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Transfer of Technology for Successful Integration into the Global Economy

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Preface

The book focuses on successful cases of technology transfer and integration into the world economy.[1] They identify factors that could enable firms in developing countries to upgrade technologies or develop new technologies with a view to enhancing their *productivity.* Thus, these cases are expected to provide lessons, in terms of best practices, to other developing countries in the context of technological capacity building.

The book deals with sectors where selected developing countries have demonstrated their ability to create new productive capacities and successfully participate in the world market. They represent examples of *created* comparative advantage–that is, cases in which a country's factor endowments were modified through investment in physical capital, human resources and the building up of capacities so as to develop and use new technologies. The lessons for other countries lie not in the actual selection of the industry but rather in how each of the three countries overcame the handicaps they faced and struggled to secure a place in the world market.

Establishing new lines of productive activity is the essence of the catch-up process and the bridging of the gap between developing and industrial economies. The case studies illustrate how this was done in three sophisticated and relatively capital- and technology-intensive industries. The relevant issues are how international competitiveness was achieved in new lines of productive activities and whether similar policy approaches can be made to work in today's relatively more open and rules-based global trading environment.

The case studies help to show that industries are created by means of a combination of market signals and government policies and institutional support. This process takes a very long time and it is not always smooth. In the early stages, protection allowed industry to grow.

The studies have been carried out under the UNCTAD/UNDP Global Programme on Globalization, Liberalization and Sustainable Human Development: Best Practices in Transfer of Technology.

[1] Three case studies were made available, as separate documents, to the WTO Working Group on Trade and Transfer of Technology, as follows: A Case Study of Embraer in Brazil, UNCTAD/ITE/IPC/Misc.20; A Case Study of the Pharmaceutical Industry in India, UNCTAD/ITE/IPC/MISC.22; and A Case Study of the Automotive Industry in South Africa, UNCTAD/ITE/IPC/MISC.21.

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The overview of the three cases was prepared by Irfan ul Haque. The case study of the aircraft industry in Brazil was prepared by Professors José E. Cassiolato, Roberto Bernardes and Helena Lastres; the case study of the pharmaceutical industry in India was prepared by Biswajit Dhar and C. Niranjan Rao, and received inputs from Veenu Gupta; and the case study of the South African automotive industry was prepared by Professors Trudi Hartzenberg and Samson Muradzikwa. Atul Kaushik provided valuable inputs to and comments on the initial draft on the international dimension of the policies adopted for supporting technological capacity building.

Thomas Ganiatsos, Paolo Bifani, David Vivas and Jagdish Saigal at the UNCTAD Expert Meeting on Best Practices in Transfer onTechnology provided comments and suggestions.[2] Comments were also received from Pedro Roffe and Yehia Soubra.

The views expressed by the authors do not necessarily represent those of UNCTAD or UNDP

[2] UNCTAD/UNDP Global Programme on Globalization, Liberalization and Sustainable Human Development: Best Practices in Transfer of Technology. Meeting on Transfer of Technology for Successful Integration in the Global Economy. Geneva, 11–12 April , 2002. See Report on the Meeting in www.unctad.org

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GLOSSARY

Doha Implementation Decision	"Implementation-Related Issues and Concerns" Document WT/MIN(01)/W/10 14 November 2001.
DSU	Dispute Settlement Understanding: The WTO Understanding on Rules and Procedures Governing the Settlement of Disputes
EU	European Union
FDA	Food and Drug Administration (United States)
FDI	Foreign Direct Investment
GATS	General Agreement on Trade in Services
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
Goods Council	The Council for Trade in Goods of the WTO
IMF	International Monetary Fund
IPRs	Intellectual Property Rights
LDCs	Least Developed Countries
Members	WTO member countries
MERCOSUR	Mercado Común del Sur
MIDP	Motor Industry Development Programme of South Africa
PROEX	Programa de Financiamento as Exportacoes of Banco do Brazil
R&D	Research and Development
SABS	South African Bureau of Standards
SCM Agreement	Agreement on Subsidies and Countervailing Measures
SMEs	Small and Medium Sized Enterprises
S&T	Science and Technology
TNC	Transnational Corporations
TRIMs Agreement	Agreement on Trade-Related Investment Measures
TRIPS Agreement	Agreement on Trade-related Aspects of Intellectual Property Rights
TRIPS Council	The Council for Trade-Related Aspects of Intellectual Property Rights of WTO; also the 'Council for TRIPS'
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
WTO Agreement	Marrakesh Agreement Establishing the World Trade Organization
WTO	World Trade Organization

Part I

Overview

INTRODUCTION

This paper reports on the main findings and conclusions of three case studies that were carried out under the UNCTAD/UNDP Programme on Globalization, Liberalization and Sustainable Human Development. These studies aimed to respond to the call in UNCTAD's Bangkok Plan of Action (TD/386), inviting UNCTAD to "examine and disseminate widely information on best practices for access to technology" (para. 128).

The three cases are examples of developing countries having demonstrated their ability to establish new industries and successfully compete in the world market. Each of the industries selected – aircraft manufacturing in Brazil, pharmaceuticals in India and the automobile industry in South Africa – is sophisticated, and relatively capital- and technology-intensive. Thus, the case studies tell stories about *created* competitive advantage, that is, where the factor endowments of a country were modified over time through investment in physical capital, human resources and the build-up of technological capabilities.

The three cases together provide an assessment of the relative – though mutually supportive – roles of government policy and market discipline. They have many elements in common but also reveal significant differences, and they offer some useful lessons for other developing countries.

The studies demonstrate that success was neither easy nor assured; and they point to handicaps and hurdles that had to be overcome before success was possible. Other countries could find such a process all too costly, even impractical. The actual selection and promotion of a particular path for technological development are conditioned by a country's specific circumstances: there are no easily transferable blueprints for country policy or strategy. However, what the three cases do throw light on are the kinds of measures, actions and policies that might help to make industries competitive in the world market, and other countries could have something to learn from this experience.

In what follows, the policy context and scope that guided the case studies are explained first. Since the three sectors have distinct characteristics and histories, each study contains its own approach in the light of country circumstances. This section is followed by an interpretative summary of the principal findings. An attempt is made not just to provide a summary of the main findings but also to interpret the significance of those findings in the wider context of technological upgrading. This prepares the ground for the final section, which attempts to draw conclusions and lessons that have relevance for other developing countries.

CHAPTER I

THE POLICY CONTEXT AND SCOPE

Behind the success of individual economies lies the performance of its leading firms, for they are the principal investors and agents of technological and economic change. Their ability to thrive, grow and compete in the world market is central to the process of catching up with the more advanced economies and overcoming poverty. Making profits and staying financially viable require a searching firms for new markets, as well as investment in physical and human capital, access to knowledge, and constant struggle to improve productive efficiency and introduce new products. Knowledge acquisition, use and generation are at the heart of this process. Thus, the three studies, which describe distinctly different histories, explore how and to what extent the requisite conditions for successful global integration were achieved in the economies in question.

However, in studying that experience, the meaning of "success" must be defined with some precision. In the present context, the word is taken to refer to the ability of firms in an industry to compete in the world market without undue reliance on government support and interventions, particularly those related to protective tariffs, subsidized inputs and artificially low exchange rates.[3] The test of the success is basically the firm's ability to increase its presence in the world market, attract foreign investment and partnerships, and generally contribute to the build-up of the country's technological capabilities.

Macroeconomic and financial policies are obviously of great consequence for overall economic performance. While policies at the macro level provide the context, the case studies focused on policies and institutions at the sectoral level. In particular, the areas listed below were held to be worthy of close examination.

- *Industrial policy and incentives regime, including tax incentives:* Markets work within a policy and institutional context. Brazil, India and South Africa are market economies, but the policy environment in each is unique, especially with regard to commercial policy at the macro level and industrial policy at the sectoral level. In explaining the success achieved, the important question is in what respects these policies differed in application and intensity. Furthermore, conditions change over time, and consequently re-evaluation and refashioning of policies are required. How the selected countries adapted themselves over time to changing circumstances is an important element in explaining the sectoral performance. Then, the question arises whether there are supplementary measures needed to make such policies yield their intended result.

- *Regulatory environment and competition policy:* An important aspect of the East Asian experience is the role played by *domestic* competition acting as a force behind national firms becoming strong competitors internationally. While the disciplining force of international competition is greatly stressed in the development literature, the domestic competitive environment can also be a major factor in the emergence of robust firms. In cases

[3] The emphasis must be on "undue reliance". It would be difficult to find a country where government support of some kind has not been significant in the success of its private sector firms.

where domestic competition fails to remove the inefficiencies or high profits engendered by protection, it is likely that domestic firms face some more fundamental weaknesses. The studies addressed this issue from the perspective of the three quite different industries.

- *Science and technology policies*: The policy and institutions related to science and technology (S&T) at the national level certainly influence the sectoral performance. However, specific S&T policies and institutions targeted at the sector are likely to be more important. This requires examination of how individual firms were able to tap into the national S&T networks and how they contributed to the build up of domestic capacities. Especially important here are the relationships between final producers and component suppliers. These backward and forward linkages in the acquisition and generation of technology are at the heart of sustainable human development.

- *Transfer of technology*: All countries rely for their economic advancement on borrowing ideas from others. The economically weak can only catch up if they can learn from the experience and practice of the more advanced countries. In fact, the experience of the East Asian and other countries points to the crucial role that importation of sophisticated technology and management practices played in their successful industrialization. In short, together with capital accumulation, access to and adoption of new technologies are central to long-run growth of economies. The establishment and maintenance of effective access to the potent sources of technology are therefore crucial. The case studies examined the means by which firms acquired technology and successfully adapted to local conditions. This included licensing arrangements, collaboration with foreign firms and the role played by foreign direct investment. Closely related to this is the issue of protection of intellectual property rights (IPRs), which is an important, necessary and usually desirable intervention in the market for knowledge-technology-intensive products. How this protection is designed has important implications for knowledge generation and domestic competition, but what a country might be able to do needs to be consistent with the World Trade Organization's Agreement on Trade-Related Intellectual Property Rights (TRIPS). The case studies included an examination of this aspect.

The discussion of the above areas of policy and institutional development was accompanied, as far as possible, by the quantitative measures of such factors as investment in plant and equipment; development of skills and worker training; the search for and development of new markets; the magnitude and effectiveness of the R&D effort; and inter-firm relationships and alliances. The case studies aimed to explore to what extent these factors were important in the growth and development of the sector. In each case study, at least one firm was selected for a closer look.

CHAPTER II

THE FINDINGS

The case studies deal with the experience of technological capability building in countries in three different continents. While they all have their own unique histories and geographical context, the economies concerned also have significant similarities, of which their relatively large size is the most obvious. Brazil's economy ranks ninth in the world, while India's and South Africa's economies rank 13th and 29th, respectively, according to the World Bank's *World Development Indicators 2002*. In terms of population, India is the second largest country (more than a billion persons), while Brazil, with a population of about 170 million, ranks fifth. South Africa has much smaller population – 43 million – but it too falls among the world's larger countries. With respect to per capita income, India is placed among the low-income group of countries, while the other two, with a per capita income ranging between $3,000 and $3,500, are in the middle-income group.[4] In terms of the purchasing-power parity, Brazil and South Africa are deemed to enjoy living standards comparable to the lower-end of the OECD countries.

The three countries have rather long experience of industrialization, with manufacturing now accounting for roughly one-fourth of domestic output, a proportion broadly similar to that of the industrialized countries. Manufactured exports constitute a major share of their exports, and the three countries are significant players in the world market and are included in the group of 20 or so "systematically significant" emerging market economies. In human capital, Brazil is considerably ahead of the other two with respect to general educational standards, although India can boast of being one of the world's largest exporters of brainpower and can lay claim to some of the world's better scientists, mathematicians and engineers. South Africa too has world-class research institutions and has been a significant contributor to the advancement of science and medicine.

The salient findings of the case studies are summarized under several broad headings. After a description of the origins of the three sectors, the evolution of government policy and its impact are explored. This is followed by a discussion of the various means adopted for the advancement and acquisition of technology, which have played a crucial role in the success of the three sectors. Dissemination of knowledge and technology transfer, and general development of technological capabilities, depend to a considerable extent on the structure of industry and inter-firm relationships. Thus, the significance of scale economies and the role played by industrial clusters are examined separately. Finally, and from the perspective of sustainability and longer-term development, the section concludes with a discussion of how the three sectors have tried to manage risk and the impact of the international market.

[4] World Bank's World Development Indicators 2002.

1. The origins of the three industries

The selected industries are significant in that they represent examples of developing countries breaking into the ranks of the developed countries in some of the most sophisticated and technologically demanding sectors. This was accomplished in defiance of the traditional trade theory of factor proportions; the countries' factor endowments could not be said to be favourable to the rise of automobiles in South Africa, aircraft manufacturing in Brazil or pharmaceuticals in India. The three industries were established in the countries concerned several decades ago, and it took a combination of government policy and private sector initiative to achieve competitiveness in the world market.

In aircraft manufacturing (especially civilian aircraft), Brazil has come to enjoy a rather unique position internationally. The only other developing country that succeeded in gaining a niche in the world market is Indonesia, but its technical and physical capacity has suffered in recent years, and the country was always a much smaller player. On the other hand, many developing countries have significant pharmaceutical and automobile manufacturing capacities, but only a few (mostly in East Asia) have gained prominence in the world market. Overall, it should be noted that this experience of technological development was far from being an unqualified or quick success, but rather typified the difficulties and handicaps that an industrializing developing country must overcome if it is to achieve rising living standards and to catch up with the more advanced countries in a changing domestic and world environment.

The foundations for the automotive industry in South Africa were laid when two transnational corporations (TNCs) – Ford and General Motors – decided to establish assembly plants back in the 1920s. The output of cars expanded rapidly for a few years but was halted by the Great Depression of the 1930s. Production recovered and grew rapidly after the Second World War when several other leading foreign car manufacturers also decided to come in. The process, rather ironically, was helped by the relative closure of the South African economy on account of its apartheid policies.

By contrast, it is difficult to be precise about the origins of the pharmaceutical industry in India; some drugs and pharmaceuticals were being manufactured locally already at the time of the country's independence in 1947. However, the first steps towards a comprehensive policy regime for the Indian pharmaceutical industry were not taken until the mid-1970s. It was in 1974 that a government committee on drugs and pharmaceutical industry (the so-called Hathi Committee) was set up to develop a strategy for the promotion of the industry and to suggest steps for improving transfer of technology, instituting effective quality control and controlling the cost of drugs.

The story of Brazil's aircraft industry followed a different and in some ways more interesting course, as the country started to build up the technological capacity and capability in aeronautics engineering and design long before the establishment of the industry. The origins of the Brazilian aircraft industry can be traced back to the setting up of the Aeronautic Technology Centre (CTA) in 1945 in cooperation with the Massachusetts Institute of Technology, which later led to the creation of the first undergraduate school – Aeronautics Technological Institute – aimed at training specialized aeronautical engineers. Research activities started at CTA in the mid-1950s and were aimed at certain basic areas related to aeronautics, namely electronics, materials, engines and flight tests, and, most notably,

improving jet-pulse engines. The development of technological capabilities in all these critical areas and production of world-class aeronautical engineers can be said to be crucial elements for the subsequent success of Embraer, the aircraft manufacturer.

While the three sectors had different origins, the initial impulse for their establishment was essentially the same namely, to produce for the domestic market. For Brazil, the aeronautical industry was seen as strategically important because of the country's very large geographical size and the poor means of surface transportation and communication. There were also national security reasons at work and the Brazilian military continued to have close involvement in the sector's progress. The rationale for promoting the domestic pharmaceutical industry in India also rested on national concerns about the availability of drugs at affordable prices, especially in view of India's perennial foreign exchange shortage.

In the case of South Africa, however, foreign direct investment of the leading TNCs, rather than protection as such.[5] was instrumental in establishing the industry. By 1960, production of cars had already reached a level of 87,000 units, far higher than in any other developing country. However, the country turned increasingly inwards as its apartheid policies came under international scrutiny and criticism, which ultimately led to the imposition of trade sanctions during the 1980s. The result in fact was that the South African automotive industry grew rapidly during this period and several other TNCs started to invest in the establishment of assembly plants and related activities.

2. The evolution of government policy

The three sectors were promoted by means of consistent government support policies and followed the traditional route of import substitution for several decades. However, policies evolved over time and were adapted to changing times and prevailing wisdom. All three countries embarked on market liberalization policies in the late 1980s, although the process of opening up followed distinctly different routes. In the case of Brazil and South Africa, there were specific events that could be regarded as responsible for the policy shift: the debt crisis of the 1980s for Brazil and the slow and painful death of the apartheid regime in South Africa. In India's case, while it faced no major internal or external crisis, domestic liberalization pressures arose as the process of import substitution had pretty much run its course and the opponents of protectionism gained ascendancy in the country's policy-making forums. But in none of these cases was the "big bang" approach of wholesale opening up adopted; instead they provide illustrations of gradualism and pragmatism, even ponderousness, in refashioning policies. What the record suggests is that, under the broad heading of deregulation, privatization and market liberalization, there can be different approaches to opening up, depending on a country's circumstances.

