is no good reason to disregard the role of the small firm in the process of building national technology capability, as small firms in developing countries do indeed acquire technological capabilities. Moreover, this is socially and economically beneficial in the sense that it contributes to higher employment and incomes in those enterprises. He argues that 'small firms have their own distinct role to play in the accumulation of technological capacity and that capability building in large firms cannot go very far towards resolving the development problem on its own' (Romijn 1999, 3). Large firms can contribute significantly towards narrowing the international technology gap between developing and developed countries, but they might not be able to resolve the technology gap within a developing country itself.

Given the shortage of appropriate, efficient, small-scale technologies in many developing countries there are reasons why adaptation would assume even more importance in small firms than in large firms (Gamser and Almond 1989). Entrepreneurs are often forced to acquire technologies that are not ideally suited to the conditions in which they will be used. Small firms also have to make technological effort after acquiring new technology because of resource constraints. Far more than in larger firms with easier access to cheaper capital,[13] there is

[13] See Chapter 6.

considerable pressure to squeeze maximum performance out of given limited resources (Massaquoi 1991).

Many competitive pressures exist in the small-scale sector too. These pressures emanate from within the sector itself, but also from larger firms that operate with more modern, productive and efficient technologies and from imported products. Small firms that wish to grow and compete effectively thus need to adopt and master increasingly advanced technologies, even if these are not the latest available. It is indeed difficult to see how much a growth strategy could be followed successfully through mere passive assimilation. The adopted technologies may be old in the sense that they have been in use for several years or even decades, but they are still new to the firm that adopts them (Romijn 1999, 26-45).

Small firms, compared to larger firms, have advantages and/or disadvantages in the process of innovation (Galhardi 1994; Malecki 1997; Rothwell and Dodgson 1994). Using the phases of the innovation process described by Wijnberg, those characteristics are presented here (Wijnberg 1990, 45-63):

1 – The invention:
A more inventive ability is ascribed to the small enterprise, notwithstanding the fact that the larger enterprise will have more employees with specialised knowledge, sophisticated instruments and the ability to use them. In the small enterprise an atmosphere is said to prevail which is more beneficial to creative work. Lines of communication are shorter within the enterprise and between its potential inventors and potential customers. A smaller firm will be more aware that innovation can be a very important way to stay in business (Kanter 1984). The more flexible and integrated structure of the small enterprise will be more conducive to creativity than that of the large enterprise, which is often rigidly divisionalised. In a discussion regarding

the size-related characteristics of Mexican firms, an entrepreneur involved with both large and small companies confirmed that 'micro and small entrepreneurs are more creative, while large firms behave in an elephantine manner'.[14]

2 – The decision to bring the invention into development:

The decision to devote time and money to an idea to transform it into something that could be produced will be riskier to a small enterprise unable to spread the risk involved over many projects. On the other hand, the decision-making processes employed by small enterprises operate faster than those in large, bureaucratic organisations.

3 - Development:

The small enterprise has the advantages of better communication and motivation. Cost-consciousness is also often higher. On the other hand, the greater availability of specialised instruments and researchers may bring the large enterprise advantages in the careful development and fine-tuning of the project. The large enterprise is likely to have more experience with specific problems, and will be more able to profit from the knowledge gathered. Moreover, it will have better lines of communication with government and professional suppliers of information and will be more knowledgeable about relevant regulations and recent developments. Of great importance is the larger enterprise's greater capability to finance innovative projects.[15] It will be in a better position to internally finance innovative development, especially if it innovates on a continual basis. It will also find it easier to locate external financing since it is better able not only to spread the risk over a number of projects, but also to cover innovative and non-innovative activities.

4 – The decision to produce or use in production:

[14] Interview # 7.
[15] See Chapter 6.

An enterprise that is large enough to reach economies of scale while producing an existing product will be less inclined to switch to a new product. The faster decision-making process of small enterprises is advantageous in this respect, as the decision-makers can quickly convince themselves that a market for the innovation exists. On the other hand, large firms could guarantee themselves sufficient demand because of their market power with regard to the product it replaces (OECD 1982).

5 – Production or the use in production:
As far as production is concerned, the reasons why a smaller enterprise will have more financing problems are less valid because the larger enterprises' possibilities of spreading risks have decreased relative to those in the phase of development. The security that the smaller enterprise can offer to its capital suppliers has increased. However, a larger company will normally be able to reap greater benefits by introducing a cost-decreasing innovation in its own production processes.

6 – Marketing:
It is supposed that the small enterprise has better communication with its customers because such communication is more informal and more often takes place with persons having decision-making power in the firm. However, this must be balanced against the market power and the skills of the larger enterprise. The large enterprise will also be better known and the value of its trademark or branding will be greater.

With regard to all phases, it appears that arguments can be presented both for and against the assumption of innovative capability of small enterprises. Table 5.2 shows a summary of the comparisons between small and large firms with regard to their capabilities to engage in a technology project.

Table 5.2. Advantages/Disadvantages of small firms relative to large firms.

Advantages
• Rapid decision-making due to a lack of bureaucracy • Ability to react quickly to changing market demands • Better prepared to deal with risk • Informal but efficient internal communication • Fast learning capability • Ability to dominate narrow market niches • Flexibility to vary output volume
Disadvantages
• Inability to support formal R&D effort or to employ technical experts • Lack of time and resources to identify and use external information sources • Difficulty acquiring capital for growth • Inability to spread the risk through diversification in several projects • Formal management skills are often absent • Inability to attain economies of scale • Little bargaining power with suppliers and distributors

Source: Galhardi 1994; Malecki 1997; Rothwell and Dodgson 1994; Wijnberg 1990.

Even if it is not possible to argue that small enterprises in general have a greater capability to innovate than large ones, it is possible to say that besides the majority of less innovative small enterprises, there are highly-innovative small enterprises which could merit extra attention and support. Furthermore, different results of empirical research deal with the relationship between innovation and size of firms, and they can serve as confirmation of the inventive potential of small firms (Jewkes, Sawers, and Stillerman 1969; Kamien and Schwartz 1982; Scherer 1984; Schmookler 1972). In modern markets, small and large firms do not operate in isolation from each other, so they enjoy a variety of complementary relationships in their technological activities as well.

Innovative capability in small firms can strongly differ from industry to industry (Rothwell and Dodgson 1994), but this work will not go into detailed sectoral analysis, [16] and, for the rest of the chapter, will concentrate on the small and medium-sized firms as a subgroup of Mexico's private sector.

5.2 – MEXICO'S PRIVATE SECTOR

Evolution of Mexico's private sector

In contemporary Mexico, industrial development of the private sector has taken place in the shadow of the state. The most important economic groups were formed years ago under state auspices; many of them grew out of government contracts or most importantly, under trade protection (Cárdenas Sánchez 1998, 19-35). Linked in an unusual symbiotic relationship, the private sector and the government, dominated by the Institutional Revolutionary Party, PRI (Partido Revolucionario Institucional), arrived in the middle of the 20th century at an understanding regarding their respective roles in society. According to Roett, the hallmarks of the relationship were favouritism, protection and obedience (Roett 1998, 223-230). The model succeeded for decades. Only recently have firms evolved to adjust to the new, more competitive globalised economy. Those firms unable to evolve and adjust have disappeared, or are in a vulnerable position.

The Mexican private sector has played an important role through the years in the development of the country's economy. It participates in practically all areas of the economy, and has been relevant to production, employment creation and institution building. Since the 1930s the industrial sector has played an important role in the country's

[16] For literature dealing with specific industry innovative activity see for instance Corona T. 1997; Freeman 1982a; Mercado García 1980; Unger 1985; Wijnberg 1989.

growth (Cárdenas Sánchez 1998). Nevertheless, the government's protectionist policies of earlier decades undoubtedly had a deep effect on the private sector. The protectionism that began as a means of controlling imports in order to protect the balance of payments in the late 1940s became a wider, more profound and complex policy as years passed (Villarreal 1976).

Domestic products were first protected from foreign competition. Then, as foreign firms entered the scene to supply the domestic market and take advantage themselves of the protective measures, national investors began to be protected against foreign investors doing business in Mexico. Thereafter, foreign investment was restricted, and areas of the economy that were previously open now became protected. Nonetheless, private investment did not react as expected, and the state stepped in (Cárdenas Sánchez 1996). More and more government agencies and companies were created to fill the vacuum left by the private sector.

Since 1982, industry and the rest of the economy have undergone a major transformation that has touched every aspect of economic life in Mexico. Trade liberalisation, privatisation of public enterprises, deregulation and the openness of the financial markets are all shaping a new economic system. The debt crisis brought the realisation that such policies had to change, and that the economy should be opened to foreign competition to ensure better levels of competitiveness and productive capacity.

After the events of the early 1980s[17] it was clear that the protection strategy and the government's involvement in the production of all sorts of goods had been taken too far and was no longer responsive to the country's needs (Solís 1981). Some other strategy had to be

[17] For a more detailed review of the 1982 crisis, its causes and effects, see Lustig and Ros 1987; Martínez Hernández 1989; Ramírez 1989.

implemented. A realisation that the economy should be open to foreign competition led the new wave of policies (Ramírez 1989). Almost without noticing, and in the midst of a severe economic crisis, the industrial sector accepted the dismantling of trade barriers. Mexico's entry into the GATT in 1986 marked the beginning of a new era, one that eventually was reflected in the composition of the industrial sector as firms increasingly faced foreign competition. A senior public sector executive, involved for many years in support programmes for firms, assesses that 'protection influenced [the private sector] a lot, and what moved firms to start to get involved with technology was fear of GATT...though they did not believe it was going to start so soon and did not really do much to prepare themselves'.[18]

With the implementation of NAFTA in 1994 and the new economic crisis of 1995 the industrial sector transformed itself even further, as heavily indebted firms unconnected to the export sector suffered high interest rates and a drop in consumer consumption. Industries related to exports, either directly or indirectly, managed much better during the recession. Thus, the industrial sector was split between those firms and sectors that had been able to adapt to world competition and those that had not; those that depended on the domestic market alone and those that could export and supply foreign demand. This is a further example of how technology capabilities can play a vital role in these respects and make a difference when entering a global market.

The problem, as recently stated by a business association leader,[19] is that Mexican firms 'were used to producing for their own market and the authorities now tell small businesses to produce thinking globally when there are no commercial structures to promote that...but there have been successful examples of sectors like textiles and furniture which have used very basic home developed technology to enter

[18] Interview #21.
[19] Interview #3.

foreign markets...that's the only way'. The opposite case would be that of former 'manufacturing companies being converted into marketing agencies of foreign goods'.[20]

With this historical background in mind, the following subsection will aim at a better understanding of the composition of Mexico's private sector and its technology-related problematics.

Mexican firms and their capabilities to develop technology

At this point, it may be useful to restate the size categories for firms used in this thesis, to better understand the implications of the private sector structure in Mexico. The categories are based on the number of employees according to Mexico's National Institute of Statistics, Geography and Information definition (INEGI 1994):

Microfirm: up to 15 employees
Small firm: between 16 and 100 employees
Medium-sized firm: between 101 and 250 employees
Large firm: more than 250 employees

Mexico's national industry comprises a dual structure. It is characterised by the coexistence of a small group of large companies, which are increasingly able to develop their own technology, and of the majority of firms, which span micro to medium-sized and which have neither the resources to develop technology nor the capability to absorb existing technologies. The latter group of firms do not have access to comprehensive information concerning the benefits of modernising their technology, and they are operating in an open economy with obsolete productive and managerial systems (Poder Ejecutivo Federal and Secofi 1995).

[20] Interview #21.

Technology development efforts are concentrated in large firms. As discussed in the previous section, this is common in the international context because technology projects involve high costs. Nevertheless, the low productivity and backwardness of small firms in Mexico requires urgent action. Former Vice-Minister of Industry Fernando Sánchez Ugarte acknowledged the existence of two kinds of enterprises, those 'on track' and already developing their own technologies - mainly the larger firms - and the medium-sized and smaller firms which 'do not know that they are in need of technology...they do not have the resources, access to finance nor the links to those who can help them solve their vicious cycle'.[21] The Director of Technology of one of the main business associations reflected the feelings of many Mexican firms when he said that it is a 'disgrace that there is no awareness that those who are saving the country are small and medium-sized firms which have less and less support'.[22]

During his intervention at the Inauguration Session of the National Coordinating Committee for Technological Modernisation (CONCERTEC),[23] Santiago Clariond Reyes, one of Monterrey's most important businessmen and former leader of the State of Nuevo Leon's[24] Chamber of the Transformation Industry, made some important remarks. According to him, and as speaker on behalf of the private sector, the tendency to get involved in technology development projects is still concentrated in larger-sized firms. Therefore, he pledged a concerted effort to promote technology modernisation as 'even if it is the direct responsibility of the industry to develop technology, the government plays an essential role in its impulse and consolidation' (Conacyt 1992, 16-17).

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[21] Interview #20.
[22] Interview #4.
[23] See Chapter 4.
[24] Monterrey, Mexico's leading industrial pole, is the capital city of the State of Nuevo Leon.

The technology problems being experienced by today's small firms can be regarded as a consequence of the private sector's recent history. In the 1970s, regardless of Mexico's protection against imports and restrictions on FDI which naturally embody technology transfers, it was believed that Mexican firms did not face a technology problem. Technology was widely available to buy from abroad, mainly from the neighbouring superpower in the form of licenses. There were virtually no restrictions on buying foreign technologies; indeed it was easy to import technology (Wionczek, Bueno, and Navarrete 1974, 48-51). The limited availability of skilled technical labour, the lack of awareness among Mexican entrepreneurs of the importance of technology, the lack of autonomous technology research and the lack of restrictions on importation at the time increased the volume of these imports without any consideration of the economic and social consequences of the situation. High protection from foreign manufactures increased the intensity of these imports. Moreover, firms could afford to spend as they wished on technology imports, as they could transfer the costs to the final consumer via price increases.

Twenty five years ago firms' attitudes were completely different from the ones found in this research. The conclusions of an OECD study in 1969 showed some of the first attempts to understand the Mexican entrepreneurs (Derossi 1970, 272). Only 7% of the firms' executives surveyed considered the lack of technology R&D as an obstacle to the country's development. The interviewees ranked the obstacles to development (from most to least important) as: the limited size of the market; the lack of highly skilled labour; the high costs of raw materials; and the interference of the State in business matters.[25]

[25] This appears to be a normal consequence of the Import Substitution model prevailing at the time, see Love, 1994; and Lee and Swagel, 1997. Pre-1987

Another survey highlighted the limited knowledge of the Mexican private sector regarding the advantages and implications of science and technology R&D (de María y Campos 1968). Some of the executives surveyed indicated that they did engage in technology development activities, citing examples such as 'quality control procedures' and 'market research'. The ones who admitted to having no technology R&D activities said that it was due to the lack of resources needed for these activities, the small size of the firms, the long-term projection of completion of these kinds of activities, the high risks involved and the slow and uncertain return of the investments. It seems as if, at that time, the private sector had not accepted its responsibility for the development of an autonomous technology capacity of the country. Have they changed their perception and attitude now that it faces different kinds of pressure?

In the Author's Survey, when asked to rate from 1 to 5 the responsibility (duty) of businessmen in the process of supporting, promoting and developing Mexico's technology, 80.6% of the respondents gave it a 5, meaning the highest responsibility, and only 1.4% thought they were not responsible and gave it a 1 (See Figure 5.B).

Two further important aspects to consider when discussing innovating firms in Mexico are the concept of 'entrepreneurship' and the creativity of Mexicans. Both can be of relevance in this matter. These subjects were raised during several of interviews conducted during the preparation of this thesis, and reflect the way in which entrepreneurs see creativity in Mexico. On the positive side, entrepreneurs consider Mexicans as being very creative, inventive and talented. They claim that the problem lies in the fact that the creativity does not convert into projects or enterprises because there is no entrepreneurial vision or

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public vs. private sector tensions were a real drawback for industrial development (Cárdenas Sánchez 1996).

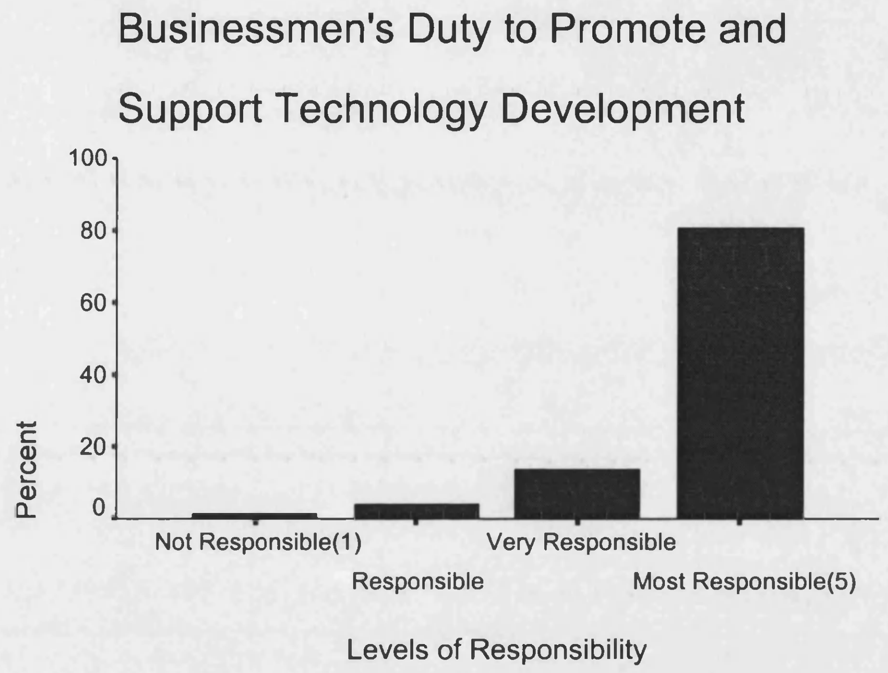
awareness of the importance of technology.[26] Furthermore, in response to the question of how creative Mexican entrepreneurs are,[27] almost 70% of the respondents of the Author's Survey said 'Most creative' or 'Very creative'. The lowest ranked answer, 'Not creative', was selected by only 4.2% of respondents. The potential therefore exists, and it is a matter of transforming that creativity into productive technological projects to strengthen the country's private sector.

According to the Ministry of Trade and Industry, Secofi, Mexico's private sector has strengthened its technological basis. But again, the Ministry bases its data on large firms. Large industrial consortia, mainly those involved in exports, have established their own R&D centres. Therefore, private expenditure on research and technology-related activities grew at an annual rate of 10.3 percent from 1984 to 1994. Large companies have helped to increase the private sector's share in the national total expenditure on R&D from 15% in 1984 to 23% in 1991 (Poder Ejecutivo Federal and Secofi 1995, 90).[28]

One viable way to help SMEs improve their position is to link larger with smaller firms to develop supplier networks for the large corporations. The latter then have a specific interest in helping the smaller firms solve their problems. Certain large firms depend on small ones as their suppliers and technological integration can occur as a result, filtering from the large to the small firm. This can be an efficient way to encourage technology attitudes among SMEs.[29]

[26] Interviews #3, 5, 9 and 13.
[27] Author's Survey: Question #9.
[28] The data presented is based on the results of the survey "Encuesta Nacional de Empleo, Salarios, Tecnología y Capacitación Laboral en el Sector Manufacturero", by INEGI, 1992.
[29] Interviews #12 and #20; an example of a successful case of a supplier programme has been the 'Compite' programme with General Motors (Interview #20).

Figure 5.B. Respondents' answers to the question: How responsible are businessmen in the promotion and support of technology development in Mexico?



Source: Author's Survey

Mexico's industry still faces a series of obstacles to the dynamism of local technology development (Mercado García 1980, 21-30). Thus, unless there is a stronger local technological capacity, the royalties paid for foreign technology licenses will continue to be high, and the process to develop a stronger innovative position, a lengthy one.

When trying to understand the position in which Mexican firms, mainly SMEs, are today, some important questions arise regarding their collective action, namely: where have the business associations been during the past few decades, and what role have they played in defending their members interests? The next section describes how industry associations have been involved in the process of transforming the economy from a protected to an open one.

5.3 – BUSINESS ASSOCIATIONS

Even if membership to business associations was historically compulsory in Mexico, there exist very few works describing the role of business and trade associations in helping industries achieve a high level of global competitiveness. The purpose of this section is to focus primarily on the role of associations in bringing about a higher level of competitiveness for Mexico's industries, and whether or not they have played this role in an adequate way. The role of an industry trade association is seldom clearly understood. Moreover, even when the role is understood, there are no guarantees that it is being implemented as well in Mexico as it may be the in other nations at a similar level of development.

In the competitiveness debate, associations have been considered by some observers to be essential to national interests, but they have also been designated by others as harmful to the general public. They have been deemed necessary for economic and political order, and yet they have been described as underutilised in their application to public policy matters (Procassini 1995). Sceptics may also argue that associational action may aggravate rent-seeking, political cartel-building activities, which usually favour large firms over small, and producers over consumers. In 1982, the OECD recognised that one of the obstacles to amalgamating technology was that chambers of commerce are usually not aware enough of their potential role and few have built up adequate technological promotion activity. Moreover, those agencies are usually either overloaded or underutilised because there is insufficient personal involvement and contact with entrepreneurs (OECD 1982, 118-126).

In 1990, George Lodge wrote:

'Industry associations are crucial to the organising of business leadership for new and more creative relationships with government...These associations manage cooperation, set visions and make strategy. Industry associations are the bridge between business specialists and politicians and government on the other. That bridge...is becoming increasingly crucial to competitiveness' (Lodge 1990, 209).

Germany and Japan offer interesting examples of effective action taken by business chambers:

- The relationship between German industry and government is cooperative, based on negotiation and consensus building. Furthermore, industry groups play a direct role in administering public programmes of industrial relevance. For example, government programme applications and state subsidies are sometimes administered by trade associations (U.S. General Accounting Office 1993:105).

- In Japan, industrial associations have played a big role in aggregating individual company interests, building intra-industry consensus, and serving as a pipeline for communication between industry and government. Trade associations in Japan communicate overall industry interests and mobilise industry programmes. Moreover, they receive early information from the government on loans, projects, regulatory changes, industrial policy, and other matters (Okimoto 1989, 165).

In general, it can be said that it is a major task for trade associations to assimilate and accommodate the wishes of their members with respect to all public policy issues of vital interest. They play a key role in generating, analysing and sharing information which helps their members to better define their own interests and strategies. Information sharing with the government is also fundamental. With this in mind, and remembering the context in which the private sector has evolved in Mexico since the 1940s, let us now review the structure and role of business associations in Mexico.

Organised interest groups in Mexico generally have a unique position, because of the structural features of the Mexican political system. The first feature of note is that the government created most of the powerful interest organisations. As a result, demands to the state by interested industry parties are channelled through formally constituted interest groups, including business organisations (Camp 1989; Mújica Romo 1997).

The government intervention resulted in two types of private sector interest organisations: the first, government initiated, are semi-official, while the second, developed solely through private sector initiative, are autonomous of the state and called independent.

The semi-official organisations include:

- The Confederation of Industrial Chambers, CONCAMIN (Confederación de Cámaras Industriales)
- The National Chamber of Transformation Industry, CANACINTRA (Cámara Nacional de la Industria de la Transformación)
- The National Council of Chambers of Commerce, CONCANACO (Consejo Nacional de Cámaras de Comercio)

The independent organisations include:

- The Employers' Confederation of Mexico, COPARMEX (Confederación Patronal de la República Mexicana)

- The Mexican Bankers Association, ABM (Asociación Mexicana de Banqueros)

In 1976, the independent associations got together with the semi-official organisations to form an umbrella organisation known as the Businessmen Coordinating Council, CCE (Consejo Coordinador Empresarial). It was formed after 18 months of negotiations in the private sector and exists to exchange information and unify criteria and points of view. It is not a substitute for the other associations.

The three most important semi-official organisations have common ground in that they were formed by the state, use a one-firm–one-vote principle, and that, until the Salinas administration ended it, membership in them was required by law.

Critics of the major confederations, including thousands of members, suggest that quantitatively the member firms are not fairly represented in confederation policy positions. They argue that the leaders are controlled by large capital and do not represent their members' interests (Camp 1989). This could explain why Mexican government agencies wanting to channel support schemes for firms encounter frustrating bottlenecks when dealing with the presidents of business chambers.[30]

According to Camp, many entrepreneurs believe that the leaders of federations do not represent the views of large firms either, because they are not themselves large-scale capitalists and are chosen by the more numerous medium-sized and smaller companies. However, owners of smaller firms argue that the chambers do what the largest member companies want. It is difficult to ascertain which view is

[30] The former Director of Conacyt goes further and comments that negotiating with business associations' leaders 'is worthless... it has to be a bubble-up process, not a trickle-down one' (Interview #10).

correct, but it can be said that the leaders, and therefore the chambers, often do not effectively represent the whole membership (Camp 1989).

The CCE's major weakness, like the organisations themselves, lies in the fact that it is unrepresentative. For instance, the Mexican Council of Businessmen, CMHN (Consejo Mexicano de Hombres de Negocios), is controlled directly by approximately 30 major capitalist families, but is treated formally in the same way as CONCANACO, which has more than 200,000 members.

Therefore, interest groups are still weak in their collective and representative action in dealing with the state. Mexican entrepreneurs have been affected by all the above-mentioned weaknesses in their representation.

The following list summarises the current and historical problems of Mexico's private sector chambers, as discussed with interviewees during fieldwork:[31]

- Highly politicised organisations.
- Closer to the government's interests than to those of the members.
- High rotation of chamber leaders (maximum term two years) and personnel.
- Lack of continuity of programmes and goals.
- Short-term vision.
- Uninformed of their members' real needs and problems.
- Lack of effective technology-related committees.
- Ignorance of the meaning of technology and its importance.
- Currently in crisis due to the new voluntary membership system.
- Poorly qualified personnel.
- Limited scope of action.

[31] Interviews #1, 2, 3, 4, 5, 7, 8, 9,10, 12 and 20.

With such a range of problems, it is easy to understand why, when asked about their feelings towards their representing associations, businessmen responded in the following negative ways:

'...the leaders are devoted to exploiting personal political interests to achieve economic benefits of their own...' [32]

'...there is corruption and a lot of political interest...nothing productive comes out of the meetings, I lost too much time attending...'[33]

'...once I was part of CANACINTRA's regional council. We were at the time discussing very hot issues for the industry...even if 85-90% of the delegates would agree on something, it would not prosper when the national president of the chamber had certain personal obligations with a government minister...' [34]

Business organisations in Mexico have a long way to go before they convert themselves into real channels of representation for their members. If the government has short policy cycles as discussed in Chapter 4, private sector associations suffer from even greater short-termism in their programmes and goals which are reconsidered every two years. If technology cycles are medium- to long-term, the match with political and business chambers cycles causes severe problems for the coordination of firms and government agencies involved in technology development projects.

The questionnaire for the Author's Survey included three specific questions related to the entrepreneur's view of the business

[32] Interview #3.
[33] Interview #8.
[34] Interview #5.

associations and their role in defending their interests, as well as their experience with them while developing their technology projects:

- First, when asked how they viewed the chambers' responsibility (meaning duty) in the support and promotion of technology development, [35] 72.2% gave a mark of 5 (most responsible), 13.9% a 4, and the remaining 13.9% between 3 and 1 (not responsible at all). In comparison with their answers regarding the responsibility of individual businessmen, they had a more favourable view of the latter (See Figure 5.B).

- Second, when answering the question of how their associations defend members' interests, [36] only 14.1% gave the top mark of 5 (very well defended), while more than 55% gave the lowest 1 and 2 marks, meaning they feel they are not defended at all or defended poorly by their representing organisations (See Figure 5.C).

- And third, when talking about their technology projects,[37] almost 80% answered that they did not receive support from the associations they belong to in the process of developing their projects.

Entrepreneurs in Mexico do not seem to have a very high opinion of the associations that represent them, and do not view them as a channel through which they can access better information, resources and advice to engage in the technological modernisation of their firms.