The Brazilian aeronautical industry faced dire conditions during the late 1980s and early 1990s, when the difficult domestic financial and economic conditions were combined with the recession that gripped the world's aircraft manufacturing industry. This was a time of general disruption of economic activity in Brazil, as industrial plants were shut down and unemployment soared. In view of the very difficult fiscal situation and high interest rates,

[5] It is likely, however, that tariff barriers made foreign investment by the TNCs an attractive proposition.

there was little interest in bailing out the troubled aircraft industry. But there were serious problems internal to Embraer as well, of which the start of a large number of projects in the face of difficult world market conditions was perhaps the most serious. Notwithstanding the company's many achievements, the management had tended to be engineering-driven and less concerned about marketing and financial results. The company needed financing at that time, but this was just not available.

As part of the National Privatization Programme, Embraer was sold to a consortium of domestic private enterprises and pension funds, which was led by Bozano Simonsen Group, a major Brazilian conglomerate with interests in financial, mineral, real estate, agriculture and manufacturing sectors. This was followed by major organizational restructuring and downsizing of productive processes, which, among other things, entailed the loss of some of the most qualified personnel. While these measures certainly helped to streamline the company's operations, the decisive turn in the company's fortunes came when Embraer won a sales contract for 200 of its newest aircraft (ERJ-145) at an air show in England in 1996. This was the result of the company having in its arsenal some very good products to sell. Thus, a matter that was a serious handicap and an embarrassment only a few years earlier – a large number of unfinished projects – became an advantage once appropriate conditions had been created.

The process of reform in India started with the introduction of a new drug policy in 1978, following the findings of the Hathi Committee mentioned earlier. The policy shift was aimed at creating a strong and robust pharmaceutical industry, with the public sector playing a leading role. The programme consisted of measures to deepen the industrial base by encouraging domestic production of basic drugs, channel the activities of foreign firms into national priorities, and promote R&D and generally improve the country's technological capabilities. All this was to be accomplished while ensuring that drugs were available to consumers at affordable prices, a matter of abiding concern to Indian policy makers. Towards those ends, the Government instituted significant modifications to the regulations governing foreign exchange, which had hitherto been specified under the Foreign Exchange Regulation Act (FERA) of 1973, and relaxation of the controls on drug prices that were instituted under the Drugs Price Control Order (DPCO) of 1970.

With regard to the role of foreign firms and access to technology, the application of the Indian Patent Act and rules governing licensing were crucially important. Under the Indian patent system, patents could be taken out only for processes and not for products (this issue is discussed in some detail in the section on technology transfer). The rules governing intellectual property rights were accompanied by the elaborate use of industrial licensing, which was directed at achieving the goal of local production of drugs from the very basic stage by favouring production of "bulk drugs" as against formulations. However, under the 1978 reforms, domestic firms were given considerably greater latitude in the production of formulations while retaining restrictions on the operations of the foreign firms. The latter still had to meet the more stringent requirements: the production of bulk drugs in their case had to account for at least 20 per cent of the total as against 10 per cent for domestic firms. Foreign firms were also restricted to a share of only 40 per cent in equity under the FERA, although exceptions were possible on grounds of "strategic importance" if the firm used "high technology".

India's drugs policy underwent another major revamp in 1994, when a concerted attempt was made to liberalize the pharmaceutical sector. Several liberalizing measures were

adopted: licensing policy was greatly relaxed, especially with regard to bulk drugs; mandated supply of bulk drugs to non-associated formulators was abolished; import of bulk drugs was liberalized; foreign firms were allowed a majority share (51 per cent) in the companies, as against the earlier ceiling of 40 per cent; and price controls were considerably relaxed. Thus, within a period of roughly two decades, India's pharmaceutical company transformed itself from a protected, highly regulated industry to one that came to rely increasingly on market signals and private initiative.

South Africa's liberalization process of was broadly similar to India's, which started in effect in the late 1980s. The thrust of government policy from the early 1960s had been import substitution, taking the form of local content requirements combined with relatively high tariff barriers and direct import controls. These policies led to the proliferation of vehicle models being produced in South Africa. As protection measures are also generally not conducive to exports, the consequence was that, in the face a relatively small domestic market, the scale of production in South Africa's automotive industry remained small and production costs high in comparison with the prevailing competitive international standards.

The liberalization process started in 1989 with the relaxation of perhaps the single most crucial protectionist policy, namely the local-content requirements, which was broadened to allow firms to include exports as part of local content.[6] The local content requirements, whose primary goal was to conserve the scarce foreign exchange, had risen from 20 per cent in 1960 to 52 per cent in 1971, and ultimately reached 66 percent for all light vehicles. Starting in the late 1980s, tariffs on imported vehicles also began to be reduced.

However, it was the Motor Industry Development Programme (MIDP) of 1995, which was formulated and is being implemented by the South African Department of Trade and Industry, that made a complete break with the policies that had guided the industry for several decades. The MIDP, which has separate provisions for light motor vehicles and medium and heavy vehicles, was aimed at improving productivity through industrial restructuring, greater reliance on the market and foreign investment. As far as light vehicles are concerned, the local content requirements have been abolished altogether, while tariff duties were phased down at a more rapid rate than that required under South Africa's obligations to the WTO. Manufacturers of light vehicles are also entitled to a duty free allowance for the importation of original equipment components to the extent of 27 per cent of the wholesale value of the vehicle. Similar liberalizing measures have been introduced for the medium and heavy vehicles as well.

After a review of the MIDP showed generally positive results for the automotive industry, it was decided in 2000 to extend the programme to 2007, with some notable modifications. While import duties will continue to be reduced, the special incentives for the small vehicle producers are being phased out. In addition, the Government is seeking to encourage larger-scale operations through "common platform engineering"[7] and a reduced number of component suppliers. To that end, a new scheme called the Productive Asset Allowance has been introduced as an incentive to invest. This involves a non-tradable duty credit, calculated at 20 per cent of qualifying investments, which is made available to manufacturers for five years. Assemblers are able to use this duty credit against vehicle

[6] In other words, if a firm exported x% of its output and used y% of its output to purchase local inputs, the firm could be said to have met local content requirements to the tune of (x + y)%.

[7] "Common platform engineering" refers to a situation where a single chassis is used to produce different versions of the same model of vehicle.

imports, which will sustain the range of imported products offered to the consumer. The MIDP, however, has given rise to one problem: the export-import complementation scheme has raised questions in the South African region, and it is being claimed that it undermines the ability of other countries' automotive sectors to compete.

3. Mechanisms for transfer of technology

All three sectors – aircraft manufacturing, pharmaceuticals and automotive – depend on technological superiority in order to be competitive in the world market. Technological superiority implies having an edge in the quality of products supplied or being more efficient, in terms of costs and reliability, in production. However, the industries differ in significant respects as far as the mechanisms for the acquisition of technological mastery are concerned. This diversity of experience suggests the need for adaptability, even innovativeness, in fashioning approaches to technological knowledge acquisition and transfer.

A. The Brazilian aircraft industry

The manufacturing and marketing of aircraft are one of the most complex and sophisticated activities. The industry is highly technology-and capital-intensive, requiring numerous parts and components (estimated at close to 30,000), and, because of the small number of producers and the critical importance of each sale contract, the competition in the world market is very fierce indeed. There is no place for “followers” in the world market, which means that each supplier has to have, in some significant respects, an innovative edge. For these reasons, Embraer provides some valuable insights into the means for acquisition and development of technological capabilities, of which the creation of a cadre of highly trained aeronautical engineers prior to the establishment of the industry was clearly the most important.

The setting up of CTA and ITA had provided Brazil with the basic infrastructure for the development and acquisition of skills and capabilities necessary for a modern aircraft industry. However, the sector also had to be helped by other government actions and policies, involving tax incentives and benefits, procurement, and, not least, continuous government support. It was also clear that the company, in order to succeed, had to be pragmatic in choosing areas of specialization and relying on foreign suppliers for some inputs not considered to be crucial to the aim of achieving "technological autonomy". The areas selected for specialization were aerodynamics, project integration, and, most notably, fuselage, which was essential for maintaining autonomy in product design. These were considered to be key technologies for the industry that also allowed for cumulative and incremental technological change. The strategy was based on the premise that mastering technology through systems integration was more crucial for competitiveness than having a larger share of the value added generated domestically. This was an important departure from Brazil’s (and other developing countries’) approach to import substitution, which placed greater weight on value added locally generated.

Closely related to the selectivity in technology mastering was the notion of developing an “aircraft family”, which was employed by other aircraft world leaders such as Boeing and

Airbus for their big commercial jet aircraft. Under this idea, several versions of the same basic model are produced; this helps to speed up production and lower costs by spreading the costs of infrastructure, maintenance, and pilot and technical personnel training. There was as such a complementarity between the technological specialization and the actual outputs.

Embraer, because of the nature of the aircraft industry, had close links with foreign suppliers and buyers. Its early aeroplanes were developed under the licence of an Italian firm, Aermacchi, and a manufacturing cooperative agreement was signed with the US Piper Aircraft Company. The company subsequently entered into cooperative agreements with several other foreign firms. However, it was only the economic and political crisis of the end of the 1980s and early 1990s that forced the company and the Brazilian Government to rethink their approach and embark on a set of new measures to save the domestic industry and Embraer from total collapse. The general financial difficulties arising out of the external debt crisis and weak macroeconomic situation resulted in a sharp reduction in expenditures for R&D and deterioration of the scientific and technological infrastructure. The situation was aggravated by the fall in procurement in aeronautics, space and defence sectors, just when the company was carrying out some large projects. The key components in the rescue of the company were outlining a technological strategy aimed at product innovation, coupled with the identification and fulfilling of client/user requirements and the globalization of the production and de-verticalization process. Embraer dedicates itself progressively more to the important project activities, such as development, systems engineering and integration, adopting strategies of seeking partners to manufacture parts and subsystems, as well as assemblies of systems and kits. Embraer also set up a department to monitor the development of critical technologies for the company by main world aircraft manufacturers such as Boeing, McDonnell Douglas and Sikorsky, and in research centres. Through this method new automation technologies were adopted.

For achieving continuous technological upgrading in this technology-intensive industry, Embraer identified "key technologies", including essential technologies for the future, such as new materials. The company strategically favoured a technology strategy for capacity training in the areas of aerodynamics, fuselage and project integration. Efforts were directed towards training and developing capabilities in two basic areas: the aircraft project and the integration of components that could not be manufactured by Embraer itself, through consulting services and technology agreements. The acquisition of technological competence for the fuselage of the aircraft was considered an essential condition for autonomy in product design and for the eventual success of the firm as a competent final assembler of aircraft. This strategy enabled the company to acquire its essential competence in the excellence of design and integration of highly complex production systems.

B. The Indian pharmaceutical industry

Although the pharmaceutical industry is also highly science-and technology-intensive, its reliance on technology and the means of its acquisition bear little resemblance to the situation in the aircraft industry. While engineering and design are at the core of aircraft manufacturing, drug companies compete primarily on the basis of the products they can bring to the market, which are the result of their own research and development (R&D) efforts. The patent system (which permits firms to appropriate the rents on their innovations) and reverse engineering (which enables firms to develop new ways of producing known drugs) are crucially important for this industry.

The industry can be divided into three product groupings, with decreasing technological sophistication: bulk drugs (i.e. chemicals having therapeutic value), intermediates and formulations (i.e. the medicines which are ready for consumption by patients). The world pharmaceutical industry is dominated by a few large TNCs, and only 10 countries (all of them industrialized) can be considered to have a sophisticated pharmaceutical industry with a significant research base. India is ranked among the next tier of countries, which are classified as having the capabilities to innovate. This group of countries is not active in discovering new molecular entities, but they have the technological capability to reverse-engineer the drugs already discovered.

The Indian patents system, which was introduced in 1970, was designed to favour reverse engineering in that the patents could be taken out only for processes and not for products. The system was further constrained by two other clauses in the Patents Act namely, the patent term was the shorter of five years from the grant of the patent or seven years from the application, and compulsory licences could automatically be given three years after the grant of the patent. The Patents Office generally took more than four years to grant a patent. These provisions were targeted primarily at the foreign companies and resulted in decline in the number of foreign drug patents and a negative impact on technology transfer through foreign firms, even as the relative performance of the domestic pharmaceutical industry improved considerably. The share of domestic firms in the production of bulk drugs virtually doubled between 1975 and 1988, when it stood at more than 80 per cent; the share in formulations also went up, though less dramatically.

Overall, the Indian R&D effort, at less than 2 percent of sales, has remained modest, even though the Government offers fiscal incentives as well as exemption from price controls. Nevertheless, some significant successes have been realized in developing new processes for known molecules. Of particular note is India’s success in New Drug Delivery Systems, which involve the modification of existing molecules to produce more “user-friendly” dosage forms of medicines. There has been a significant rise in applications for patents for these formulations.

India’s main success lay in progressively shortening the lag between the introduction of drugs by the leading TNCs in the world market and their introduction in the Indian market. The basic approach has been for the Indian firms to identify important drugs under patent, reverse-engineer the process, and use that process for producing drugs for the domestic market. This has been a learning-by-doing process, with continual improvement of the production process. The advantage of this process has been that as soon as patents in the industrialized countries expire, the Indian firms are ready to export the generic versions to the world market.

Despite the market liberalizing measures adopted during the 1990's, there has been little impact on the transfer of technology or foreign firms' interest in investing in India. The Government has adopted easier procedures and removed restrictions on royalty and other fee payments, and abandoned the restrictive clauses in licensing and collaborative agreements, but so far with little to show. The main hindrance is considered to be the Indian Patent Law, which still excludes patents for products. Under the TRIPS Agreement, India is to remove this remaining restriction in 2005, which might change the situation.

A key aspect of technological change in the pharmaceutical sector in India is the close interaction between private sector firms and publicly funded laboratories of the Council for Scientific and Industrial Research (CSIR) that are most active in drugs research.

Moreover, in the transition from process development to applied and basic research, there has been a growing realization in India that is needed to leverage collective wisdom. Such leveraging implies intense networking between academia, government and industry to allow the channelling of intellectual resources towards significant incremental progress. The other dimension of this partnership among academia, government and industry is the alliance between industry and national laboratories/universities. On the one hand, companies should educate themselves on scientific research and, on the other, the scientists should become familiar with the world of business. These "knowledge partnerships" are increasingly considered efficient, sustainable and reliable in the pharmaceutical sector in India.

C. The South African automotive industry

The South African automotive industry provides yet another model of technology transfer and development of technological capabilities needed for remaining competitive in the world market. The core elements of the South African approach have been reliance on foreign direct investment (FDI) for technology and establishing a world-class local institution for quality control, namely the South African Bureau of Standards (SABS).

Unlike in Brazil or India, the distinguishing feature of the South African auto industry is that all automobile assemblers are now wholly or partly owned by their respective parent company in Japan, the United States or Europe. South Africa has attracted substantial FDI in both automotive assembly and component production, and foreign companies have been closely involved in local operations. With the end of apartheid in 1994 and of economic sanctions, there was great interest among foreign investors in the South African economy. This was particularly true of the Japanese companies, which had been barred from investing in the country on account of the apartheid policies.

The foreign investment in the automotive industry was targeted at improving the management and operations of the local subsidiaries. There is evidence of positive spillovers in technology transfer, human capital development, organizational development, and, not least, improving access to export markets. Technologies, previously not available to South Africa, have now spread across the entire automotive industry, with significant improvements in product design and production techniques. Human capital development included the transfer of managerial skills, which were needed to improve the efficiency of local operations. But foreign investment also came with a penalty: key investment and marketing decisions are made outside South Africa, with a focus on extending the parent company's global reach rather than improving South Africa's economic growth prospects. Of particular significance is the fact that most of the R&D activity is concentrated within the parent companies and is fashioned by the company's own marketing strategies.

Quality standards were improved as closer links developed between the auto and component producers, which were needed if South Africa's automobile manufacturers were to successfully compete in the global economy. There exists a blend of cooperation and competition among firms in the automotive industry. While vehicle assemblers compete with one another in prices, cooperative relationships are found between vehicle assemblers and

components producers. There is a great deal of inter-firm cooperation between suppliers and customers on matters of product development and quality. This cooperation involves collaboration on design and product specifications.

Although some R&D continues to take place within South Africa, with the automotive exporting firms spending as much as 2.5 per cent of total sales, it is the collaboration between motor assembly firms and the South African Bureau of Standards (SABS), as well as the engineering faculties of some of the leading universities,[8] that have played a particularly important role in the development testing and certification facilities, which are increasingly improving local companies' access to foreign markets. Collaboration between the SABS and various automotive firms has been an encouraging feature in the industry's quest for international competitiveness. In particular, collaboration between the SABS and automotive firms has led to the establishment of the EuroType Test Centre (Pty) Ltd, a state-of-the-art laboratory that can perform vehicle emissions testing to the most exacting European, American and Japanese environmental requirements, making South Africa the only major country in the world that does not require any control over the poisonous gases emitted by motor vehicles. Tests are available for engines and catalytic converters, in which South Africa can now claim to be one of the world leaders. SABS relies on international test methods, and inspects, tests, and analyses the products produced in South Africa to ensure that they meet the compulsory specifications and standards.

4. Industrial structure and inter-firm links

Economies of scale are central to how industries are structured and interact with foreign and domestic competitors and suppliers. They are also important in determining the means adopted for technology transfer and development. Typically, larger firms are better placed to finance R&D and such sales-related expenditures as advertising and promotional campaigns since the expenditure can be spread over a larger volume of output. Marketing strategies and inter-firm links are, therefore, heavily influenced by economies of scale.

The three industries differ in significant respects as far as the scale of operation is concerned. India’s pharmaceutical industry is dominated by a few large firms (some of which are affiliated with foreign firms), but there are a very large number of small and medium-sized firms (about 2,400 against a total of more than 2,500 industrial units). Within the sector, there are producers of the so-called bulk drugs (which are primarily used as inputs) and formulations (which rely on bulk drugs). Bulk drugs tend to be produced by large firms, many of which are foreign-affiliated, while small domestic firms produce mostly formulations. This is a pattern of intra-industry relationship opposite of that found in automotive and aircraft manufacturing, where domestic component suppliers are mostly relatively small firms. Currently, the automotive industry in South Africa consists of 8 light vehicle assemblers and 11 producers of medium and heavy commercial vehicles, while there is only one aircraft manufacturer in Brazil.

In the case of Brazil and South Africa, the rise of the selected industries was part of the development of a cluster of mutually supportive industry. The Brazilian aircraft industry is

[8] At the University of Stellenbosch, for example, important work has been done on emission control and engine testing in collaboration with the regulatory bodies in the European Union.

concentrated basically in the São José dos Campos region in São Paulo state, where Embraer, the manufacturer, is located. This is an industrialized region, accounting for a significant share of value added and the number of firms engaged in manufacturing. The automotive industry in South Africa is located in three geographical clusters, namely the Port Elizabeth/East London, Durban/Pinetown and Pretoria/Johannesburg regions. This geographical proximity is important for interaction between vehicle assemblers and component manufacturers and suppliers. Local firms produce a wide range of components – leather car seats, tyres, catalytic converters, etc. – on which the local automobile industry relies, but have also become key suppliers to producers overseas. Most important, however, is the fact that the testing facility of the SABS is located in the Port Elizabeth/East London cluster, which, as noted earlier, has been a key support institution for the automotive industry.

In their earlier phases of industrialization, each of the three countries tried to create domestically self-sufficient industries, and industrial concentration and vertical integration were encouraged. This changed during the last two decades as markets were liberalized and deregulated and greater emphasis came to be laid on efficiency and profitability ("bottom line"). This change was of particular significance to the aircraft industry in Brazil and automotive industry in South Africa, since in each case final products depend critically on the quality and cost of a myriad of components. While attempts were made to foster domestic component production (through, for example, South Africa's import-export complementation scheme), trade liberalization has had adverse impact on the domestic component suppliers. Many have found it difficult to compete with foreign suppliers, which are much bigger firms with global reach. But there have also been notable exceptions, such as the supply of catalytic converters and leather seats in South Africa, where domestic suppliers have assumed positions of pre-eminence in the world market. The intimate relationship of Embraer with its domestic sub-contractors, which receive the design and raw materials from the final producer, has also helped nurture domestic industry.

5. Strategic alliances and risk management

There are inherent risks in any investment, but when protection is removed and sectors are exposed to world competition, risks multiply. It is in this context that alliances with foreign investors and suppliers become important means for sharing risk. In each of the three industries, such links have been forged but they differ in details. The most notable example, of course, is that of Embraer, which is a single large-scale enterprise, competing in a market dominated by the world's largest aircraft producers. When the company was privatized in the 1990s, the company was acquired by a consortium of domestic enterprises and pension funds. But as the company's exposure in the world market increased, it felt impelled to take on board foreign stakeholders as well. Thus, in order to access new technologies, components and markets, it sold 20 per cent of its shares to a French consortium led by Aerospatiale Matra, Dassault Aviation, Thompson-CSF and Snecma. This was done in order to double its customer base, while opening up new possibilities for external financing.

At the same time, close strategic links were forged with overseas companies through a model of "risk partners". Thus, during the programme to develop the ERJ 145 aircraft, periodic consultations were held with the risk partners as well as potential customers and pilots' associations. Risk partners were selected on the basis of prior relationships and

experience with Embraer, going back to the old turbo-prop projects. There are several levels of partnership. At the first level are the risk partners defined as those that assume financial risks in the projects mostly a few large international firms that participate in the co-design process and add technological value. At the second level are suppliers of components, parts and services ordered by the company; these are almost entirely located abroad. The relationship with these firms is both technological and commercial. At the third level are the sub-contractors, companies and individuals that receive raw material and design from Embraer. Relationships at this level have two dimensions: project and engineering services, and milling services. This group of firms is directly subordinated to Embraer and most of them are located in São José dos Campos.

A similar activity in establishing foreign partnerships can also be seen in the case of India's pharmaceutical industry, where at least one leading domestic firm has entered into a strategic alliance with one of the world's largest TNCs on more or less equal terms. Thanks to its own efforts at developing novel drug delivery systems (NDDS), Ranbaxy Laboratories – the leading Indian firm – was able to establish close partnership with Bayer AG, a German company, in the development of a new generation of antibiotics called ciprofloxacin. This happened when Ranbaxy Laboratories were able to improve on the original product, developed by Bayer AG: instead of the multiple dosage per day, the modified formulation could be taken once a day, which was considered to be a major advance from the perspective of the consumer.

The case of South Africa is rather different as a large part of the automotive industry is foreign-owned and commercial risks are borne primarily by the parent company. Through the system of franchise, the parent companies take responsibility for providing technical support, training programmes, and finance for new or expanded operations. Another example of foreign collaboration is the EuroType Test Centre (Pty) Ltd., which is a state-of-the-art laboratory that can test vehicle exhaust emission to the most exacting European, American or Japanese environmental standards. The Centre has secured contracts from Daimler-Chrysler and BMW to perform vehicle emission testing for all their export vehicles.

6. Promotion of industry and global trading rules

There is hardly a country that industrialized without the Government's active support and facilitating policies. The three industries under discussion were no exception, as has been observed earlier. However, since the conclusion of the Uruguay Round of multilateral trade negotiations and the establishment of the World Trade Organization (WTO), the rules governing international trade have been considerably tightened, and countries have had to adjust their national policies. Given their generally low income levels and early stage of industrialization, and weakly functioning markets, the developing countries have a stronger need for government support and promotion of national development objectives.

If the three industries were being established today, the countries concerned would have to conform themselves from the start. In the case of Embraer, apart from offering fiscal incentives, special rules governing government procurement as well as government involvement in the design of sales agreements, which contained provisions for technical assistance and technology transfer, were important elements in the strategy to promote the

Brazilian aircraft industry. More relevant, the Federal Government arranged financing for the sale of aircraft through the Brazilian National Economic and Social Development Bank (BNDES) at interest rates comparable to those prevailing in the international financial markets, a measure that was successfully challenged by Canada (a close rival) in the WTO on the grounds that it amounted to subsidizing Brazil's exports.[9]

Policy interventions in support of the domestic pharmaceutical industry in India were more extensive. Apart from tariff protection, the Government relied on differential price controls, restrictions on foreign ownership of the industrial enterprises, and, perhaps most significantly, the peculiar Indian patents regime, which offered protection to the innovator for a rather short period of time and confined itself to innovations in processes rather than products. The latter is now in conflict with the TRIPS Agreement and will have to be modified by 2005. Favourable tax treatment was also given to R&D expenditures incurred by firms. These measures were considered to be "non-actionable"–that is, they could not be challenged under the WTO Agreement on Subsidies and Countervailing Measures for a period of five years following the entry into force of the Agreement.[10]

In the case of the automotive industry in South Africa, the policies that would be in conflict with the existing WTO rules related to the differential impact of tariff protection and rules governing the local content, both of which were intended to promote domestic production of not only the final products (automobiles) but also components. However, since the mid-1990s, South Africa has gradually reduced its import tariffs and eliminated local-content requirements.

While the WTO rules may provide some latitude in the promotion of local R&D, technology transfer and the development of backward regions virtually all traditional means for protecting and promoting domestic industry are now disciplined by multilateral rules. The special and differential treatment for the developing countries provides longer periods for implementing agreements and bringing their policy regimes into line with the WTO rules. However, negotiations on outstanding implementation issues, carried out under the Work Programme agreed at the Doha Ministerial Conference, will provide a new scenario for supporting development.

[9] Although the WTO ruling found against Brazil on the issue of subsidizing overseas sales based on a scheme of interest rate equalization, it nevertheless raises a rather fundamental question: should the interest rate charged to a buyer be comparable to what it can obtain in the world's financial market or linked to the cost of raising finances on the part of the seller? The WTO ruled in favour of the latter position. Developing countries may find themselves in a distinctly disadvantageous situation since their credit rating in the financial markets tends to be much more unfavourable than that of the developed countries.

[10] The Fourth Ministerial Conference at Doha accepted the proposal to examine the issue as regards subsidies for research and development activities in developing countries and recommended that such measures not be challenged in the interim period.

CHAPTER III

CONCLUSIONS AND LESSONS

The case studies narrated stories of how some of the most demanding and technologically sophisticated industries became established in three developing countries. However, it is important to note that what has been called success is a rather recent phenomenon. The three sectors – aircraft manufacturing in Brazil, pharmaceuticals in India and the automotive industry in South Africa – were in fact established in the countries concerned a long time ago and went through some very difficult periods in their development, when their rationale became questionable.

It should also be noted that the measure of success adopted in the present context – namely, penetration of the world market, growth in sales, and financial returns – may not be universally acceptable. Certainly, some may reasonably argue that these indicators could not provide an adequate basis for evaluating the efficiency in resource use, which raises the following question even though profits are now being generated in these sectors, could resources have been better employed elsewhere? However, the scenarios of "what-if" situations are not very reliable, considering that the range of counterfactuals and possible outcomes is practically limitless. The real test is how to make the most of the existing situation.

As noted at the outset, the case studies did not aim to make a case for establishing the three sectors in other developing countries, but rather attempted to explore and identify the key factors that were responsible for the actual outcome. Putting it differently, the issue of interest for other developing countries is not whether aircraft manufacturing, pharmaceuticals or automobiles would be suitable industries for promotion in their local contexts, but rather one of achieving international competitiveness in a relatively open world trading environment in new lines of productive activities, which they must develop if they are to catch up with the more advanced countries.

In one important respect, the proponents of both free trade and protection share a common belief: they both hold that the rules governing international trade are crucial for the development of robust, competitive industry. One view holds that free trade, by exposing domestic producers to foreign competition, will promote efficiency. The other holds that protection is needed in order to allow infant industry to grow to maturity and international competitiveness. Both views tend to ignore, or at least underplay, *the importance of the myriad other components of industrial policy* that help industry to grow and technologically dynamic and competitive firms to rise. It is the complexity of the policy outcome nexus that the three studies attempted to bring out in that is, there is not a unique policy, but rather flexibility in policy response for adjusting to a changing environment that is central to achieving success.

What the case studies help to show is that industrial champions are *created* by means of a combination of market signals and government actions and support. And this process

takes a very long time: infants take decades to mature. In this respect, the experiences of the three case studies are rather similar to the experience of industrial development in such East Asian economies as the Republic of Korea and Taiwan Province of China. From the perspective of long-term growth of incomes and productivity, it matters what lines of industrial activity countries specialize in. For other countries, the lessons lie not in the actual selection of the industry but rather in how each of the three countries overcame the handicaps they faced and struggled to gain a place in the world market.

A related point is that government policy in each case was not confined to protection measures, but to a host of complementary measures to sustain, support and protect the industry concerned. Thus, in the case of pharmaceuticals in India, policies regarding the investment in R&D, regulations concerning the production of bulk drugs, an elaborate system of price controls (with its differential impact), and, not least, the peculiar features of the Patent Law all played significant roles in the development of the industry. For the promotion of the Brazilian aircraft industry, tax incentives promoting R&D activities were combined with government procurement rules and facilities for financing sales. However, the emphasis on the development of human resources and technological capabilities – all undertaken in the public sector – was the crucial factor; it is inconceivable that other policies would have worked without this element in a technologically highly sophisticated industry. On the other hand, in South Africa, the automotive industry was driven by foreign investment, but it took root behind high tariff protection as well as stringent local-content requirements in production. In recent years, together with the liberalization of the sector, the development of domestic capabilities to control product quality – led by SABS, a public sector institution – has been instrumental in giving South Africa a significant presence in the world market.

The success of each industry in the world market to a considerable extent rests on a few products where it has become internationally competitive and earned a high reputation. Thus, Brazil's aircraft manufacturing is driven by the spectacular success of its ERJ-145 aircraft and the promise of ERJ-170/190 aircraft. The first aircraft's competitiveness in the world market depended primarily on its cost, but the later models compete on the basis of technological superiority. For India's pharmaceutical industry, the breakthrough came when its leading firm, Ranbaxy Laboratories, developed a more user-friendly variation of an important new antibiotic. This was facilitated by the focus of Indian research institutions on advances in molecular biology, which was in turn helped by the country's patent regime. Finally, South Africa has made its name in the world market in producing catalytic converters and car leather seats, where the country enjoys a position of pre-eminence.

The question then arises as to how *to establish a niche in the world market*. Unfortunately, there is no magic formula for this that could be adopted and emulated by others. However, the case studies do underscore a couple of points. One, there is little a priori basis for predicting which products would succeed in the world market. A strategy based on developing a single product – an aircraft, an automobile or a drug – is fraught with commercial risks: there are numerous examples from industrial countries, where much touted innovative products never became commercial successes. So, a more reliable approach is to develop a whole range of high-quality products, some of which could then become commercially viable in the world market. The most dramatic example of this was Embraer's product pipeline in the mid-1990s, when the company faced dire financial difficulties. The situation changed completely when Embraer won a major sales contract to sell two hundred ERJ-145 at an air show in 1996.

This leads to the point that, ultimately, it is past investments in physical capacity, human resource development, build-up of technological capabilities, and, not least, establishment of collaboration arrangements with foreign companies to penetrate new and dynamic markets that contribute to success. In other words, enterprises cannot expect to be able to sell their products in the world market simply on the basis of their lower cost; the actual marketing is a much more complex matter. Why the three sectors under study took a long time to mature is at least partly due to these considerations.

Firms compete on the basis of quality and cost of their products, and both require investment in building up technological capabilities. It is frequently argued that developing countries should take advantage of their cheap labour and produce labour-intensive goods. While this advice has considerable commonsense appeal, it is at best of rather limited value. A key goal of economic development is to raise living standards, which includes raising real wages. Thus, for a successfully developing economy, the low-wage advantage can only be temporary; the country actually plays in the world market on the basis of its productivity. The higher the productivity, the higher the level of sustainable real wages.

From the viewpoint of long-term national development, the areas of productive activity that a country starts to specialize in matter a great deal. It is the lines of activity where the potential for productivity growth is greatest that would generally permit rising living standards over time. Thus, in devising their policies and strategies for long-term growth, countries have not only to assess carefully what they can successfully produce and sell in the world market immediately but also develop areas of productivity growth for the longer term, for which *the importance assigned to domestic knowledge generation* is crucial.

It is in this context that the wider relevance of the experience of the three cases should be seen. In each case, deliberate and conscious efforts were made at the industry level to develop human resources and technological capabilities necessary for the advancement of the industries concerned. To get started, there is obviously a need for the existence of the basic technological resources required for the industry concerned, but the technological capabilities have continuously to be built up over time if the sector is to remain in the world market.

But the experience of the three cases shows that it is not sufficient, for successfully integrating into the world market, just to keep up with the technological advances taking place elsewhere in the world; the industries, at least in some areas, must become technological leaders and pioneers themselves, and contribute in some way to the advancement of knowledge. This is important for several reasons. First, if a sector relies exclusively on imitation, it can never expect to catch up with firms in the more advanced countries. Secondly, by gaining an edge in certain lines of activity and creating a niche in the world market, firms can take advantage of being the supplier of a diversified product. Finally, when the firm is active in knowledge generation, it can be expected to assume a stronger bargaining position when entering into knowledge-sharing arrangements with foreign collaborators, investors or suppliers.

In other words, the transfer of technological knowledge takes place at two levels. The common notion of knowledge transfer in the context of developing economies is one where a sharp distinction is drawn between the generators of knowledge (typically, the developed countries) and the recipients of that knowledge (typically, the developing countries). But there is also a tremendous flow of ideas and knowledge among peers. While there is no question that the economically better-off countries are also technologically more advanced, there is

nevertheless a great deal of knowledge that is generated also in developing countries. Thus, the transfer of technology should be seen as a two-way flow, and the more active developing countries are in generating knowledge, the stronger their position would be in accessing knowledge being generated elsewhere.

There is, however, one aspect of the experience in this important area of technology generation that gives rise to some concern, and this relates to the withering away of local technological capabilities that may arise as a consequence of liberalization processes and to some mechanisms for knowledge transfer. With the opening up of the Brazilian economy and the increased reliance on foreign component suppliers at the expense of domestic sources, domestic generated technologies were abandoned in many sectors. While producer and supplier interrelationships have been seen to be important means for technology transfer and build-up of domestic technological capabilities, this poses a dilemma for policy makers: producers should be free to choose their suppliers; however, this often implies dismissing domestic suppliers even when they may efficiently produce quality goods and contribute to knowledge generation. In the case of the South African automotive industry, the generation of local technologies also suffered as a result of the centralization of research activity in the parent companies.