How do the associations respond to the demands of their member firms? In regard to their involvement in direct technology support activities, business organisations have recently created private

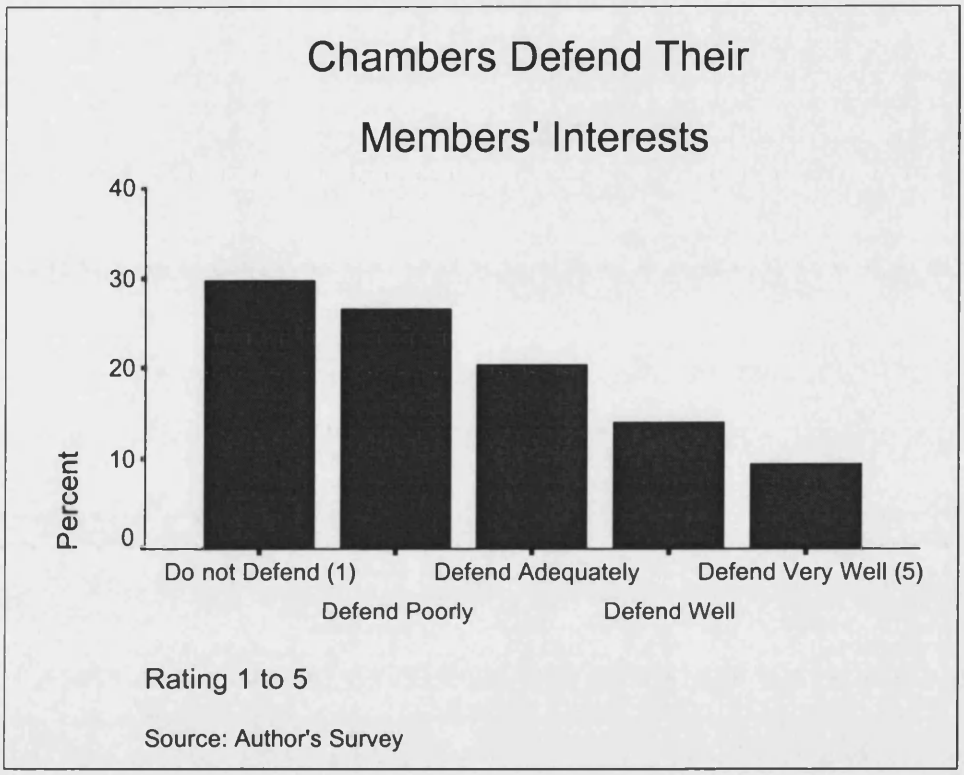
[35] Author's Survey: Question #11.
[36] Author's Survey: Question #38.
[37] Author's Survey: Question #37

institutions oriented towards the promotion of a technology culture within firms, especially smaller ones. Technology support centres have been created for the textile, electronics, electric and plastics industries. CONCAMIN has established the Mexican Foundation for Innovation and Technology Transfer in Small and Medium-sized Firms, FUNTEC (Fundación Mexicana para la Innovación y Transferencia de Tecnología en la Pequeña y Mediana Empresa). In addition, CANACINTRA created the Technology Transfer Unit, UTT (Unidad de Transferencia Tecnológica), which provides advisory services to firms with technology-related projects (Poder Ejecutivo Federal and Secofi 1995). CANACINTRA's Director of Technology feels optimistic about the role the chamber is playing, and considers that it will facilitate the support for firms with the new service centres.[38] FUNTEC's Executive Director talks highly of the achievements of the Foundation mainly in areas of articulation schemes.[39]

Opposing views consider FUNTEC as stagnant due to CONCAMIN's highly politicised organisation: 'resources have been wasted and not channelled to the final users...business politics are more political than politics...chambers are incapable of managing the foundation'.[40] Thus, time will show whether these new centres are able to effectively support member firms with their technology problems.

[38] Interview #4.
[39] Interview #12.
[40] Interview #20.

Figure 5.C. Respondents' answers to the question: How well do business chambers defend their members' interests?



The next section deals with the private sector and its organisations in their interaction with the government in the different stages that the Mexican economy has gone through in the past few decades.

5.4 – BUSINESS-GOVERNMENT RELATIONS AND THE EFFECTS ON SMEs AND TECHNOLOGY

Historical background of the relationship

In this final section of the chapter, the aspects reviewed in the previous sections are reconsidered in the light of the relationship between government and firms in the recent events of the country's development, to analyse the effects on technology and innovation.

An important feature of the Mexican polity's influence on interest group activity is the power of the presidency and the historical expansion of the executive branch's influence on interest group communications towards agency heads and the president. An analysis of private sector interest groups reveals the extent to which private–public relations have been institutionalised along formal lines, and the extent to which these organisations serve as useful channels in the decision-making process (Camp 1989).

One consequence of state-initiated interest organisations was that the government emphatically identified semi-official organisations or confederations (groups of chambers) as the channels through which businessmen should conduct their affairs. Frank Brandenburg wrote that the state wanted businessmen to act in concert in presenting their demands, rather than as individual entrepreneurs (Brandenburg 1958).

From the private sector's point of view, the formation of these organisations provided them with a logical vehicle through which they could make their perspectives known to the government. They acquired strength through numbers. Brandenburg even claims that these organisations are consulted by the government every time a bill affecting their interests is passed.

The dominating objective of political stability, and the incapacity to define long-term objectives for industrial and technological development, generated a vacuum where government officials were highly vulnerable to manipulative pressures from private interest groups. The latter were characterised by their strong inclination towards high profitability rates aimed at short-term recovery of investment. In addition, the long-term perspective required by the objectives of science and technology policies was lacking (Nadal Egea 1995, 130-135)

It can be assumed that the state acted out of self-interest in creating semi-official business organisations, not out of an unselfish desire to see the private sector strengthened. In doing that, the state not only legitimised semi-official organisations, but de-legitimised the development of independently supported interest groups modelled on those in the United States. It discouraged semi-official and voluntary types of business groups from taking an aggressive political posture (Camp 1984).

The following brief historical outline depicts the broadest strokes in the complex relationship between the private sector and state in Mexico. It starts with the protectionist and state-led era, as the background to a more detailed explanation of the period of economic liberalisation that led to the North American Free Trade Agreement.

Echeverría's government (1970-1976) began to contribute more than the private sector could to economic growth. By expanding the role of state investment, he sent a message to the private sector that his government supported a statist model of development. Echeverría's actions had many consequences for the private sector. According to many observers, the private sector became more unified in its opposition to government policy than at any time previously. It could be argued that Echeverría's anti-entrepreneurial rhetoric encouraged entrepreneurs to strengthen their own organisations (Ortiz Pinchetti 1982).

When López Portillo was inaugurated in 1976, relations between the private sector and the state were at their worst since 1920. By 1977, this relationship had altered substantially. The state required the private sector's assistance to make its economic model perform effectively. The most critical decision López Portillo made was to change the government's rhetoric, to seek out private sector cooperation in an outward, positive manner. Both public and private investment soared

(Solís and Zedillo 1984). López Portillo intended to take Mexico into GATT in 1979, but was dissuaded from doing so by opposition groups in the private sector. After 1981, the quality of the private sector-state relationship declined rapidly, finally breaking down entirely with the president's 1982 decision to nationalise the banks.[41]

When de la Madrid took office later in 1982, conditions in Mexico were once again worse than at any point in recent history. Just two months later, Emilio Goichochea Luna, president of CONCANACO, declared that 'never before has the private sector had such difficulties communicating with the government' (Hispano Americano 1983).

Mexican businessmen's view of the state in the early 1980s can be summarised as mistrust. But even in the 1980s, most businessmen favoured a substantial government role in economic development (Camp 1989, 35-53).

The recent period of economic liberalisation

One of de la Madrid's best achievements was improved channels for communication, but it was not enough. His administration's message to the private sector had an overall philosophy of economic liberalisation, visibly symbolised by Mexico's policy reversal in 1985 when it decided to reopen negotiations to join GATT. If anything, liberalisation heightened the debate within the private sector, between those who believed Mexico's international economic competitiveness to be essential to future economic expansion, and those who favoured continued state protection.

Most of the presidential term of Carlos Salinas de Gortari (1988-1994) comprised preaching business-government harmony and general

[41] See Chapter 6.

business support for the neo-liberal economic agenda (Johnson Ceva 1998, 125-130). It is important to remember that during Salinas' presidency, and dating back to de la Madrid's, it was 'fashionable to have the support of the business class for everything...no politician nor director of a government institution could progress or have an important public image without the blessing of the oligarchy: CONCAMIN, CANACINTRA, CONCANACO, and the rest of those kind of bodies...which are nothing but structures created by the state itself to simulate the support of the business class...even for technology policy, the government had to give those organisations something to please them and pretend something was being done'.[42]

Nevertheless, a parallel voice of resentment, discontent, and even discord emanated from the business community from the start of the NAFTA negotiations in 1990 (Johnson Ceva 1998, 125-130). One common call was for the government to focus not only on macroeconomic issues but also on the microeconomy. Another was for the government to develop an adequate industrial policy, one that could help Mexican firms become more competitive in the context of trade liberalisation and regional integration. A small group of policy-makers within the Salinas administration was involved in the NAFTA negotiations, closely counselled by business leaders. On the one hand, the negotiations illustrated the close nature of the business-government collaboration that characterised the Salinas years. On the other, they also put in place a system of business representation that for the most part excluded small and medium-sized firms, and therefore did not adequately represent the growing diversity of business interests in a liberalised economy.

Large business groups, whose members were best positioned to compete within a free trade area, generally supported the government's

[42] Interview #10.

intention to negotiate NAFTA. But smaller firms and microenterprises, still primarily oriented toward production for the domestic market, remained marginalised from many avenues of business representation, and most knew very little about how the terms of the free trade agreement might affect them.

Smaller enterprises born and prospering under the policies of protectionism and import substitution, and commonly affiliated with CANACINTRA, had historically opposed unilateral trade liberalisation and Mexico's accession to GATT, which occurred in 1986. And since that time such smaller producers have suffered severely, particularly from Asian competition in clothing, shoes, leather products, metal products and toys (Alba 1994).

Vocal opposition to NAFTA by small and medium-sized firms was fairly marginal, however, for several reasons. First, President Salinas and his trade ministry officials put a tremendous effort into publicity to pre-empt potential opposition, conducting meetings about NAFTA with hundreds of business groups before the formal negotiations began. Second, there was a lack of accurate information about free trade available at that time to small and medium-sized businesses.

Secofi encouraged the formation of a new business trade advisory group that would be organised by economic sector. Although a business sector may strongly support the formation of a trade advisory group, SMEs are unlikely to receive adequate representation within this structure. Despite their enormous importance, and the specific needs each may have, SMEs in such advisory groups are clustered together with large firms and treated as members of separate industry groups. In this institutional framework the needs of small and medium-sized firms as well as large firms are seen as similar and dependent on the characteristics of the particular sector of the economy to which each belongs (Del Castillo and Vega Canovas 1995).

Thus the advisory group may foster greater sectoral identity and networking, particularly on issues of common interest to most firms in the sector, but in the context of trade liberalisation the needs of smaller firms will most likely differ from those of the larger ones in their sector. This is particularly true in developing countries such as Mexico, where economic activity is concentrated in a small number of very large business groups. In particular, the smaller firms are less likely to have access to credit for new investments and more likely to have a weaker technology platform and need additional support to face new competition. As a result, the lack of representation of the smaller firms may ultimately work against the express goals of the advisory group.

Between 1990 and 1993 Mexico's trade advisory group, the Coordinating Body of Foreign Trade Business Associations, COECE (Consejo de Organizaciones Empresariales para el Comercio Exterior), represented the Mexican business sector in the NAFTA negotiations and advised government officials negotiating the treaty. At first COECE, with its sectoral structure, appeared to be much more representative than the traditional business chambers represented in the CCE in organising the entire business community. Nevertheless, large firms still had the most influence over the sectoral studies that COECE undertook in preparation for the negotiations.

Most of the debates about the findings of the studies went on at the highest levels of the business-state coalition, with questionable input from smaller firms. Small and medium-sized producers openly complained that COECE never truly represented them at the negotiating table (Pastor and Wise 1994, 480-481).

As the prospect of increased competition grew imminent, many of the smaller firms became more keenly aware of the obstacles they faced in becoming competitive in an increasingly liberalised economy. Such obstacles included their lack of technology, low quality of product, and lack of access to credit and capital. Protests started against the lack of adequate financing for economic adjustment. Although most small and medium-sized firms did not oppose NAFTA *per se*, their grievances continued to focus on their lack of representation in COECE, the speed and timing of the reforms, and the lack of adequate support to help them to meet increasing competition.

An unexpected finding during fieldwork for this thesis was that the surveyed firms did not necessarily view the economic opening of the country as negative for them,[43] even though the sample consisted of micro, small and medium-sized firms (See Table 5.3). Out of the 72 firms, only 22 perceived it as a negative situation for them: 22 did not see any effects, and 30 saw it as positive mainly because of the new opportunities to export.

The state can ignore interest group arguments when small and medium-sized member firms are believed to hold a view different from the large capitalist members. Second, if the small and medium-sized firms believe themselves to be unrepresented by an organisation's position on important issues, their resentment divides the private sector on other concerns (Camp 1989). Thus, the problem of representation is to be addressed with caution.

The government's reply to businesses' criticism of economic policies, especially the lack of an industrial policy under Salinas, is best summarised in remarks by Jaime Serra Puche, minister of Secofi during the Salinas years: 'NAFTA is our industrial policy; we don't want the government to replace business initiative with an industrial policy. We already did our work, now you do yours' (Mercado 1995, 11).

[43] Author's Survey: Question #8.

Table 5.3 Respondents' answers to the question: How have the effects of trade liberalisation been for your firm? (per firm size)

Effects of Economic Opening * Firm Size Crosstabulation				
		Firm Size		Total
		Micro	Small&Med	
Effects	Positive	9	21	30
	Negative	12	10	22
	No Effects	14	6	20
Total Number of Firms		35	37	72
Source: Author's Survey				

More specifically, the Mexican government claimed that an industrial policy, particularly in a vertical form, was not appropriate under the current neoliberal economic model. Because NAFTA itself offered no support for vulnerable business sectors, many business owners believed it was up to the Mexican government to develop support mechanisms within the parameters of the trade agreement (Becerril and Rodríguez 1994, 31).

The Zedillo administration (1994-2000) modified policies toward small and medium-sized businesses. Zedillo maintained that the increased competitiveness of small and medium-sized firms was a top priority for his administration (Flores 1995). A new National Council on Micro, Small, and Medium Enterprise (Consejo Nacoinal para la Micro, Pequeña y Mediana Empresa) was established in the first year of the Zedillo administration. Nevertheless, none of the respondents to the Author's Survey conducted in 1998 mentioned the new Council when talking about government's programmes to support them. And according to FUNTEC's Executive Director, the Council for SMEs 'was supposed to be the magnet to collect the needs of that sector...but it has not been like that, so the private sector does not have the mechanisms to express clearly its needs...there are no studies to understand the needs, and the chambers are not playing that role'.[44]

It seems as though there still remains a significant distrust among owners of various sized businesses in the government's ability to manage the economy properly. As it will be developed further in Chapter 7, SMEs still feel that the government's policies are neither effective nor long-term, and that their technology backwardness prevents them from freely competing in an open economy.

According to Carlos Bazdresch, Director General of Conacyt during President Zedillo's administration, the indifference of Mexican entrepreneurs - mainly large firms - does not contribute to general growth in the country. 'They prefer to maintain their monopolies', he said. During an interview with the newspaper *El Universal*, he pointed out that such indifference is caused by the fact that they are not worried about competition; their immediate strength prevents them from seeing into the future. Therefore he described the private sector as 'passive' when the country needs aggressive initiatives. 'A culture change is needed', he concluded (Díaz 1998).

Substantially changing a culture embedded in the country's recent history may be difficult, at least in the short run. The technology gap has to be closed, however, to prevent a substantial number of firms, mainly SMEs, from disappearing in the face of international competition. To quote Sánchez Ugarte in conclusion: 'There is a lack of leadership in regard to technology, someone is needed to head the promotion, do the lobbying, but in a coordinated way'.[45]

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[44] Interview #12.
[45] Interview #20.

CONCLUSIONS

In twenty-first century Mexico, several tasks remain to make the private sector regionally and globally competitive. This chapter has presented an account of the leading literature, mainly agreeing with the evolutionary approaches on technology capabilities for developing countries and SMEs. These approaches, also referred to as institutionalist, or structuralist, emphasise the importance of and need for technological change within the developing countries themselves. Along with the empirical evidence gathered for this research, some important conclusions can be made.

Firms of different sizes all have a contribution to make to the economic and technological development of LDCs. New opportunities for viable new forms of small-scale production emerge continuously in a growing economy. But in order to benefit from those opportunities, firms need to be able to produce in their own unique and innovative ways. An open trading regime, openness to foreign direct investment and technology licensing all allow the acquisition of knowledge from abroad. Agreed. But as has been thoroughly discussed in this chapter, technology produced in other countries has to be adapted to local conditions. The creation of a strong indigenous technology base is therefore needed to adapt and absorb adequately, reducing technology dependence and closing the international and domestic gaps. Thus, the ability to make independent technological choices, to adapt and improve techniques and products and eventually to innovate endogenously are essential aspects of the process of economic development

The discussion of the relative role played by small and large firms in innovation is a controversial and sometimes contradictory one. From the theoretical as well as from the empirical point of view, it can be argued that large, established corporations are the most powerful engine of technological change, and that the high cost of industrial R&D

activities means that they can only be carried out by firms having the resources associated with considerable size. However, small firms are also an important vehicle of economic growth and can be more important for the creation of employment and income in developing countries. Furthermore, different results of empirical research presented in the chapter deal with the relationship between innovation and size of firms, which can serve as confirmation of the inventive potential of small firms. Therefore, a more realistic statement is that large and small firms are a necessary complement to each other, rather than alternatives. A viable way to help SMEs improve their position is to develop supplier networks for the large corporations.

Given the desirability of building technological capabilities in small firms, the process could be supported through appropriate policy interventions. There is a case for institutional support because capability building is a much-neglected area (Romijn 1999). In fostering the domestic creation of knowledge, governments have a special role in supporting potentially productive research, while establishing the necessary conditions for the private sector in response to market forces. Nevertheless, the government will not be able to design appropriate mechanisms if it has no specific knowledge of the needs of the private sector and SMEs in particular.

Business associations need to develop a more active and aggressive attitude to serve as an effective link between their associates and those institutions which can help them improve their technological platform. To date, few have built up adequate technological promotion activity. Global competitiveness and its elements (technology, internationalisation, and business-government partnerships) are affecting industry associations. Private sector interest groups, mainly SMEs, are still weak in their collective and representative action in dealing with the state, and have been affected by such weaknesses. Therefore, it is important that they start to respond by giving assistance to their associates or they may even be abandoned in favour of new organisations.

In Mexico, the government's protectionist policies of earlier decades undoubtedly had a deep effect on the private sector. Since the beginning of the opening of the economy in the mid 1980s, many large and medium-sized firms, as well as some small and micro ones, have been able to adapt to competition and the new global environment, and there is a new technology culture in the country, with a growing awareness of its importance amongst entrepreneurs. However, the challenge for the country today is to incorporate larger segments of society into this process. Many more firms need to produce more effectively to become competitive and serve both domestic and international markets. Incentives need to be increasingly made available for private firms to take on their own R&D, initially in adapting, understanding, and refining the technologies they are already using, but eventually moving into research in those areas where they are close to international best practice. Therefore, government policies have to be more effective, coordinated and long-term oriented

Chapters 2 through 5 have focused mainly on technology policy on the side of the government, and the development of technology on the side of the firm. The next two chapters consider another factor in the process of innovation: financing. Chapter 6 analyses the Mexican system for financing technology development, centring on the banks and firms. Chapter 7 provides a case study of government programmes for direct project financing which will put together all the different participants of the system.

Chapter 6

THE ROLE OF BANKS AND FIRMS IN THE FINANCING OF INNOVATION IN MEXICO

> 'Financing has not received the attention of economists that it deserves as one of the three major inputs of the process of innovation.'
>
> Frits Prakke, 1988

INTRODUCTION

Any serious definition of innovation involves both technical novelty and utility. Every business decision on innovation must therefore rely on a combination of technical feasibility and economic demand. But 'to consummate this combination there must be a third input: some commitment of funds' (Prakke 1988, 71).

In a broad sense, financing innovation can sometimes require small-scale, short-term investment, but more typically it involves quite substantial sums and a high level of uncertainty. Therefore, one of the most important institutional preconditions for starting the process of innovation is the ability to finance the project. Certain national institutional factors in financial systems are important to firms when they need to obtain finance for their investments in new technologies (Christensen 1992, 146-150).

This chapter relates precisely to those national institutional factors present in Mexico, and discusses why, even after a recent process of banking reforms, firms find it difficult to obtain funds for innovation. Mexico's national financial system for supporting technological investment is evaluated and used to illustrate the theoretical discussion.

Section 1 establishes the theoretical concepts needed to understand a national system for financing innovation: its categories, components, functions and properties. The recent evolution and institutional aspects of the Mexican banking system are presented in Section 2, to show the dramatic shifts it has experienced. The latter serves as a context to analyse, in Section 3, the way in which banks see technology and innovation projects and small entrepreneurs as their potential clients.In Section 4, the demand for funding is assessed by investigating the situation of innovating firms in Mexico and the problems they face in their interaction with commercial banks.

Different elements throughout the chapter show where the deficiencies of the system lie, raising further questions on the role of government in their potential correction. That will be further discussed in the next chapter.

6.1 – THEORY AND CONCEPTS INHERENT TO A SYSTEM FOR FINANCING INNOVATION

National financing systems

As discussed in previous chapters, technological change is a process that takes place over a period of time, from basic research to the development and marketing of a new product.[1] In order to complete such a process, the commitment of capital resources is required, at various stages of the project (Goodacre and Tonks 1995, 298-315).

Financial resources are essential for those firms undertaking technology development projects. Some authors argue that the concept of a National Financial System has become less and less relevant due to internationalisation, deregulation and globalisation of financial markets

[1] See Chapter 2 and Chapter 3.

in recent years (Christensen 1992, 146-150; Kluth and Andersen 1999, 122-126). Opposing views state that liberalisation and integration of financial markets at the international level relate solely to the assets listed on those markets, while other forms of capital investment in industry are still primarily governed by country-specific economic circumstances, institutional arrangements[2] and established practices. The configuration of forms of industrial investment and industrial risk appraisal, including government intervention, is peculiar to each country (OECD 1995, 51). Institutions are historically rooted and culturally embedded, and their properties exhibit an element of rigidity (Kluth and Andersen 1999, 122-126). Therefore, in spite of globalisation trends, there are still local differences in financial systems which must be taken into account because they affect firms' Research and Development decisions.

This chapter deals with the way different entities interact in the process of financing innovation within Mexico. But before these interactions are developed more fully, it is important to understand the basic concepts of a financial system.

A financial system can be defined as the network of institutions connecting the owners of financial capital to that which ultimately gives them value. In other words, it is the mechanism for transforming savings or credit into investments and for advising firms (Christensen 1992, 153-155; Tylecote 1994, 259-267). Financial systems operating in a market economy are characterised by a set of components, functions and properties inherent in them (see Table 6.1). Therefore, financial systems differ in the way they function, the way they are composed and characterised, and in the way they can be transformed, based on their institutional context. In all countries, the institutional context is the outcome of a process during which institutions,

[2] For a more detailed discussion on institutions, see Chapter 4.

procedures and mechanisms have taken shape, as a result of choices on how to meet their market challenges (OECD 1995, 56-62).

Table 6.1. Components, functions and properties of a financial system.

Components
Institutions providing external finance for investment (loans, shares and other securities). Internal financing (self-funding). When retained earnings are allocated to different investment projects. The contracts[3] between owners and managers of investment funds, which define the terms for the use of operating surpluses for self-financing.
Functions
The provision of capital. Supervision of the way capital is used. Creation of resources.
Properties
Flexibility: ability to assume a range of industrial/technological risk portfolios. Adaptability: ability to change its own structure to sustain the structural adjustment of industry. Specific functionalism: aptitude for promoting certain types of industrial specialisation or adjustment processes more than others. Resilience: capacity to adjust structures without losing its 'personality' under the waves of globalisation.

Source: Christensen (1992, 153-155); OECD (1995, 32-39); Tylecote (1994, 259-267).

Various criteria are used to categorise a financial system. Christensen (1992, 153-155) groups them according to two aspects: the relative importance of financial markets and financial institutions in the transformation of savings to investments; and the role of government in this process and in the regulation of the financial markets. He then defines three distinct categories:

1. A market- and competition-oriented system, where funds are allocated through a developed capital market and with little government influence. Institutions here are highly specialised and numerous. Firms are supplied with long-term capital, partly by the developed capital market. Banks are limited to the provision of short-term capital or to linking firms with potential funds. The US and the UK have both been said to be in this category.

2. A credit-based system, where financial institutions, mainly banks, transfer savings to investments under considerable government control and regulation. Long-term capital is provided mainly through loan markets where some prices are controlled by the government. Government influences the flow of capital to areas of high priority. The relative importance of the capital market is small. France and Japan in the 1980s are examples of this system[4] (Sally 1995, Chapter 5).

3. A credit-based system dominated by financial institutions with little government intervention. Financial institutions influence prices independently of government. There are very strong ties between industry and finance. The firms are not only dependent on the banks; the banks often control a considerable share of the votes in the company. In the German financial system, for example, the banking system and bank-industry relations work quite freely and with little public regulation (Sally 1995, Chapter 5).

With regard to the financing of innovation, and based on the above-mentioned categories, it can be said that two components of the

[3] Contracts are more or less explicit and define the terms under which the owner surrenders some prerogatives to corporate managers for the use of operating surpluses for self financing (OECD 1995).

institutional context are of primary importance. These components determine both the sharing roles between the public and private sectors regarding the realisation and financing of R&D and the efficiency of the private financing system (OECD 1995, 56-62).

Tylecote (1994, 259-267) groups financial systems in a different way, and relates those categories to the funding of innovation:

a) Bank-based financial systems: only a small number of large firms are public companies quoted on the Stock Exchange. They and other private companies look to banks as their main source of external funding. Their relationship with banks is close, and lending is long-term.

b) Stock exchange-based financial systems: firms look to the stock market as their main source of equity. Banks are not used as a major source of risk capital since their lending is transactional rather than relational, with each loan seen as a one-off operation.

The real differences between the two systems cannot be understood without taking into account the role of shareholders. In his further development of the differences between the two systems, Tylecote states that generally, a bank-based system is a good supporter of innovation, and that the stock exchange-based economies will suffer from a lack of perception due to the distant relationship between firms and the sources of finance, whether banks or stock markets. Moreover, state-dominated bank-based economies can provide strong support in areas targeted by the state but, like the stock exchange-based systems, tend to discriminate against innovation where visibility is poor. Private bank economies tend to discriminate against innovation in high

[4] The French financial system used to feature an important role for the government, but banks more concerned with short-term financial profit criteria have made the system more Anglo-Saxon (Sally 1995, Chapter 5).

risk and major start-up areas. Tylecote concludes that all bank economies are virtually immune to short-termism since they do not involve placing decision-making power in the hands of outsiders, who tend to give priority to profit but are unable to assess long-term prospects of innovation investments.

Short-termism is one of the possible ways in which a financial system can inhibit innovation; another is the toleration of managerial inability or unwillingness to force change that would be in the interest of shareholders, otherwise known as 'conservatism'. Moreover, a country without a deep venture capital market can lag behind those with one. On the side of the capital market, two further innovation constraints exist: high interest rates and high margins for financial intermediaries, as well as an effective cost of capital for innovation well above the general level of interest rates.

The risk issue

The problems or constraints on innovation described above all relate to the issue of risk. The simple term 'risk' can imply negative connotations: it relates to danger, to chance, to unknown results (Longman Group Ltd. 1978, 958). Investment in innovation usually implies more uncertainty than other investments. The large element of risk involved in R&D investment is obviously a major factor in determining the scale of investment in innovation in a business enterprise. This goes both for market uncertainty and technical uncertainty. In addition, learning processes in production and consumption are somewhat longer for a new product, and possibilities for security are less than for known products (Christensen 1992; Freeman, Poignant, and Svennilson 1963).

International evidence has shown that it is much more difficult to borrow money for an investment in R&D than for investment in fixed capital, and firms which for one reason or another cannot finance R&D from their own resources will find it much more difficult to engage in research than firms with better self-financing possibilities (Freeman, Poignant, and Svennilson 1963). Risky investments in innovation are often initially self-financed. This applies especially to large companies: small and medium-sized firms may have less opportunity for internal financing. Nevertheless, large companies also increasingly tend to use external finance. Higher R&D costs and shorter life cycles for most high technology products also make technology-based firms more dependent on external finance (Christensen 1992).

Back in 1962, Arrow identified the fundamental issues surrounding the R&D decision: if a firm is considering a project that is risky, and is unable to shift any of this risk, then the firm will be less likely to undertake the investment than if it was safe. One way of shifting the risks is to spread them across a wide number of suppliers of capital. Instead of a single entrepreneur bearing all the risks of an R&D project, he should sell equity claims in the project and thereby dissipate the risks among a wide range of investors. Capital markets allow firms to spread R&D risks and mitigate the under-investment problem.

External finance for R&D activities comes in two main streams: equity and debt. The difference between them from the point of view of an investor is that the income from equity is random and risky. The income stream from debt is fixed and in the event of a firm's insolvency the debt holders will have a primary claim on the firm's assets, making it a safer proposition. From the point of view of the firm, equity holders are entitled to a share of the profits, and in consequence bear some of the risk of the project. Debt, on the other hand, represents the commitment of a series of interest payments irrespective of the liquidity of the firm, and if the firm does not have sufficient income to meet these payments, the debt holders can force the firm into bankruptcy and receive the proceeds from the sale of the firm's assets. Since equity holders bear risk which debt holders do not, the expected return on holding equity will he higher than the returns on debt (Goodacre and Tonks 1995, 318-319).