These three case studies, however, show that there is *diversity in modalities of FDI and foreign partnerships*, ranging from straightforward ownership of local enterprises, as in South Africa, to complex strategic partnerships with foreign suppliers including of finance, as in Brazil, or to highly regulated arrangements governing foreign investors, as in India.

What the three cases demonstrate is that domestic policies are important in ensuring that foreign investment and strategic partnerships actually support national development. The engagement on the part of foreign stakeholders should be seen in the context of domestic policy environment and depends also on the host country's technological capabilities. In technology-intensive industries, domestic technological capabilities are crucial to bargaining power, as has been seen in the case of Brazil and India.

The domestic policy environment has also to be seen in the light of WTO rules. Under the WTO's TRIMs Agreement, certain investment measures (notably, domestic content requirements or "trade balancing requirements"[11]) are held to be trade restricting and distorting, and consequently inconsistent with the obligation of national treatment under Article III of the GATT 1947. South Africa has accordingly changed its automotive policy based on local content requirements, as mentioned earlier. It has taken similar action regarding other kinds of discrimination in favour of domestic investors and against foreign investors.

[11] These are measures where inputs imported by an enterprise are linked to its export capacity.

Part II

Case Studies

A Case Study of Embraer in Brazil

INTRODUCTION

It is widely recognized that the capacity to generate and use knowledge is the most important element for sustainable competitiveness and growth of firms and countries. In fact, as emphasized by the evolutionary approach to innovation, knowledge creation and diffusion are fundamental sources of sustainable economic dynamism. Learning, the key source of change, is seen as the most important mechanism for knowledge accumulation, innovation and growth. Firms are obviously at the centre of these processes. However, it is increasingly observed that interactions among them and their interactions with a number of other organizations (dealing with such aspects as education, training, research and development (R&D), financing and policy support) play an important role in the process of knowledge creation and diffusion.

To deal with such complexity the notion of systems of innovation was developed. Furthermore, the concept of national systems of innovation (NSI), which stresses the importance of knowledge and innovation in explaining the economic performance of firms and countries, has become accepted as a useful way to understand the interactions occurring in the process of generation and diffusion of technologies and the institutional diversity which is part and parcel of this process (Freeman, 1987; Lastres, 1994).

However, there have been limited attempts to use the idea of NSI in analyses of developing countries. These have generally taken for granted both the hypotheses and analytical categories elaborated for industrialized countries, with little effort made to qualify the concept and adapt it to the development environment. In fact, until recently, development theory, when considering the possibilities open to developing countries to establish production and participate efficiently in the world market, has focused on comparative wage rates, natural endowments and other related advantages as necessary preconditions. It is true that a number of authors have emphasized the role of technological change in the growth of developed countries. However, development economists have not typically thought of industrialization in terms of technical change, despite the emergence of a large and important body of literature on technical change and development.

The basic aim of this paper is to analyse the recent success of Embraer, the Brazilian aircraft manufacturer, as an example of how innovation systems have been used in a country that are still in its development stage. The paper argues that mastering technical change has always been essential for development, even more important in the present era of world capitalism, known as the Knowledge Era. The analysis of the Brazilian aircraft innovation system is part of an ongoing research project on National and Local Systems of Innovation in the MERCOSUR countries, carried out by several institutions and scholars in the region. The project aims at gathering and analysing information on local productive clusters with a view to contributing to discussions about national systems of innovation in developing countries

(characterized by even higher levels of diversity and institutional instability than those of the developed economies).

The paper is organized in the following way. Chapter I discusses the importance of Embraer and the Brazilian aircraft innovation system in the Brazilian economy. Chapter II analyses the development of the Brazilian aircraft industry and related innovation system from their origin in the mid-1940s till the early 1990s when structural changes in Brazil led to Embraer's privatization. This analysis shows that strong and continuous support by the federal Government and the state and a particular technological strategy were essential for the consolidation of the innovation system and the recent success of the company. Chapter III concentrates on a discussion of Embraer's strategy after privatization and chapter IV describes Embraer's recent success based on its understanding of competition in the aircraft market during the 1990s; its productive and innovative strategy is also discussed. Chapter V presents the aircraft innovation system of São José dos Campos, as it is today, pointing out its fragility and strong points. Finally the concluding remarks present policy prospects.

CHAPTER I

THE IMPORTANCE OF EMBRAER AND THE AIRCRAFT INNOVATION SYSTEM IN THE BRAZILIAN ECONOMY

Since the early 1990s, structural reform, through liberalization, deregulation and privatization, has significantly affected innovative behaviour at the microeconomic level in Brazil, with important consequences for its national systems of innovation (NSI). The following are some of these consequences, as suggested in an earlier paper (Cassiolato and Lastres 2000):

- The substitution of imported capital goods for domestically-produced machinery and equipment;
- A significant decline in public expenditure on science and technology (S&T) as a result of structural reform, and particularly privatization;
- Although private agents were expected to play a more important role in technological activities empirical data show that this has not been the case;
- The discontinuation of local engineering activities by subsidiaries of transnational corporations (TNCs);
- Most of the local innovative firms have been acquired by TNC subsidiaries that, as part of their strategies, are downgrading the technological activities carried out locally;
- Independent and public R&D institutes are changing the mix of activities they conduct: they are reducing the number of research projects they undertake and increasing the share of consultancy and technical assistance activities, which provide them with the resources they need.

One of the most significant results of these changes has been that the Brazilian economy has specialized in sectors and areas of relatively low dynamism. As table 1.1 shows, in 1998 the share of exports of "very dynamic" goods (those in which international trade grew at least 10 per cent in value between 1982-1984 and 1996-1998) in total exports, was 18 per cent in Brazil. Although this pattern is similar to that of other Latin American economies such as Argentina and Chile, it significantly contrasts with the experience of other countries that have benefited from globalization such as the United States (42 per cent of dynamic goods' exports), Japan (55 per cent), Germany (46 per cent), Malaysia (57 per cent) and the Republic of Korea (48 per cent).

In fact, given the specialization pattern of Brazil's economy, its participation in trade flows in new technologies is negligible. Brazil's share of world exports of technology-intensive products (aerospace, informatics, electronics and telecommunications), as defined by OECD, 1996 fell from 0.6 per cent in 1985, to 0.26 per cent in 1991 and 0.19 per cent in 1995. This pattern is similar to that of the other members of the Southern Common Market (MERCOSUR), such as Argentina that witnessed its share decline from 0.08 per cent in 1985 to 0.04 per cent in 1995 (see table 1.2).

Table 1.1. Share of exports of "very dynamic" goods* in total exports, selected countries, 1998

Country	%	Country	%
Japan	55	Malaysia	57
United States	42	Korea, Rep. of	48
Germany	46	India	19
France	41	Brazil	18
Spain	40	Argentina	16
Italy	38	Chile	9

*"Very dynamic" are goods for which the world trade grew by at least 10 per cent in value between 1982-1984 and 1996-1998.
Source: IEDI[12] (2000), quoted in *Folha de São Paulo*, 25 April 2000.

Table 1.2. Total exports of high-tech products, selected groups of countries, 1985-1995 (US$ million and percentage)

	1985		1991		1995	
	$ million	%	$ million	%	$ million	%
European Union	139 795	50.6	136 761	43.1	193 871	38.0
NAFTA*	61 846	22.4	92 054	28.9	121 194	23.7
Latin America (excl. Mexico)	1 959	0.7	1 074	0.3	1 314	0.3
- Brazil	1 697	0.6	817	0.26	982	0.19
- Argentina	232	0.08	221	0.06	222	0.04
Asian tigers**	64 583	23.4	69 777	21.9	149 588	29.3
Australia	423	0.15	709	0.22	1 392	0.27
New Zealand	140	0.05	88	0.03	213	0.04
South Africa	NA		322	0.10	516	0.10
Total	276 237		317 999		510 710	

* NAFTA: North American Free Trade Area, comprising Canada, Mexico and the United States.
** Japan, the Republic of Korea, Taiwan Province of China and Singapore.
Source: European Union (1997)

This downgrading of Brazil's specialization happened during a period when structural reforms were adopted with a view to modernizing the economy and increasing its competitiveness so as to accelerate the country's integration into the globalizing, knowledge-based economy. A strong effort to attract new foreign direct investment (FDI) was an essential component of this strategy, which Brazil aggressively pursued during the 1990s. However, the new FDI of the 1990s was directed mainly at mergers and acquisitions of existing firms rather than at greenfield investment. A recent study which attempted to identify the strategies of TNC subsidiaries that are planning new investments found that they are basically import-intensive and aim at producing for the internal MERCOSUR market; they are not export-oriented (Laplane, Suzigan and Sarti, 1998).

[12] Instituto de Estudos para o Desenvolvimiento Industrial (IEDI), São Paulo, Brazil.

These two features of FDI in Brazil – relative concentration in acquisitions of local firms and market seeking, import-intensive forms – have had a critical impact on local innovation systems in the high-tech sectors. Several experiences in Brazil illustrate this. For example, in 1996 and 1997 a number of TNCs acquired several large domestic auto-parts producers that were specialized in technology-intensive goods, such as Metal Leve, Freios Varga and Cofap. Subsequently, the R&D activities of the local firms were downgraded, and notably their more advanced R&D was relocated to the parent firms' R&D centres in their home countries.

Even in many of the country's high-tech firms, R&D activities were scaled down when TNCs bought into them, as happened when Alcatel purchased Elebra – one of the most important producers of switching systems – in 1992. In 1999, Zetax and Batik, two domestic firms producing and developing a technologically advanced switching system called Trópico, became part of Lucent Technologies. Interviews indicated that Lucent was not interested in local R&D, preferring to rely on technologies developed in the parent company. A similar process has been observed in other telecommunications TNCs active in Brazil. Since they are increasingly exposed to international competition, they are scaling down local R&D as a cost-reducing strategy. In particular, R&D activities geared to the development of new products is discontinued, with a shift to the more simple adaptation of imported processes and products. In most cases, this has meant that highly qualified engineers engaged in R&D are transferred to other, less-specialized, functions such as production, quality assurance, sales or marketing. A related process observed in the hi-tech telecommunications and information technology clusters in Campinas and São Carlos is that the newly-established affiliates are not linking into locally-based supplier networks. Instead they operate in isolation from the domestic innovation system, preferring to deal with their parent companies and other affiliates rather than with local firms. This too has a negative impact on local R&D capacity.[13]

As a result, the country is losing the competitive edge it had developed in some product markets. This has reinforced a process of increasing import intensity that began with trade liberalization in the early 1990s. For example, the import penetration coefficient for parts and components in the car industry increased from 8 per cent in 1993 to 20–25 per cent in 1996; import penetration in information technology and telecommunications products soared from 29 per cent in 1993 to around 70 per cent in 1996 (Laplane, Suzigan, and Sarti, 1998). If local production of high-tech intermediate inputs in production continues to decline, the share of imports is bound to increase further. The impact on technology would then be reinforced by an adverse impact on the trade balance.

Given the above-mentioned emerging pattern of international system of production, the case of the Brazilian aircraft manufacturer, Embraer, stands out as an admirable exception. As shown in table 1.2 above, Brazil's total exports of hi-tech products in 1995 amounted to less than a US$ 1 billion (US$ 1 = Real$1). According to official statistics (table 1.4), Embraer was responsible that year for US$ 182 million (i.e. 0.7 per cent) of all manufactured goods exported by Brazil. Four years later, the company became the largest Brazilian exporter, with US$ 1.7 billion worth of foreign sales in 1999 and US$ 2.7 billion in 2000 (table 1.3); this represented 6.48 per cent of all Brazilian exports of manufactured goods in 1999 (table1.4). In 1997, during the Aerospace Fair at Le Bourget, Paris, it signed contracts worth US$ 6.6 billion – a record in the world aeronautics industry. In a period of less than five years Embraer was able to reverse its near bankruptcy to become, in 1998, the world

[13]For details, see Cassiolato, Lastres, and Szapiro, 2002; and Szapiro, 2002.

leader in the commuter/regional jet market. It is now the fourth largest Western aeronautics firm, just behind Boeing, the Airbus Consortium, and the Bombardier Group, the latter being its direct competitor. Having designed, developed, produced and commercialized two successful medium-sized aircraft, the ERJ-145 (50 seats) and ERJ-135 (35 seats), Embraer has become the only world player among Brazilian firms in the technology-intensive area. It is also the only important locally-owned firm in this area that has so far resisted acquisition attempts by foreign TNCs.

Table 1.3. Main Brazilian exporters, 1999 and 2000

	Exports	
Firms	US$ million	
	2 000	1 999
Embraer S/A	2 702.0	1 691.5
Cia Vale do Rio Doce	1 596.1	1 542.1
Petrobras S/A	1 456.5	739.8
Volkswagen do Brazil Ltda	1 128.9	527.4
Bunge Alimentos S/A	976.9	925.6
Cia Siderúrgica Tubarão	948.8	753.9
Fiat Automóveis S/A	622.6	813.4
Motorola Industrial Ltda	597.2	150.9
Aracruz Celulose S/A	587.0	488.3
General Motors do Brazil Ltda	572.6	456.2
Total (10 largest)	11 188.6	8 089.1
Others	43 897.0	39 922.3
Total	55 085.6	48 011.4

Source: Brazil – Secretaria de Comércio Exterior (SECEX), 2000.

Table 1.4. Brazil: Total exports, exports of manufactured goods and exports of aeroplanes, 1995-1999 (US$ million)

	1995	1996	1997	1998	1999
A. Total exports	45 506	47 747	52 994	51 140	48 011
B. Exports of manufactured goods	25 565	26 413	29 194	29 387	27 329
C. Exports of aeroplanes	182	284	681	1 159	1 772
D. C/B	0.71	1.08	2.33	3.94	6.48

Source: Brazil – Secretaria de Comércio Exterior (SECEX), 2000.

Embraer's remarkable recent success is certainly the result of deep restructuring processes in production and business following its privatization in the 1990s. However, most importantly, it is also the result of long-term government-sponsored institutional and technological developments that date back to the 1950s. The next chapter discusses the origins and historical development of the Brazilian aircraft industry.

CHAPTER II

DEVELOPMENT OF THE BRAZILIAN AIRCRAFT INDUSTRY UP TO PRIVATIZATION: STATE SUPPORT AND TECHNOLOGY STRATEGY

Brazilian aircraft production is concentrated in the São José dos Campos region of São Paulo state, which is where Embraer is located. São José dos Campos is 80 kilometres from the city of São Paulo. According to official statistics for 1996, this region was responsible for 6 per cent of the value added, 3 per cent of the total number of firms, and 4 per cent of the industrial workforce of São Paulo state.

Chart 1.1 presents the most important events that have affected the evolution of the Brazilian aircraft industry (BAI). In fact, the origins of this industry can be traced back to the setting up of the Aeronautic Technology Centre (CTA) in 1945 as an institution of the Ministry of Aeronautics, which was created four years earlier. The Centre was initially made possible through a cooperation agreement with the Massachusetts Institute of Technology (MIT), United States. In 1947, CTA set up the first undergraduate school, Aeronautics Technological Institute (ITA), with the aim of training specialized engineers and it has been one of the best engineering schools in Brazil.

At the beginning CTA and ITA were located in Rio de Janeiro, which was Brazil's capital at that time. However in 1950 they were transferred to São José dos Campos. In the mid-1950s CTA began research activities with the setting up of the Institute of Research and Development ((IPD, in Portuguese) for undertaking research in some basic areas related to aeronautics (aircraft projects, electronics, materials, engines and flights tests). One of the first technology projects, by IPD's Department of Engines, aimed at improving jet-propulsion engines. In 1954 an ambitious project, the Convertplane, was also conceived, aimed at designing an aeroplane with a vertical take-off propeller and a horizontal flight trajectory, to be used as a conventional plane. This resulted in the prototype of BF-1 (*Beija Flor*), a two-seater helicopter.

The main idea behind the setting up of a technology centre (CTA) and an institution (ITA) devoted to training high-quality engineers, modelled on MIT (ITA), was to establish, develop and acquire skills and capabilities in aircraft manufacture. In fact, since the creation of CTA, Brazilian policy had envisaged the setting up of a national aircraft industry as the ultimate goal for the sector. CTA was to occupy a central place in the strategy, as it would foster the development of the requisite human resources and technological capabilities. And the setting up of Embraer as a State-owned manufacturer of aircraft, under the Ministry of Aeronautics was a natural outcome of these earlier developments. State actions and policies, unprecedented in Brazil's technological and industrial history, which used tax incentives and benefits, procurement, and continuous government support, enabled the recent successes of the country's modern aircraft industry.