Most large and medium-sized firms finance R&D from internal cash flow (Tassey 1997, 190-191). However, since this thesis is concerned with the innovation efforts of small and medium-sized enterprises, this chapter focuses on the relationship between them and the financial system, in the sense that they depend greatly on external sources of funding. Thus, even if the types of market failure that are intrinsic for the R&D process did not exist, substantial under-investment in R&D could occur because of imperfections in the financial infrastructure that supplies investment funds to these SME firms. Furthermore, Arrow develops his arguments to show that the risk sharing solution to under-investment may still result in less than the optimum level of R&D, since the introduction of capital markets induces incentive and information difficulties (Arrow 1962). Arrow's demonstration that a market economy tends to under-invest in research and development gives rise, as previously stated, to the issue of State intervention. This problem of underinvestment can in essence be referred back to the concepts of information and risk aversion.

As rapid market changes make information hazy, there is a hazard in the sense that both industry and finance become more reluctant to forge long-term contracts, when they face problems to acquire adequate information. This situation tends to be self-perpetuating as the market itself is unable to solve the problem due to asymmetric information among participants. On the contrary, the number of poor risk takers increases, which again forces banks to claim a higher premium among those remaining courageous high-risk-taking firms to stay on the market (Svensson and Ulvenblad 1995; Williamson 1983).

Venture capital

One further concept is that of 'venture capital'. Credit is the lifeblood of a developed economy (Kluth and Andersen 1999, 122-126). The relationship between finance and industry often appears problematic in times of rapid economic and technological change, due to increased uncertainty about future market development. By looking at the financing of enterprises which still depend on national credit institutions, it is possible to discern financial structures that vary from country to country due to historical traditions. These variations, as previously discussed, can lead to constraints in the financing of technology development efforts in private firms, specially SMEs.

Venture capital then, is a key source of long-term funds to SMEs with high growth potential, often referred to as new technology based firms (NTBF). Fast growing companies backed by venture capital produce many new well paid and highly skilled jobs, and are an important source of applied technological innovation. Consequently venture capital is considered an important instrument assisting in spurring economic growth and industrial renewal by the OECD countries (OECD 1996). The OECD uses a three-point classification system for venture capital funds:

- Independent funds: these are often privately held or publicly listed companies.
- Captives: These are venture capital subsidiaries of industrial corporations or financial institutions.
- Public sector: These are venture capital organisations which are principally funded from government sources (OECD 1996).

Each type can be found in most OECD countries. Conceptually, venture capital has been regarded by policy-makers all over the world as an outstanding method of ensuring funds and managerial skills are directed to particularly high technology entrepreneurs.

Venture capital markets in the US are more developed and effective than in most industrialised nations, and the number of small firms that start up and prosper reflect this strength of the US financial infrastructure. However, Tassey (1997, 189-203) argues that venture capital markets have been characterised on numerous occasions as inadequate. He gives three reasons for his concern:

a) the supply of venture capital is too cyclical, resulting in deserving firms not having access to funds at crucial points in their growth;
b) the risk preferences and organisation of venture capital firms have shifted towards less-risky, later-stage developing companies with relatively shorter expected times to commercialisation;
c) the knowledge of venture capitalists tends to be concentrated in certain technologies, thus leaving other areas without the needed financial support.

Market failure

R&D policy should be concerned with the availability of adequate funds in some of the forms discussed in this section to ensure the continual supply of new technologies. As will be discussed thoroughly in the next chapter, most countries offer government-backed incentives to alleviate the market failure in the allocation of resources to technological projects (Stoneman and Vickers 1988). Incentives can take several forms: direct financing, subsidies and favourable tax treatments being the most common. However, even when it is accepted that some form of incentive is necessary, the decision concerning which method to adopt, which organisations should benefit and by how much is far from easy. To be in a position to make such a decision rationally requires knowledge of the likely impact and relative effectiveness of alternative forms of incentive. Public authorities in several countries use quite remarkable sums of money in subsidising product and process development in private firms.[5]

Using the concepts examined in this section, the Mexican system for financing innovation can now be analysed in the rest of this chapter. When reading this, keep in mind that innovation is not a specialised economic activity but one of the mainsprings of economic development: to innovate is to invest, and the content of innovation-related investment and its uncertainties create financial problems. These problems cannot usefully be analysed in isolation from more general problems of the reconciliation of financial and industrial logics. This reconciliation takes different forms in different countries. Deregulation and globalisation of financial markets facilitate the finance of some types of investment but tend to destabilise national financing systems and do not always steer them automatically towards the most urgent structural adjustment tasks. Market failure may create chronic insufficiency in innovation-related investment (OECD 1995).

The mere fact that an innovative project does not find funding is not in itself an indication of a failure of the financial system. The empirical evidence presented for the Mexican case will help to judge whether:

On the demand side:

- the innovator is able to formulate his project in a sound business plan;
- the innovator is ready to use the appropriate financial channel, including when it involves sharing of information and control associated with external equity funding.

[5] Consequently the impact of these subsidies on R&D efforts has been the subject of several empirical studies. Results vary and can even be

On the supply side:

- the innovator has proper access to a complete set of competing financial channels;
- the innovator can identify financial players who can fully assess the project, even a technologically complex one involving a high share or intangible investment; and
- the financial investor is offered appropriate exit facilities, to meet his liquidity requirements.

6.2 – THE MEXICAN BANKING SYSTEM

National banking systems throughout the world have been subject to immense pressure due to the deregulation process and the prominence of the free capital movement discourse (Kluth and Andersen 1999). The case of Mexico is no exception. Changes in Mexican policy toward financial institutions have moved them to a more open and riskier environment.

Much has been discussed over the last two decades regarding the dramatic shifts that the Mexican financial sector has experienced. Such a complex interrelation of events is difficult to illustrate in detail, but the main events that have taken place will be highlighted here, with recommendations for further reading where necessary.

The Mexican financial system includes commercial banks, development banks, brokerage houses and securities markets, insurance firms, and other non-bank financial intermediaries including credit arrangements outside the formal banking system for the poor (Gruben and Welch 1996, 63-75). This study concentrates mainly on the banks, both private and government owned, because of their relative importance

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contradictory depending on the particular case and methodology employed. See Kauko (1996).

compared to the rest of the financial institutions in the financing of innovation.

There have been striking changes in commercial banking in the last twenty years. Changes in government policy towards financial institutions are a major indication of the changing relationship between the state and the economy, and in Mexico there have been many such changes. The major ones are described below.

In 1982, the Lopez Portillo administration nationalised the banks in a panicky response to the dual economic shock of weakening oil prices and rising real rates of interest (Barnés 1992, 1-21). As the then President wanted to make sure they stayed nationalised, he incorporated the nationalisation into the constitution (Gruben and Welch 1996, 63-75). During nationalisation the banking sector was consolidated into fewer units and was prevented from engaging in risky and speculative ventures. By 1990, of the 58 banks originally nationalised only 18 remained (Banco de México 1992; Barnés 1992; Gruben and Welch 1996).

In 1984, the de la Madrid administration began to privatise brokerage houses, insurance firms and other bank property. Non-bank financial institutions' assets increased from 9.1% to 32.1% of financial system assets (Banco de México 1992). This started a trend continued later in 1990 by Salinas' government to liberalise the financial system by eliminating the controls over banks and move towards universal banking.

In 1988, Mexico deregulated interest rates by eliminating controls of rates and maturities on all traditional bank instruments. Restrictions on loans to the private sector were also eliminated and lending at below market interest to the public sector was discontinued.

In December 1989, to further strengthen banks and other institutions involved in credit and stock market operations, the Mexican Congress approved wide-ranging institutional reforms. These measures were intended to increase competition and reduce enforced market segmentation by expanding the scope of permissible activities for different types of institutions (Barnés 1992, 1-21).

In 1990, the Mexican Congress amended the constitution again to permit the sale of the nationalised banks, although only to Mexican investors. On May 2nd, President Salinas submitted a bill to Congress to amend articles 28 and 123 of the Constitution, permitting full private ownership of commercial banks. The Credit Institutions Law, enacted in July 1990, allows commercial banks to be majority owned and controlled by the private sector (Barnés 1992, 1-21).

The government sold its 18 banks in 14 months, from June 1991 through July 1992, at the extraordinarily high average price-to-book value ratio of 3.49. Having paid this inflated price, buyers expected competition to be kept amongst only a limited number of banks. However, in 1993, Mexico began to expand its banking markets to new domestic entrants. It has been said that Mexican banks at that time were roughly two-thirds as efficient as US banks (Gruben and Welch 1996, 63-75); this can be explained by the protection of Mexican banking and competition resolved the problem. In 1993, the number of Mexican banks almost doubled. In 1994, as a result of NAFTA, foreign banks were allowed to operate in Mexico, subject to size restriction. Foreign banks as a whole were limited to up to eight percent of total Mexican bank capital. Some 53 financial institutions were licensed to operate in Mexico.

In the wake of the privatisations and faced with increased competition, banks began to expand consumer credit, despite limited information on the creditworthiness of the borrowers (Gruben and Welch 1996, 63-75) – offering credit to customers about whom little was known.[6]

The Mexican financial system was severely affected by the financial crisis that erupted in late December 1994. The crisis created serious liquidity and solvency problems for a wide range of financial institutions, exposing their weak capital base and widespread portfolio problems. The government intervened in the operations of ten banks, including some later investigated for fraud by their owners,[7] and put in place several bank and debtor support programmes involving high fiscal costs. According to International Monetary Fund (IMF) staff estimates, the total cost to the government of these programmes could amount to almost ten percent of GDP (IMF 1997, 8).

The UDI[8] loan structuring scheme was introduced in April 1995, allowing the conversion of outstanding floating interest rate loans into long-term loans, denominated in UDIs that carry a fixed real interest rate (IMF 1997, 8). That same year, to rescue Mexico's unsound banks, foreign banks were allowed to purchase any other than the three largest Mexican banks. New rules allowed up to 25 percent of a bank's capital to be foreign-owned.[9]

After the December 1994 exchange rate crisis,[10] devaluation triggered capital outflows and high inflation. As a result, interest rates rose so

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[6] As a private sector association leader said '...after the reprivatisation, banks just inundated the country with credit cards and that is one of the main causes of the current financial crisis' (Interview #4).
[7] In retrospect, a first level government official says '...bankers were not interested in 10 years maturity projects, their perspective was one year, and then run away to Europe' (Interview # 20).
[8] A UDI (Unidades de Inversión) is a reference unit of account with constant real value as indexed to the consumer price index.
[9] The restriction no longer applies and subsidiaries of foreign banks can operate in Mexico and banks can be owned by foreign capital.
[10] For literature related to the 1994 financial crisis see Cárdenas Sánchez 1998; Gavito Mohar, Silva Nava, and Zamarripa Escamilla 1998; Girón and Correa 1997; Johnson Ceva 1998; UNAM-Facultad de Economía 1995.

high that they put both borrowers and lenders at risk, as major increases in interest rates pushed up loan default rates. Some banks were reported to have suspended all mortgage, auto and consumer loans until further notice and to have cancelled loans to farmers. To address the mounting problems of undercapitalisation among the increasing number of troubled banks, the government designed a special recapitalisation programme through the nation's deposit insurance authority, known as FOBAPROA[11] (Gruben and Welch 1996, 63-75).

In general, financial crises lead to diminished levels of financial intermediation and hence to less capital accumulation and lowered economic growth, and therefore are costly for nations. Moreover, they produce a deficient allocation of real resources and may threaten the functioning of the payments system, thus engendering social costs well beyond the banking business and even the financial market as a whole (Gavito Mohar, Silva Nava, and Zamarripa Escamilla 1998, 88-105).

The origins and consequences of Mexico's 1994 crisis have been much debated. In preceding years, market-oriented reforms had not delivered the anticipated level of economic success, yet there had been no consensus that the strategy should be changed. Up to 1994, observed results from these reform policies seemed in general satisfactory, but by the end of that year the Mexican economy was in a vulnerable condition. Economic growth and real interest rates had not evolved as expected, and the government's liquid reserves were too low to deal with short-term liabilities. Firms and households were also seriously over-indebted (Gavito Mohar, Silva Nava, and Zamarripa Escamilla 1998, 88-105).

[11] FOBAPROA (Fondo Bancario para la Protección al Ahorro) is the Fund for the Protection of Bank Savings. The government, through FOBAPROA, purchased

These conditions had been brewing for several years. Between 1982 and 1988 the level of private sector debt decreased due to various adverse conditions, including contractions of domestic aggregate demand, high and volatile interest rates, foreign exchange uncertainty and low availability of loanable funds. This trend reversed in 1988, however, when the macroeconomic setting became more favourable.

The deep structural change that took place in Mexico during the following years delivered a leaner public sector with healthier finances, stable macroeconomic indicators and financial liberalisation. In addition, new policies to deregulate economic activities and speed up the trade-opening process stimulated the business sector to restructure, to become more competitive in a free-trade environment (Gavito Mohar, Silva Nava, and Zamarripa Escamilla 1998). Nevertheless, in the context of the transition from the Salinas to the Zedillo administrations, unsustainable macroeconomic policies, together with the defective regulation of the banking system, seem to have ultimately conspired to produce the eventual collapse of the Mexican financial system, leaving the banks' soundness to rank 57th out of 58 in the most recent Global Competitiveness Report. Moreover, the report ranks Mexico 51st in respect to the possibility to obtain a loan with a good business plan and no collateral, and ranks the country 52nd when assessing whether in the past year credit has become easier to obtain (World Economic Forum and Harvard-CID 2000). The implications for financing of innovation are quite obvious.

6.3 - BANKS AND THE FINANCING OF TECHNOLOGY AND INNOVATION

In the rest of this section, a series of qualitative and quantitative data collected during field research is presented to suggest how the above-

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subordinated debt instruments issued by commercial banks to alleviate the effects of the 1995 financial crisis.

mentioned events affected the way in which innovating firms obtain financial resources for their projects. The views of the three main players - firms, government and banks - will be seen to reflect the attitude that commercial banks have towards financing technology projects.

President Salinas referred to Mexican banks as 'thrown to the ground'[12] and when discussing the subject was unsurprised to hear of the passivity of banks in the financing of technology, because, as he said, they are 'being passive in giving credit in general to firms'.[13] Although it can be agreed that the privatisation of the Mexican banking system was designed to bring positive results, it needed to be complemented with a general structural transformation oriented to improve efficiency and productivity. The financial sector reforms had to be consistent with the general structural trend of the economy (Barnés 1992, 1-21).

On this topic, one interviewed businessman said: '...the last good experience I had with a bank, Banamex, was before the nationalisation, when bankers were real bankers...during the period of nationalised banks things were bad, but now after the reprivatisation they got worse, and there is absolutely no support for technology development in the country...'. [14] And when a Nafin manager talked about his experience with the newly reprivatised banks, he recalled '...they wanted to reduce their costs and would not consider technology projects even if they were relatively few in their overall portfolio...they don't consider the fact that these kind of projects can be good businesses because they only see their inherent risk...'.[15]

[12] Interview #19.
[13] Ibid.
[14] Interview #4.
[15] Interview #18.

During a workshop organised by the OECD, aimed at identifying those obstacles to amalgamating technology and finance, the participants agreed that those obstacles were (OECD 1982, 118-126):

a) Assessment of projects:

Most banks and many other institutional investors do not understand innovation because they do not have staff able to evaluate technical risk. Moreover there is a fundamental issue of objectivity and filtering. Who is a qualified and legitimate expert to judge the innovative project rigorously? Nobody; ultimately the market is the judge. Thus, in order to get to the market, the project needs to be developed.

The problem in Mexico is that banks rarely understand that a technology development is unique and implies long-term investment, different to normal credit where banks recuperate in a short period and have guarantees.[16] This is a vicious cycle: small innovation firms generally do not have guarantees, and without guarantees and a totally defined commercialisation plan, private banks and even development banks will not authorise credit. Credit evaluators often lack understanding of what technology means and are reluctant to take risks, being concerned with the provision of guarantees.[17] A credit applicant at Bancomer stated: 'they didn't even understand what we were talking about, they couldn't evaluate a project like ours...'.[18]

b) Mutual understanding and confidence:

Many SMEs do not understand the needs and requirements of bankers. Essentially they are very difficult clients requiring much time and attention from bankers in relation to the volume of business they

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[16] The term 'guarantee' refers to the surety or collateral needed to obtain a loan.
[17] Interviews #1, 4, 12, 13, 18, 22 and 23.

provide. Moreover, innovators have a tendency to be secretive about the technical characteristics of their projects.

Mexican bank executives agree that currently their internal operation costs are high and therefore they seek a good margin when giving credit. Thus, due to the greater administration costs related to the nature of technology credits presented by SMEs, they do not match their client profile.[19] One of the interviewed executives said: 'if they apply for credit to finance technology development, they are out of the question...we just can't take them...'.[20]

The situation in Mexico is worrying when, on the other side of the confidence and understanding problem, businessmen perceive banks as not being open to technology projects. Moreover, they find the available banks' credit lines to be designed for products already in the market.[21] An entrepreneur responded: '...the mere thought of getting bank credit for technology projects terrifies me...'.[22]

The problem of confidence might be interpreted as a communication gap between the SMEs and the banks. The scenario does not look very promising when the Executive Director of FUNTEC[23] perceives that the positions of bankers and entrepreneurs 'have been divorcing more and more...they don't trust each other...the distance between them is bigger and bigger...the chances of reconciliation or linkage are less and less as time goes by...'.[24] This gap can only be closed by daily mutual involvement (OECD 1982).

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[18] Interview #1
[19] Interviews #22, 23, 24 and 25.
[20] Interview #23
[21] Interviews #2 ,5, 7, and 9.
[22] Interview #9
[23] FUNTEC is the Mexican Foundation for Innovation and Technology Transfer in Small and Medium-sized Firms, (Fundación Mexicana para la Innovación y Transferencia de Tecnología en la Pequeña y Mediana Empresa). See Chapter 5 for further details.
[24] Interview #12

c) Lack of comprehensive local services:

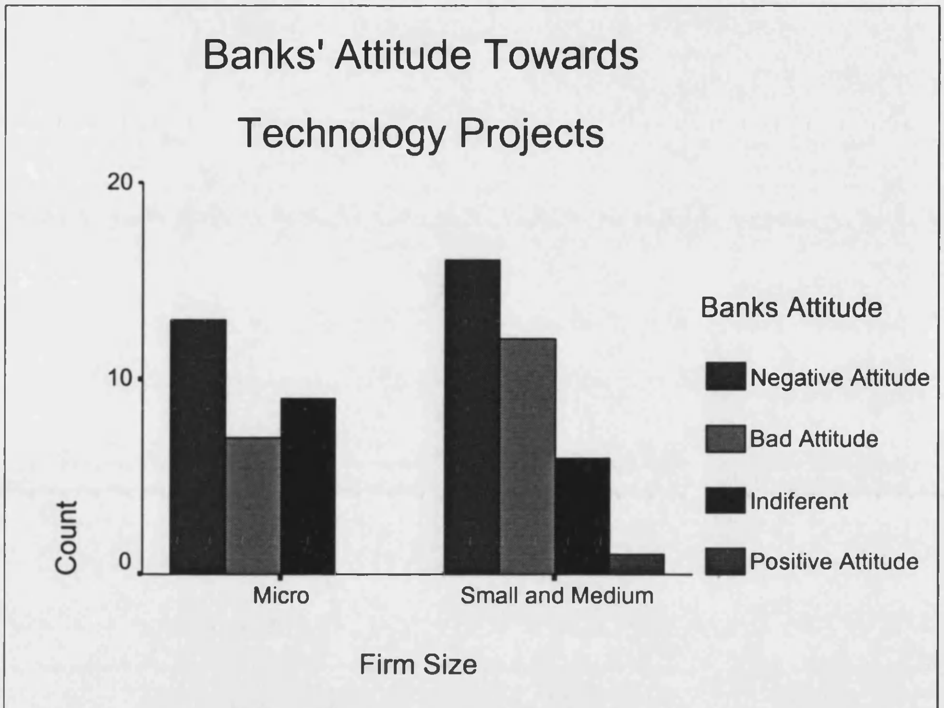
There is a great need for local services to bridge the gap between investors and innovators, helping both to prepare the basis for assessments and to build confidence. Chambers of commerce are usually not aware enough of their potential role and only a few have built up adequate technological activity.[25] Regional agencies are either overloaded or underutilised because there is insufficient personal involvement and contact with entrepreneurs.

The main agent of this analysis of the financial system is the banking system which, under normal circumstances, channels funds to industry through operations in various financial markets (Sally 1995). Therefore, if the financial system in which it operates is ineffective, a new element of market failure in the process of financing innovation is present. Could it be argued that this is the case in Mexico? Certainly the levels of operation are low: in the first six months of 1998, Bancomer had not requested a single guarantee of Nafin's scheme for technology projects. Banamex had requested four guarantees to Nafin, though not under the technology programme.[26]

When asked about the way they perceive banks' attitude towards technology projects,[27] none of the micro-sized firms surveyed responded that they had a 'positive attitude'. Only one firm in the whole survey considered it as positive. As it can be observed in Figure 6.A, most of the respondents favoured the 'negative' and 'bad' attitude responses.

[25] This topic has been discussed previously and more fully in Chapter 5.
[26] Interviews # 22 and 23.
[27] Author's Survey: Question #42.

Figure 6.A Respondents' answers to the question: How do you perceive the financial institutions' attitude towards technology projects?



Source: Author's Survey

In 1984, Araoz argued that in Mexico, industrial financing is given on the basis of the expected investment returns from the firms. Large firms absorb most of the internal available credit and the financial sector has not operated according to industrial sector priorities (Araoz 1984, 1182-1189). Although more than 15 years have gone by since this was written, and major events have developed, the situation has not changed much for SMEs. Currently large banks only lend to large companies and, since the reprivatisation, many owners of large firms are also owners of the banks. These owners, therefore, can self-finance their businesses using the savings deposited in the banks.[28]

According to Araoz, it would not be fair to blame the situation fully on the banks. The problem they face is not a matter of principle but rather a technical issue. Even if they would like to consider externalities, long-term effects, technological development etc., they would still have problems in quantifying these aspects and introducing them to their evaluation methods. For instance, a credit executive at Bancomer recalled: '...I have seen a case of a project that can give 5 to 1 guarantees because the family is well off, and nevertheless, because of the fact that it involves an innovation, we have been evaluating it for ten months already with no answer yet...'.[29]

Risk may influence the conservative behaviour of banks. Risk aversion and security attitudes limit solutions to the problem at every stage of a project, mainly at the pre-investment phase. Maybe now is the time for smaller, more aggressive private banks to start changing their attitude towards technology financing. A good signal may be that in the first six months of 1998, one of these smaller banks had requested almost 900 guarantees from Nafin.[30]

The main players, both private banks and the public sector in its role as investor, have not yet understood that in order to learn they have to take risks, and that taking risks is fundamental for the generation of technical knowledge. And again, the perception of risk from the point of view of the banks may be significantly different than that of the developers of the project, who believe in its results,[31] as can be observed in Figure 6.B.

As discussed in the first section of this chapter, uncertainty and profit vs. risk sharing assessments can be an obstacle to innovation projects if financial institutions are risk-averse (Christensen 1992). Moreover, if Mexico ranks 50th out of 59 in respect to entrepreneurs with innovative

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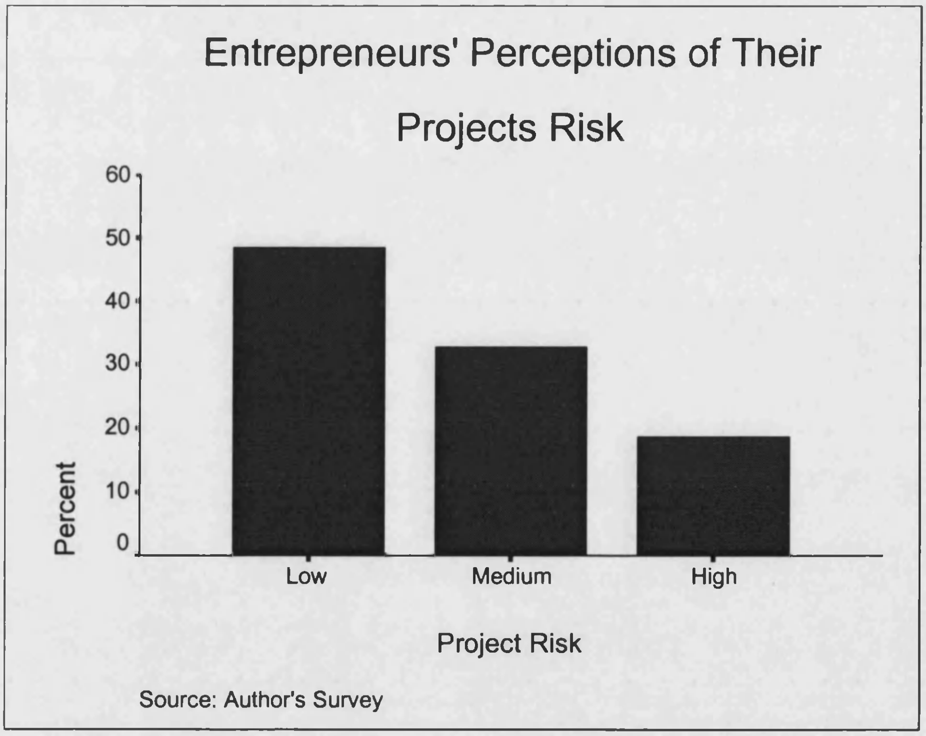
[28] Interviews #3, 4, 5.
[29] Interview #23.
[30] In his statement, this executive of a small bank was referring to small and medium-sized firms' credits in general, and not specifically to technology credits (Interview #24).
[31] Author's Survey: Question #25.

but risky projects being able to find venture capital[32], then a venture capital market has to be fostered in parallel to the traditional financial system. At the moment, '...if you can't give guarantees to a bank you can't access a credit for technology innovation...';[33] and there are indeed '...some venture capital structures but they have several barriers...',[34]. However, a solution does not lie 'in the creation of little schemes of technology financing, the true solution is the creation of a real venture capital mechanism to finance risk...it should operate in the same way as they do in countries with high innovation activities, but we are still far away from achieving that...'.[35]. As these entrepreneurs have clearly stated, further work needs to be done in this area.

Figure 6.B Respondents' answers to the question: How risky is your firm's technology project?



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[32] As stated in the Global Competitiveness Report 2000 (World Economic Forum and Harvard-CID 2000).
[33] Interview # 6
[34] Interview #1.
[35] Interview #10.

Moreover, the time horizon in financing investments is perhaps more important than interest rates to innovation projects. The duration required to develop the project is highly uncertain, as is the introduction to the market. If lenders are expecting a return in the short-term, this may pose problems for innovation. The experience in Mexico has been that current schemes of technology credits are calendarised as any other regular credit from the beginning, without consideration of the different stages of development. Private and development banks do not take into account the fact that technology projects do not necessarily have a concluding date, that due to their own nature delays can occur, technical obstacles may have to be solved, or that new discoveries can even shift the direction of a project. Therefore it is important that banks are ready to react timely to restructure the credits.[36] Otherwise, the consequence for technology financing is a pressure on projects to show results in a period of time that may be impossible for innovation. Indeed firms need to employ different payback periods depending on the expectations of the development of competing technologies and the cost of capital.

The risky nature of a firm's R&D and the heavy initial investment before the project pays any returns both create difficulties in assessing the potential of an R&D project and obtaining finance. This section has stated this problem from the point of view of the supply of finance: the commercial banking system. The following section will deal with such issues from the side of the demand for funds: innovating SMEs.

6.4 – FIRMS: THE DEMAND FOR FINANCING TECHNOLOGY AND INNOVATION

Schumpeter was one of the first authors to discuss the importance of credit in the process of innovation. According to him, the entrepreneur

[36] Interviews #2, 5, 7 and 18.

is the driving force in the process of innovation, but he must be able to convince the banks to provide him with credit to finance the innovation (Schumpeter 1934). The simplest way to approach this relationship is from the point of view that any good business project, implying some kind of commercially viable innovation, will eventually convince someone to lend the money to develop it. But as discussed in the previous section, things can be more complex than that when the financial system is in crisis, risk aversion prevails and confidence and communication between banks and firms is lacking.

This appreciation becomes even more critical when talking about financing newly established, innovative SMEs in early technology development projects. According to the OECD (1995), innovations applying cutting-edge technologies may not always be the prime victims of financial market malfunction. They can access instruments designed especially for such projects, or can be the first to benefit from the fallout from public science and technology investment. The kind of innovation most likely to suffer from under-financing is that with a medium-high technology content. Such innovations combine three drawbacks: they are too risky for banks, promise returns that are too slim for venture backers, and are too dull to attract government aid.

Early stages of project life cycle

The sources of finance which are available to a firm depend to a large extent on the stage of development of the organisation. At the 'seed' or idea stage, in which financing is needed for research and product development, risk finance is typically provided by the founders and their friends or relations (Goodacre and Tonks 1995, 322-328). The experience of interviewed entrepreneurs confirms this:

'...in the beginning of the project, when we developed the prototype of our idea, we used our own personal resources and a personal credit line from the bank...';[37]

'...for the initial research I had no external funds, I used my savings, nobody believed in the project then but me...with the first successful results I started the second phase and established the micro-firm. It was not until then that I managed to get external credit...'.[38]

To continue with Goodacre and Tonks' (1995) argument, it can be said that loan capital may also be available from banks, but will usually require significant personal collateral[39] and will often bear comparatively high interest charges – as was thoroughly discussed in the previous section and is here supported by the following complementary statements from an entrepreneur and a bank executive:

'...as a small firm in Mexico you need guarantees from 3 or 4 to 1 with real estate properties to back up a technology research project...'.[40]

'...the majority of the projects applying for credit are good technology projects. The problem is when you ask the entrepreneur to mortgage his house to guarantee the credit, it is very unlikely that he will risk his family's patrimony, we are talking of small new firms with hardly any other guarantees...'.[41]

At the early stage of development, the technological feasibility of an innovation is questionable, and the market feasibility is often unknown. The unusually high risk associated with this situation, and the unproven capabilities of the entrepreneur to manage such a project make seed-

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[37] Interview #2

[38] Interview #8.

[39] For a more detailed discussion on the role of collateral in determining productive investment in Mexico since 1989 see IMF (1999).

[40] Interview #4.

stage investment an unattractive proposition for many providers of capital. This has resulted in what has been described as a 'finance gap' for small firms (Goodacre and Tonks 1995, 322-328). In Mexico's case, and particularly with such small firms, we find that they consider themselves weak and limited in financial and managerial aspects.[42]

According to the OECD (1982, 118-126), the finance or venture capital gap in the R&D phase has important consequences such as:

- Significant projects cannot be properly developed to the point where they can attract interest from possible lenders; so there are likely to be a large number of 'high potential' projects stopped in their embryonic phase.
- Small firms tend to move to innovations with shorter time periods between ideas and production, just as bankers have moved from more risky to less risky ventures; this can easily relate to Mexico's situation as discussed in the previous section.
- Firms encountering problems in obtaining funds before they can demonstrate a market-ready prototype tend to neglect important market research, which in turn leads to sales/distribution and cash flow difficulties once production begins;
- The innovator is led to assemble a package of money, which can be a multiple-form venture capital. It may be equity, long-term debt and short-term loans, overdrafts, business establishment funds, funds convertible into equity, innovation project grants, even trade credits and similar money. This subjective and rather vague concept of venture capital contrasts with the bankers' more specific concept. The innovator frequently does not distinguish fixed capital from working capital, and ignores the simple relationships between equity and debt which can lead to over-borrowing and inherently unstable financial structures.

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[41] Interview #25.
[42] Interviews #2, 3 and 8.

Firms' characteristics: Newly vs. long-established and small vs. large

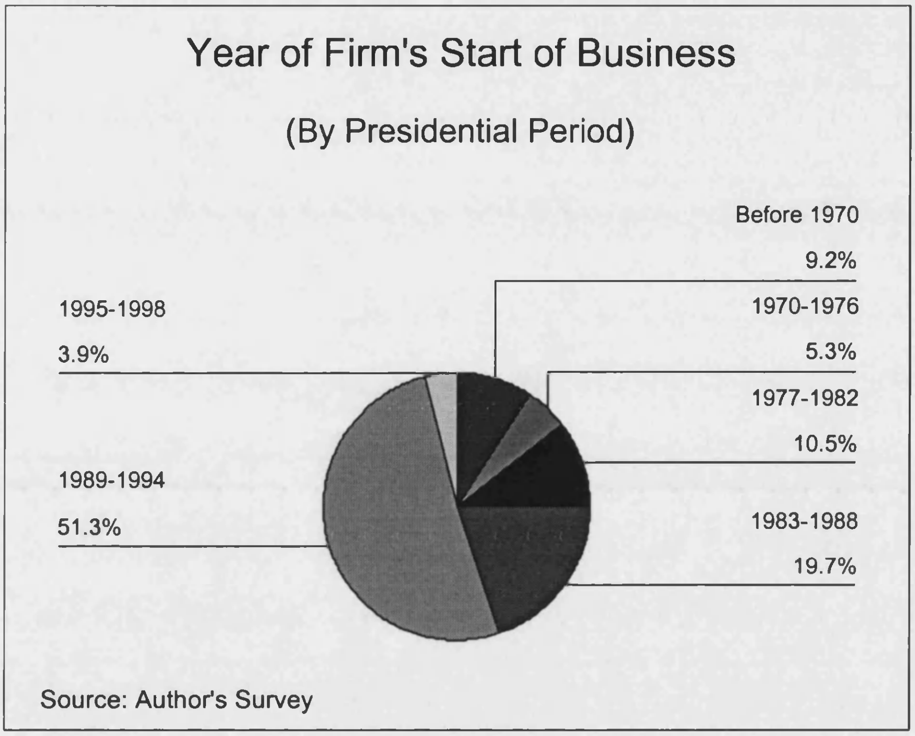
Another important aspect in the study of firms seeking funds for technology projects is the length of time they have been established. Experience shows that new technologies are often promoted by new firms, which face technical and marketing problems and cost more to finance than conventional start-ups as the financing risk is thought to be higher (OECD 1982). Figure 6.C shows how long surveyed firms have been established.[43] All surveyed firms attempted to obtain financial support for a technology project. It is interesting to observe that more than half of them were established between 1989 and 1995. The recent creation of a high percentage of firms applying for funding can be an example of the relation between new firms being established to develop a technology project at the time.[44]

The suggestion that entrepreneurs find it very difficult to obtain small amounts of capital, whether to initiate a new business or to expand a young one, was made as early as 1931 by the Macmillan Committee in London (Macmillan Committee 1931). Similar arguments in the US with particular reference to technological innovation are reviewed in Bean, Schiffel, and Mogee (1975).

[43] Author's Survey: General Information Question. Firms were asked the year in which they were established, and the responses were grouped by presidential terms.

[44] The periods are divided into presidential terms for the convenience of analysis of a series of variables of the model. The main argument for this section is the correlation between the long vs. short establishment of firms and their will to develop technology.

Figure 6.C. Presidential periods (post-1970) during which surveyed firms were established.



For brand new firms undertaking R&D, the future cash flows are highly uncertain. A new firm would not want to issue debt to finance this investment since there is a strong chance that early in the life of the debt package the profits generated by the R&D project will be insufficient to cover the interest payments, forcing the firm into liquidation (Long and Malitz 1985). When talking about such issues, a technologist involved in an agro-industrial project in the south of Mexico said:

'...as innovators turned entrepreneurs we have an ignorance problem in financial matters...we can easily get involved with a credit that is not suited for an innovation project and eventually be bound to bust...'.[45]

Similarly, potential debt holders may be unwilling to purchase a new firm's debt since they realise the inherent risk and perhaps more importantly are unable to secure their loan against any fixed assets, since by its nature some R&D investment will have a low resale value. This would explain why most of the empirical evidence for this study shows that banks request up to four to one guarantees in order to finance a technology project. These arguments suggest that new firms are unlikely to finance their R&D investment by issuing debt, rather they are more likely to use equity or venture capital as a source of finance (Goodacre and Tonks 1995, 319-321). Unfortunately, as has been seen throughout the chapter, venture capital is still in a premature phase in Mexico.

When analysing Latin American firms, Nolff determined a series of obstacles they have to face regarding competitiveness, technological innovation, and external collaboration (Nolff C. 1974, 175-181). To him, some of the main obstacles are the difficult access to financial sources, lack of capital markets and backwardness of the banking system. A more recent study carried out at UNAM amongst 100 innovating Mexican firms asked them to identify and prioritise the main obstacles encountered in the process of innovation. They replied as follows.

For micro and small firms, the main problems are specific to the project, but the obstacles to obtaining financial resources and investment capital run a close second. They also list the high risks of getting credit, the bureaucratic and long procedures, lack of fiscal incentives, and high taxes, which directly or indirectly refer to financial issues of the project.

Medium-sized firms find investment capital the main obstacle for innovation, and secondly the knowledge about technology. The latter is

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[45] Interview #8.

the first problem mentioned by large firms. It can therefore be assumed that the larger the firm, the more important the problems related with technology knowledge become. On the other hand, the larger the firm, the less of a problem to obtain financial assistance to develop technology (Corona T. 1997, 47-56). In the words of an interviewed small-size firm owner:

'...large firms can access foreign credits that are cheaper than domestic ones or they can even have access to venture capital, they are listed in the stock exchange. None of that applies to medium or smaller firms...'.[46]

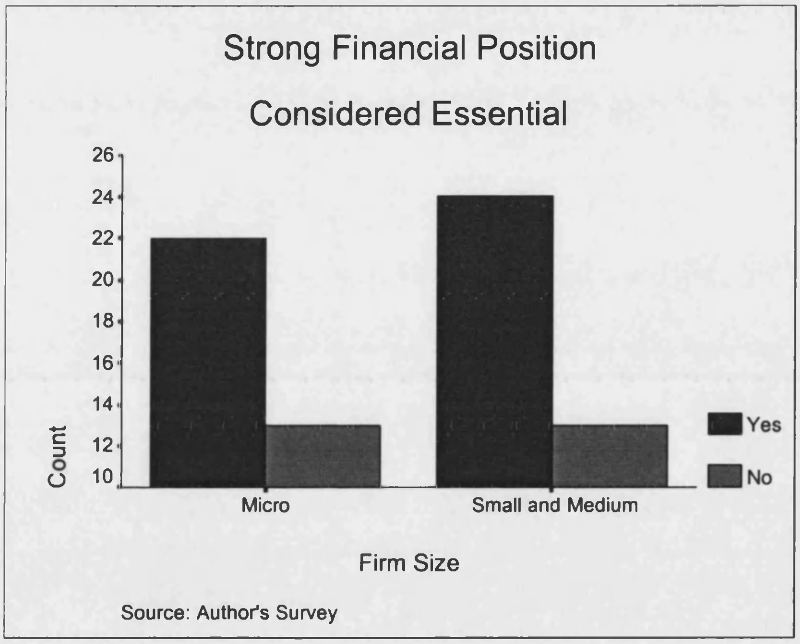
Similar tendencies were found in the Author's Survey. Figure 6.D shows that micro, small and medium-sized firms consider it most important to have internal financial strength,[47] as they encounter severe constraints to access external funding.

Once a firm has worked through the R&D stage and can demonstrate, within a more formal business plan, the potential to generate large returns, venture capital financing becomes a possibility. Venture capitalists have traditionally been willing to accept a reasonably high level of risk in the expectation of a commensurately high return. However, even if there was a real venture market in Mexico, recent trends in the provision of venture capital (in the UK and the US) seem to suggest a change of attitude. Less finance has been available for early stage companies with more for later stage companies. The attraction of such investments is fairly obvious. They offer prospects of an earlier return, and often less risk both in terms of the market for the product and the already part-proven ability of the management team. There is a concern within the industry that short-termism is emerging via pressures on institutional fund managers to maximise immediate

[46] Interview #5.
[47] Author's Survey: Question #7

performance; this conflicts with the long-term outlook required of venture capitalists (Pratt 1990).

Figure 6.D. Respondents' answers to the question: Is an internal financial strength essential for a firm's technological capacity?



Another market failure in the financing of the development of small, technology based firms is alleged to occur at the commercialisation and post-commercialisation stages of project development. Here, a small, high-tech firm has developed a new product or process and needs substantial capital to 'scale up' for production and market penetration. This stage is typically much more capital intensive than the R&D stage and consequently requires substantially larger amounts of financing (Tassey 1997, 195-197).[48]

[48] According to their own experiences, interviewed entrepreneurs agreed with this discussion (Interviews #2, 5 and 8). One of them elaborated: '...for the commercial stage we've had to use whatever self-funding we can manage, and it has become a very slow process therefore...nevertheless, when I started to sell my new products I had quite a good market response, and even with the crisis and the devaluation I was going to be able to pay my previous credit. It was the credit institution that didn't respect the initial payments calendar and claimed back the loan earlier than initially agreed...' (Interview #8).

If a market failure were proven to exist here, government programmes providing equity financing would be a continuing option. However, as will be discussed in the next chapter, debt financing would also be an option in this situation for three reasons:

a) technical risk has been greatly reduced and commercial risk has at least been lowered; thus overall risk is low enough for lenders to rationalise loans with their relatively constrained rates of return;
b) small firms can handle debt financing at this point because they are beginning or are about to begin to generate a cash flow;
c) entrepreneurs who own small firms do not want to give up any more of their firm's ownership (equity) than they have already yielded to venture capitalists during equity financing in the R&D stage.

So far, the cases presented have centred on firms with projects at early and later stages and newly-established firms. There is, however, one more variant: the long-established firm. Their situation is somewhat different since they can cross-finance their activities; for example, a firm that has diversified into a stable industry with a regular profit stream could use these profits to pay the interest payments on debt raised to finance R&D in another subsidiary. An existing firm could also use existing assets as security against loans raised. We might therefore expect that large diversified firms are as likely to use debt as equity to finance R&D, whereas smaller undiversified firms are more likely to finance R&D by issuing equity (Goodacre and Tonks 1995, 319-321).

Summing up, the financial burden of research is often the most important obstacle to innovation, particularly in the case of smaller firms, and also for projects which require a good deal of development work. Thus, the case for government participation in the financing of firms' R&D activities cases can be justified (Freeman, Poignant, and Svennilson 1963). The next chapter is concerned with the specific instruments which Mexican public institutions have used to directly finance R&D activities in private firms.

CONCLUSIONS

This chapter has presented the theoretical concepts of a National System for Financing Innovation, arguing that, in spite of globalisation trends, there are crucial local characteristics in financial systems to take into account because they affect national firms' R&D decisions. Following this, the dynamics and consequences of the interrelations within Mexico of two of the system's main players – banks and firms – have been analysed.

It has been found that a financial system does make a difference when comparing possibilities for financing innovations. The financial obstacles in the way of innovation are potentially greater for SMEs than for large corporations. This appreciation becomes even more critical when talking about financing newly-established, innovative SMEs in early technology development projects. Such innovation can be inhibited by banks and their short-termist attitude, amongst other things.

At the beginning of the chapter it was questioned whether the failure of an innovative project to find funding is in itself an indication of a failure of the financial system. The empirical evidence presented for the Mexican case shows that the problem lies on both sides:

On the demand side, innovating firms, mainly small and newly established ones:

- are not always able to formulate their project in a sound business plan for the banks
- do not have the collateral or guarantees required by commercial banks

- are not ready to share information, thus lmiting their options to use the appropriate financial channels.

On the supply side, the financial institutions:

- have not yet developed a set of competing financial channels, appropriate to technology projects
- do not have the capacity to fully assess the projects, which are usually technologically complex and involving a high share of intangible investment
- require appropriate exit facilities, to meet their liquidity requirements, thus affecting the natural calendar of projects of this nature.

It is rather a matter of understanding how, and at what price, two approaches can be reconciled: maximisation of the financial return on invested capital and the creation of wealth through innovation. In reality, these worlds cannot move apart since they are structurally interconnected. The reasons for any clash must be found within the web of interconnections itself. One way to provide confidence is by repetitive contracts between a borrower and a lender, accumulating knowledge through interactive learning. Credit rationing could be reduced through closer relationships between them. Thus, it must be remembered that for each successful R&D project there may be several unsuccessful ones.

Perhaps the current situation in Mexico is a temporary result of the rapid, drastic and quite traumatic changes that the banking system has undergone in less than two decades. The system has not been able to achieve the typical properties of market-oriented financial systems: flexibility, adaptability, functionalism and resilence.[49] Furthermore, as it

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[49] As presented in Figure 6.A: Components, functions and properties of a financial system (Section 1).

is still in the process of adjusting to the effects of the recent crisis, it is not possible yet to fit the Mexican system into one of the categories presented by either Christensen or Tylecote.[50] Time may help calm the waters and bring the system to a level of stability which leads to more harmonious relations between the two worlds, that of finance and that of innovation.

The handicaps presented in this chapter affect enterprises that are required to respond in a competitive way in the face of globalisation, but are deprived of the financing facilities that globalisation provides. Therefore, as Gruben and Welch have argued, the favourable outlook for the recovering Mexican economy should bring with it an improvement of its financial sector, which is not yet competitive and efficient by developed country standards (Gruben and Welch 1996). The reprivatised banks have failed to lend more actively the resources needed for technology. Furthermore, recent events surrounding the rescue of Mexico's banking system can be discouraging. The increase in volume in the supply of venture capital is not enough in a country where such mechanisms are still in a very early stage. Further institutional development of venture capital mechanisms is needed and remains a long-term goal.

Different institutional setups of financial systems will support or limit the development of relations between the lender and the borrower. A culture must be fostered in which the relationship and communication between technologists and financiers can improve. This indicates that the connection between the development of the financial system and industrial and technical change has to be improved. One possible way to deal with this problem is to foster the development of more specialised financial institutions adequate to the needs of innovating firms. In the words of Colin Mayer:

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[50] See Section 1.

'The distinctive feature of successful financial systems is their close involvement in industry. A primary characteristic of a market-based system is an arm's length relation between investor and firm...The fundamental challenge that faces any institution or government that can affect the practice of finance is to encourage the emergence of closer relationships...(Mayer 1988, 1183)'.

The next chapter focuses on the role of the government in the financing of innovation and its bridging function between banks and firms through its programmes of direct project funding.

Chapter 7
MEXICO'S GOVERNMENT PROGRAMMES FOR DIRECT PROJECT FINANCING: A TECHNOLOGY POLICY CASE STUDY

> 'The possibility of market shortcomings on R&D financing, and the subsequent need for public funding have long been acknowledged ...government intervention is so strongly and universally endorsed that it came through the wave of economic liberalism of the 1980s unscathed.'
>
> OECD, 1995

INTRODUCTION

This analysis of an individual policy case study aims to provide a clearer picture of the interaction between the various players within Mexico's technology system. This chapter brings together the roles of the system's participants in the light of the theoretical aspects, historical background, and Mexico's economic, political and social evolution previously presented in this thesis.

Chapter 6 developed a series of arguments regarding the interaction between firms and commercial banks in a national system of financing innovation. At various stages, the participation of a third, and equally important player was outlined. That third player is the government.

The events that have shaped Mexico's financial system in the last two decades (described in Chapter 6) have caused there to be a lack of effective schemes available for firms to fund technology projects. Private banks are in crisis and do not seem to be a reliable source for technology projects, at least in the short-term.[1] The discussion of the justification of government intervention is of optimum relevance in a situation like this, when the market is not providing the necessary funding. Therefore, development banks and government agencies in Mexico can supply important instruments for long-term funding of technology investment projects, mainly of SMEs.

The policies of Mexico's government agencies featuring the most striking changes in the orientation of their programmes are those related to direct financial support, mainly in Conacyt. Although some important adjustments are also clear in those policies regarding the building up of R&D infrastructure, information and linkage between the academic and private sectors, this part of the thesis concentrates on the specific case of direct project financing.

Not much has been written about these specific programmes in Mexico. This chapter reconstructs the events surrounding the design and implementation of this particular set of policy tools, based primarily on the information given by participants' experiences when interviewed and surveyed by the author. Conacyt's financing instruments are the core of the chapter, but some other institutions' programmes are also reviewed.

This specific policy tool is a significant case study not only for its intrinsic importance. It is a comprehensive example that reflects Mexico's recent history in the light of macroeconomic policy changes: it involves different government institutions and policy outcomes; it involves private firms as the users of the policies and programmes; it involves the financial institutions as intermediaries. Moreover, it generates positive and negative experiences in the country's ability to develop indigenous technology.

[1] See Chapter 6.

Section 1 introduces the general concepts related to the role of government in financing innovation, both directly and indirectly. Section 2 presents two programmes: the National Trust for Industrial Equipment, FONEI - from the Central Bank, BdeM (Banco de México) and the Technology Development Programme of the National Development Bank, Nafin (Nacional Financiera). Both played a role in the funding of technology projects over different periods in recent decades. Section 3 analyses the three stages of Conacyt's evolution of its financial programmes. The Shared Risk scheme, RCM (Riesgo Compartido Multimodal) is the focus of this section as it was the first real attempt to offer funding to private firms for technology projects. The rest of the programmes are presented as a context of the policy directions of each stage. Section 4 is dedicated to the financial programme designed by Conacyt at the time of Mexico's fundamental changes in opening and deregulating its economy and markets. The Research and Development fund for Technological Modernisation (FIDETEC) is a credit programme mainly oriented to the support of SMEs. The internal and external influences for the performance of this instrument are analysed. Section 5 presents the experiences and views of the users of the programmes – banks and firms – and shows the positive and negative effects of the instruments discussed in the previous sections.

7.1 – THE ROLE OF GOVERNMENT

Governments in general play the role of regulator of financial systems (Sally 1995). According to the definitions that Dodgson and Bessant use in their work on the new approach to effective innovation policy, a series of public policies exist for innovation support, ranging from financial support – both direct (grants, subsidies, loans, etc.) and indirect (venture capital) – to the existence of scientific and technical infrastructure (Dodgson and Bessant 1996). Moreover, government intervention can take other forms such as tax policy, subsidies, monetary policy and control of interest rates, as well as allocation of funds differentially to sectors and firms. An interventionist versus a liberal mode of economic environment will inevitably lead to a different setup of financial systems (Rybzinsky 1984). This chapter concentrates mainly on the way in which government acts as regulator of the system, and on its direct funding programmes for private innovation projects.

The innovation process includes a number of factors unknown even to the industrialist involved - not the sort of risk that the financial market knows how to assess.[2] Under-investment would be the inevitable consequence if the government did not intervene in the areas of greatest uncertainty. Those areas are upstream in the innovation process, and basic and pre-competitive research (OECD 1995, 56-62). The problem remains in setting the parameters to distinguish the borders between pre-competitive and competitive stages[3], and the institutionalised ways to determine the stages for specific projects.

The linear model of innovation (basic research, experimental development, commercialisation) is embedded in government notions about its role in supporting technology finance. This linear model is usually linked to the classical justification for government intervention, in terms of market failure (Freeman, Poignant, and Svennilson 1963). Governments therefore have a 'green light' to support pre-competitive R&D but this light turns to amber and red as one moves downstream in the innovation process (OECD 1995, 101-103).
Governments have the potential to explore new, promising technological trajectories without the same dramatic financial consequences faced by the private firm or investor, who may be using a large share of their capital on a project which eventually fails. Many projects are too risky for an individual, but in government funding the

[2] See Chapter 6.
[3] See Chapter 2.

risk is spread. This is one reason why government programmes often target innovation projects in the early stages, where failure rates are high (Christensen 1992,152).

Government R&D spending in industry can affect the supply of industrial innovation through three channels (Mowery 1995, 524-525):

1. Complementing private R&D spending, increasing total industrially-directed R&D investment
2. Serving as a catalyst for inter-firm collaboration, thereby (possibly) increasing the efficiency of private and public R&D investments under the management of industry
3. Targeting specific technologies for support under industrial management.

According to Budworth, government financial support for innovation can take two forms (Budworth 1996, 165-168):

- Direct support. The justification for support schemes is the concern of economists that the amount of R&D performed will be sub-optimal from the national point of view if its financing is left entirely to the private sector.[4]
- Indirect support. R&D expenditure has been a popular object of favourable tax treatment, and several countries have introduced permanent or temporary schemes to encourage an increase in such spending. The argument for giving favourable tax treatment to R&D is that companies cannot afford to spend as much as they would like to, or should do, in the interests of the national economy, given the other pressures on them. The credits are usually offset against tax, but in some schemes are directly refundable, amounting in effect to

[4] The corresponding danger that government support might lead to wasteful expenditure has been less well appreciated, although some cases, such as Concorde, brought it to light (Budworth 1996, 165-168).

a subsidy (Freeman, Poignant, and Svennilson 1963). Some countries are introducing new schemes and others are abandoning or modifying them as there have been instances of abuse.

The nature of the policy instrument required is very different in each case. Tax policies are more effective for addressing general underinvestment in R&D, while direct funding mechanisms are more efficient for specific market failures affecting a particular phase of R&D or a specific category of technology. In either case, once the general policy response is selected, based on initial market failure identification, considerably more analysis is required to design and implement a specific mechanism that targets the market failure without including investment in areas not affected by the barrier (Tassey 1997, 107-130).

In many developing countries, only 'official' banks give long-term financing for investment projects. Development banks have become a very important instrument for economic growth, and they constitute the main, if not the only, source of long-term funding in this type of countries (Araoz 1984, 1182-1189). Kim discusses the extensive use in South Korea of low-interest debt to finance corporate R&D expenditures, and notes that in 1987 more than 94% of industrially-funded R&D was derived from low-interest R&D loans from state-controlled banks and other sources of public funds (Kim 1993).

Governments that rely on broader tax incentives and subsidies to support private R&D investment have little or no stipulation as to the technologies to which the investment should be directed (Bell 1988). Such policies also relieve public policy-makers of a need to make decisions on technologies or markets. Some of these policies do not appear in budget documents as outlays of public funds, and therefore may be preferred because of their lower political visibility. The role of fiscal measures in policies to support technology development has not yet been fully analysed. All OECD member countries allow fiscal deductions for current R&D expenditure, although the treatment varies greatly from country to country (OECD 1995). The acknowledgment of the crucial problems encountered in financing the R&D phase has led to the development of government aids to SMEs and small inventors. This move has been witnessed in all the OECD countries, including those like the United States or Switzerland that have been traditionally reluctant to develop direct aids (OECD 1982).

Another type of R&D subsidy, used by a number of European governments, provides grants to firms for R&D in selected areas. Many of these grants are directed at small and medium-sized enterprises. Little is known about the effectiveness of these programmes, although Vickery's survey provides a favourable summary verdict, implying that the grants did not substitute for expenditure by firms of their own funds and that they did extend and alter the R&D agenda of these firms (Vickery 1988). The economic justification for such subsidies must be based on the uncertainties and limited information faced by innovators, as well as imperfections in the capital markets available to small firms. If a new technology is characterised by important externalities, subsidies may be justified (Katz and Shapiro 1986).

Despite all the benefits that government intervention may bring, there are some drawbacks. Some general points of consensus on the scope of instruments used to support innovation (OECD 1982, 118-126) are as follows:

- Government support measures can be too centralised and overall awareness of government programmes is often low. There is a crucial lack of information at local level for all those involved in innovation financing, thus increasing the difficulty and time required to generate an acceptable project and business plan.

- Informative promotional material tends to be too lengthy and complex, and is often written in official language that is not clear for SMEs.
- Most public support measures involve bureaucracy and, however qualified, this has inherent deficiencies: the filtering of ideas in passing approval stages; the delays in decision-making, especially critical for technological projects; and the risk aversion of the administrators, who tend to give support to projects proposed by larger and long-established firms.
- There has been a tendency towards 50-50 funding. This means that although the government may fund up to 50% of a project, the innovator still has to find the remaining 50% of required funds from private sources.
- Information diffusion on sources/funds takes time, even in small countries. It can take three to four years before a new programme or a new agency gets into its stride.

If the case can be made for a financial market failure in early-stage funding, some governments may respond with loan subsidy programmes; but loans are not a viable mechanism for financing start-up or early-stage firms for several reasons (Goodacre and Tonks 1995; Tassey 1997, 195-197):

- Debt is an inferior mechanism for funding high-risk research with long time horizons, because the potential rates of return on debt are too low to compensate for both high risk and substantial discounting, and the borrower must repay the loan although the project generates no cash flow for some time.
- The lack of information or inability to analyse available information seems to cause lenders to ration credit rather than increase risk premiums.

- Debt has other onerous characteristics, such as making firms more susceptible to takeovers by increasing leverage of their financial structures. This is a particular concern for small firms.

Ironically, in recent years Mexico's government has mainly fostered loan schemes for early stage technology projects. Policy-makers are faced with important dilemmas regarding the public sector's role in financing innovation. The remaining sections of the chapter present some important results of Mexico's government programmes, so that the case of direct technology financing policy can be assessed.

7.2 – BANCO DE MEXICO AND NAFIN

When assessing the government's efforts to directly finance technology projects, the focus has to be on the three institutions which have, since the 1970s, established the most important programmes. These are the National Council for Science and Technology (Conacyt), the Central Bank (BdeM), and the National Development Bank (Nafin). It can be argued that the most important institution is Conacyt as it is the Federal Government's arm for science and technology policy, although financially the other two have played an important role. This section deals with these two parallel institutions' programmes. Conacyt's schemes are analysed in Sections 7.3 and 7.4.

Banco de México's FONEI

The World Bank's Industrial Recovery Loan (IRL) was the fifth in a series of loans to Mexico's National Trust Fund for Industrial Equipment, FONEI (Fondo Nacional para el Equipamiento Industrial) in the mid 1980s. FONEI, established in 1971, was operated by BdeM. Its main objective was to help the long-term financial needs of large and medium-sized industrial enterprises (Nadal Egea 1977, 264-278). It is important to remember that at the time Mexico's economy remained practically protected, with the commercial banks run by the public sector. This section looks at FONEI from the time of IRL because of the latter's new components to more aggressively support technology projects.