Embraer was conceived as a State-owned company that would concentrate its efforts on the assembly of aeroplanes. The important point about Embraer's initial plans was that the local manufacture of aeroplanes was to be undertaken through aircraft projects designed and conceived in Brazil by Brazilian engineers and technicians. The basic concept behind the plan

was the acquisition of "technological autonomy", meaning the capacity to understand the whole technological cycle of aircraft production by developing and manufacturing it. It is worth pointing out that this concept was similarly used in some other areas where the Government had played an important role in the 1950s and 1960s, such as oil production (with Petrobras) and even car manufacture (with FNM).[14]

In 1969 Embraer was set up as a government-controlled enterprise (Sociedade de Economia Mista), with the Brazilian Government keeping at least 51 per cent of the voting capital. It commenced its manufacturing activities in January 1970 with a staff of 150 employees, all recruited from CTA (more specifically IPD). Blue-collar workers were recruited mainly from the automobile industry, which had been set up in Brazil in the late 1950s. The initial capital subscribed by the federal Government was about 5 million cruzeiros (around US$ 1 million).

Given its size, Brazil used to be a large importer of small aeroplanes (up to 10 seats) from the United States. During its early stages, Embraer signed a manufacture cooperation agreement with the PIPER Aircraft Company of the United States to carry out production of an import substitution kind. In 1971, its first aircraft, the Ipanema, was launched; it was designed for civilian use, specifically the agricultural market. Also that year, Xavante – an aeroplane designed for the military market – was launched. The Xavante project was developed through a licensing agreement with an Italian firm, Aermacchi. In 1973, Embraer's most successful aircraft, the 19-seater Bandeirantes, was launched, intended for both the civil and military markets.

From the late 1970s to the late 1980s Embraer successfully embarked on several ventures. In 1978, Xingu and Tucano aircraft directed at the Brazilian market were launched. In 1981 the Brasilia aircraft project was relaunched. This aircraft was intended to be an improvement on the successful Bandeirantes, while using the same basic technologies.

In 1980 another project, the AMX, to manufacture a military aircraft, was set up as a joint venture with Italian firms: Aeritália (with a 46 per cent share) and Macchi Aeronautic (with 24 per cent), and Embraer had a 30 per cent share. Embraer also entered into an agreement with Argentina in 1989 for the 12-X project, a prototype aimed at replacing the Bandeirantes, as part of the political agreement between the two countries, which culminated the creation of MERCOSUR. However, this project turned out to be Embraer's biggest failure.

It was also in 1989 that the development of what would become its biggest success started: the ERJ-145 was to be the first jet produced by Embraer. It was a project conceived under the so-called "communality" concept that in fact meant designing a jet aeroplane using similar basic concepts as the previous turboprop technology, with many components common to the Brasilia and CBA-123.

Embraer has conquered the regional air transport market, both in Brazil and internationally, with its EMB-110 Bandeirante for 19 passengers, and, more recently, the EMB-120 Brasilia for 30 passengers. Both turboprop aeroplanes acquired an international reputation becoming leaders in the United States market in their category. As a matter of fact,

[14] The project of manufacturing a locally developed car with FNM was subsequently abandoned when foreign-owned car assemblers were chosen to lead the Brazilian strategy in the area. In fact when Volkswagen of Germany acquired FNM in the early 1960s the project was scrapped.

in the early 1990s, the Brasilia had a 24 per cent share of the world market for aircraft of the same category (Dagnino, 1987).

Embraer's success in technology and innovative development was exceptional and unprecedented in Brazil's industrial history. It should be pointed out that crucial to this success was the technology developed by the IPD. Although license and cooperation agreements with foreign firms were essential for the success of Embraer, the origins of the three projects (the EMB-110 Bandeirantes, the IPD-6909 Ipanema and the EMB-326 Xavante) can be traced to IPD in the late 1950s. In fact most products, technologies and human resources that became the backbone of Embraer originated in IPD. Embraer absorbed this technology in the simplest way: by hiring all IPD personnel when the company was created. The entire technical team, administrative personnel and of almost all of IPD's Aircraft Department (and other smaller departments) were assigned to Embraer (Pasqualucci, 1986:41). It attracted qualified labour by offering favourable working conditions, and a good salary and career prospects. However, the acquisition by Embraer of what was important in IPD, insofar as technological know-how was concerned, led to a virtual "hollowing out" of that Institute. Practically two decades elapsed between the end of the project developed in the 1960s and the beginning of new research of any significant technological content in IPD, namely the development of an unmanned aircraft (Cabral and Braga, 1986).

Embraer focused its efforts on those key technologies that define the aeroplane as a final product. It was a significant departure from the dreams of the 1930s and 1940s of building a totally national aeroplane, with motors, components, parts and avionics made in Brazil. The company strategically favoured a technology strategy towards capacity training in the areas of aerodynamics, fuselage and project integration. Efforts were directed towards training and developing capabilities in two basic areas: the aircraft project and the integration of components that could not be manufactured by Embraer itself. The reasons behind this important decision not to organize production vertically were basically scale, market size, reliability and technical difficulties.

The acquisition of technical competence for the fuselage of the aircraft was considered to be strategic for the competitive future of the company. According to interviews with senior officers of Embraer, competence in fuselage "was the only key area in which the know-how required could not be obtained satisfactorily outside the Brazilian borders". This was considered an essential condition for autonomy in product design and for the eventual success of the firm as a competent final assembler of aircraft. As experience would show, this approach proved to be essential to Embraer's future, since this gave it independence and autonomy of decision-making. It enabled Embraer to master the basic technologies of the aeronautical industry, manage its own business, and create market opportunities. "It was more important for the commercial success of the company than the control of the most sophisticated and numerous technologies that the production of an aircraft requires and of the other thousands of items that comprise it" (Dagnino, 1987).

Thus, the strategy outlined for the company, was based on the premise that the capacity to master technology through systems integration was more crucial than having a larger share of the value-added of the aircraft being produced in Brazil. It is worth pointing out here that most of the Brazilian industrialization through import substitution was based in the idea of increasing local production. According to Dagnino (1994), if the public authorities of the aeronautical sector had pursued the illusion of increasing local content, approximately 50 per cent of local value added could have been reached by the mid-1980s. However, to

attain this goal and, at the same time to complete the mastering of technology, the Brazilian strategy would have had to be entirely different and it probably would have been impossible to achieve both the goals. Costs probably would have been prohibitive and the time span required to successfully enter the market would surely have been longer. In fact under such a strategy Brazil should have pursued the reproduction of the entire development cycle of aircraft found in developed countries. It is enough to highlight, for example, that there are no more than five countries manufacturing aeronautical motors with own technology.

The fundamental notion behind Embraer's strategy was to target key areas responsible for all basic technological development, supporting incremental technical change and building core competence. This distinctive perception about accumulation of productive and technological capabilities was vital to the success of its strategy. It led the company to identify "key technologies" necessary for a progressive technological upgrading, and included essential technologies for the future as, for instance, new materials.

The most important aspect of this strategy is that it allows for the independent conception of projects. In a similar vein, by adopting the concept of "aircraft families", used both by Boeing and Airbus for their big commercial jet lines, Embraer acquired the benefits derived from the development of several versions of the same basic models, which entailed lower costs, faster development and a shortening of the production cycle. A "family" has the advantage of a common concept that brings lower infrastructure and maintenance costs, standardized pilot and technical personnel training and common crew upgrade possibilities; In short, lower costs and faster aircraft production. This allowed for a reduction in the time-to-market, to about two or three years, less than half the time that a new project usually takes. This concept was applied in the development of several aeroplanes, such as the Bandeirante, Xingu, Brasília, CBA-123 and ERJ-145, some of which became great commercial successes in the world commuter aviation market and brought recognition, prestige and fame to the company.

These three approaches – the "family" concept that permitted the drawing of benefits from common resources; cumulative paths and coherence in the organizational and technological training of high complexity, allowing identification of the critical key technologies that foster improvement and appropriation; and the strategy of vigorous investment in training of human resources – formed the backbone of Embraer's pursuit of technological autonomy.

Chart 1.1 The main events in the evolution of the aircraft production system of São José dos Campos 1947–1999

- 1947 – Construction of the Aeronautic Technical Centre (CTA) begins. The planning and construction is supervised by OCATC (Organizational Commission of the Aeronautics Technical Centre) of the Aeronautics Ministry, established on 29 January 1946 and disbanded on 26 November 1953.
- 1950 – CTA and its engineering school, ITA (Aeronautic Technological Institute created in 1947) are transferred from Rio de Janeiro to São José dos Campos. The students are scholarship holders sponsored by the Ministry of Aeronautics; besides free tuition they get free lodging, food and health care. It is a developmental milestone in university education in Brazil.
- 1954 – The Institute of Research and Development (IRD) is set up at CTA with the aim of developing research in basic areas for aeronautics (aircraft project, electronics, materials, engines and flights tests).
- 1954 - Convertplane project set up.
- 1969 – Embraer set up.
- 1970 – Embraer starts manufacturing activities.
- 1971 – The Ipanema and Xavante are launched.
- 1973 - The Bandeirantes is launched.
- 1974 – Cooperative agreement with the US PIPER Aircraft Company is signed.
- 1978 –Xingu and Tucano aircrafts are launched.
- 1980 – Development of the AMX programme begins.
- 1981 – The Brasilia aircraft project is relaunched.
- 1989 – Development of the12-X project (Brazil-Argentina's Cooperative Agreement) begins.
- 1989 – Studies for the development for ERJ-145, (first jet produced by Embraer) begin.
- 1992 – Embraer is included in the national privatization programme.
- 1994 – Embraer is privatized
- 1996 – Two hundred ERJ-145 are sold at the Farnborough Air Fair in the United Kingdom.
- 1997 – After a dramatic dispute with the Bombardier group, Embraer gets the largest contract in its history at Le Bourget Aeronautic Fair, in France.
- 1997 - Development of a new regional jet, the ERJ-135 for 37 passengers, begins.
- 1998 – Development of a new regional jet, the ERJ-140 for 40 passengers, begins.
- 1999:

  – Development of a new family of regional jets, the ERJ-170/190, begins.

  – Twenty per cent of Embraer's ordinary shares are acquired by a French consortium led by Aérospatiale Matra, Dassault Aviation, Thompson-CSF and Snecma.

  – The new families of regional jets and military products are presented to the market.

  – The Swiss company Crossair becomes the first Embraer client for the ERJ-170/190 programme. At Le Bourget Fair, a contract worth US$ 4.9 billion, for 200 jets, is signed.

Source: Embraer

The company outlined a strategy regarding not only the *know-how*, but also, especially, the "*know-why"*, concerning training processes and technological innovation, since it was a State-owned company. In that sense, as Dagnino (1987) pointed out, the solid and continuous government support offered to Embraer throughout its history differed from the experiences of other countries. This support was given through budgetary allocation of sufficient financial resources for the science and technology (S&T) infrastructure and procurement. According to Dagnino, the main axis in the technological strategy adopted by Embraer was not the import of "technological packages" ("black boxes"), to be subsequently "opened" and adapted to local conditions and eventually optimized by "reverse engineering". On the contrary, investment and efforts were directed towards developing competencies by providing solid training in applied and basic research and by continuous concern with training to enhance capabilities and skills in the development and design of specific technological solutions, through consulting services and technology agreements. This was the road chosen to increase the innovative potential of the firm. Typically, Embraer followed what is known in the literature as a "learning strategy". The learning was mainly of the "learning by doing" type, but sometimes it was also of the "learning by adapting" kind. The process of "learning by doing" characterized the first period of the company. Starting from training in aeronautical projects (especially in aerodynamics) it was possible not only to assimilate the remaining know-how – not specifically technological – but also to open up organizational learning paths. This endowed the company with a capability to formalize problems and solutions, which was crucial for the process of aircraft certification.

It should be added that other ways of learning through recruiting ("learning by hiring") and subcontracting ("learning by interacting") were important. The former was obtained both by association with outside partners and by government policy, particularly from the Ministry of Aeronautics, through procurement. A good example was the decision by the Ministry of the Aeronautics to equip the Brazilian Air Force with MB-326 aeroplanes in the late 1970s. Instead of buying these aeroplanes in the international market, the Ministry sought to develop local production. As a result Embraer signed an agreement with the Italian Aermacchi for production of the Xavante military aeroplane. The development of the project required several Italian specialists to come to Brazil for helping local production and for the transfer of technology. Another example was the agreement Embraer set up with Piper, which used to sell aeroplanes in Brazil before the Ministry of Aeronautics established rules that imposed, in practice, a market reserve.

Other important agreements signed by Embraer that had a significant impact on the development of its human resources capabilities were:
a) Technical assistance and aircraft maintenance agreements with airline operators; and
b) Manufacturing of complex components by order (with McDonnnell Douglas and Boeing).

Finally, Brazil's Air Force bought the F-5s from Northrop Grumman of the United States, and the Ministry of Aeronautics included, as part of the sales package, a technological training programme for Embraer in the areas of metal welding, composite materials and in the use of digitally-controlled machines (Dagnino, 1994).

Learning through user/supplier interaction was intense and global. Embraer became known in the world market as being a user of extremely qualified equipment and software. It was not satisfied in simply knowing how to operate services or technology that it acquired,

but, above all, the company aimed at modifying the technology to its requirements. In many cases, this led to improving, correcting defects, and even opening up new market opportunities for the product. Embraer also became an active and highly qualified technology user, with significant gains from "learning by using." It distinguished itself for its long-term strategy and for its training programmes and for its employees' professional education in general. The excellence of its human resources was always considered a critical factor to its successful growth. And in that sense, the importance and the strategic focus of the company on learning by training was crucial. In the early years of the company, during the process of the transfer of technology for production of the Xavante programme, about 70 employees were trained in Italy. Thus the company was able to proceed rapidly from assembly operations to the national production of this aeroplane. Especially relevant were the partnerships for the training of personnel, developed with the AMX programmes and later, in the 1990s with the ERJ-145 programme.

To sum up, the federal Government supported and promoted a coherent, cumulative and continuous technological policy, which targeted Embraer, the S&T infrastructure in São José dos Campos and strong interaction among the several institutes of CTA and Embraer itself. In practice it allowed Embraer to obtain technological training and a quite uncommon competitive position in relation to other developing countries. However, it is interesting to note that although this phase of the aircraft industry in Brazil was characterized by a strategy of development, learning and consistent and successful technological training, where active forms of technological learning were identified, there were some pitfalls. Embraer experienced a crisis in the early 1990s, but quickly recovered. The next chapter discusses this recent period.

CHAPTER III

THE 1990s: CRISIS, PRIVATIZATION AND RECOVERY

The economic and political crisis in Brazil at the end of the 1980s and the first half of the 1990s deeply affected Embraer and the entire Brazilian economy. This general crisis was aggravated by world crises in the aerospace and defence industries. However, the second half of 1990s saw recovery, and a new investment and economic growth cycle was inaugurated.

The roots of this crisis were to be found in the previous decade. Macroeconomic problems were associated with a significant decrease in government spending. A sharp reduction in the R&D budget and a progressive weakening of the scientific and technological infrastructure had a significant impact on the aircraft innovation system. Procurement also diminished, since the budget crisis meant fewer funds for government purchases in the aeronautic, space and defence sectors.

During the crisis, federal industrial and technological policies virtually disappeared. Several financing mechanisms normally used to support aircraft sales were scrapped. Also, as an outcome of the democratization process, the military – that constituted a powerful pressure group for Embraer's interests – lost its political clout. On the external front, the recession in the regional aviation market and the end of the Cold War strongly affected Embraer. At the microeconomic level, Embraer rapidly experienced financial troubles for the following reasons:

- It had started several new big projects without appropriate financial backing. The overall economic crisis also meant that even the few private financial institutions that were willing to give long-term credits were charging very high interest. Embraer, being a State-owned company, had to submit all its financial dealings to the national Congress. This was a long and uncertain process, and Congress seldom gave authorization for loans. Therefore, the Company was forced to seek short-term loans that charged much higher interest rates. As a result its financial problems spiralled;
- Projects were developed without detailed market research and a thorough examination of potential clients' needs;
- Embraer's management was excessively technology-driven, focusing more on technological capabilities and product development than on financial matters; and
- as a result, cost considerations were not given a high priority.

The final result was a rapid loss of competitiveness in both internal and external markets. In the internal market the situation was aggravated by the fact that the Government not only stopped its financial backing of Embraer, but also opened the economy to international competition in a way that favoured imports. Also, macroeconomic instability led to high interest rates, as mentioned above, that made loans more expensive.

Brazil's economy in the first half of the 1990s was marked by structural reforms and macroeconomic stabilization plans based on the free-market concept, accompanied by the dismantling of policies for financing industrial, technological and export growth; for example, in 1991, as part of a wider reform process, the federal Government ended the programme, Finex, which aimed at providing long-term finance for Brazilian exports. Furthermore, a

decline in government orders and a drastic reduction in employment and manufacturing resulted in a loss of the country's competitive position both on the domestic and world markets.

In the early 1990s, the recession in the world aircraft market affected EMB-120 Brasilia aircraft sales. Moreover, Embraer's own problems contributed to the rise in financial costs, with a direct impact on the price of the aircraft. There were already clear signs of preference for jet aircraft. From the buyer's point of view, lack of competitive credit lines for export was another negative factor affecting aeroplane sales. An example of the negative repercussion of the crisis experienced by the company on its international prospects was the loss of an important public tender in the United States, called JPATS (Joint Primary Aircraft system). This was a tender for the supply of 711 training aeroplanes to the United States Air Force and Navy worth US$ 7 billion. Embraer spent years preparing itself for this tender with the Super Tucano turboprop, in consortium with Northrop of the United States. It lost to the Swiss Pilatus PC9, associated with United States Beechcraft that is part of the Raytheon group (which had won the bid for the Amazonian Surveillance System – Sivam - installation in Brazil).

According to specialists, from the technical standpoint the Super Tucano and Pilatus are equal. The Embraer aeroplane had already been chosen in other tender competitions in the United Kingdom, France and Egypt against its Swiss competitor. Another competitor in the JPATS tender along with Embraer and the Raytheon/Beechcraft entry, Pilatus, was Cessna of the United States with its Citation jet. These latter two companies were preferred because they already supplied aeroplanes to the United States Navy and Air Force. The JPATS contract was destined to replace the Navy's Beechcraft T-34 and the Air Force's Cessna T-37. Some analysts have attributed Embraer's crisis to its losing this contract. This loss also affected its credibility and left it in an even more vulnerable financial position. One important result was that the company cut its workforce by half. Approximately 13,000 highly specialized jobs related to the aerospace sector were eliminated; Embraer alone was responsible for the elimination of 8,000 jobs.

In 1992, as part of the deep structural changes undertaken in Brazil, Embraer was included in the national privatization programme. It is important to point out that the costs of retrenchment of the workforce and administrative restructuring, in the most dramatic phase just before Embraer's privatization, were borne by the Brazilian federal Government. After that, the company was ready to be offered to the private sector, and was eventually privatized on 7 December 1994. It was acquired for US$ 265 million by a consortium of local enterprises and pension funds led by the Bozano Simonsen Group, one of the leading Brazilian conglomerates, which operates in the financial, mineral, real state, agricultural and manufacturing sectors. The consortium acquired 40 per cent of the voting capital. Among the main investors were: Bozano Simonsen Limited (13.65 per cent), Bozano Leasing (3.63 per cent), the pension fund, Sistel (10.42 per cent), Previ (10.40 per cent), and Cesp Foundation (1.9 per cent). Ten per cent of the shares were reserved for the company's employees.. The privatization of the company implied further organizational restructuring. Downsizing of production processes was envisaged and some qualified personnel were made redundant.

These changes in Embraer bore fruit when, at the Farnborough Fair in the United Kingdom in 1996, 200 ERJ-145 (its new jet aircraft) were sold to the United States carrier, Continental Express. The strategy to produce this new aircraft proved to be successful. In 1997, at Le Bourget Aeronautic Fair in France, Embraer, after a dramatic dispute with the

Bombardier group, landed the largest contract in its history. This contract was worth around US$ 1 billion for the sale of 67 ERJ-145 jets to American Eagle, the regional airline subsidiary of American Airlines. The new contract also included replacement parts and technical assistance, with firm sales reaching US$ 1.6 billion and options adding another US$ 4 billion over a seven-year period. The contract represented the consolidation of the recovery process and restored the company on the international market. In addition, it allowed for the financial recovery of Embraer and ensured production of aircraft during the subsequent three years. Also in 1997, Embraer started the development a new regional jet, the ERJ-135 for 37 passengers, and the ERJ-140 for 40 passengers.

In short, Embraer was able to rapidly overcome an adverse situation and avoid bankruptcy. It achieved important and successful sales with its two main medium-sized aircraft: ERJ-145 (50 seats) and ERJ-135, and became, in 1998, the world's leader in jet sales. The contracts of US$ 6.6 billion, made during the Aerospace Fair, in Le Bourget, Paris, represented a record in the world's airspace industry. At the time, Embraer was building 22 aircraft models, conducting strategic programmes for the national defence sector, commercializing more than 5,200 aeroplanes in more than 40 countries, and it had approximately 8,000 employees in Brazil. In 1999, the foreign market accounted for 98 per cent of Embraer's revenues, and revenues by segment were distributed as follows: commercial activities accounted for 85 per cent, defence 7 per cent, and spare parts and services 8 per cent (see table 1.5).

The new family of regional jets (ERJ-170, ERJ-190-100 and ERJ-200 for 70, 98 and 108 passengers respectively) was introduced into the market in 1999, requiring about US$ 850 million for their development. The importance of this new family of products was that it would compete on a different market of larger aircraft, which so far had been the domain of Boeing, McDonnell Douglas and Airbus. The new military products were also presented – the ERJ-145 AEW&C and ERJ-145 RS and ALX. The Swiss company Crossair became the first Embraer client for the ERJ-170/190 programme. At Le Bourget Fair that year a contract worth US$ 4.9 billion, for 200 jets, was signed. On 23 July 1999, as part of a strategy of accessing new technologies, products and markets, 20 per cent of Embraer's shares were sold to a French consortium led by Aerospatiale Matra (5.67 per cent), Dassault Aviation (5.67 per cent), Thomson-CSF (5.67 per cent) and Snecma (2.99 per cent). Shareholder control remained with the Brazilian Bozano Simonsen Group (20 per cent) and the pension funds Previ (20 per cent) and Sistel (20 per cent), the Brazilian Government (3.2 per cent) and other companies (16.7 per cent). The main objective of this new strategic alliance was to double its customer base and open up new possibilities of international financing. This would include setting up in China, considered to be the fastest growing market in the world. Moreover, Embraer aimed at emerging markets, the acquisition of business expertise, commercial and logistic infrastructure as well as critical technologies in the civil and military area, increased installed capacity and a larger scale of production. Also in 1999, Embraer launched a new 44-passenger regional jet, the ERJ-140, a variant of the ERJ-145 family. At the same time, it consolidated its name in the world market as the leader in the commuter segment.

Table 1.5. Indicators of Embraer's financial performance (Million real)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Gross revenue	582	402	333	261	177	295	380	833	1.581	3.379
Sales										
Foreign market. (%)	37	32	32	38	40	39	35	84	89	98
Domestic market (%)	63	68	68	62	60	61	65	16	11	2
Total assets	1 092	1 435	1 227	1 125	1 067	1 107	1 221	1 424	2 618	3 717
Equity	126	324	86	156	281	188	281	-	420	697
Losses/profit	(265)	(241)	(258)	(116)	(310)	(253)	(123)	(33)	132	412
Debt										
General (%)	88.3	77.2	93.6	86.2	73.6	82.2	71.2	45.8	51.5	
General	620	804	877	758	410	470	535	382	379	305
Short-term	502	241	309	394	221	226	214	251	-	-
Long-term	118	563	568	364	189	244	321	131	-	-
Backlog (US$ million)	-	-	-	-	647	729	1 227	3 011	4 112	6 367

Source: Embraer

As shown in table 1.6, by 1999 Embraer had captured a 40.5 per cent share of the world market, slightly ahead of its main competitor Bombardier (38.5 per cent) and well ahead of Fairchild Dornier (19.9 per cent) and British Aeroespace (1.1 per cent). Embraer and Bombardier of Canada are the main competitors in these important segments of the jet aircraft sector. Tables 1.7 and 1.8 below provide some general comparative information regarding both companies and their most competitive products as for years 1999 and 2000. A fierce competitive battle between these two firms began five years ago. The competitive position of Embraer has been based on radical changes in its strategy in the 1990s, resulting in its becoming leader in a network of firms participating in a chain of production. Chapter IV analyses these changes.

Table 1.6. Embraer's share of sales in the world market for jet aircraft, 1999

MODEL	SEATS	SALES		DELIVERIES		BACKLOG	
EMBRAER		Quant.	%	Quant.	%	Quant.	%
ERJ-135	37	6	1.1	16	7.4	124	13.6
ERJ-145	50	125	22.5	81	37.3	176	19.3
ERJ-170	70	40	7.2	-	0.0	40	4.4
ERJ-190/200	108	30	5.4	-	0.0	30	3.3
TOTAL		201	36.2	97	44.7	370	40.5
BOMBARDIER							
CRJ 100/200	50	172	30.9	82	37.8	253	27.7
CRJ 700	70	3	0.5	0	0.0	99	10.8
TOTAL		175	31.4	82	37.8	352	38.5
FAIRCHILD DORNIER							
328 JET	32	78	14.0	15	6.9	82	9.0
428 JET	44	40	7.2	-	0.0	40	4.4
728 JET	70	60	10.8	-	0.0	60	6.6
TOTAL		178	32.0	15	6.9	182	19.9
BRITISH AEROSPACE							
RJ 85	32	2	0.3	11	5.1	7	0.8
RJ 100	44	2	0.3	12	5.5	3	0.3
TOTAL				23	10.6	10	1.1
TOTAL		556	100.0	217	100.0	914	100.0

Source: Embraer

Table 1.7. General indicators for the Embraer and Bombardier Groups

Bombardier Aerospace Group	Embraer Group
Set up in December 1986 Gross revenues (1999): US$ 4.412 billion Profits (1999): US$ 467 million Headquarters: Dorval, Québec (Canada) Main Products, Feb 2000: Regional Jets Regional jets represent 80% of total revenues: • Series 100 (version of 50 seats) • Series 200 (50 seats) • Series 700 (70 seats): in development Number of employees (1999): 34 000	Set up in August 1969 Gross Revenues (1999): US$ 1.889 billion Profits (1999): US$ 230 million Headquarters: São José dos Campos, São Paulo, (Brazil) Main Products, Feb 2000: Regional Jets Regional jets represent 85% of total revenues: • ERJ-135 (37 seats) • ERJ-140: (40 seats) • ERJ-145: (50 seats) • ERJ-170: (70 seats) • ERJ-190-200 (108 seats) Number of employees (1999): 9 000

Source: Embraer and Bombardier.

Table 1.8. Comparisons of the most competitive models of Embraer and Bombardier planes

	Embraer	Bombardier
Model	ERJ-145	CRJ-200
Capacity	50 passengers	50 passengers
Engines	2 turbofans Rolls-Royce AE-300	2 turbofans General Electric CF34-3B1
First flight	1995	1992
Basic price	US$ 18.5 million	US$ 21 million
Maximum speed	833 km/h	860 km/h
Basic weight	12 007 kg	13 740 kg
Operational cost (in 400nm[15])	US$ 2 613.00	US$ 2 832.00
Cost by seat	US$ 7.05	US$ 7 065

Source: Embraer and Bombardier

[15] Nan o meter: one billionth (10^9) of a meter

CHAPTER IV

UNDERSTANDING EMBRAER'S RECENT SUCCESS

Throughout the 1990s, Embraer and the aircraft production system became increasingly important for the Brazilian economic and industrial structure. It also became the largest Brazilian exporter during this period. Table 1.9 shows that sales of the aeronautical sector jumped from 0.2 per cent of GDP in 1996 to 1.1 per cent in 2000. It is estimated that in 2002 the sector will account for sales of around US$ 4.2 billion, representing 1.2 per cent of Brazil's industrial gross domestic product (GDP).

Two interconnected reasons explain this extraordinary success. First, and most importantly, the sector has received continuous government commitment and support for more than 40 years. Second, important strategic decisions were taken after privatization which were possible thanks to the previous innovative strategies that Embraer pursued in its first 20 years. It is worth analysing some of the main factors behind this success.

Table 1.9 - Importance of the aeronautical sector in the Brazilian economy

Economic indicators	1996	1997	2000	2002
Industrial GDP (US$ billion)	317	277.7	321.4	362
Sales of the aeronautical sector (US$ billion)	0.6	0.8	3.4	4.2
Share of the sector in industrial GDP (%)	0.22	0.29	1.06	1.16
Exports (US$ billion)	0.2	0.7	2.5	3.1

Source: Bernandes (2000).

1. Competition in the aircraft market during the 1990s

The international market for aircraft is divided in two main segments: civil and military. Both have very differentiated productive, economic, technological and logistic dynamics. The civil segment has several important competitiveness factors (chart 1.2). Some of them are internal to the firm, such as design, trademark, R&D, marketing and human resources, while others relate to product and markets. However the industrial structure and the incentive and regulatory regime play a very important role. In general the world market for aircraft may be classified into four different segments. The first refers to large-sized aircraft (more than 120 seats - both for cargo and passengers transport). This is the most profitable market, led by Boeing and by the Airbus European Consortium. This segment can be divided in four groups: 111 and 125 seats, 150 and 175 seats; 210 and 250 seats; 300, 350 and 400 seats; and more than 400 seats.

The second is related to medium-sized aircraft (10 to 120 seats). This "commuters" market, which is covered by regional air traffic companies concentrates on short/medium distances, connections to long distances. Embraer and Bombardier have become the only competitors in this market after some other key rivals went bankrupt in the 1990s. Small-sized

aircraft constitute the third segment. This is the market covering business, sports, agriculture and other related needs. It is a more segmented market characterized by a relatively large number of producing firms catering for different market niches. Finally there is the market for aircraft for corporate use. Here, the aircraft are not used for profitable and commercial purposes, but for transporting executives and clients of big businesses; it is a special area of the small-sized aircraft segment.

Chart 1.2. Critical factors of competitiveness in the civil aircraft industry

Internal to the enterprise	• Trademark
	• Design
	• Fostering R&D
	• Focus on strategic competence
	• Market intelligence:
	  • Logistics
	  • Productivity
	  • Marketing
	  • Human resource
	  • Technical support
	  • Financing structure

Product	• Image • Time-to-market • Innovation • Aversion factor to different types of engines • Family concept • Communal concept • Seats acquisition cost • Operational costs (seats/covered distance) • Performance/delivery
Market	• Concentrated structure/differentiated oligopoly • Market niches • Substitute turboprop aircraft for jet propulsion systems • Technical segmentation needs • Restricted and selective buyers • Catering to clients' specific requests • Global
Industrial configuration	• Strategic alliances • Specialized economy • Users' interaction • Strong scientific and technological system
Incentives and regulatory regime	• Support to technological risk and to R&D • Government subsidy • Customs and associated incentives • Selective protection • Government procurement • Users' credit and exportation financing

Source: Bernardes (2000)

A high degree of internationalization of markets characterizes all these segments. This specificity of competition in aircrafts is related to two points. First, apart from the United States, there is no single country with a sufficiently large and dynamic internal market to support R&D costs to manufacture a large-sized aircraft. Secondly, the rigid safety requirements and performance parameters needed for certifying aircrafts (without which they are not allowed to fly) are internationally agreed, rendering any production geared only to the internal market impracticable.[16]

An event that radically modified the aircraft market in the last 20 years was the growth of the "commuters'" market based on jet propulsion. Market forecasting for the United States suggests that over the next 10 years, medium-sized aircraft will replace large ones in this market (Boeing, 2001). Embraer's new regional jet family (ERJ-145 and ERJ-135) targets precisely this type of market, which favours quieter and faster aeroplanes (as compared to older turboprop aircraft) larger autonomy to perform non-stop flights and more stability in the case of turbulence.

2. Embraer's production and innovative strategy

Table 1.10, below, summarizes Embraer's aircraft production from 1980 to 1999. It shows that during the 1990s the jet aircraft has gradually replaced the turboprop aircraft. In fact between 1997 and 1999, the new family of regional jets (ERJ –145 and ERJ -135) accounted for more than 60 per cent (195 units) of the total of 310 aircraft produced. This type of aircraft has become the most important marketable good for Embraer. However, the company still maintains a wide range of products and related services as its core business (see box I).

Table 1.10. Embraer's aircraft production (in units)
1980-1999

Model	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
Civilian																				
Bandeirante	73	67	32	10	23	2	4	7	10	2	8	1	2	0	0	1	1	0	0	0
Xingu	25	12	18	26	2	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0
Brasilia	-	-	-	-	-	6	20	38	46	54	55	35	15	10	7	20	17	8	12	7
ERJ-145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	32	62	81
ERJ-135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16
Light Aircrafts (Piper/Ipanema)	315	169	117	66	106	112	107	111	81	121	67	51	33	49	43	28	24	24	26	17
Military																				
Xavante	5	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brasilia	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Tucano	0	0	0	26	57	49	35	45	54	10	5	0	1	5	8	18	15	-	6	-
AMX	-	-	-	-	-	-	-	-	-	4	5	8	7	6	1	4	3	5	10	3
TOTAL	418	265	167	128	188	170	167	203	191	203	141	93	54	70	60	66	64	71	115	124

Source: Embraer

[16] The United States market, for instance, represents around 60 per cent of Embraer's sales.

In order to make the ERJ project viable, and given the difficulty of keeping the support of the Brazilian Government during a period of deep structural changes, Embraer, after privatization in 1994, set up a production and strategic model, that would prove to be crucial to its future success. The company formulated a business plan based on achieving financial results through deep organizational and productive restructuring. Embraer started to build a new relationship with clients and suppliers. An action plan was designed in which the mission of the company and a new market strategy were envisaged and production and organizational restructuring was planned. High priority was given to examining the feasibility of the ERJ-145 project.

Embraer's current competitive edge is structured around some basic axes. The first axis consists of outlining a technological strategy aimed at product innovation, coupled with the identification and fulfilling of client/user requirements. In essence, it follows the old technological strategy with some important changes. The company's essential competence lies in the excellence of design and integration of highly complex production systems. The company focuses its activities on adding value as systems' integrator that dominates the different technical phases of the subsystems. It is not important to manufacture them, but to retain the capacity to combine and adapt them according to its project requirements. As an aircraft is made up of over 28,000 parts and components, the capacity to design and specify the product, and to integrate components into several sub-systems in a harmonious way within the fuselage of the aircraft is both complex and difficult. Such a task forms the core of Embraer's strategy. Coupled with marketing and technical services, it is the central element of the company's core competencies. In this respect, Embraer holds the strategic assets that allow it to coordinate the network of the risk partnerships and the global productive chain, thereby strengthening its competitive position.