FONEI was the executing agency charged with allocating resources offered by both the Mexican Government and the World Bank. With FONEI resources, commercial banks could finance their clients' investments for industrial equipment (Márquez 1982, 74-77). In order to access FONEI's resources, the firms had to present a project that included one of the following investment components: feasibility studies, productivity improvement, pollution controls, or technology development (FONEI-Banco de México 1987b).

The Technology Development subcomponent of FONEI could finance a full range of technology-related activities. The programme supported R&D, adaptation of production means, as well as the design, construction and testing of capital goods including prototypes and pilot plants (FONEI-Banco de México 1987a). FONEI could give up to 80% of the total funds required by the project, and depending on the technological merit of the investment, a maximum of 30% of the budget could be in the form of a grant. Interest rates were 3 points lower than those of the average percentage of banks' capture costs, CPP (Costo Porcentual Promedio), and the loan could be repaid over 13 years, with a three-year period of grace.

FONEI offered an additional scheme of guarantees to protect the commercial banks for up to 90% of the total credit. It did not cover the total as it seemed important to involve the bank in the control of the credit by sharing some of the risk. Also, by giving them an interest in the projects, it was hoped the commercial banks would be less fearful of these kinds of industrial investments – especially the technology-related ones – so it was seen as 'an educational process for the commercial banks'.[5] In the case of technical failure FONEI could absorb 70% of the total losses implied by the project.

According to the completion report of IRL, its task of contributing to financial market transformation and innovations was not achieved. The total cost of the 262 sub-projects approved under IRL amounted to the equivalent of US$307 million. 98% of the projects were presented by existing firms looking to expand, and 89% of the total credit went to large enterprises. The expected demand for such instruments by smaller enterprises and their banks never materialised (Nacional Financiera and World Bank 1992, 10). Results were modest but based on a sample of 41 sub-projects, it is estimated that about 10,000 new jobs were generated.

The programme was carried out in a rapidly changing economic environment. Thus, it is important to bear in mind the macroeconomic context and the transformation of the Mexican economy and its financial institutions at the time. The World Bank recognised that a deeper knowledge of the country's financial sector would have helped to formulate appropriate conditionality to provide more incentives for a better operation of the programme at the time (Nacional Financiera and World Bank 1992).

In the rapidly changing environment of the late 1980s and early 1990s, the consolidation of a number of trust funds in Mexico became a matter of discussion. As FONEI was a relatively small institution, the probability of it being absorbed by a larger entity was high, as was the probability that its programmes would be dismantled. By 1988, new economic policy brought a new financing policy, forcing the development banks to reorient themselves. Nafin had to integrate all of its trust funds in one, including the absorption of FONEI.[6]

[5] Interview # 21.
[6] Interview #18.

In June 1989 FONEI was transferred to Nafin, and shortly thereafter it was fully absorbed into the bank's operations. The change in the role of FONEI, and related financial reforms that were taking place in the country[7] led to uncertainty among the staff of the two agencies as well as their clients. This explains some of the difficulties in realising the innovative components of the scheme (Nacional Financiera and World Bank 1992).[8]

One of the most important assets that FONEI accumulated over its period of operation was the competence of its staff, who acquired high quality evaluation skills and supervision methods. After a continuous operation of 13 years, with only one Director and a close link with the banks, 'a group of evaluators who knew how to analyse a technology project was formed...[yet] it has been lost in time...and it is difficult to rebuild it under the new structures'.[9] With the transfer to Nafin, a significant part of FONEI's human capital was lost (Nacional Financiera and World Bank 1992).

Some of the problems and effects of the transfer of FONEI to Nafin were highlighted by former FONEI executives, who currently work at Nafin.[10] In summary they assess that:

- At the beginning efforts were duplicated and resources wasted. For instance, the computer systems used by the two agencies were incompatible.
- By converting it into a common credit scheme in 1990, much of FONEI's advantages, designed within a technology policy operating in synchrony with the macroeconomic environment before GATT,

[7] See Chapter 6.
[8] A Nafin executive described the situation as 'a 'terrible salad of approximately 34 different funds' (Interview #18).
[9] Interview #18.
[10] Interviews #18 and 21.

were lost. This included the benefits of the 30% grant component of the programme, and the failure costs assumption when projects were not successful.

- As a result of the transfer, FONEI became massive. Only the banks were clients, and FONEI favoured them instead of the firms it had been set up to help.
- Commercial banks tried to fit all kinds of credits into the new technology programme.

Nafin's Technology Development Programme

Since the 1920s, Mexico has maintained a system of publicly-owned development banks and trusts that focus specifically on specialised categories of finance in which market failure has been perceived. From the 1970s through the mid-1980s, the development banks' primary role was financing the government, public sector enterprises, and the large private sector corporations. The development banks' importance in the financial sector ebbed through most of the 1980s as the publicly-owned enterprises to which they lent were sold to the private sector. They regained importance in the 1990s, though the form of development bank lending shifted from direct loans (first-tier operations) to rediscounting paper from banks (second-tier operations). Flows of finance to the private sector from the development banks as a share of total flows in the banking system rose from 10% in 1989 to 30% in 1993 and edged further upward to 30.4% in 1994 (Werner 1995). As of December 1996, the development banks and trust funds accounted for about a third of the total assets of the consolidated banking system and about a quarter of the total loans granted by the banking system (Gruben and Welch 1996, 63-75; IMF 1997, 15-20).

Nafin, Mexico's largest development bank, was created in 1934 and since then has engaged in a multitude of activities, ranging from equity investment in public and private enterprises to acting as fiduciary for the federal government. Nafin has adapted its role according to the prevailing economic and political environment of the country over the years (Ramírez 1986). This section deals mainly with Nafin in the context of the transition from a state-owned banking system to a re-privatised one in the process of economic liberalisation.

After Nafin condensed its trust funds and assimilated those of other institutions (including FONEI) at the end of the 1980s, it was left with a set of six basic programmes including the Technology Development Programme. As will be seen later in this discussion, this latter programme became the counterpart of Conacyt in 1992. The important aspect here is to mention how Nafin's programmes currently operate in general terms.

Nafin's main clients are the banks. The current programmes for industrial modernisation are under the umbrella of the Single Programme for the Financing of Industrial Modernisation, PROMIN (Programa Unico de Financiamiento a la Modernización Industrial). According to its promotional leaflets, its resources can be aimed at six main areas of investment: modernisation, technology development, industrial infrastructure, environmental improvement, passive restructuring or capital participation.

Nafin has its own interest rate and firms get this plus the intermediation points that the commercial banks charge. Loans can be repaid over periods of up to 20 years. For the sub-programme of technology development, guarantees can be up to 80% for micro or small firms, but interest rates are the same. No extra incentives are given to entrepreneurs with high-risk projects.[11]

[11] Everything is seen 'through the same lens...it can be the construction of a sophisticated industrial plant or the opening of a restaurant, it is all the same' (Interview #18).

By 1993, the small grant formerly included in FONEI had disappeared, together with interest rates benefits, high coverage guarantees and risk sharing. All were deleted from the programme. An important reason for these policies was to facilitate Mexico's access to the OECD; the Ministry of Finance (SHCP), required from Nafin a series of documents to demonstrate that there were no internal or external subsidies of any kind.[12]

From the creation of the new programme until 1995 Nafin financed approximately 500 firms. Nevertheless, estimates for 1992 show that Nafin was able to provide financing to only 4% of the approximately 1.5 million small and medium-sized businesses in Mexico, and that even to these, interest rates up to 22% were charged (Castañares Priego 1992). The programme peaked between 1992 and 1994 (Johnson Ceva 1998, 133-138), reflecting the general boom in Mexico of credit of all kinds. Nevertheless, just as in all other cases, the financial crisis of 1995 brought it to a halt.

Since the crisis of 1995 and with the current state of the banking system in Mexico, very few new Nafin credits have been granted, not only for technology projects but for any of the rest of the sub-programmes. It seems as if Nafin has 'stopped being a development bank'.[13] The situation does not seem to have a clear resolution since the SHCP is not open to discussion on alternative ways to provide funds to smaller firms with technology projects.[14]

On the other hand, commercial banks do not take Nafin's guarantees as real ones.[15] Moreover, private banks' credit evaluators are not suitable technology project evaluators, as there are big differences between the

[12] Interviews #18 and 21.
[13] Interview #18.
[14] Inteviews #18 and 21.
[15] Interview #4.

two.[16] When talking about his experience as an evaluator for Nafin's projects, a scientist and entrepreneur points out that he was 'surprised by the viability of most of the technology projects evaluated...the problem is that Naifn's guarantees are not enough for the banks and small entrepreneurs have to give their houses as collateral...it is hard to risk their family patrimony'.[17]

The new design of Nafin's Technology Development Programme has made it more orthodox, less promotional, more bureaucratic, and more distanced from the final clients. It has so far fallen well short of its goal to have an increase of 20% of firms supported per year.[18]

Having now reviewed the programmes of BdeM and Nafin, it is time to shift attention to Conacyt and the evolution of its financial instruments since its creation in 1970.

7.3 – THE EVOLUTION OF CONACYT'S FINANCIAL PROGRAMMES

Some of the most important efforts made by Concayt in the promotion of technology and innovation are concentrated in the financing of technological projects. Since its creation in 1970, Conacyt has featured an array of different programmes to finance technology projects: some in the form of grants and more recently in the form of credit. It could be said that there have been three stages in the evolution of the programmes, going from mere grant schemes to aggressive credit schemes (Conacyt 1978; Conacyt 1986; Conacyt 1989; Conacyt 1992; Conacyt 1993a; Conacyt 1993b; Conacyt 1994c; Conacyt 1994d; Conacyt 1996a; Poder Ejecutivo Federal 1984; SPP and Conacyt 1990). These three stages are analysed below.

[16] Interviews #18, 21 and 23.
[17] Interview #1.
[18] Interviews #12, 18 and 21.

First stage (1971 – early 1980s)

This stage is characterised by a lack of awareness of the importance of the private sector in the process of technology development. The main effort was that of deciding which areas and sectors were to be considered industrially strategic (INIC 1970). This brought with it an isolation from industry's real needs and the projects were basically academic, with no real intention of linking them to the problems experienced by private firms. In this context, grants were the way of financing projects. It was a very similar operation to the scientific and basic research programmes (Comité Asesor de las Naciones Unidas sobre la Aplicación de la Ciencia y la Tecnología al Desarrollo 1973).

The first mechanism to assign funds to the technological area was through the Indicative Programmes of Science and Technology in 1971. These were sectoral tools to plan, promote and fund specific activities. They were meant to link scientific and technological actions with a strategy to solve national development problems, with a hierarchy set according to governmental macroeconomic goals (Conacyt 1978; Nadal Egea 1977). Funding could be used for training or infrastructure. Areas were determined by sectoral studies also financed by Conacyt.

It was not until 1980 that technological projects were differentiated from the scientific ones (Márquez 1982).[19] In 1984 the National Programme of Technology and Science Development (PRONDETYC) was designed, and it defined the priorities for support of technology development activities. Priorities were determined by an annual national convocation. So, based on the previous Indicative Programmes, the new Programme for Technology Projects was created. It gave grants to studies in the defined priority areas, with funding given to researchers

[19] See Chapter 2 for the definition of the concepts of science and technology.

in order to produce generic knowledge rather than to benefit individual firms.

The problem with this programme, just as with its predecesor, was the poor or non-existent link with the needs of firms. It continued to be an academic programme and recipients were concerned with building up their own R&D infrastructure rather than helping to improve industrial performance. The benefits of the scheme were concentrated in the improved equipment of the country's R&D centres. The programme ended together with PRONDETYC, but its limited results showed the need to design future linkage schemes with the private sector (Conacyt 1996a).

Second stage (early 1980s – 1991)

The previous experiences made evident the need to consider the importance of bringing together R&D institutions and industry. Nevertheless, to include firms as subjects of public support meant resolving the dilemma of how and when subsidies were justified.

One way around this dilemma was to make the private companies jointly responsible for the projects. In 1979, Conacyt created the Shared Risk scheme (RCM)[20] which was a basic kind of venture capital programme. Under RCM, Conacyt would invest 50% of the total cost of a project as a credit repayable when results were proven successful. If technological objectives were not accomplished then it would be declared a technological failure and the debt written off. In such cases companies would lose the rights over the commercial use of the

[20] RCM and FONEI were designed at the same time (end of 1978), 'when the Directors of the Central Bank and Conacyt were going to an international reunion in Vienna where they had to show how countries support technology efforts...so, in both institutions we took our pens and wrote the programmes' (Interview #18).

research findings, with the property being transferred to Conacyt (Conacyt 1986; Conacyt 1989).

This first experience with the private sector had some positive technological outcomes. Certain important projects paid back their credits, including some related to optical material and fruit drying processes.[21] But it also faced a few problems:

- Although it was the first formal attempt to support firms' projects, the experience of one user was that 'the rules were more oriented to researchers or inventors, rather than to entrepreneurs...they made me restructure my application to make it look more like a laboratory than a company'.[22]
- There was no proper project evaluation beforehand.
- Credit recovery activities were not strong enough to follow up on the success or failure of projects. Once the programme was closed it became even more difficult to recover the investments.[23]
- In legal terms, with a contract clause giving Conacyt the rights to the project results it is not surprising that companies declared failure even if it was not the case. This way they could avoid the obligation to repay the loan, and still benefit from the research.
- The follow-up and control were weak.[24]

RCM was the longest running programme of the Council, continuing until major policy shifts took place, and a new administration ended it in 1991. The new Director of Conacyt at the time saw it as a scheme that

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[21] Interview #13.
[22] Interview #6.
[23] An entrepreneur recalls that they wanted to pay but 'Conacyt would not make any efforts to recover the loan...they charged us the first instalment, but with the change of administration it took until 1994 to come to an agreement...they said they had lost the files' (Interview #4).
[24] According to users of RCM: 'There was no systemic control of projects in what was supposed to be a shared risk...as entrepreneurs we saw it more as lost money for Conacyt' (Interview #9). 'They never sent evaluators, never asked for reports' (Interview #4).

did not actually share the risk and was mainly an 'assumed risk programme'.[25] To him it was an instrument for indiscriminate subsidies paid by Conacyt, as it did not have any real tools to recover the credits. By not motivating entrepreneurs to conclude their projects, it was a way to 'give away free money', he concluded.

In 1990, the concept of a National System of Science and Technology was included for the first time under the framework of the National Programme for Scientific and Technology Modernisation - PRONACYMT (Nadal Egea 1995; SPP and Conacyt 1990). The system was meant to articulate under the same objectives all public agencies involved in the process of technology development, from the generation of knowledge to its incorporation into productive activities.

The Programme of Industrial Production Technology, TIPP (Tecnología Industrial para la Producción), was designed with the aim of coordinating technology development actions between government and the private sector. It was launched when Conacyt signed an agreement with the former Ministry of Budget and Planning (SPP), the Businessmen Coordinating Council (CCE), and the Confederation of Industrial Chambers (CONCAMIN). The private counterparts were responsible for promoting the programme amongst their members.

TIPP operated by the constitution of a trust fund in which each participant would give –simultaneously and in cash – a minimum of 500 million pesos (1990 pesos). For each peso that a firm invested, the government (via Conacyt) would invest two pesos in the form of a grant: one of those two pesos should be used to solve specific problems of the company, and the other used in projects of generic use to the technology community. In practice, this second peso was never given

[25] Interview #10.

and in 1993 it was agreed that SPP would allocate that money directly to Conacyt's budget (Conacyt 1996a).

In 1991 the programme was no longer open to new participants, but ongoing projects kept operating until their conclusion in 1994. The minimum investment condition restricted the participation of small-sized firms, so TIPP mainly supported medium-sized and large firms with better financial situations and a more aggressive attitude towards innovation.

Third stage (1991 onwards)

This last group of programmes shows the shift from giving grants to giving credits. With a change of administration in Conacyt at the end of 1991, and according to the new economic policies set by the Salinas administration, FIDETEC and FORCCYTEC were created. FIDETEC will be analysed in a more extensive way in the following section. For now, let us look at FORCCYTEC.

The presidential fund, called the Fund for the Strengthening of Firms' Scientific and Technological Capacities, FORCCYTEC (Fondo para el Fortalecimiento de las Capacidades Científicas y Tecnológicas Estratégicas) was established to promote the creation of private R&D centres to serve specific industrial sectors. Unlike FIDETEC, this programme operates with softer financial conditions as the benefit goes to a group of firms rather than one firm. Credits are repayable in ten years with no interest (Conacyt 1994d). It seems a good deal. Nevertheless, demand for FORCCYTEC has never been high. It is difficult to start R&D centres from scratch and particularly so if there has to be a group of firms willing to coordinate the project. In 1995, public R&D centres and individual firms willing to open an R&D area expressed their will to be potential subjects of FORCCYTEC funding, but the rules were rigid and hard to change (Conacyt 1996a).

7.4 – CONACYT'S FIDETEC: THE CREDIT PROGRAMME FOR SMEs' TECHNOLOGY PROJECTS

At the beginning of President Salinas' administration (1988–1994), a completely new culture arose regarding the financing of private sector activities with public funds. Grants were no longer justified unless a clear public benefit was involved: if there was a private and exclusive benefit, the specific private firm should pay for it. With this 'crowding out' attitude from the government, companies should become more proactive. As technology R&D activities are always risky, and as banks had just been reprivatised, credit from them was rarely available. A market failure was evident but, even if government intervention was justified, at this stage projects subject to support had to prove profitability. The new schemes were aimed towards recycling the funds when firms paid back (Chavero González 1993, 107-114; Conacyt 1993b). Conacyt joined forces with other institutions like Nafin and Secofi.

With the arrival in 1991 of Fausto Alzati as Director of Conacyt, grant schemes virtually disappeared and, with the resources liberated from the former programmes, FIDETEC was created under a joint programme with Nafin.

Alzati says that FIDETEC was created in recognition of the financing problem, and that it was aimed at eventually becoming a 'small technology bank'.[26] Due to the initial budget limitations, he recalls that it had to be mainly focused on the early stages of technology development, from the idea to the prototype. The best way to incorporate a comprehensive support programme was to join up with Nafin's Technology Development Programme.[27]

[26] Interview #10.
[27] See Section 2.

Through the joint programme with Nafin, FIDETEC would support the pre-commercial stages of a project, and then Nafin would scale it up to industrial production. FIDETEC would detect and support these kinds of projects with softer[28] credit, and when they grew stronger Nafin would continue the support. Another new player, private banks, had to be involved in the operation of the fund, as deregulation of the financial market was taking place and public agencies should not disturb the market by operating directly with the clients/final users.

FIDETEC was also meant to give special attention to micro and small-sized firms which by nature do not have the financial or technical capacities to engage in R&D. FIDETEC is a fully financial-oriented mechanism, giving credit similar to that of private banks: in fact, the credit scheme function is similar to that of Nafin giving credit via banks (using Nafin as its fiduciary).

Interest rates are either the CPP [29], Nafin's or UDIs [30] rates, plus some fixed points that the banks could charge to the credit holder. Guarantees could be complementary to those of Nafin so that micro and small firms with high technology merit projects could have 100% coverage. In cases of technological failure, FIDETEC can absorb part of the losses, being a risk partner with the entrepreneur, as it gives the guarantees in favour of the firms. FIDETEC, in comparison with former instruments, became a more transparent mechanism for the allocation of resources.[31]

Moreover, FIDETEC has a Technical Committee to approve all proposals applying for funds. Before the sessions, FIDETEC and Nafin personnel carry out financial and economic evaluations. The technical evaluations

[28] For instance giving credit with preferential interest rates or long repayment periods.
[29] CPP (Costo Porcentual Promedio) is the rate calculated by the average percentage of banks' capture costs.
[30] UDIs (Unidades de Inversión) are units of account with constant real value.

are carried out by Conacyt's registered Technology Consultants, and then the IMPI searches for patent duplicity. The Technical Committee is formed by representatives of Conacyt, Nafin, IMPI, SHCP, Secofi, and two representatives from the private sector associations CONCAMIN and CANACINTRA. Alfredo Philips, former Deputy Director for Technology Modernisation in Conacyt, considered the participation of the private sector associations as highly important 'including the regional branches to direct support to their local needs' (Phillips Greene 1994).

Operation and some results

The very first clients for FIDETEC funds were those formerly with RCM.[32] New obstacles had to be set to filter the real technology projects with industrial business orientation; the main one being that credits had to be operated via commercial banks. Nevertheless, working through the private banks caused a series of severe problems, with long delays in the operation of credit and sometimes causing the private firms to lose the technological opportunity. Those firms that are out of the financial system are in a difficult position because they lack the guarantees required by commercial banks to evaluate their credits and access the development banks' resources (Sánchez Ugarte 1994, 127-128).

Regardless of the commercial banks' handling obstacles, there was the need to support firms willing to develop technology projects to compete and survive in the newly opened economy. Efforts were made in different directions to try to make the programme work. On the demand side, an aggressive national marketing campaign was launched in 1993 (Conacyt 1994b). As a result, 115 new applications were

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[31] Interview #14.

received and 71 projects were approved. By the end of 1994, approved projects peaked at a total of 94 (Conacyt 1993a; Conacyt 1994c). Nevertheless, the problem of operating the credits persisted. Only 19 had been processed through commercial banks and 11 had already been operated directly with the permission of SHCP under the new exception clause. The rest continued their negotiations with the intermediaries.

In parallel, and in order to try to facilitate the scheme with private banks, agreements were signed with some of the largest banks to commit them to operate FIDETEC. During the second session of the National Coordinating Committee for Technology Modernisation (CONCERTEC),[33] Bancomer and Banco Union signed agreements (Conacyt 1993a). But they did not prove effective in practice.[34]

Before the end of the Salinas administration, it seemed important to make a thorough evaluation of the results of the programme based on the experiences of the different participants. The purpose was to leave a basis for the new administration to work on to implement the changes needed for FIDETEC to become a programme of broader impact (Conacyt 1993a). A two-day event took place in Veracruz involving entrepreneurs, bankers, government executives, technology consultants and the members of FIDETEC's Technical Committee (Conacyt 1994a). The design, operation, roles of participants, problems and potential solutions were discussed and left in a document for the new administration. As discussed in Chapter 4, the programme was a victim of the government's tradition of not implementing plans or instruments from previous administrations and to substitute them as soon as possible. Thus, when the new administration took office at the

[32] According to the Director of Conacyt at the time: 'as with all institutional reforms there is a historical clientele that you have to face...in this case these clients were used to getting subsidy all their life' (Interview #10).
[33] See Chapter 4.
[34] Interview #23.

end of 1994, the proceedings from the event in Veracruz were simply filed.[35]

Due to the mechanism's own problems and to the new crisis of 1994–1995, demand collapsed. Since 1994, SHCP had authorised that in exceptional cases, FIDETEC could give resources directly to firms when it was proven that no bank would operate a successful FIDETEC application. A new redesign of FIDETEC took place in 1995 allowing it to operate the credits directly with the firms as long as they could provide the guarantees, and interest rates were fixed by inflation rates (UDIs). These reforms have not yet attracted important demand and FIDETEC is practically paralysed.[36]

Assessment of the operation and evolution of FIDETEC and the Joint Programme

Many of the participants of the original Technical Committee (most of whom have remained members) were interviewed for this thesis. Together with the views and experiences of FIDETEC's personnel, an account has been compiled of the main obstacles and problematic situations that have tampered with the operation of the programme. This is shown below, classified by broad subjects.

a) *On the design of FIDETEC:*

- Most of the credit conditions are not adequate for SMEs' precompetitive technology projects. Interest rates, grace periods, repayment conditions, and the lack of a grant component are obstacles for demand of funds.[37]

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[35] Interviews #3, 4, 5, 11, 15, 16 and 17.
[36] Interviews #11, 13, 15, 16 and 17.
[37] Interviews #3, 4, 11, 12, 15, 16, 17 and 18. Nevertheless, according to Conacyt's Director at the time:' the credit conditions were not too benevolent

- The guarantees given by FIDETEC and Nafin are not good enough for the banks, which in turn require additional collateral of up to three times the value of the credit.[38]
- When the programme was designed, a supposed advantage was having banks complete the credit evaluation before giving out the funds. In retrospect, the operation via commercial banks did not work. Banks have no incentive and no idea how to evaluate a technology-related project.[39]
- FIDETEC, like many programmes and policies in Mexico, was designed without knowing the clients and the system in which they have to operate. For instance, small entrepreneurs, researchers starting a new business or SMEs in general have neither the experience nor the personnel to present and defend a credit application for a technology project. They need thorough training and help to build their financial statements or commercial projections. The instrument does not provide for the support of these pre-stages of the project.[40]

b) *On the operation of FIDETEC and the Joint Programme with Nafin:*

- The procedures are too long and by the time a credit is approved the technological opportunity is lost. This happens whether application is made via a bank or via direct credit; the requirements for both options are too complicated.[41]
- Conacyt and Nafin have deep-rooted institutional differences, making them incompatible in their perception of the operation of the programmes. They act like competitors rather than allies.[42]

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but were the correct ones, especially after the experiences with the previous programmes like RCM' (Interview #10).

[38] Interviews #13, 15, 16 and 17.
[39] Interviews #4, 10, 12, 13, 15, 16, 17, 18 and 20.
[40] Interviews #12, 15, 16 and 17.
[41] Interviews #4, 11, 15, 16 and 17.
[42] Interviews #3, 10, 13, 15, 16 and 17.

- The interface with Nafin never worked. The integral scheme does not flow. Firms do not have an automatic entry to Nafin when they finish their precompetitive phase with FIDETEC. They have to start from scratch, losing time and opportunity.[43]
- Neither Conacyt nor Nafin have the personnel or infrastructure to act like a commercial bank and properly evaluate credit. Conacyt has the capacity to carry the technical evaluation but not the financial one.[44]

c) *On the politics and policies surrounding FIDETEC:*

The Ministry of Finance, SHCP, does not want to have state funds operating directly parallel to the private banks. Under the policies operating since the early 1990s, SHCP and BdeM are against subsidies, softer credits or any mechanisms that can disrupt the market. In the case of technology credits, it was a long time before SHCP would authorise the direct operation of FIDETEC in those cases where banks did not respond promptly.[45] Alzati remembers that the subject was 'taboo', and that in an attempt to discuss it with the Minister of Education, Ernesto Zedillo[46], he had 'an absolute negative response, and without his support I could not even try to talk about it with Aspe,[47] thus the initial idea of the technology bank never prospered'.[48]

Sánchez Ugarte, Vice Minister of Industry during Salinas' administration claims that the explicit instructions to channel all financial programmes through the private commercial banks was like 'religious dogma'.[49] Former President Salinas confirmed that an exception regarding credits

[43] Interviews #10, 11, 13, 16.
[44] Interviews #3, 15, 16, 17 and 20.
[45] Interviews #3, 4, 10, 16, 18, 20 and 21.
[46] Ernesto Zedillo became Mexico's President at the end of 1994.
[47] Pedro Aspe was the Minister of Finance during Salinas' administration.
[48] Interview #10.
[49] Interview #20.

for technology or innovation projects was not viable at the time according to the macroeconomic policies coordinated by Aspe.[50]

d) *On FIDETEC after 1994:*

- With the change of Presidential administration, and followed by the country's financial crisis, FIDETEC stopped giving credits and the ones already given were stopped.
- There were policy shifts with the change of President and Conacyt's Director General, but internal personnel changes also affected the programme. The high rotation of personnel, mainly from Conacyt's deputy director level and FIDETEC's director and sub-directors, brought new operation procedures, new programme orientation, new information literature and forms, even a new logo for the programme. It was confusing for the clients and slowed down the whole mechanism.[51]
- As described before, many entrepreneurs, bankers, Technical Committee members and technology evaluators participated in the FIDETEC congress in Veracruz at the end of the presidential administration in 1994. But their recommendations were never given attention by the new administration. The feedback gathered from the experiences of the first years of operation of the programme was lost in the realm of the institutional changes and the financial crisis.[52]
- As a consequence of the financial crisis, a stronger emphasis has been placed on the financial strength of the projects to ensure the repayment of funds and protect FIDETEC's patrimony, thus relegating the technology importance of the projects, which should be the driving force behind the programme, to a lesser importance.

[50] Inteview #19.
[51] Interviews #3, 4, 11, 13, 15 and 16. On the other hand, interviewees agreed that Nafin has a more stable and institutionalised civil service which develops a longer learning process within the programmes
[52] Interviews #4, 9, 11, 13, 15 and 16.

If there are any new credits, they go to large firms with solid finances to guarantee repayment. SMEs have no alternative way to fund their technology projects, since no other mechanism has been designed to replace what FIDETEC used to do.[53]

- As the original objective of the programme seems to be fading away, members of the Technical Committee of FIDETEC have lost interest. They have stopped attending the reunions or send lower level representatives.[54] CANACINTRA's delegate stopped going as he finds the reunions to be 'useless'.[55] The Director General of IMPI regrets that the Institute is no longer consulted before the reunions to check the patents, and sees a diminished role of the Committee members in FIDETEC.[56]

To conclude this section, it is relevant to quote ex-President Salinas' comments when asked about the role of financial programmes like those of Nafin and Conacyt to support SMEs and their technology projects:

'Development banks like Nafin and agencies like Conacyt play a very important role and their programmes should be more continuous...technology is vital for Mexican firms competing internationally...there can be a market failure in the supply of funds for technology projects where government intervention could be justified, but during my administration that was not recognised, we tried to downsize the government' s role, and we thought the new model of market deregulation would cover it'.[57]

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[53] Interviews #4, 11, 12, 13, 15, 16 and 20.
[54] Interviews #3, 4, 11, 15 and 17.
[55] Interview #4.
[56] Interview #11.
[57] Interview #19.

7.5 – THE OTHER SIDE OF THE PROGRAMMES: THE 'CLIENTS' AND THEIR EXPERIENCES

Banks

As seen in Chapter 6, private banks are reluctant to finance innovation and technology development projects. They are even more reluctant if they are dealing with SMEs. Therefore a case for government participation to provide the funds for these activities can be defended. This chapter has shown the evolution of Mexico's instruments to finance these activities via the government.

One of the most important aspects of their recent redesign to operate via private banks has proven a bottleneck. The commercial banking system in Mexico has not met the expectations of being the main operator of governmental funds for technology. The initial idea was for the government to provide the funding while giving the recently privatised banks a 'learning by doing' opportunity about the benefits of financing innovating firms. This has clearly not happened. As discussed in the previous sections, the government and private firms blame the private banks for the stagnant situation in the financing of technology projects. Apart from the deficiencies attributable to banks and their current situation since the 1995 crisis, some other issues seem to affect their negative attitude towards these kinds of programmes. Therefore, it is also important to consider the opinions and experiences of the private banks when analysing the operation of funds like FIDETEC and the Joint Programme with Nafin.

When asked about the way in which they see those instruments, the credit evaluators interviewed seemed to agree on the following views:[58]

[58] Interviews #22, 23, 24 and 25.

- The agreements of the government and banks to operate the funds are political ones and never really work. They are signed by top level politicians and banks' presidents or chairmen.
- They are designed from the politicians' desks and they do not match the ways in which banks operate.
- An inter-bank committee has been established to discuss different issues. One of the subjects on which all participants agree is that the government keeps designing instruments that are not good business for banks. The margins are too small for the work and investment needed to manage them.
- The guarantees are only for contingencies and they imply a cost to the bank. The banks are responsible for the recovery of the credit once the guarantee has covered them.
- Technology projects are too risky and complex to evaluate and manage. It should be up to the government to support them with types of instruments other than credit.
- The banks have established general conditions that their credit-holders must meet. The profile of firms applying for governmental funds rarely complies with the banks' profile of creditworthy clients.
- Banks do not trust the government because it changes its policies frequently. Experience shows that programmes open and close down too fast. Banks do not want to get involved and be left with a problem when new administrations in the government decide to create a new instrument and forget the old ones.

This shows that there are always at least two sides to a story and aptly demonstrates the ineffectiveness of communication between the participants in this supposedly integrated system for financing innovation in Mexico.

Even if the majority of banks are not willing to operate funds like FIDETEC, some potential lies in medium-sized banks like Banorte which seem open to exploring and operating technology schemes. Moreover, Bital, a rapidly expanding bank, has redesigned its operation to give more importance to technology for environmental projects.[59]

Firms

This story has a third side: the perspective of the final users of the instruments analysed in this chapter, that is, firms with technology projects financed by a government programme.

Out of the 77 firms surveyed during fieldwork, 59 actually applied for funding from one of the programmes described (RCM, FIDETEC or Nafin's Technology Programme) between 1981 and 1996. [60] The other 18 were either unable to fulfil the requirements or were disappointed with the long and bureaucratic procedures involved. Of the 59 applicants, 45 claim to have received support even if the process was long.[61] The experiences of those 45 firms reflect how innovating SMEs in Mexico engage in their projects with government agencies as an ally.

As the survey sample was generated from directories of the main financing programmes of Conacyt and Nafin the results presented here do not differentiate between specific programmes (unless a result is directly linked to a programme), as the purpose is to give a general idea of the way in which firms and government interact in the process of funding technology developments.

According to the respondents, 93% of them feel that their applications were approved due to the technical merits of the project.[62] Almost half of the projects mentioned by the entrepreneurs relate to pre-competitive stages, and the other half to industrial-scaling stages.[63]

[59]Interviews #23 and 24.
[60] Author's Survey: Questions #30 and 46.
[61] Author's Survey: Question #21.
[62] Author's Survey: Question #53.
[63] Author's Survey: Question #24.

Nevertheless, none of the firms that used FIDETEC for initial financing of a pre-competitive project found an easy way to 'jump' to Nafin's programme.[64]

Technology projects have two important timing aspects. On one hand, they must catch their opportunity while they are still innovative; thus the start and completion must be prompt. On the other hand, the complex nature of an innovation and the uncertainty of the results can make for a long process, so long-term funding and flexible financial schemes must be available to adjust to the situations as they arise. This duality requires financial institutions and programmes (either private or government ones) to be willing to respond quickly to their applications, and then to commit to them with adequate terms according to the nature of the projects. The example of González Camarena, the famous Mexican who invented colour TV, is a typical case of the absence of support to develop an innovative project. He had to sell his project to the Americans when he could not find the funding to develop it further (Sánchez Osio 2001).

Figure 7.A shows how lengthy the financial programmes of Conacyt and Nafin can be. The operation rules state that applicants should have a response within three months from the submission of the forms. Only 13.3% of the survey sample received an answer within three months; 22.2% waited up to six months and almost 65% had processes that took from six months to more than two years.[65]

Once approved, credits' funds still had to find a way to be channeled to the firms. The process of negotiation with banks could bring further delays. If no bank would operate the credit, an application to give the funds directly (in the case of FIDETEC) was started. Alongside the development of the project, firms needed to adjust to a certain degree

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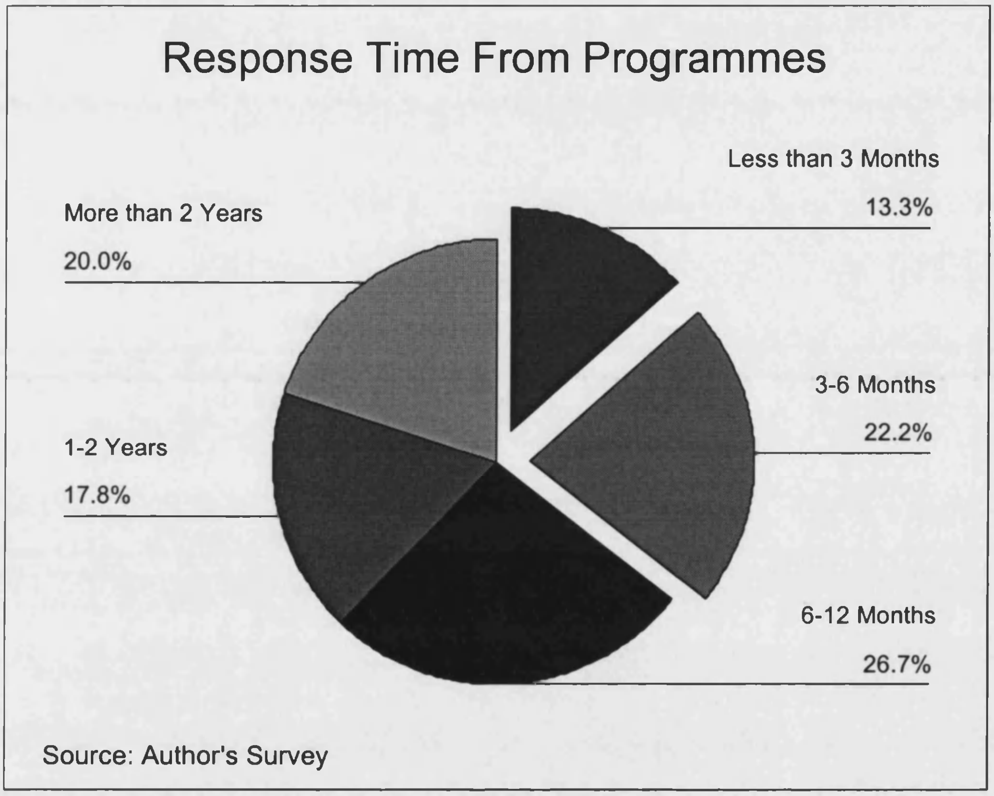
[64] Interviews #13, 14, 15, 16, 17 and 18.
[65] Author's Survey: Question #52.

their completion times, budget, costs, etc. New procedures to restructure the credits are constantly started.[66]

Figure 7.A. Respondents' answers to the question: How long did it take you to get a response from the programme you were applying to?



According to the survey, these latter situations can be just as difficult for the conclusion of the project (See Table 7.1). Out of the 53.8% of firms whose projects did not end in the time planned, almost 50% attributed it to funding or financial problems.[67] Moreover, fewer firms started their projects late, but of those who had delays, 70% said the cause was related to the funding.[68] Most of them explained that they used their own resources first while waiting for the government funds.

[66] Interviews #2, 5, 7, 8, 13, 15, 16 and 17.
[67] Author's Survey: Question #32.
[68] Author's Survey: Question #31. It is important to mention that those who started on time did not by definition mean that they did not experience no difficulties with the funding from the programmes.

Table 7.1. Respondents' answers to the questions: Did your project start and end as planned? Why?

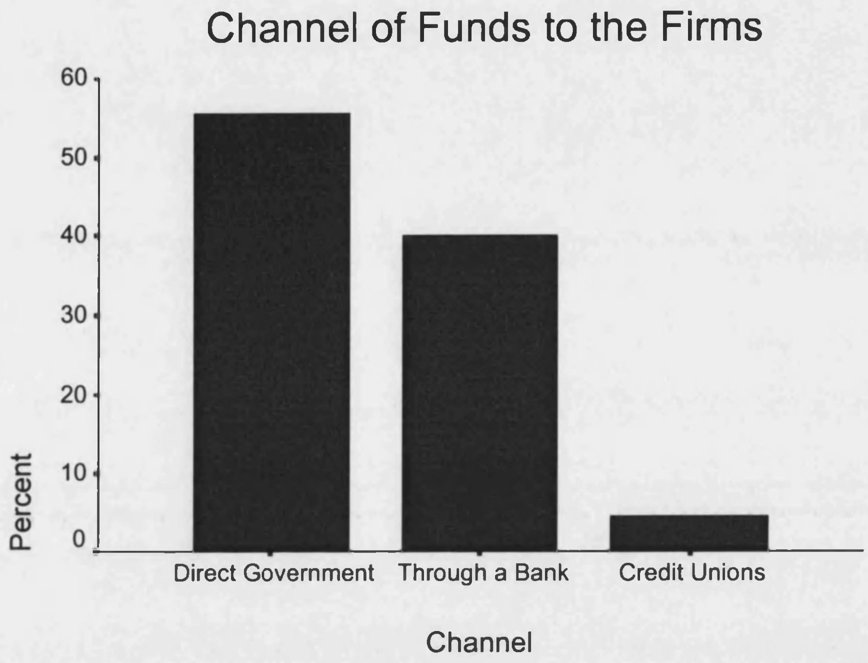
	Yes %	No %	If No, was the cause funding or financial delays? Yes %
Project started as planned?	68.3	31.7	70.0
Project ended as planned?	44.2	53.8	48.3
Source: Author's Survey			

As discussed earlier, the problematic situation of private banks, which are expected to operate as the managers of the credits approved by the government's programmes, makes it difficult for firms to access the funds via a commercial bank. RCM could operate directly, but FIDETEC and Nafin were not designed that way. They should only operate via banks. Nevertheless, with the SHCP authorisation to operate FIDETEC directly in exceptional cases at the beginning of 1994, a group of projects that were previously stuck in the process were given their resources through Conacyt. Figure 7.B. shows how important the direct operation has been in financing the approved projects.[69]

Apart from the importance of giving funds to technology projects, the government programmes are implemented with the intention of being a catalyst for the market to start operating by itself. Government participation should gradually reduce, leaving the system to work on its own. For instance, FIDETEC was conceived as a temporary corrective scheme to cover the deficiencies of the financial markets of the country.[70]

[69] Author's Survey: Question #48. The responses do not include Nafin as it does not operate directly.
[70] Interview #10.

Figure 7.B. Respondents' answers to the question: How were the resources given to your firm?



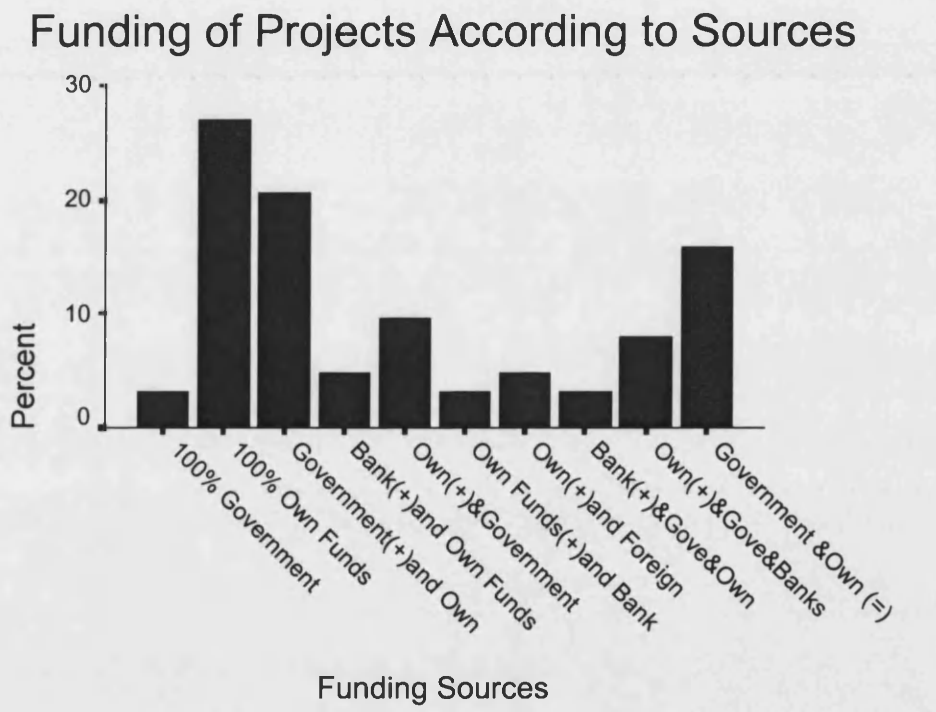
Source: Author's Survey

This explains the importance of having the banks involved and making them understand the needs of innovating firms. Furthermore, firms need to learn how to deal with credits. It is, at least in the conception, a learning process for both, fostered by the government while the dynamics mature. The fact that FIDETEC and the Joint Programme with Nafin require firms to invest part of the total, and that they want banks to operate the credits and absorb part of the risk by not giving them full guarantee coverage, are examples of this intention. Firms have started being responsible for their share of the investment as, in the end, they are the beneficiaries of the project. Figure 7.C shows how almost 30% of the firms surveyed have had to finance their projects completely when the state or the banks did not give them positive or rapid responses.[71] Those who funded their projects between the government and the firm, either with one part investing a larger percentage or with

[71] Author's Survey: Question #43.

50-50 funding, accounted for 46% of the survey sample. There were no instances in which banks participated with 100% of funds: they did participate as the main contributor of funds in 8% of the cases, and involved their own resources in some way in almost 20% of the cases. There is a long way to go before the system can be regarded as mature, and government participation will be playing a vital role, at least in the short-term.

Figure 7.C. Respondents' answers to the question: How was the project financed?



Source: Author's Survey

As has been discussed throughout this thesis, changes of President, Institution Directors, and rotation of personnel at all levels imply shifts of policies and orientation of specific instruments. Sometimes those shifts have been drastic. Entrepreneurs negotiating with government agencies have to learn how to deal with these situations, especially when lengthy response times and consequential delays to the development of their projects force them to confront different faces and different rules en route.

Table 7.2 summarises the number of personnel changes that surveyed firms witnessed during the development of their project, from the application for funds to the conclusion of the project itself.[72] Only 3% have not experienced a change of Director of the Institution or changes to the specific Programme. The most striking aspect here is that the longest term for such a project can be 15 years, but almost 60% of these firms were established between 1989 and 1998 [73], reducing the time to nine years for more than half of the cases. 40% of those surveyed have experienced two changes in programme director, and 24% three or more changes.

Table 7.2. Respondents' answers to the questions: How many changes of personnel took place during the development of your project? At which levels?

	Rotation of personnel at different levels (%)			
Frequency	Institution Director	Programme Director	Mid-level personnel	Technical personnel
Never	3.03	3.03	15.15	33.33
Once	57.57	33.33	33.33	45.45
Twice	30.31	39.39	33.33	15.15
More often	9.09	24.24	18.18	6.06
Source: Author's Survey				

According to a FIDETEC mid-level executive, 'changes in the programme director are the ones with the highest effect, because that person is the one that puts together the main institutional policies, inter-institutional negotiations, problems with the banks, and the needs of the firms...at that level there is an important political weight plus a capacity to operate and orient the programme according to more

[72] Author's Survey: Questions #60 and 61.
[73] See Figure 6.C in Chapter 6.

personal styles'.[74] This in turn impacts on the way firms interact with the institution. Those impacts range from redesign of main policies to the attitude with which the bureaucrats treat the entrepreneurs; the latter being the most important as it is at this level that the entrepreneur has more contact with the institution. 76% of the respondents feel that these changes affected their projects (see Table 7.3).[75] The effects can be in the form of: new and inexperienced personnel; less interest in the programme by the new executives; and all aspects related with the lack of a civil service and therefore continuity of former schemes.

Table 7.3. Respondents' answers to the questions: Did changes of personnel affect your project? In which ways?

Effects of changes	Yes %	No %
Policy and programme changes; Destroy the former; No continuity	50	50
Internal institutional disorganisation; Less follow-up; Slow procedures; Bad service	65.4	34.6
Lack of civil service; Change of attitude; Unexperienced personnel; Less interest	76.9	23.1
Source: Author's Survey		

Regardless of what seems like a difficult experience for firms dealing with government agencies, when rating the average quality of the service provided the respondents were not that critical.[76] Just over 10% gave the lowest marks to bad or poor service. 31% gave the service the top mark (5), and the remaining 58% considered it to be either adequate or good enough. All in all, 88.7% of the surveyed

[74] Interview #16.
[75] Author's Survey: Questions #62 and 63.
[76] Author's Survey: Question #51.

entrepreneurs would recommend other firms to seek government support.[77]

As discussed in the previous sections, one of the main criticisms of the different government programmes was the lack of effective control, supervision and follow-up evaluations of the projects. It seems as if this historical handicap is being corrected. 86.7% of the firms with governmental funding for their projects say that they were visited by evaluators to assess the viability of their project and 82.2% confirmed that they had follow-up evaluations.[78]

When interviewed, some of the entrepreneurs expressed regret that FIDETEC does not give funds for the industrial scaling of the projects, as they lose continuity and in most cases become stuck with prototypes. They do not see strong support for technology in the country. They see FIDETEC as a small programme with plenty of limitations.[79]

Evidence shows that all is not necessarily negative in the way firms perceive their relationship with the government, but there is plenty of room for improvement if there is to be an effective technology development market in Mexico, especially one where SMEs play an important role. There are small firms with substantial projects, some of them already implementing new technologies into their processes, some even exporting their innovations. The government programmes have already been involved with projects like these. As shown in Appendix 2, they come from a range including such technologies as a new process for gold and silver extraction, safety clips for courier packaging, a revolutionary bactericide and new filter jars to catch cow's embryos, as well as locally important projects like a maize mill to

[77] Author's Survey: Question #70.
[78] Author's Survey: Questions #54 and 55.
[79] Interviews #2, 3, 4 and 5.

produce enriched *tortillas*, a process for stuffing and preserving *jalapeño* peppers, or the adaptation of *maracuyá* (passion fruit) to suit the climate conditions in Mexico, where it had never been grown.[80] As the Director of the IMPI argued when talking about the importance of supporting and financing indigenous innovations in the country: 'If one in ten supported projects succeeds, it will cover for the nine failed ones and more'.[81]

CONCLUSIONS

This chapter presented the case of a specific technology policy tool: direct project financing. The discussion of the justification for government participation showed that there are situations in which the government may act to support firms in their efforts to develop technology. Such cases are mainly the financing of pre-competitive R&D activities, highly innovative proposals involving long-term development and high risk, and those projects being developed by small firms with limited access to commercial bank funding.

It seems as if in Mexico, direct project financing schemes have not yet found a way to operate that allows the government to channel resources effectively to innovating SMEs. Based on the findings presented throughout this chapter, a series of vicious circles can be detected. On the one hand, the government designs programmes aimed at supporting private firms' technology projects without really understanding them as their clients. Those programmes have not been fitted to the real needs and nature of technology projects. Moreover, the changes in government policies often affect the way in which specific schemes operate. Thus, information diffusion and the learning

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80 See Appendix 2 for examples of specific technology successes in Mexico and their experience with the government programmes.
81 Interview #11.

process for the clients to understand the way in which a government programme works are affected by those constant shifts.

After experiencing difficulties in achieving successful results, the government changed its former soft-credit and grants programmes to credit-oriented ones by the end of the 1980s. Considering itself not qualified to evaluate credit, the government delegated that function to the recently privatised banks. But again, the programmes were designed without knowing either the capacities, needs or problems of the immediate clients: the banks. At the time the new schemes were implemented, the Ministry of Finance and the Central Bank had the confidence that the banks would know better who was a good credit holder. It did not happen that way. Now it is well known that they did not know how to measure the risks. Even worse, bankers and their credit evaluators have neither knowledge of nor interest in technology projects; especially if the applicants are small firms. The whole mechanism of operation through banks collapsed and there is no alternative effective model to substitute it with. The direct operation may be a way out in the short run but care should be taken not to fall back into the previous programmes' vices.

In summary, banks are not playing their role as intermediaries. Government agencies' programmes and development banks are stuck with their trust-funds not operating. When none of the parts involved understands each other, chaos is likely to arise, leaving the final users – small private firms – without the necessary support to develop their technology projects.

Government intervention is not a popular policy nowadays, so not only the effort to justify it is wasted, but so are the allocated resources for these purposes if the government does not understand the financial system's current situation, as well as the peculiar characteristics of technology projects. The public sector must continue to adjust its national financial policy and in doing so, it should aim at being an instrument for technological and industrial development; being an effective regulator of the financial system; creating an internal capital to finance long-term projects and strengthening the development banks to intervene when needed. Its role as a regulator of the system is crucial. If the government decides to continue its support for technology and innovation developments within firms, it should do so in an articulated way with its clients and intermediaries. Only then will it render positive effects in the development of indigenous technology capacities which, as discussed throughout the different parts of this thesis, have a potential worth exploiting.[82]

[82] For examples of recent successful technology projects carried out by small Mexican firms see Appendix 2.

Chapter 8
CONCLUSIONS

This thesis began with the hypothesis that the poor performance of the innovative system in Mexico can be explained not by headline policy shifts, such as stabilisation and liberalisation, but rather by political economy deficits -notably conflicting interests - within the national innovation system.

Successive chapters have sought to elaborate this argument and to provide evidence to justify the key questions raised. Having developed a theoretical framework in Chapter 2, which explained the link between economic performance and investment in innovation, Chapter 3 demonstrated that Mexico exhibits a poor national system of innovation in comparison with not only those countries at a similar level of development, but also its key competitors and those advanced economies with evolved systems of innovation support.

The subsequent three chapters disaggregated the national system of innovation into three interrelated components, and examined the nature of each and the processes connecting them. In the case of government policy, Chapter 4 demonstrated that there is no coherent approach, either within any one administration, or over the 30-year period in question. This lack of coherence was shown to impact particularly strongly upon SMEs. Chapter 5 showed that despite strong demand from SMEs for assistance in realising technological investment, the inefficiencies of the system, compounded by the poor representation by business organisations, inhibits the potential of these companies to innovate. Chapter 6 revealed that the banking system is similarly failing to foster investment in technology by its reluctance to fund activities perceived as risky and slow to offer returns.

The detailed case study presented in Chapter 7 centred around the government's mechanisms for direct project financing, demonstrating the need for the government to actively participate in conjunction with the market. However, the evidence presented proves that these particular initiatives have been unsuccessful as a consequence of their inappropriate design in the Mexican context.

This evidence supports some concluding remarks. As a starting point it can be said that technology has an effect on economic growth. As discussed throughout the thesis, it should be borne in mind that both theorists and empirical studies argue that technology has a direct link to economic growth. Thus, nations, whether developed or developing, have an interest in the strengthening of their technology capabilities, though keeping in mind their context of differing national endowments and capacities. That is, not viewing the strengthening of technological capabilities as a one-size-fits-all package. The same can be said about firms and organisations within nations, whether large or small; all have to be concerned with their technology capacity in order to compete both domestically and internationally, again, bearing in mind their own particular context. The case of Mexico and its SMEs is no exception. Recent research has demonstrated the intimate relationship between entrepreneurship and regional and local development. An ability to innovate developed within local inter-firm networks both supports existing firms and presents opportunities for entrepreneurs to start new businesses in order to serve newly identified markets.

It is difficult for any solution from one place to work as effectively when transplanted directly into another environment, with its unique culture, capabilities and networks. Policies work best when they are tailored to local conditions. The same applies to domestically-developed technologies incorporated into local firms that provide services according to the conditions of the national market.

The Mexican system of innovation has the same main actors as any national system of innovation. There are providers of technology services to the industry; firms in need of technology; institutions and public agencies involved in the promotion of technology development; intermediaries and bridging institutions; and finally a legal framework to protect industrial property rights at international standards. Moreover, there are indeed firms that have achieved industrial application of their new technologies, and some that are even exporting it. The problems, therefore, do not lie in the existence of players and infrastructure. Rather, they are related to the interactions, coordination, communication and lack of unified goals among them. Principally, the short-termism of almost all actors in the system clashes with the lengthy innovation processes and long-term nature of technology development. For instance, the nature of Mexico's political system has encouraged a reinvention of policy every six years and this has resulted in a lack of stable institutions and continuous policies aimed at the strengthening of long-term capabilities.

These problems are reinforced by the absence of effective pressure mechanisms to negotiate with the government, as the formerly overprotected private sector has suffocated business associations which have been more an ally of the government than of the SMEs. Therefore, technology policy has been designed from the desks of top politicians without consideration and understanding of the real needs of the end-users. Moreover, they have been implemented by a weak bureaucracy that has responded solely to the interests of politicians or high level officials.

User firms have frequently been isolated in the middle of their projects when they are caught by policy shifts inspired by a new presidential term or even by changes in those officials responsible for agencies and programmes. The specific policies may be in accord with, and directly related to, the macro-economic policies operating at any one time, but the problem is that those macro-economic policies have themselves shifted drastically over short periods, either because of new conceptions of the role of government, or in response to the recurrent economic crises of the past three decades. Thus, those shifts in public policy in such short periods of time tend to disorient the private sector, which is already facing fierce international competition with a considerable technological gap. This not only has negative technological and economic effects, but leads to a mistrust of government – firms no longer want to get involved with government programmes due to the uncertainty of their continuity.

The apparent contradiction between a strong state which cannot effect long-term, coherent policies may be explained by the structural differences between such authoritarian states. Not all authoritarian states have the same goals and *modus operandi*. Since the 1920s, the state goals in Mexico have been dominated by the priority of maintaining political stability. This dominant goal has been transformed into a short-term objective of maintaining the state party officials in power by all means. This has had a negative impact on the realm of technology and industrial policies (Evans 1995; Nadal Egea 1995). Moreover, a weak rule of law coupled with a lack of both accountability and a democratic political system undermine the possibility of designing and implementing a strong and robust science and technology (S&T) policy which is not subject to manipulation. Without political accountability and effective representation it is difficult for firms to demand the continuity required for innovation and technology projects.

In spite of this, some theorists opposing state intervention say that the private sector has sole responsibility for technology, and that the market is to be left alone to provide the necessary resources. Some even argue against *any* state participation on the grounds that the market is better placed to assess its own requirements, and state intervention is bound to fail. Nevertheless, the arguments presented in this thesis provide justification for the government to intervene and channel funds to develop the country's technology capabilities. Nevertheless, the most important aspect of such intervention is the kind of role the government should have, being the provider of the appropriate framework for innovative performance in combination with justified cases of selective participation. Other countries, like Hong Kong, have opted for an exclusively framework technology policy participation, whereas others, like Singapore, use a combination of framework and selective intervention. This thesis argues for Mexico's government important participation in both lines of policies, at least while the economic environment of the country improves, and companies are in a better position to engage in technology-related activities.