The second crucial aspect is the so-called "off-load" strategy, which focuses on the globalization of production and the de-verticalization process. Embraer is "trying to dedicate itself progressively more to the noble project activities, such as development, systems engineering and integration, adopting strategies of seeking for partners to manufacture parts and subsystems, as well as assemblies of systems and kits. In this way, its investment in the milling and stamping sectors has been restricted to the partial upgrading of the existent equipment, according to the needs of the production and the absence of suppliers" (Mendonça, 1997). The basic idea behind this model was to spread the high risks associated with such a big project and the pattern of competition in the sector. The model is global in nature, whereby risks, incentives and benefits are shared. Embraer coordinates the whole network that acts in a well-defined, hierarchical structure at three different levels.

At the first level are the risk partners, defined as those that assume financial risks in the projects. At this level there are very few large international firms that participate in the co-design process and add technological value. At the second level are suppliers of components, parts and services ordered by the company. These are almost entirely (98 per cent) located abroad. The relationship of Embraer with these firms is both technological and commercial. It could be characterized as "information networks" through which companies supply such items as equipment, avionics and components according to Embraer's specifications. At this level, there is significant learning-by-interaction, but not such intense innovation as at the first level.

Box I. Embraer's aircraft

The following is a list of Embraer's present commercial aeroplanes:

1. EMB120 – The 30-seater Brasilia: turboprop aeroplane: More than 400 units have been sold. Its main market is the United States. Sales leader in this category for many years, the plane is used by 26 enterprises in 14 countries, and has done more then 3 million-flight hours.
2. ERJ 135: A regional jet for 37 passengers, it is a compact version of ERJ-145. It has the same fuselage (3.5m shorter), wings and wrappings, cockpit (same pilot's licence), turbo-fan motors (Rolls-Royce Allyson), low fuel consumption and noise, common procedures of training and maintenance. In addition, it has a longer range than 2,340km, better performance in higher runways and high temperatures, and low costs of acquisition and operation. Its development entailed a US$100 million investment that must be amortized over a period of 10 years with the sale of 500 aircraft.
3. ERJ140: A new regional jet for 44 passengers, following the "jet family" concept started by ERJ-145. It uses many common features thereby obtaining operational and maintenance benefits, including the same pilot's certification. The development of this aircraft required an investment of about U$45 million.
4. ERJ145: A jet plane with 50 seats, it is intended for the regional market, with 119 units sales confirmed. This product has given the company leadership in the world commuter market. The cost of production was US$350 million.
5. ERJ170: A jet aeroplane with 70 seats. A new platform has been developed as the base for ERJ-190. It is expected to receive certification in the second half of 2002. The estimated sale price is US$22 million for the sale of 400 units.
6. ERJ190-100/200: A jet plane, it is a larger version of the ERJ-170, as a result of the addition of a fuselage section, with stronger engines, a larger wingspan and reinforced landing gear. Two versions are planned, with 98 (ERJ-190 / 100) and 108 (ERJ –200) seats. The process of certification is expected to begin in 2004.
7. Light aeroplanes: Neiva's EMB201 Ipanema, EMB400 Urupema, BEM 710 Minuano, BEM 721 Sertanejo, and BEM Seneca.

Apart from commercial aeroplanes, Embraer also manufactures several military aeroplanes:

1. Tucano is military training aeroplane and world market leader; it stands out because of the ease of flying it and low maintenance costs. More than 640 units have sold.
2. Super Tucano/ ALX is military aeroplane derived from Tucano EMB-312. It represents the new generation of military turbprop aeroplanes developed from the experience acquired with Tucano (BEM-312) in terms of operation and training. This aircraft has a similar cockpit to a fighter, with advanced avionics provided by Elbit from Israel. The ALX fulfils a Brazilian Air Force requirement for a light attack aircraft, to be used in border vigilance. It will also be used for advanced training and operational missions in Amazon, supportingthe SIVAM Project.
3. AMX is a military tactical aeroplane that was conceived and produced by the Aeritalia consortium: Alenia and Embraer. Its most recent version is the AMX-T.
4. The Radar Multimodal Boarded Project developed a "doppler" radar to be part of the AMX aircraft.

///....

(Box I, concluded)

Besides these commercial and military aircraft and projects, Embraer is engaged in several other partner ships with major aircraft producers. It supplies flaps for MD11 – McDonnell Douglas (certified by the Douglas quality system), and produces the dorsal fin and the wingtip for Boeing 777 aeroplanes (certified by D1900 – Advanced Quality System for Suppliers of Boeing). It also has a partnership with Sikorsky for the production of S92 helicopters.

Source: Embraer

At the third level are the subcontractors – companies and individuals that receive raw materials and design from Embraer. Relationships at this level have two dimensions: project and engineering services; these are activities involving greater expertise and scientific content rendered by technology companies, and companies that provide milling services, chemical treatment, coating and other production services of lower technological complexity. This group of firms is directly subordinate to Embraer, and most are located in São José dos Campos.

From the operational point of view, several techniques were introduced. In terms of work organization, Embraer introduced methods of functional work flexibility through innovations in operational management of the production processes. Particularly worth mentioning is the setting up of interdisciplinary groups for permanent productivity and quality improvement – *kaizen* – a well-known Japanese work philosophy based on the collective and continuous commitment of workers to improve quality and productivity. Another technique that radically changed the work and production processes was the adoption of the liaison engineering system, a system for linking together several corporate areas, supporting decision-making and eventual resolution of problems of a work team. A specific team is allocated full-time to this activity, and renders support in the assembly or production phase of a product. With the adoption of liaison engineering, a reduction of 50 per cent of the work cycle in the production phase of the EMB-120 and ERJ-145 aircraft was obtained (see table 1.11).

In 1996, the company invested approximately US$ 8 million in improving production processes in order to increase productivity (see box II)**.** In 1997, investments of some US$ 25 million were made to upgrade equipment and machinery, layout and information systems as well as production control and programming. In the operating area, efficiency gains resulted in reduction of the manufacturing time of the Brasilia, from 14 months to 8 months, and later to 6 months. The restructuring process also resulted in higher productivity, which went from US$ 42,000 per employee in 1994 to US$ 98,000 in 1996, US$ 227,000 in 1998 and US$ 252,000 in 1999. This figure is only 19 per cent below the world average for the sector, which is approximately US$ 300,000 per employee (table 1.11).

Table 1.11. Embraer's production indicators

Production indicators	1993	1994	1995	1996	1997	1998	1999
Production cycle (months)							
EMB – 120 - Brasília	-	14	12	8	6	6	5.5
ERJ-145	-	-	-	8	7	5.5	5.5
Production rate (number of aircraft)			-	5.9	4.5	3.6	11
Productivity (sales over number of employees) (US$ '000)	41	42	82	98	166	227	252
Trash/ rework index (%)	-	-	-	2.4	1.2	1.0	0.9
Number of lost days/work hours			132	191	77	72	-
Frequency rate (in millions of work hours)	4.5	5.9	7.1	5.9	4.5	3.8	-

Source: Embraer

Box II. Embraer's main facilities

In 1999 the company's facilities included 106 digitally controlled machine tools and 11 digitally-controlled milling centres. It also had 4,500 personal computers (486, 586 and Pentium) of which 250 were dedicated to CAD/CAE and workstations, and 150 Intergraph stations with 1 CAE server. In the technology department, the information technology (IT) density is 1/1, that is, one computer for each engineer. For the company as a whole, with a total of 8,000 employees, the density is 1 computer for every 2 employees.

The Stamping Division (GFC) sought to increase the production rate of the ERJ-135 and ERJ-145 aeroplanes in 1999 by implementing a new management system inspired by Japanese production techniques called "lean manufacture". The new system was employed in the milled coverings of the central fuselages II, III and IV of the aircraft, resulting in a reduction of 52 per cent in the assembly cycles and in a 100 per cent of improvement of the total aeroplane kit.

Source: Embraer

Another important institutional innovation in Embraer's strategy was the setting up of a department to monitor critical technologies for the company. Before privatization such activity had been internalized as part of the firm's strategy for training human resources and in the overall activities of its technical departments by constantly reviewing specialized literature and articles and magazines about the sector. The establishment of partnerships and permanent contacts with international suppliers was also important. The company had constantly been working to improve its technological processes, quality and use of new information technologies. This strategy was formalized by establishing a programme based on a more intensive evaluation of Embraer's external environment through benchmarking by a programme called Brainware. The idea was to monitor the development of new technologies

by the main, world-class aircraft manufacturers such as Boeing, McDonnell Douglas, and Sikorsky and by research centres. This resulted in the adoption of new automation technologies for plates and riveting, identification of parts by bar code, and automation of the cabling factory, among others. In 1999 the programme was terminated, since the technological upgrading objective had been successfully reached and the engineering area considered it fully incorporated into Embraer's strategy and production routines. In its regional aircraft segment, vis-à-vis its direct competitor, the company is fully updated and tuned in to best world practices.

Table 1.12 provides some information regarding the evolution of Embraer's R&D expenditure during the 1990s. The crisis in the early 1990s led to a fall in R&D expenditure from US$ 128 million in 1990 to US$ 24 million in 1992 and US$ 35 million in 1993. With the recovery, R&D expenditure increased again to US$ 141 million in 1998, when the main technology efforts of the EMB-70 family peaked. It is also worth pointing out that expenditure in IT equipment also increased significantly in the second half of the 1990s, as part of the modernization strategy. According to Embraer, about 50 per cent of technology expenditure is directed to internal R&D, 30 per cent to industrial design, 15 per cent to new product commercialization, and 5 per cent to capital expenditure in plants, machinery, software and other equipment associated with new products or processes.

Table 1.12. Embraer's technology expenditures, 1990 – 1999 (US$ million)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
R&D/sales (%)	12	7	4	7	17	17	14	5	5	4
R&D total	128	48	24	35	55	92	96	69	141	68
R&D civil	-	-	-	-	-	69	84	44	56	20
R&D military	-	-	-	-	-	23	12	25	85	48
IT equipment	0.9	0.5	0.2	1.1	1.0	1.5	3.2	5.0	14.0	6.0

Source: Embraer

3. The strategy in action: the ERJ-145 and ERJ-170/190

Together, the restructuring and the partnerships strategy were responsible for creating a new corporate logic and dynamic and a competitive business architecture. They generated both pressure points and synergies, particularly in the area of production, and had a deep impact as far as cost reduction was concerned. However, the ERJ-145 programme and the ERJ-170/190 family, although having several similar concepts, represent two different approaches. The first may be characterized as having a greater focus on costs, with the risk partners being considered by Embraer more as suppliers of components than real partners. The ERJ-170/190 programme was developed in a different context, with value aggregation and technology, rather than cost, being considered as essential for the feasibility of the project. The two cases are summarized in boxes III and IV.

The coordination and administration of the contracts and the supply chain in the business organization model for the ERJ-145 programme was an invaluable learning process for Embraer. As mentioned above, Embraer had a very positive experience with international corporations. The lessons learned from the AMX cooperation project, promoted in 1979 by the Brazilian and Italian Governments, were fundamental for the managerial development and harmonization of the dynamics of the business relationships of the ERJ-145 programme. In this sense it could be argued that this successful experience was also built upon earlier strategies developed when the whole aeronautical programme was government-controlled.

To synchronize the progress of the several participants in the ERJ-145 programme, a steering group was established, which held periodic meetings with the representatives of each partner, potential customers and representatives of the pilots' associations. For Embraer, perhaps the single most important lesson from this project was in the management of contracts between companies, rather than the acquisition of new technologies. In fact the only technology it acquired for the ERJ-145 was a leading-edge de-icing system. Embraer developed all the other important technologies, either alone or jointly with the risk partners, from the older turboprop technologies of the Brasilia and Bandeirantes projects. Technologies developed and accumulated over the years by Embraer were fundamental for the new project, to the point that some commentators have argued that the new jet aircraft (the ERJ-145) was basically the same old Brasilia (a turboprop aircraft) with jet engines. An associated benefit of the project was a reduction in production costs through the subcontracting strategy. By radically vertically disintegrating the production process, Embraer created the conditions that made it possible to reduce the final price of the aircraft. This simple approach was probably responsible for the most important competitive weapons of the ERJ-145: its low price, and ease and low costs of maintenance. In short, even though the strategy that guided that partnership programme was clearly a focus on cost reduction and financial engineering, the success of the enterprise was possible because the ERJ-145 project was designed using updated technologies from the older turboprop projects.

Box III. The ERJ-145 programme

The ERJ-145 programme was designed in 1989, while the company was still State-owned. However, it only became financially feasible after it gained business flexibility and agility following privatization of the company and the creation of risk partnerships. It is important to point out that Embraer was able to attract partners on the world market who believed in, and invested in the ERJ-145 project because the company had design and technology capabilities that other competitors did not. Certainly, if the company had not enjoyed a strategic position on the market, as a generator of the technology, the possibilities for securing partnerships would not have been so promising. The ERJ-145 programme, with four companies (Gamesa of Spain, ENAer of Chile, SONACA of Belgium, and C&D Interiors of the United States) as risk partners, was based on the idea of spreading risk among partners and on the commitment of each participant to develop a sub-system of the product. This programme reflects the strategy outlined above; that is, a new standard of corporate organization that was better integrated and flexible was developed and articulated in the form of core networks of development, learning and technological innovation. This works for the financing of projects as well as partially diluting the risk of market uncertainties. Besides learning the coordination of business networks, other important capabilities were acquired including the management of complex contracts, time- frames and flows of parts and components and the controlling of work cycles and product quality, all of which helped to radically changing Embraer's corporate habits. Years ago this type of international project and aircraft production would have been unusual and not viewed favourably on the part of the Brazilian Government which was more concerned with security implications, especially in industrial secrecy. Today, due to escalating costs and the long R&D cycles inherent in the entire conception and production of a new aircraft, as well as the uncertainties and the long time frame for a return on investment, these corporate and institutional arrangements have become the rule for those who wish to survive in this arena. In the technological field, the programme did not present a problem and Embraer had all the necessary conditions to manufacture the aircraft at its facilities.

The main obstacle to viability was Embraer's lack of credit. The firm was in debt and internally disorganized. The estimated cost for the development of the ERJ-145 programme was US$ 300 million. The risk partnerships established in 1992/93 with suppliers gave a new impetus to the programme. In 1995, with Embraer already privatized and under control of a new administration, the programme was taken up again and given high priority. The solution was the identification of international companies interested in investing in the programme and in assuming responsibility for the production of parts of the aeroplane with the acquisition of aeronautical technology from Embraer, and in return they would share in the profits from sales of the aircraft. Of the total anticipated investments, Embraer put up approximately US$ 140 million for the development of the aeroplane, assuming 60 per cent of the cost, while the risk partners and suppliers bore the remaining US$ 100 million in costs.

In Brazil, Embraer's big partner was BNDES, which financed US$ 100 million. Between 1995 and 1997, the total investment in the programme for technological development and productivity was US$ 287 million with another US$ 120 million in 1998. The Spanish company Gamesa was responsible for the production of the wings, engine nacelles, fairings of the wing/fuselage junction and the doors of the main landing gear. Sonaca, headquartered in Belgium, committed itself to the production of the luggage, service and main doors located in the fuselage, a front and a rear section of the fuselage and the two motor pylons. The Chilean company ENAer produced the horizontal stabilizers and rudder controls. The interior of the passenger cabin and luggage compartment was developed and manufactured by C&D Interiors – one of the largest companies of the world specializing in this area. The programme has 68 suppliers of components, besides employing 2,300 people in outsourced partners and 350

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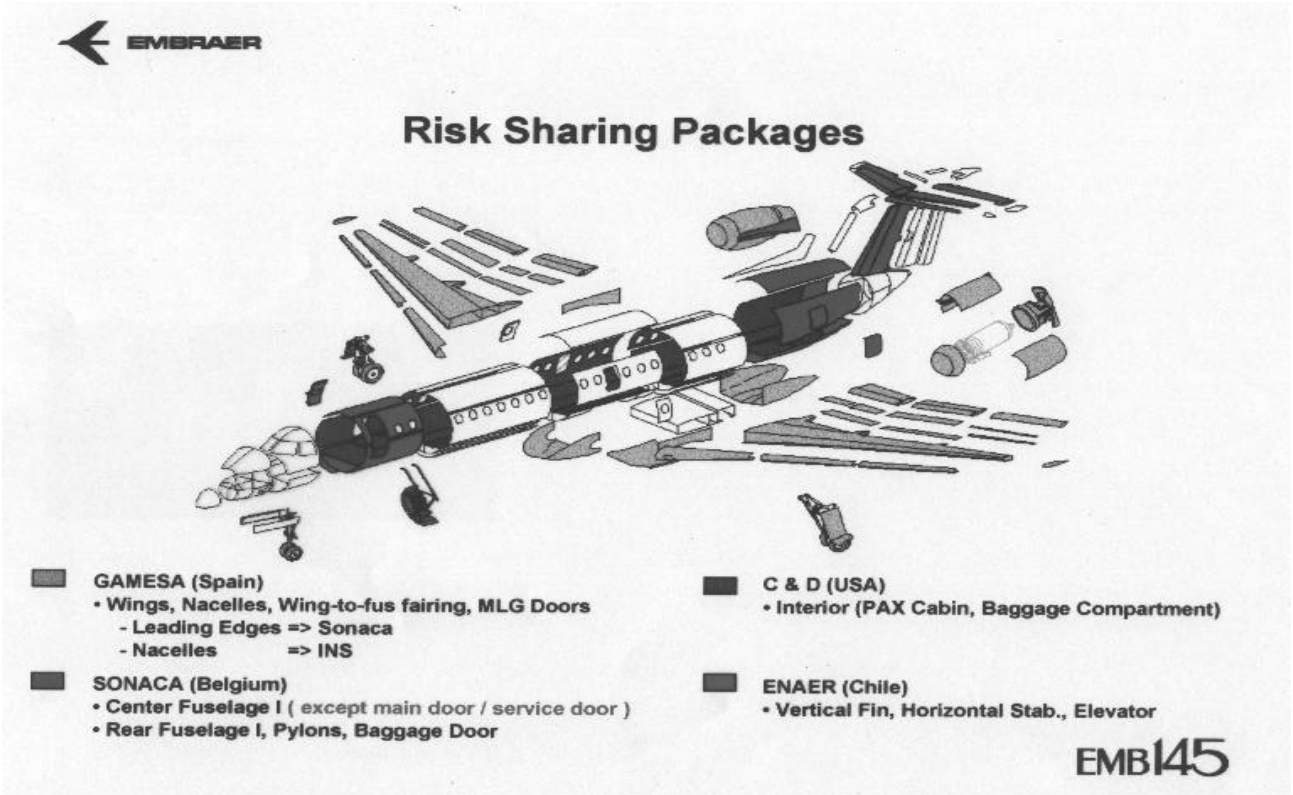
(Box III, concluded)

people directly at Embraer. Figure 1 below provides a more detailed visual of the risk partnership programme. It is worth mentioning that the risk partners were selected based on their previous associations with Embraer. They had been important suppliers or associated firms during the old turboprop projects and decided to accept the risk of a project that had a yet unknown future. Embraer had to take this line because it did not have the financial muscle to proceed alone, and was sure that from the technical point of view the partnerships would be successful.