This is most critical for SMEs which do not have their own financial capacity to bear the costs associated with innovation and technology developments. Furthermore, the recently reprivatised banking system has been too concerned with the recovery of what it paid to buy the banks and with the effects of the 1995 economic crisis. Its attitude has been to finance short-run/high-return projects rather than investing in high-risk/long-term technology projects. The public sector, in consequence, needs to review its national financial policy and in doing so, aim it towards being an instrument for technological and industrial development; being an effective regulator of the financial system; creating internal capital to finance long-term projects; and strengthening development banking to intervene when needed. Its role as a regulator of the system is crucial.

The conclusions that Wionczek (1981) presents in his work, following his ten-year period of analysis, could be extrapolated to the whole period of this study. In particular, his hypothesis that the formation of any long-term and coherent policy in this field is not viable in Mexico can be defended by analysing Conacyt's activities during recent years.

Another interesting parallel is that he underlines the fact that, with the economic/financial crisis of Fall 1976, many of the science and technology promotion activities were suspended, significantly reduced, or allowed to stagnate (Wionczek 1981). The country has since faced three more crises, in 1982, 1987 and 1995, which have rendered similar negative impacts on the strategic field of science and technology, proving once more the lack of memory within Mexico's policy-making system.

Without learning from these past experiences, Mexico runs the risk of becoming marginalised in a continuing cycle of unsustainable growth. As Lee and Swagel rightly argue, developing countries undergoing trade liberalisation and structural adjustment programmes, *unaccompanied by requisite technological change* may get locked in a 'development trap' as they concentrate in low technology and resource intensive industries (Lee and Swagel 1997). This thesis has demonstrated the reality of this fear and in so doing has reaffirmed the importance of the relationship between economic performance, technology and innovation. Novelty being so important as many can follow up a thing when found, 'but to find it first is the gift of the few' (Gracián 1637).

Policy recommendations

By approaching this subject from an original perspective, this thesis suggests new directions for state technology policies which can only work as intended in a climate of macroeconomic stability, external openness, and market-based competition at home. Moreover, state power should be directed towards enhancing private productive capacities through responsible public management. Without state reform -in particular the setting up of a politically neutral and highly specialised 'S&T bureaucracy' in charge of innovation and technology policy- no single instrument or programme will bring long-term results. A predictable environment of political operation and decision-making is a prerequisite for long-term investment. This section presents a series of specific policy recommendations which can only be feasible if the economic and political stability premises are understood.

Focusing on the problems encountered by SMEs, standing at the intersection between innovative development and national economic growth, this work helps to re-centre concerns away from the funding of R&D *per se* towards its realisation in the productive sector. Therefore, new policies should focus on facilitating the long-term investment in technology and innovation by SMEs. Macroeconomic policy stability and permanence as well as its repercussions for industrial and technology policies form the basis for a company's adequate long-term planning and decision making.

Based on the general conclusions of this study, and following Evans' (1995) main argument that state involvement is a given and that the appropriate question regarding intervention is not 'how much' but 'what kind', a number of specific policy recommendations can be made under five categories:

1-*Institutional strengthening, stability and permanence*

- Conacyt must develop a 'S&T civil service' composed of officials and engineers capable of designing, setting up, implementing, controlling and evaluating those programmes directed towards the encouragement and financing of innovation activities within private firms. Such a bureaucracy would acquire enough knowledge to make sure the rest of the policy recommendations presented in this section are pragmatic and efficiently managed within Conacyt and in coordination with the rest of the public agencies involved in related policies such as the building up of R&D infrastructures, education and training.

- Public agencies participating in the National System of Innovation, with Conacyt at the core, have to work on a more coordinated and integrated agenda. Every organisation should develop well established career civil services, with a clear division of responsibilities to avoid duplicity of functions and optimise resources. They need to prevent drastic policy shifts and high personnel rotation which inhibit long term-stability of institutions and confuse their 'clients', namely private firms.

- It is important to continue strengthening the legal framework to protect innovation and industrial property rights to match international standards. As SMEs have difficulties in following the advances of technology developed outside the country's borders, the government needs to support firms through technology forecasting and through establishing international rules for the sharing and protection of intellectual property rights.

2-*Coordination among public and private institutions and investments.*

- It is important to encourage the interactive learning between producers and users by establishing close cooperation programmes with both suppliers and consumers. Also, it is important to ensure good communication between universities and schools on the one hand, and firms, on the other. Moreover, it is crucial that the knowledge created in one firm is used to stimulate innovation in other firms. Seminars, conferences, technology-related fairs are important means for firms to interact with each other.

- In order to understand the real needs of the private sector, the government has to find alternative ways to dealing mainly with formal business chambers and associations. Meetings between government officials and entrepreneurs should be established for both sides to exchange points of view, experiences and feedback.

- By supporting education and training systems, the government can help to lower the costs and facilitate the creation of capabilities in firms. Likewise, by supporting public research, the universities and basic scientific research, the government indirectly encourages firms to invest in their own R&D to be able to tap into a more extensive external network of research. Thus, public research acts as a catalyst for the widening of private research.

- The fiscal policy related to incentives for R&D expenditures has to be revised for it to constitute a real benefit for the firms taking risks by investing in innovation projects. Deductions and tax credits have to be increased to match those policies existent in countries such as OECD members or Mexico's main trading partners.

3-*Availability of funding for innovation projects in SMEs*

- Alternatives to commercial banks' credit have to be designed for the funding of technology projects, mainly those emanating from SMEs. The government can provide programmes tailored to the specifics of such projects, providing a grant component, a long-term recovery plan, below-market interest rates, and that accept the technology development itself as collateral. A professional and specialised team of evaluators, advisors and controllers of such financial schemes is required if they are to succeed.

- The government should participate temporarily while the financial system recovers from the recent crises and learns to communicate with the productive sector and to understand the importance of upgrading its technology apparatus. Therefore, it is necessary to promote close finance-industry relations based on mutual sense of purpose. These relations in turn have to stretch over a long time span due to the nature of innovation processes.

- One way of providing funds to SMEs with high growth potential is through venture capital which in general is a key source of long-term funds to smaller firms. An important benefit of venture capital is that the investors usually work closely with the entrepreneurs who have created the business. The government can create venture-capital style schemes to generate an initial market for the financial sector and potential private investors to understand the benefits of participating in innovation projects. It can eventually withdraw its seed investment and leave the venture capital market to work on its own.

4-*Public and private R&D infrastructure for technology and innovation*

- The government can promote benchmark studies to compare the national system of innovation as a whole with those operating in other countries, to highlight missing linkages and promote closer cooperation among the participants.

- It is important to evaluate whether specific regions in the country have potential innovative capacities in any given area of R&D. In this respect, the institutional arrangements, local industry and technology specialisations of regional systems of innovations should be supported in conjunction with local government agencies.

5-*Technology policy in an open economy*

- One last set of policy recommendations is based on the fact that Mexico is an open economy exposed to globalisation trends. Therefore, the government has to be aware of the impacts of globalisation in the field of technology and innovation, and how it can play a role for the country to take advantage of the fact that knowledge is easily transferred across countries. Thus, public policies and instruments have to be targeted to exploit internationally the innovations generated domestically. For instance, it can support national firms to appropriate their innovations by preserving and developing competitive advantages in technology-based industries. It can do so by organising conferences and workshops where entrepreneurs are informed about exports opportunities, processes to secure property rights, aspects of fair competition, and the importance for firms to reinvest profits in new innovative projects of international scope.

- Even if this thesis has emphasised the importance of indigenous innovation, it has also highlighted the importance of technology transfer and adaptation of imported technologies. Thus, international cooperation is another important aspect for the public institutions. Scientific exchange programmes should be organised, resources and incentives must be destined for international scientific projects, and infrastructure for technology collaboration should be developed. Moreover, foreign direct investment has to continue being an important aspect of technology transfer into the country. Therefore, the government must provide real incentives for the location of new innovative activities with foreign capital, and should promote the collaboration between national firms and foreign leading firms that operate in the country.

The policy recommendations presented above need to be included as part of an integral vision of the country's development, which should seek to maximise the utilisation of domestic technologies that will allow the accomplishment of short-, medium- and long-term objectives. In other words, Mexico's technological development can only occur effectively when the government appreciates the need for a holistic approach, including the development of a strong and specialised bureaucratic apparatus and overall policy coherence. It must take the lead to coordinate the participants of the innovation system under common goals, which must seek to be coherent, consistent, flexible, complementary and realistic.

Future research

The exhaustive quantitative analysis in relation to the experience of Mexican SMEs engaged in technology activities provides strong evidence to support the majority of the arguments presented above. Nonetheless, the impact of bureaucratic fragmentation was assessed through a limited study of the application of one policy by a group of government institutions. Although one has to be circumspect in generalising from this restricted evidence, it seems that this is an important factor in the inhibition of technological innovation. Certainly, it was an issue persistently raised in interviews with managers of SMEs. Future research may seek to qualify this relationship by examining other policies and instruments designed and implemented by other agencies.

Furthermore, future approaches may revisit prior concerns with the performance of the R&D sector, to examine how it has changed in the new era of liberalisation. This may then open opportunities for a union between this current research and a renewed interest in the R&D sector, here treated as a given. It may be appropriate to broaden this research to include larger firms, as well as industrial and regional differences. First, to question the assumed invulnerability of large enterprises to the dramatic instability of recent Mexican economic history; second, to explore sectors more likely to engage in innovation activities; and third, to evaluate whether regional systems of innovation influence the overall performance of the national environment, taking into account that technology processes may be conditioned by space, as knowledge and capacities tend to cluster. Finally it is relevant to extend and apply this model to examine the experience of other countries threatened by a similar technological development trap.

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Appendix 1
METHODOLOGY AND RESEARCH TOOLS

Methodology framework

Given the different natures of the actors and interactions to be examined in the research project, a cross-examination of several sources of data (primary and secondary/qualitative and quantitative) was needed. To be able to analyse the economic, political, and cultural factors involved in the design, implementation, use and effects of technology policy in the Mexican context, a multi-method research was designed, based on the study of related quantitative and qualitative research literature.[1] The following sources, methods, and tools were used to collect the data for the thesis:

Sources of data, methods and tools

Documents

BdeM / FONEI: Programme operation rules, guides and performance reports.

Conacyt: Access to archival historic information from Conacyt since its foundation in 1970, including statistics, publications, policy outlines, internal documents, programme operation guides, and both official and internal material concerning the results of the main programmes under analysis.

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[1] Including Archibugi and Pianta 1996; Blaxter, Hughes, and Tight 1996; Brouwer and Kleinknecht 1996; Denzin and Lincoln 1998; Healey 1996; Hoel and Jessen 1977; Meyer-Krahmer 1990; Moser and Graham 1971; Oppenheim 1992; Phillips and Pugh 1994.

Nafin: Information regarding the technology programme is not thoroughly documented and the information gathered mainly comprises reports and operation rules.

Secof / IMPI: National industrial policy plans, which include important technology policy references. From IMPI internal statistics and reports, both official and internal were collected. Documents regarding the previous and current law for industrial and intellectual property protection were also used.

SHCP: The fiscal incentives laws for investment in technology and R&D, including the newest changes at the beginning of this year. Economic indicator publications.

Semi-structured / in-depth interviews[2]

The impact of government programmes and policies on technology efforts has been subject of several empirical studies. One of the study methods most frequently used is the interview study (Kauko 1996). For this work, a total of 25 interviews[3] were conducted to collect qualitative data from the government/policy-makers and implementers (officials of different levels at the agencies involved in the policy network); the private sector (leaders of business associations and entrepreneurs of specific importance); and the banks (credit executives).[4] The topics covered derived from the research questions presented above and were differentiated depending on whether the interviewee belongs to the public, private or financial sector.[5]

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[2] Apart from bank executives, all interviews were conducted as attributable and were tape recorded. From the recordings, transcripts were made for each interview.
[3] See Appendix 3.
[4] For the reference numbers and details of interviewees see Appendix 3.
[5] See Appendix 4 for a summary of the topic guides used during the interviews.

Analytical survey [6]

A national survey was conducted to collect data from users: private firms which need technology to conduct their business and are the eventual beneficiaries (or not) of technology policy.

Population: Private firms which have applied for government funding for their technology projects via Conacyt and/or Nafin and/or Banco de Mexico in the period 1980–1998. The period starts in 1980 because it was the first year of the Shared Risk Programme (Conacyt), the first industrial-oriented programme. The most recent cases give evidence of the problems faced with the 1995 crisis. During this period the transition from a closed to an open economy and the shifts from grants to credits are covered. The population was defined based on the assumption that in no country do public authorities give R&D subsidies to randomly chosen companies; instead, subsidies are distributed between applicants (Gannicott 1984); thus applications for financial support filed by a firm are certainly highly dependent on its intentions to invest in R&D, and those are the companies useful in a study of this nature. The main difficulty in this research laid in obtaining and updating lists and directories of the users of the Conacyt, Nafin and Banco de Mexico programmes. The total population was about 700 firms.

Sample: A sample of 10 per cent of the population was the goal to be able to obtain statistically satisfactory results. It was met as 74 entrepreneurs responded to the survey.[7] A simple random sampling

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[6] For a detailed description of the uses, advantages and limitations of analytical surveys see Oppenheim (1992).

[7] There were some entrepreneurs that had dealt with more than one government programme or had more than one project. They responded individually for each experience, therefore the total database consists of 77 observations.

method was used,[8] thus ensuring representation of small and medium-sized firms, geographical location, types of programmes used, and results of the project (successes and failures). 40.3 per cent of the firms are located in Mexico City's metropolitan area and the rest are from locations in various parts of the country. 85.8 per cent of the respondents were either the owner or general manager of the firm, while the rest were technical directors or project directors. 46.8 per cent of the firms were micro-sized and 53.2 per cent small and medium-sized (classified under the same category). Only 9.1 per cent were partly owned by foreign capital.

Questionnaire: Because of the size of the sample, their geographical dispersion and the nature of the information, a 70-question questionnaire[9] was designed in Spanish[10] and was administered mainly by telephone. A pilot questionnaire was tested at the "V Technology Forum" in Mexico City to pre-test its effectiveness, clarity, comprehensibility and the time required to complete it.[11] The final version incorporated improvements based on the experience with the pilot. Most of the questions were closed, but a few were open questions to allow for additional comments.[12] It covered mainly the following topics: technology culture, the nature of the project, the funding for the project, the relationship and experience with the government, research institutions and banks, and the firm itself.

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[8] For a description of the random sampling method and its advantages see Blaxter, Hughes, and Tight 1996; Moser and Graham 1971.
[9] See Appendix 6.
[10] For the English translation of the questionnaire see Appendix 7.
[11] On April 17, 1998, six entrepreneurs responded to the preliminary version of the questionnaire. By attending the Forum an interest on technology issues was assumed by the Author. Chosen randomly, they were considered similar respondents to those that were going to be surveyed.
[12] For the interpretation and classification of the open questions' answers, a reliability exercise was made with two intercoders. 97 per cent of the Author's codes matched the intercoders', and for the mismatched ones a revision was made to give an agreed coding.

Processing of data: The statistical software SPSS version 8.0 was used to process the data from the survey. A database of 123 variables was built, where each answer possibility was given a different label and value. 108 of the variables corresponded to the questions related with the respondent's views and experiences. The rest are variables used to categorise and classify the firm (i.e. size, location, etc.). Using SPSS a series of statistical analyses was done, using mainly descriptive and inferential statistics,[13] to support the arguments discussed throughout the thesis.

Specific firms' case studies

From the information gathered using the questionnaire and interviews, some particularly interesting cases were detected, and their validity relies on the concept of 'purposive sampling', which allows for hand-picking supposedly typical or interesting cases (Blaxter, Hughes, and Tight 1996, 79). Three cases were selected for deeper analysis. This involved a mixture of qualitative methods including visits to the firm for observation, talking to different people within the organisation, etc. A reconstruction of the events was possible and this helped to shed light on the problems that firms face when developing a technology project within the context of this analysis. A summary of the findings, is presented in Appendix 2.

Caveats

Documents: The different documents and official sources used for this work have their own institutional methodologies, particular interests and, therefore, limitations in their use for a different purpose to the one for which they were originally produced.

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[13] For a detailed explanation of these statistical concepts see Healey (1996).

Interviews: although special care was taken with the selection of the interviewees, it is not possible to reconstruct with perfect accuracy all the networks, interactions, problems and results of the process of technology development in Mexico based on the roles played by particular participants. Their views must be taken as a result of their own experiences, which may be biased in different ways.

Survey: The measures of the effectiveness of technology policy are based on the perceptions of industrial managers, and this might be an insufficient guide to reality. There is, in fact, a general tendency for managers to overestimate the negative influences of governmental intervention and to understate its positive influences (Rothwell 1986). They can also tend to overestimate the potential benefits of their projects.

Appendix 2

THREE TECHNOLOGY SUCCESSES OF MEXICAN SMALL FIRMS AND THEIR EXPERIENCE WITH THE GOVERNMENT

The examples below are provided to illustrate the nature of Mexican technology projects carried out by small firms, and the way in which the government and banks participated with them. The three firms were visited during fieldwork and in each case an in-depth group interview was conducted with one or more of the following project participants: Director/owner of the firm, Project Manager, Accountant/financial advisor and Researchers/technical personnel. For simplicity, only the Director/owner is named in the list of interviewees.[1]

1-Firm: Química Agronómica de México [2]

a) Technology Project and Relevance of Innovation

A researcher at the local University in Chihuahua, Miguel Alvarado, started a micro-enterprise to develop his project, in which a 'gentamicin sulphate' (aminoglicosido) is used for the first time to combat bacteria that attack apple and pear crops. Proven effective, this revolutionary bactericide has won several awards. It has been patented in the US, Australia, New Zealand, Argentina, Venezuela, Ecuador and Mexico, and at the time of the interview, was awaiting authorisation from 22 additional countries. It is the first time the Environmental Protection Agency (EPA) in the US has evaluated a Mexican registration application.

[1] See Appendixes 3 (for the List of Interviewees), and 5 (for the List of Surveyed Firms).
[2] Interview # 1.

b) Commercial Results/Potential

In 1996, the German transnational BASF signed an exclusive distribution agreement for the product. This allows Química Agronómica to expand its presence almost worldwide. BASF calculates sales of US$3 million in the first three years of the contract, with a forecast of US$15 million for the following ten years.

c) Financing of the project/experience with government's programmes

The first credit was given by Nafin via the state-owned Rural Bank, Banrural (Banco Rural). The initial investment was US$2 million. Having the approval of Banrural acting as the commercial bank the process was relatively easy. Banrural's role is to support agriculture-related projects. Conacyt's FIDETEC complemented the credit and guaranteed the remaining 20% needed by the firm. It was a case of a micro-firm with a high merit technology project that could have up to 100% coverage between both institutions. Once Nafin had authorised the main credit, Conacyt just carried out two technical evaluations to approve its part.

The project took two years to develop. With the first sales the firm managed to start generating the cash flow to repay the loan. The grace period is now over and the firm needs to restructure to be able to reinvest and continue growing. Compared to the initial authorisation, which was speedy, the restructuring is taking longer as there is no longer any coordination between Nafin and Banrural since an ordeal back in 1994 that led them to stop operations for six months. This was at the time of the devaluation of the peso and the Mexican financial crisis. The project was put at risk with the delays and the additional dollar-based debts of the firm. The initial sales saved it.

d) Additional remarks

Regarding innovation projects in Mexico, Miguel Alvarado considers dealings with the government agencies and operation in an uncertain economy as a matter of 'patience and resistance'. Nevertheless he finds that the support his firm has received from the government has been influential and feels he has been 'backed up.' Ideally, he believes programmes like Nafin's and Conacyt's should operate without the intermediation of the banks.

2-Firm: Compañía Minera La Metálica [3]

a) Technology Project and Relevance of Innovation

This project, developed as a partnership between a researcher and an entrepreneur, has been graded as a radical innovation or an 'assault technology' by technology raters. It is a development of worldwide impact as it revolutionises gold and silver extraction. The innovation lies on the cost-reducing improvement of the use of cyanide as a reactive. Less cyanide is needed per ton and less pollution is generated.

b) Commercial Results/Potential

Through association with some Canadian firms the project has continued, despite the difficulties it encountered, mainly with Conacyt. This is a new process technology that can be implemented in Mexico or in any other mining region of the world. Contacts have been made to license the technology to foreign counterparts. Conacyt's regional Delegate considers the project as a successful development, 'despite the problems it had with Conacyt'.[4]

[3] Interview #5.
[4] Interview #13.

c) Financing of the project/experience with government's programmes

La Metálica presented the application for a FIDETEC credit, believing what the propaganda said: that there would be a response in maximum of three months. The technical evaluation alone took six months. The final approval of the credit came after more than a year and a half. Due to inflation, currency devaluation and adjustments to the project, the costs had changed while they waited. In their experience, the negotiation process with Conacyt was very complex. Conacyt's local branch has very limited faculties and mainly deals with basic administration, acting as a courier to the central offices. Changes of personnel in Mexico City delayed the whole process because it implied changes of norms and criteria. Almost in parallel the firm submitted the application with Nafin, Conacyt's countepart. As the banks were only recently privatised, they were not operating credits like this one. Being members of a local Credit Union, they managed to operate the credit that way. But together with most of the country's Credit Unions, this one closed down. The credit was transferred to another Union, which had no idea of how to manage the loan.

At the time of the interview the managers of La Metálica could not tell exactly where their credit was. They claim to have been in that situation for more than a year and a half. No restructuring has been made, and long delays in the flow of the credit funds to the firm have resulted in the firm being unable to finish the final stage of the project. An extension of the initial credit was approved three days before the end of the 1994 devaluation (almost 100%). Those new funds came directly from Conacyt, leaving the firm with several institutions to deal with in the management of the loan. The resources shrank and were not enough to buy the imports needed. The programme does not cover currency fluctuations. The initial credit was of US$1.2 million and the extension of US$300 thousand. Together, they reached US$1.5 million, which was the maximum amount of a FIDETEC credit. The project was left halfway through with a funds shortage. If the owners had not been able to inject fresh capital the project would have gone bust, despite being a technology with high commercial potential.

d) Additional remarks

For Javier Félix, the experience with the government's agencies to finance the project has been a costly and painful one. When asked how they had managed to carry on with the project with all the adverse circumstances encountered, he pointed at a cartoon hanging on the wall above his desk and said 'we are the little frog who believes in the project and the big seagull is the government with its bureaucratic and ever-changing programmes'. At his request, a copy of the cartoon is shown below in Figure A.1.

Figure A.1. Cartoon illustrating a small firm-government relationship. The translation of the expression is: 'Never give up!'

3-Firm: Agroindustrias Carla [5]

a) Technology Project and Relevance of Innovation

Ms. Natividad Reyes is an agricultural engineer devoted to the application of her research on the growth of new tropical species in the south of Mexico. Her main project concerns the adaptation of Maracuya (passion fruit) to the climactic conditions of Mexico, where it has previously never been grown. The project is an integration of a process from the cultivation of the fruit to its industrialisation to produce different products including liquor and preserves.

b) Commercial Results/Potential

The pilot crops were a success and the first pilot plant is already operating and generating the first sales of the Mexicanised passion fruit and its innovative subproducts. Consumption of Maracuya is growing worldwide, and historically it was grown only in Brazil, primarily because of the climate.

c) Financing of the project/experience with government's programmes

Being a new micro-firm, Agroindustrias Carla had no experience of financial negotiations. Conacyt gave it a FIDETEC credit based on the potential of the technology transfer and adaptation. After a lengthy and unsuccessful negotiation with several banks eventually a Credit Union accepted the project but under its own conditions, omitting the clauses of FIDETEC. When the project started, the costs had increased, but the extension needed to continue was not granted after the 1995 events. Nafin was supposed to give one third of the budget but it never happened. The commercial/industrial part of the project was stopped

[5] Interview #8.

and it is expected to gradually restart once the sales generate enough cash flow for reinvestment.

d) Additional remarks

Natividad Reyes is grateful to Conacyt and FIDETEC for the support given during the initial stage of the project, as without the loan, it would have not been possible to develop it. In her experience, the changes of administration in Conacyt brought a different attitude towards the projects in general: 'there was no commitment with anything started by the previous team, it seemed as if the institution did not matter'.

Appendix 3

REFERENCE NUMBERS OF INTERVIEWS AND DETAILS OF INTERVIEWEES (NAME, CURRENT[1]/FORMER POSITIONS, DATE AND PLACE OF INTERVIEW)

Private Sector: Entrepreneurs and Business Associations' Representatives

1. **Miguel Alvarado**: Entrepreneur. User of governmental technology programmes. 4-2-98, Chihuahua, Mexico.
2. **Carlos Barceló**: Entrepreneur. User of governmental technology programmes. 23-4-98, Villahermosa, Mexico.
3. **Antonio Castro**: Entrepreneur and former Director of CONCAMIN's Technology Commission. 30-4-98, Mexico City.
4. **Andrés Cohen**: Entrepreneur and current Director of CANACINTRA's Technology Commission. 11-5-98, Mexico City.
5. **Javier Félix**: Entrepreneur. User of governmental technology programmes. 24-1-98, Chihuahua, Mexico.
6. **Guadalupe Muñoz**: Entrepreneur. User of governmental technology programmes. 12-5-98, Mexico City.
7. **José Represas**: Entrepreneur. User of governmental technology programmes. 11-5-98, Mexico City.
8. **Natividad Reyes**: Entrepreneur. User of governmental technology programmes. 23-4-98, Villahermosa, Mexico.
9. **Raúl Tovar**: Entrepreneur and Technology Evaluator for Conacyt's Programmes. 11-5-98, Mexico City.

[1] 'Current' means the position held at the time of the interview.

Public Sector: Politicians and Government Agencies' Officials

10. **Fausto Alzati**: Former Director General of Conacyt and former Minister of Education. 28-4-98, Mexico City.
11. **Jorge Amigo**: Former Secofi's Director General of Technology Development and current Director General of the Mexican Institute of Industrial Property (IMPI). 30-4-98, Mexico City.
12. **Héctor Arangua**: Former Nafin's Deputy Director General and current Executive Director of FUNTEC (CONCAMIN). 7-5-98, Mexico City.
13. **Ma. Jesús Calleros**: Conacyt's Regional North-Centre Delegate. 4-2-98, Chihuahua, Mexico.
14. **Martín Celaya**: Conacyt's Regional Baja California Delegate. 11-5-98, telephone interview, Mexico City-Ensenada.
15. **Patricia Franco**: Conacyt mid-level employee. 29-4-98, Mexico City.
16. **Alonso Mercado**: Former Credit Evaluator in Conacyt (FIDETEC), and current economics advisor at SHCP. 28-4-98, Mexico City.
17. **Ma. Amparo Olivares**: Conacyt employee, 29-4-98, Mexico City.
18. **Juan A. Ramírez Bustos**: Former Manager of Nafin's Technology Development Programme and Former employee of FONEI (BdeM-Central Bank). 30-4-98, Mexico City.
19. **Carlos Salinas de Gortari**: Former President of Mexico. 23-10-98, London.
20. **Fernando Sánchez Ugarte**: Former Vice-Minister of Industry and current President of the National Commission for Competition. 24-4-98, Mexico City.
21. **José Urquiza**: Manager of Nafin's Technology Development Programme and Former employee of FONEI (BdeM-Central Bank). 21-4-98, Mexico City.

Financial Sector: Private Banks' Executives (non-attributable)

22. Banamex's Credit Evaluator. 8-5-98, Mexico City.
23. Bancomer's Credit Evaluator. 8-5-98, Mexico City.
24. Bital's Credit Evaluator. 11-5-98, Mexico City.
25. Banco Mexicano's Credit Evaluator. 12-5-98, Mexico City.

Appendix 4
SUMMARY OF TOPICS FROM THE GUIDES FOR INTERVIEWS

A – Private Sector

a) Interviewees: Entrepreneurs and business associations' leaders or representatives before government technology committees.

b) Topics:

- What is their position regarding technology?
- How do they perceive the state's attitude and actions to promote technology?
- Have they presented specific requests and/or proposals to the public institutions in charge of it?
- How would they describe the technology culture of members of their business associations and their capacity to innovate, develop, or adapt technology?
- Do they think Mexican firms are capable of developing technology? Why?
- Do their associations have any programmes to support members in this sense? If so, what is the response from them? Results?
- Whose responsibility is the financing of technology projects?

B – Public Sector

a) Interviewees: Politicians, public officials and bureaucrats.

b) Topics:

- Who are the main players in the policy network?
- What are their roles, strengths and resources?
- What is the decision-making process like?
- What have been the main events that have led to shifts in the design of technology policy? Why? What have been the effects?
- Whose responsibility do they consider the financing of technology projects to be?
- With what importance is technology viewed within their institution? Are there big contrasts between hierarchical levels within the political and bureaucratic positions? And between them?
- What do they consider to be the role of the private banks in the financing of technology projects?
- Do they think Mexican firms are capable of developing technology? Why?
- Are there justifications for the state to intervene in the support of technology development? Why?
- How do they perceive the state's attitude and actions to promote technology?

- Why, if it is generally agreed that technology is vital for economic development, has Mexico not developed a long-term policy to encourage it.

- Why, when the firms needed it the most to compete against the world, did liberalisation policies not include the need for strong state intervention in the case of technology?

- Are they aware that in Mexico there is not a support package for technology innovation and R&D similar to those in the countries against which Mexico is competing?

C – Financial Sector

a) Interviewees: private banks' credit executives.

b) Topics:

- Do they have an explicit policy for technology projects? If so, is it in favour of or against them?

- Do they know of any technology projects to which their bank has given credit? How many? Do they see the bank giving credit to these activities in the near future?

- What has been the experience and results?

- Do they know of government funds they can access to give credits for those projects?

- Which ones do they know? Have they used them? If not, why not? If yes, what was the experience like?

Appendix 5

NAMES OF THE FIRMS WHOSE OWNER OR DIRECTOR-GENERAL RESPONDED TO THE SURVEY'S QUESTIONNAIRE

Survey conducted in Mexico by telephone: 24 April to 13 May, 1998.

	NAME OF FIRM	LOCATION (City and State)
1.	Agroequipos Laufel	Zapopan, Jalisco
2.	Agroindustrias Carla	Villahermosa, Tabasco
3.	Alimentos Institucionales	Guadalajara, Jalisco
4.	Aluplastic	México, DF
5.	Anticat	México, DF
6.	Asesores en Biología Pesquera	Ensenada, Baja California
7.	Bexel Internacional	Monterrey, Nuevo Leon
8.	Biósfera	México, DF
9.	Cajas de Cartón Murguía	Iztapalapa, Edo.México
10.	Calipo	Ensenada, Baja California
11.	Caña Alcohol	Córdoba, Veracruz
12.	Cartonera Tap	San Pedro, Edo.México
13.	Celsol	Sta. Catarina, Nuevo León
14.	Centro de Moldes y Troqueles	Chihuahua, Chihuahua
15.	Chibelt	México, DF
16.	Cimbys Emresarial	Lomas Verdes, Edo.México
17.	Cinética Química	Monterrey, Nuevo León
18.	Compañía Transf. Geometalúrgica	Hermosillo, Sonora
19.	Compañía Minera la Metálica	Chihuahua, Chihuahua
20.	Consorcio de Desarrollo Tecnológico	Tijuana, Baja California
21.	Consorcio de Profesionales Petroleros	Naucalpan, Edo.México
22.	Consultores en Ingeniería y Proyectos	México, DF
23.	Contrataciones Conaro	México, DF
24.	Craft Instrumentos Científicos	Azcapotzalco, Edo.México

25.	Diseño e Innovación Tecnológica	Azcapotzalco, Edo. México
26.	Dispositivos Nafi	México, DF
27.	Don Pez Tesia	Navojoa, Sonora
28.	Envases Microonda	León, Guanajuato
29.	Fase de Morelos	Cuernavaca, Morelos
30.	Fermic. Iztapalapa	Estado de México.
31.	Francisco Conabal	México, DF
32.	Genetro	Villahermosa, Tabasco
33.	Hielera Juárez	Ciudad Juárez, Chihuahua
34.	Holotec	Ensenada, Baja California
35.	Horacio Guerra	Monclova, Coahuila
36.	Industria Nacional de Tanques	Monclova, Coahuila
37.	Industrial Xalapa	Ezequiel Montes,Querétaro
38.	Industrias Plas	México, DF
39.	Informática Directiva Aplicada	México, DF
40.	Informática e Ingeniería Integral	Cuernavaca, Morelos
41.	Ingredientes Funcionales de México	México, DF
42.	Innovaciones de Sistemas	Mexicali, Baja California
43.	Langostinos y Camarones de Oriente	Veracruz, Veracruz
44.	Losamex	México, DF
45.	Maldonado Computadoras	Colima, Colima
46.	Moisés Harari	México, DF
47.	Mol-Ane	Mérida, Yucatán
48.	New Products D'sign de México	México, DF
49.	Nixtasol	México, DF
50.	Oficina Especializada de Servicios	Chihuahua, Chihuahua
51.	Onyx Servicios en Ingeniería	Mexicali, Baja California
52.	Oxxo	México, DF
53.	Pisis Grupo de Desarrollo	México, DF
54.	Plásticos Industrializados Micle	León, Guanajuato
55.	Porcícola Río Lerma	La Piedad, Michoacán
56.	Procesadora de Fibras Textiles	Puebla, Puebla
57.	Procesadora y Envasadora	Toluca, Estado de México

58.	Productora de Colágeno	León, Guanajuato
59.	Productos Químicos de Chihuahua	Chihuahua, Chihuahua
60.	Proveedor Oriente de Equipos	Puebla, Puebla
61.	Proyectos Integrales de Ingeniería	México, DF
62.	Quality Exports de México	Leon, Guanajato
63.	Quim de México	León, Guanajuato
64.	Química Agronómica de México	Chihuahua, Chihuahua
65.	Raips	Oaxaca, Oaxaca
66.	Resinas y Materiales	Tlanepantla, Edo.México
67.	Soc. Cooperativa Productos Tecoxpa	México, DF
68.	Tecnología Sistemas y Aplicaciones	México, DF
69.	Tecnológico de Chihuahua	Chihuahua, Chihuahua
70.	Tpi Consultoría y Servicios	México, DF
71.	Triskel	México, DF
72.	Uacj	Cd. Juárez, Chihuahua

Appendix 6
SURVEY QUESTIONNAIRE (SPANISH)

ENCUESTA DE OPINION EMPRESARIAL SOBRE EL DESARROLLO TECNOLOGICO DE MEXICO
UNIVERSIDAD DE LONDRES

INTRODUCCION A LA ENCUESTA:
Buenas tardes. Mi nombre es --------- . Estoy apoyando un proyecto de investigación de la Universidad de Londres, relacionado con un estudio internacional sobre el desarrollo tecnológico en diversos países. Actualmente estamos realizando una encuesta a nivel nacional, entre aquellas empresas que han demostrado interés en desarrollar proyectos tecnológicos. El objetivo es evaluar las condiciones a las cuáles se enfrentaron para la viabilidad de sus proyectos. La encuesta es sencilla y dura aproximadamente 15 minutos. La información proporcionada servirá para detectar factores que influyen en la generación de un mercado tecnológico en México. ¿Podríamos contar con su opinión?

1. En una escala del 1 al 5, siendo el 1 lo menos y 5 lo más, ¿qué tan importante es la tecnología para el desarrollo del país ?
   1 2 3 4 5

2. En una escala del 1 al 5, siendo el 1 lo menor y 5 lo mayor, ¿qué tan importante es la tecnología para el crecimiento de su empresa ?
   1 2 3 4 5

3. ¿Considera que las empresas mexicanas pueden desarrollar tecnología propia?
   Si_____ No_____

4. ¿Cuáles de las siguientes categorías empresariales pueden desarrollar tecnología?
   a) Micro
   b) Pequeñas y medianas
   c) Grandes
   d) Transnacionales

5. De las siguientes formas de invertir en tecnología, seleccione las 2 que considere más importantes para el crecimiento de su empresa:
   a) Adaptar
   b) Innovar
   c) Comprar tecnología nacional
   d) Importar

6. ¿Considera que su empresa tiene capacidad innovadora ? Sí_____ No_____

7. De los siguientes conceptos, mencione si considera que son esenciales para que una empresa tenga capacidad innovadora:
   a) Experiencia
   b) Antigüedad
   c) Personal capacitado
   d) Solvencia financiera
   e) Infraestructura
   f) Otros_______________________________________

8. ¿Qué impacto ha tenido la apertura comercial en su empresa ?
____
____
____

9. En una escala del 1 al 5, siendo 1 lo menos y 5 lo más, ¿qué tan creativos considera Ud. a los empresarios mexicanos ?
1 2 3 4 5

10. En una escala del 1 al 5, siendo el 1 lo menor y 5 lo mayor, ¿qué tanto deben los **empresarios** apoyar y promover el desarrollo tecnológico ?
1 2 3 4 5

11. En una escala del 1 al 5, siendo el 1 lo menor y 5 lo mayor, ¿qué tanto deben las **asociaciones empresariales** apoyar y promover el desarrollo tecnológico ?
1 2 3 4 5

12. En una escala del 1 al 5, siendo el 1 lo menor y 5 lo mayor, ¿qué tanto deben las **instituciones educativas** apoyar y promover el desarrollo tecnológico ?
1 2 3 4 5

13. En una escala del 1 al 5, siendo el 1 lo menor y 5 lo mayor, ¿qué tanto deben los **centros de investigación y desarrollo** apoyar y promover el desarrollo tecnológico ?
1 2 3 4 5

14. En una escala del 1 al 5, siendo el 1 lo menor y 5 lo mayor, ¿qué tanto debe el **gobierno federal** apoyar y promover el desarrollo tecnológico ?
1 2 3 4 5

15. En una escala del 1 al 5, siendo el 1 lo menor y 5 lo mayor, ¿qué tanto deben los **gobiernos estatales** apoyar y promover el desarrollo tecnológico ?
1 2 3 4 5

16. En una escala del 1 al 5, siendo el 1 lo menor y 5 lo mayor, ¿qué tanto deben los **organismos internacionales** apoyar y promover el desarrollo tecnológico ?
1 2 3 4 5

17. ¿Ha llevado a cabo su empresa algún proyecto de desarrollo tecnológico? Sí_____
Cuántos_____ No_____
Si la respuesta fue negativa, preguntar :
¿Por qué ?
____
____
Pasar al final de la encuesta y tomar los datos.

18. ¿Solicitó apoyo del gobierno para desarrollar su proyecto ?
Sí_____
No_____ ¿Por qué?_________________________
Si la respuesta es negativa pasar a la pregunta 22.

19. ¿Qué tipo de apoyo solicitó ?
_____Financiero
_____Orientación y asesoría
Otros____

20. En una escala del 1 al 5, siendo el 1 lo menos y 5 lo más, ¿cómo califica la atención y el servicio del gobierno a su solicitud ?
1 2 3 4 5

21. ¿Obtuvo financiamiento del gobierno para el desarrollo de sus proyectos?
Sí_____ En cuántos_____
No_____ ¿Por qué?______________________

Si la respuesta es positiva y más de 1, solicitar que seleccione el proyecto más importante en base a su experiencia personal para continuar con el cuestionario.
Si la respuesta es negativa y hay más de un proyecto, solicitar que seleccione el más importante en base a su experiencia personal para continuar con el cuestionario.

22. De los siguientes conceptos, que tipo de proyecto fue el de su empresa:
a) Innovación
b) Mejora
c) Adaptación de tecnología extranjera
d) Adaptación de tecnología nacional
e) Otros____

23. Su desarrollo tecnológico se relaciona con:
a) Producto
b) Proceso
c) Servicio

24. El proyecto es : _____Precompetitivo
_____Escalamiento industrial

25. Es un proyecto de riesgo tecnológico :
Bajo Medio Alto

26. ¿Quién fue líder del proyecto ?
a) Propietario(s)
b) Director General
c) Responsable del área involucrada
d) Persona contratada especialmente
e) Asesor externo
f) Otros_____________________________________

27. ¿Utilizaron servicios de alguna institución de investigación y desarrollo?
Sí_____ Cuáles______________________________
No_____

Si su respuesta es negativa, pasar a la pregunta 29.

28. En una escala del 1 al 5, siendo 1 lo peor y 5 lo mejor, ¿cómo califica el servicio proporcionado por la institución de investigación y desarrollo?
1 2 3 4 5

29. ¿En qué etapa se encuentra?
a) Planeación
b) Inicial
c) Media
d) Final
e) Terminado

30. ¿Cuándo inició el proyecto ? ____________________________________

31. ¿El proyecto inició en el tiempo planeado ?
Sí_____
No_____ ¿Por qué?____

Si el proyecto no ha concluido pasar a la pregunta 35.

32. ¿El proyecto concluyó en el tiempo planeado ?
Sí_____
No_____ ¿Por qué?____

33. En una escala del 1 al 5, siendo el 1 lo menos exitoso y 5 lo más exitoso, ¿cómo califica los resultados técnicos ?
1 2 3 4 5

34. En una escala del 1 al 5, siendo el 1 lo menos exitoso y 5 lo más exitoso, ¿qué cómo califica los resultados comerciales ?
1 2 3 4 5

35. El proyecto ¿se relaciona directamente con el giro de la empresa ?
Sí_____ No_____

36. ¿Tiene planes para continuar con otros proyectos ?
Sí_____ No_____

37. ¿Ha recibido asesoría y apoyo de las asociaciones empresariales a las que pertenece para desarrollar el proyecto ?
Sí_____ No_____

38. En una escala del 1 al 5, siendo el 1 lo menos y 5 lo más, qué tanto las asociaciones empresariales defienden los intereses de sus asociados respecto a la tecnología ?
1 2 3 4 5

39. Recomendaría a otras empresas desarrollar proyectos tecnológicos ?
Sí_____
No_____ ¿Por qué?____

40. ¿Solicitó apoyo a instituciones financieras ?
Sí_____
No_____ ¿Por qué?____

41. ¿Cuál fue la respuesta ? Positiva_____ Negativa_____

42. En una escala del 1 al 5, siendo el 1 negativo y 5 positivo, ¿cómo califica la actitud de las instituciones financieras hacia los proyectos tecnológicos?
1 2 3 4 5

43. De los siguientes conceptos, ¿en qué porcentaje fue financiado el proyecto ?
a) Recursos del gobierno_____
b) Créditos de instituciones financieras_____
c) Recursos propios_____
d) Créditos del extranjero_____
e) Otros____

44. ¿Cuánto tiempo le llevó reunir los fondos necesarios ?
_____Menos de 3 meses _____De 3a 6 meses _____De 6 a 12 meses
_____De 1 a 2 años _____Más de 2 años

45. ¿Obtuvo apoyo de más de 1 programa de financiamiento del gobierno para desarrollar su proyecto? Sí____ No____

46. ¿De cuáles de los siguientes programas obtuvo apoyo?
_____Fonei
_____Desarrollo Tecnológico de Nafin
_____Proyectos Tecnológicos de Conacyt
_____Riesgo Compartido de Conacyt
_____Fidetec de Conacyt
Otros___________________________________

47. En caso de haber tenido distintos apoyos del gobierno para el mismo proyecto, contestar las siguientes preguntas para cada uno de los programas en que participó.

48. ¿Cómo recibió los recursos ?

a) Directamente de la Institución b) Por medio de Banco c) De Unión de Crédito d) Otros _____________	a) Directamente de la Institución b) Por medio de Banco c) De Unión de Crédito d) Otros _____________	a) Directamente de la Institución b) Por medio de Banco c) De Unión de Crédito d) Otros _____________

49. ¿Cómo se enteró de los programas del gobierno a los que solicitó apoyo ?

a) Publicidad b) Recomendación c) Acudió a solicitar información d) Otros_____________	a) Publicidad b) Recomendación c) Acudió a solicitar información d) Otros_____________	a) Publicidad b) Recomendación c) Acudió a solicitar información d) Otros_____________

50. En una escala del 1 al 5, siendo el 1 lo menos y 5 lo más, ¿qué tan clara fue la información que le otorgaron ?

1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

51. En una escala del 1 al 5, siendo el 1 lo menos y 5 lo más, ¿cómo califica el servicio que recibió ?

1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

52. ¿Cuánto tiempo le tomó obtener el resultado de su aplicación ?

a) Menos de 3 meses b) De 3a 6 meses c) De 6 a 12 meses d) De 1 a 2 años e) Más de 2 años	a) Menos de 3 meses b) De 3a 6 meses c) De 6 a 12 meses d) De 1 a 2 años e) Más de 2 años	a) Menos de 3 meses b) De 3a 6 meses c) De 6 a 12 meses d) De 1 a 2 años e) Más de 2 años

53. Cuáles cree que fueron los factores que influenciaron la decisión ?

____________________ ____________________ ____________________ ____________________ ____________________ __________	____________________ ____________________ ____________________ ____________________ ____________________ __________	____________________ ____________________ ____________________ ____________________ ____________________ __________

54. Fue visitada su empresa por evaluadores?

Sí ____ No ____	Sí ____ No ____	Sí ____ No ____

55. ¿Hubo evaluaciones de seguimiento durante el proceso de desarrollo ?

Sí ____ No ____	Sí ____ No ____	Sí ____ No ____

56. ¿Alguna vez le solicitaron retroalimentación sobre su experiencia o le pidieron sugerencias para mejorar el programa ?

Sí ____ No ____	Sí ____ No ____	Sí ____ No ____

57. Su proyecto inició durante un periodo presidencial y continuó en otro ?

Sí ____ No ____	Sí ____ No ____	Sí ____ No ____

58. ¿Afectó este cambio a su proyecto ?

Sí ____ No ____	Sí ____ No ____	Sí ____ No ____

59. ¿De qué manera ?

____________	____________	____________

60. ¿Hubo cambios del personal responsable del programa durante el desarrollo de su proyecto?

Sí ____ No ____	Sí ____ No ____	Sí ____ No ____

61. ¿De qué nivel?

a) Dirección General del Organismo, Cuántas veces______ b) Director del Programa, Cuántas veces______ c) Subdirectores, Cuántas veces______ d) Personal Técnico, Cuántas veces______	a) Dirección General del Organismo, Cuántas veces______ b) Director del Programa, Cuántas veces______ c) Subdirectores, Cuántas veces______ d) Personal Técnico, Cuántas veces______	a) Dirección General del Organismo, Cuántas veces______ b) Director del Programa, Cuántas veces______ c) Subdirectores, Cuántas veces______ d) Personal Técnico, Cuántas veces______

62. ¿Afectaron estos cambios a su proyecto ?

Sí ____ No ____	Sí ____ No ____	Sí ____ No ____

63. ¿De qué manera ?

64. Si no hubiera tenido ayuda del gobierno, ¿habría llevado al cabo el proyecto de cualquier manera ? Sí_____ No_____

65. ¿Considera necesario que el gobierno participe en estas actividades que finalmente son para el beneficio de empresas particulares ?
Sí_____ No_____

66. ¿Ha recibido asesoría para proteger su desarrollo ? Sí_____ No_____

67. ¿De quién ? ____

68. ¿Ha iniciado trámites de protección ? Sí_____ No_____

69. En una escala del 1 al 5, siendo uno lo menos y 5 lo mejor, cómo califica los procedimientos para obtener la protección de su desarrollo?
1 2 3 4 5

70. ¿Recomendaría a otras empresas solicitar apoyos gubernamentales ?
Sí_____ No_____

DATOS DE LA EMPRESA

NOMBRE:____

DOMICILIO:____

CIUDAD :________________________ ESTADO :______________

TELEFONO______________

DATOS DEL ENTREVISTADO NOMBRE Y PUESTO:

TAMAÑO DE EMPRESA:

a) Micro
b) Pequeñas y medianas
c) Grandes

¿CUENTA CON CAPITAL EXTRANJERO ? Sí_____ No_____

SECTOR:____

ACTIVIDADES PRINCIPALES:

FECHA DE CONSTITUCIÓN:

ASOCIACIONES A LAS QUE PERTENECE:

Sr. ------------- Su información nos ha sido de gran utilidad. Muchas gracias por el tiempo que le hemos robado.

FECHA :_______________________________________

DIRECTORIO :____

Appendix 7
SURVEY QUESTIONNAIRE (ENGLISH TRANSLATION)

SURVEY: ENTREPRENEURS' OPINION OF MEXICO'S TECHNOLOGY DEVELOPMENT
UNIVERSITY OF LONDON

INTRODUCTION TO THE SURVEY:
Hello. My name is -------. We are conducting a research project at the University of London about technology development in different countries. This is a national survey amongst firms that have shown interest in developing technology projects. The purpose of the study is the evaluation of the conditions in which projects are developed. The questionnaire is simple and takes approximately fifteen minutes to be answered. The information given will help in the identification of those factors that impact the generation of a technology market in Mexico. Could we have your opinion?

1. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how important is technology for the country's development?
   1 2 3 4 5
2. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how important is technology for the growth of your firm?
   1 2 3 4 5
3. Can Mexican enterprises develop technology?
   Yes_____ No_____
4. Which of the following categories of firms are able to develop technology?
   a) Micro-sized firms
   b) Small and medium-sized firms
   c) Large firms
   d) Transnationals
5. Which of the following methods of investment in technology are the two most important for enabling your firm to grow?
   a) Adaptation
   b) Innovation
   c) Purchase of national technology
   d) Imports of technology
6. Does your firm have an innovation capacity? Yes_____ No_____
7. Which of the following concepts are essential for a firm to have or develop innovation capacities?
   a) Previous experience
   b) Long establishment
   c) Skilled personnel
   d) Financial strength
   e) Infrastructure
   f) Other____

8. What have been the effects of trade liberalisation for your firm?

____

____

9. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how creative are Mexican entrepreneurs?

   1 2 3 4 5

10. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how responsible are **businessmen** for the process of promotion and development of the country's technology (do they consider it their duty)?

   1 2 3 4 5

11. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how responsible are **business associations** for the process of promotion and development of the country's technology (do they consider it their duty)?

   1 2 3 4 5

12. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how responsible are **education institutions** for the process of promotion and development of the country's technology (do they consider it their duty)?

   1 2 3 4 5

13. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how responsible are **research centres** in the process of promotion and development of the country's technology (do they consider it their duty)?

   1 2 3 4 5

14. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how responsible is the **federal government** for the process of promotion and development of the country's technology (does it consider it as its duty)?

   1 2 3 4 5

15. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how responsible are **state-level governments** for the process of promotion and development of the country's technology (do they consider it their duty)?

   1 2 3 4 5

16. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how responsible are **international organisations** in the process of promotion and development of the country's technology (do they consider it their duty)?

   1 2 3 4 5

17. Has your firm developed any technology projects?

   Yes_____ How many?_____ No_____

   If the answer is negative, ask :

   Why?

   ____

   ____

   Go to the end of the questionnaire and request the general information for this firm.

18. Did you request or apply for any governmental support to develop the project?

   Yes_____ No_____ Why?__________________________

   If the answer is negative go to question 22.

19. What type of support did you request?
    _____Financial
    _____Advice and information
    Other____

20. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how was the service you received from the government?
    1 2 3 4 5

21. Did you receive government funding to develop your projects?
    Yes_____ For how many?_____
    No_____ Why?____________________

    If the answer is Yes and for more than one project: ask the respondent to select the project he/she considers the most important to continue the questionnaire.

    If the answer is No and the respondent mentions the existence of more than one project: ask the respondent to select the project he/she considers the most important to continue the questionnaire.

22. Which type of project did your firm develop?
    a) Innovation
    b) Improvement
    c) Adaptation of foreign technology
    d) Adaptation of domestic technology
    e) Other___________________________________

23. The technology project relates to:
    a) Product
    b) Process
    c) Services

24. The stage of the project is : _____Pre-competitive
    _____Industrial Scaling

25. The risk involved in the project is:
    Low Medium High

26. Who is the leader of the project?
    a) Owner(s)
    b) Director-General
    c) A person responsible for the specific area
    d) Someone hired specifically for the project
    e) External consultant
    f) Other________________________________

27. Did you use the services of research and development institutions?
    Yes_____ Which ones?__________________________
    No_____

    If the answer is No, go to question 29.

28. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how do you rate the services provided by the research and development institution(s)?
    1 2 3 4 5

29. At the moment, at which stage is the project?
    a) Planning
    b) Beginning
    c) Intermediate
    d) Final
    e) Finished

30. When did the project start? ____

31. Did the project start as planned?
    Yes_____
    No_____ Why?______________________________________

    If the project has not concluded go to question 35.

32. Did the project end as planned?
    Yes_____
    No_____ Why?______________________________________

33. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how successful are the technical results?
    1 2 3 4 5

34. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how successful are the commercial results?
    1 2 3 4 5

35. Does the project relate directly to the firm's main activities?
    Yes_____ No_____

36. Are there plans to continue with more projects?
    Yes_____ No_____

37. Have you received advice and/or support for your project from the business chambers and associations that your firm belongs to?
    Yes_____ No_____

38. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how much do business chambers defend the interests of their members in relation to technology issues?
    1 2 3 4 5

39. Do you recommend other firms to develop technology projects?
    Yes_____
    No_____ Why?____

40. Did you apply for funding from financial institutions?
    Yes_____
    No_____ Why?____

41. How was their response? Positive_____ Negative_____

42. On a scale of 1 to 5, 1 being negative and 5 positive, how do you rate the attitude of private financial institutions towards technology projects?
    1 2 3 4 5

43. How was the project financed (percentages)?
   a) Government funding_____
   b) Credit from financial institutions _____
   c) Own resources_____
   d) Foreign credit_____
   e) Other_________________________________

44. How long did it take to get the necessary funding?
   _____Less than 3 months _____3 to 6 months _____6 to 12 months
   _____1 to 2 years _____More than 2 years

45. Did you receive funds from more than one government programme or institution?
   Yes____ No____

46. From which programmes did you receive funds?
   _____Fonei
   _____Desarrollo Tecnol6gico (Nafin)
   _____Proyectos Tecnol6gicos (Conacyt)
   _____Riesgo Compartido (Conacyt)
   _____Fidetec (Conacyt)
   Other_____________________________________

47. *If there was funding from different programmes or institutions the following 15 questions should be answered for each of them, using one column per programme or institution.*

48. How did you receive the funds?

a) Directly from the institution b) Via a commercial bank c) Via a credit union d) Other______________	a) Directly from the institution b) Via a commercial bank c) Via a credit union d) Other______________	a) Directly from the institution b) Via a commercial bank c) Via a credit union d) Other______________

49. How did you know about the government programmes for which you applied?

a) Advertisement b) Recommendation c) Visited the institution d) Other______________	a) Advertisement b) Recommendation c) Visited the institution d) Other______________	a) Advertisement b) Recommendation c) Visited the institution d) Other______________

50. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how clear was the information you received?

1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

51. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how do you rate the service provided?

1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

52. How long did it take to receive a response to your application?

a) Less than 3 months b) 3 to 6 months c) 6 to 12 months d) 1 to 2 years e) More than 2 years	a) Less than 3 months b) 3 to 6 months c) 6 to 12 months d) 1 to 2 years e) More than 2 years	a) Less than 3 months b) 3 to 6 months c) 6 to 12 months d) 1 to 2 years e) More than 2 years

53. Which do you think were the factors that influenced the decision?

54. Was the firm visited by evaluators?

Yes ____ No ____	Yes ____ No ____	Yes ____ No ____

55. Were there follow-up evaluations during the process of the project being developed?

Yes ____ No ____	Yes ____ No ____	Yes ____ No ____

56. Were you ever asked for feedback regarding your experience with the programme or were you asked for suggestions for how to improve the service?

Yes ____ No ____	Yes ____ No ____	Yes ____ No ____

57. Did the project start during one presidential term and end or continue during a different one?

Yes ____ No ____	Yes ____ No ____	Yes ____ No ____

58. Did this affect your project?

Yes ____ No ____	Yes ____ No ____	Yes ____ No ____

59. In what way?

60. Were there changes in the personnel responsible for the programme during the development of your project?

Yes_____ No_____	Yes_____ No_____	Yes_____ No_____

61. At which levels?

a) Director-General of the Institution. Frequency______ b) Programme Director. Frequency ______ c) Mid-level personnel. Frequency______ d) Technical personnel. Frequency______	a) Director-General of the Institution. Frequency______ b) Programme Director. Frequency ______ c) Mid-level personnel. Frequency______ d) Technical personnel. Frequency______	a) Director-General of the Institution. Frequency______ b) Programme Director. Frequency ______ c) Mid-level personnel. Frequency______ d) Technical personnel. Frequency______

62. Did the changes affect your project?

Yes_____ No_____	Yes_____ No_____	Yesí_____ No_____

63. In what way?

______________________ ______________________ ______________________ ______________________ ______________________ ______________	______________________ ______________________ ______________________ ______________________ ______________________ ______________	______________________ ______________________ ______________________ ______________________ ______________________ ______________

64. If you had not have support from the government, would have developed the project?
Yes_____ No_____

65. Do you consider it necessary for the government to participate in the support of technology activities even if they are for the benefit of individual firms?
Yes_____ No_____

66. Have you received advice or support regarding how to protect the rights of your project?
Yes_____ No_____

67. From whom? ____

68. Have you started the process to protect the rights of your project?
Yes_____ No_____

69. On a scale of 1 to 5, 1 being the lowest and 5 the highest rating, how do you rate the procedures and laws to protect the rights of your project?
1 2 3 4 5

70. Do you recommend other firms to apply for government support?
Yes_____ No_____

GENERAL INFORMATION REGARDING THE FIRM

NAME:____

ADDRESS:____

CITY :____________________ STATE :____________

PHONE NUMBER___________

NAME AND POSITION OF THE RESPONDENT:

SIZE OF THE FIRM:

a) Micro
b) Small or medium-sized
c) Large

DOES IT HAVE FOREIGN CAPITAL? Yes_____No_____

SECTOR:____

MAIN ACTIVITIES:

ESTABLISHMENT DATE:

BUSINESS CHAMBERS OR ASSOCIATIONS IT BELONGS TO:

Your information is most valuable. Thank you very much for your time.

DATE :______________________________

DIRECTORY:______________________________________

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