Source: Embraer

Figure 1 – Division of Labour between Embraer and its Risk Partners for the ERJ-145/140/135



Source: Embraer

The development programme for the ERJ-170/190 project was conceived using a different approach to that of the ERJ-145 programme. The development of the new family of

regional jets required an investment of about US$ 850 million. To secure this magnitude of funding, it was necessary to seek a larger participation of companies and international financial institutions capable of financing the whole project. From the technological point of view, given the tight timetable Embraer had to select partner companies and abandon any idea of fostering local capabilities, at least for the most sophisticated technologies. The selected companies would also participate in the development of process engineering and tooling production of the aeroplane's components. The strategy of seeking out multinational partners aimed at securing added technological value to meet three high level requirements: technical training, supply capability and integration of "technological packages", in addition to assuring a sound financial and investment structure.

The innovation strategy also involved a process of institutional and organizational updating. It consisted, for instance, of the upgrading of the electronic mock-up. In the ERJ-145 project, the principles of *concurrent engineering* were applied in order to eliminate the need for modifications originating from production and maintenance problems. Applying concurrent engineering with real time connection via CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) during the entire development process involved several project teams, and manufacturing and technical assistance from Embraer and its main suppliers. The design of each component and part, totalling approximately 19,518 different items, was facilitated by the use of a new technology based on CAD already used in the development of the Brasilia.

The electronic mock-up not only made it possible for the ERJ-145 to be totally designed by computer, but also practically eliminated one of the most traditional stages of an aircraft's development. By generating three-dimensional images of each part and component of the ERJ-145 in real time and integrating them in a single database, the electronic mock-up allowed a meticulous analysis of each part of the aircraft and its relation with the other components connected to it. The use of the electronic mock-up eliminated the traditional mock-up work (a full-scale study model manufactured in wood). This resulted in a 50 per cent reduction of personnel (from 75 to 38 engineers) and a saving of approximately 93,000 man-hours (or US$ 3 million).

Another fundamental improvement was the flight simulator of the EMB-170, in which a database containing the aerodynamic characteristics of ERJ-145 was introduced. Through this artifice the pilots "flew" the ERJ-145 before it even existed, collecting information and correcting flight imperfections. The simulation of the airflow around the aeroplane, made possible by CFD (Computerized Fluid Dynamics) technology, was fundamental in the development of a new "cleaner" wing, with a supercritical profile developed by Embraer. The complete development of the jet involved two million working hours or approximately four years.

Box IV. The ERJ-170/190 programme

The first major difference of this programme as compared to the ERJ 145 is the greater integration and sophistication of strategic partnerships. The project of the aircraft, for instance, was co-designed with the partner companies. Embraer has a 45% share in the design and is responsible for the integration of all systems, aircraft structure and final assembly technique. The group of risk partners integrating the programme of the new family of regional jets for 70, 98 and 108 passengers, designated the ERJ-170, ERJ-190-100 and ERJ 190-200, were selected based on the analysis of 85 potential partners; of which 58 were pre-qualified and 16 were chosen.

The risk partnership idea got more complex with the new programme. General Electric (GE), the largest participant is responsible for the supply of the turbines. The engines represent about 20% of the sales price of the aircraft, estimated to be around US$ 22 million in the case of ERJ-170 and US$ 27 million for the ERJ-190. GE also holds 99.6% of Celma, an Embraer supplier of motors, accessories and parts, located in Petrópolis in the state of Rio de Janeiro. According to the specifications, the new aircraft is faster than the ERJ-145, cruising at Mach 0.80, and meeting the challenge of low operating costs in relation to competitors. Other important partnership is with the US Honeywell (taken over by GE for US$ 48 billion in 2000), who supplies most avionics. Gamesa, which integrated the previous programme, develops and supplies the *empennages* and the rear fuselage. Hamilton Sundstrand is responsible for the fuselage rear cone, among others. Figure 2 provides a visualization of the risk partnerships for the ERJ-170 family. There has been also an important progress related to the reduction of the number of suppliers, with the increase of the number of parts and components for each one. The aerospace division of Kawasaki Heavy Industries, from Japan, is also among one of the ten companies chosen as risk partner. Kawasaki will invest US$ 100 million in the development of the central part of the wing, control surfaces and pylons (motor support structures). And, finally, EDE, the Equipment Division of Embraer, established a joint venture with Liebherr (Germany) for the supply of the landing gear.

Several elements are crucial to the understanding of this programme. The first is that a rigorous and strategic selection of the new partners, emphasizing capacities to develop new technologies and investment. The second point to be emphasized is the decision by Embraer, after 20 years (since the Brasilia programme), to internalize the production of the aircraft wing. This task, in the ERJ-145 programme, was the responsibility of the Spanish company Gamesa and Embraer considered it to be too critical to the company to be left to other partners. Finally, there was a change in the system of innovation and development of the project engineering, towards a system of more integrated routines and co-ordination among the partners. From the operational point of view, the ERJ-170/190 programme was organized in three phases (which can be visualized in Chart 1.3). Phase 1 - "Initial Definitions" – involved the concept and detailing of the aircraft design. This was done before the choice of risk partners. A business plan was prepared focusing on market requirements and product detailing. Cost planning, analysis of the life cycle; investment, analysis of the risk and return on the investment were part of this phase. In addition there was a specific market identification study with a methodology prepared by Embraer.

The second phase - "Joint Definitions" - was characterized by the division of the aircraft in several sections and the division of the work among the companies; it was followed by the joint definition of the aircraft parameters among the partners and Embraer. The innovation made during this phase was the internationalization of R&D routines that were developed through the use of a *co-operative engineering*, i.e. the setting up of a network of R&D between plants and laboratories of the several international partners centralized and co-ordinated by Embraer in Brazil. This institutional arrangement involved the establishment of decentralized multi-disciplinary teams, in a type of matrix structure. Innovation teams organized it across the entire company, for the joint development of aeroplane components with the partners. These procedures allowed the integrated development of the

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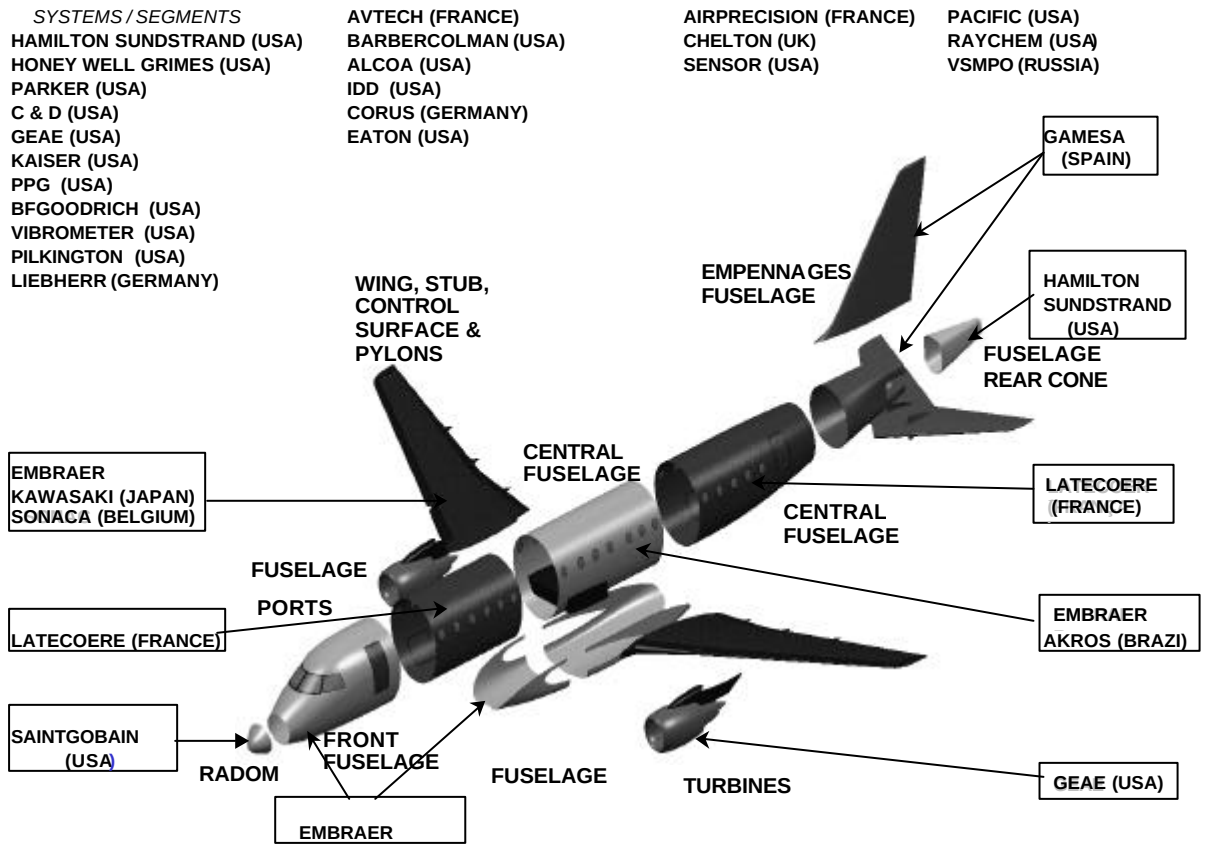
(Box IV, concluded)

product, since all decisions taken were made by specialists from company partners and who therefore, had the decision-making authority. About 600 full-time engineers were assigned to the programme, with 300 specialists from Embraer and 300 specialists of the other international partners, from Japan, Spain and the U.S., among others, who worked intensely and "in-house" at the Embraer headquarters in Brazil. The engineering work and project was performed in the Embraer advanced data-processing centre that provided a fully integrated project atmosphere. The co-design strategy permitted savings 18 months in the development of the aircraft (36 instead of 54 months), with substantial gains in quality. With the implementation of web systems and EDI - Electronic Data Interchange, it was possible to call on-line the network of partner firms in the electronic mock-up and the ERJ170/190 database that were centralized in the Embraer IT structure. The general design modifications made by the partners and suppliers were sent electronically to Embraer, where they were checked and validated for later updating of the mock-up and database. The final phase - "Detailed Design and Certification" – is where the final definition of the aircraft is made. The engineers and technicians of the partner companies return to their home countries to finish the detailing phase and require the certification of the aircraft in different markets.

Source: Embraer

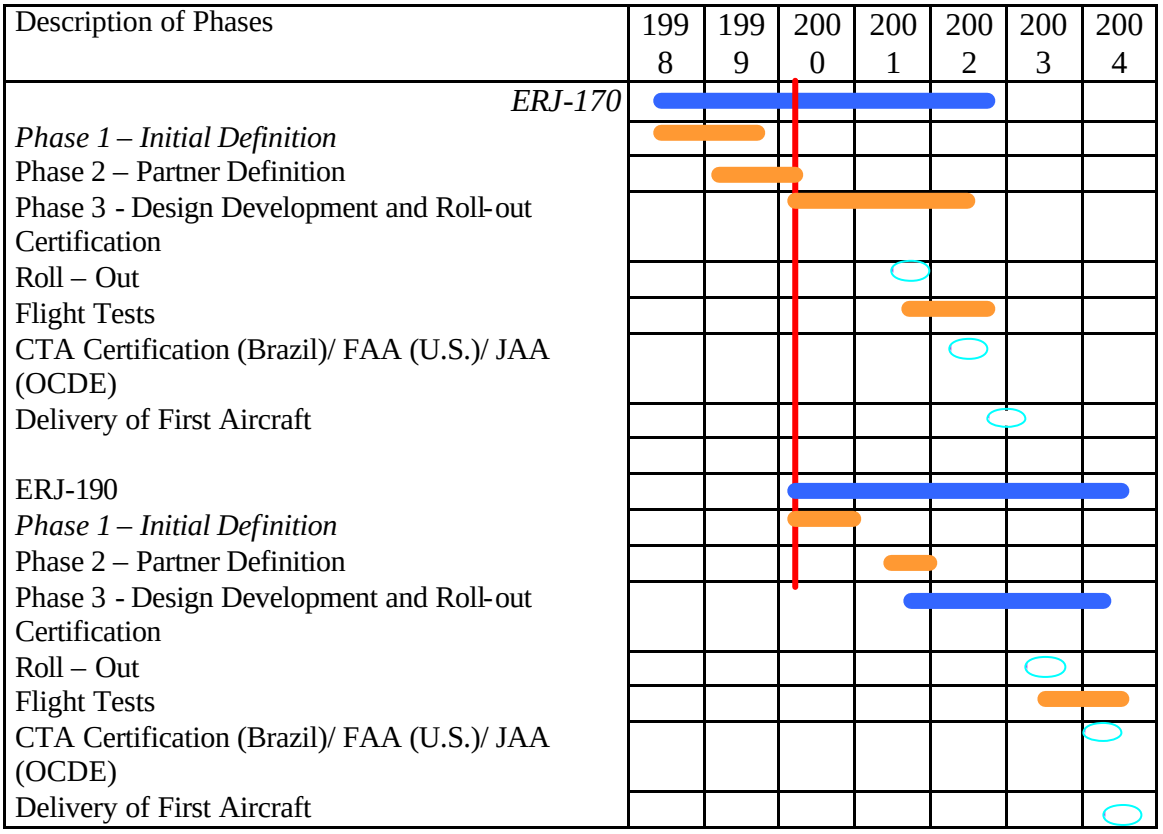
Figure 2 Division of Labour between Embraer and its Risk Partners for the ERJ-170/190



Source: UNCTAD based on Embraer.

Another important improvement was in the transition of the electronic mock-up to digital mock-up and in the project software, migrating from the Intergraph used in the ERJ-145 programme for Catia software developed by the French company Dassault (employed in the ALX and Sikorsky programmes), to the Virtual Reality Centre (VRC). The knowledge acquired in the use of Catia was fundamental for the implantation of the VRC.[17] Its use in the development of the new family of ERJ-170 and ERJ-190 regional jets enabled a more effective decision-making process, with early identification of problems, mistakes and design flaws. It enabled a reduction of 50 per cent in the time of the activity cycle (from completion of the design of the aircraft to certification) and the time-to-market. The development time frame of the ERJ-170/190 was cut to 38 months instead of the 60 months taken by the ERJ-145 programme, representing a cost and time saving for manufacturing of between 5 and 10 per cent.[18]

Chart 1.3. Time schedule of the development stages of the ERJ-170/190



Note: CTA (Technological Airspace Centre, Brazil), FAA (Federal Aviation Administration, United States), JAA (Joint Aviation Authority – European equivalent to FAA), OECD (Organisation for Economic Co-operation and Development).

Source: Embraer

[17] Embraer built the VRC in partnership with SGI Silicon Graphics Inc., which represented the biggest investment of the company in IT, at a cost of US$ 2.6 million. The Centre began operation on 7 February 2000.

[18] Until end-2001, besides Embraer, only Petrobras in the petrochemical sector and GM (General Motors) in the automotive sector operated with such a system in Brazil, and only partially.

One of the main advantages to the company in assembling the Virtual Reality Centre was that it expedited the development process of aircraft using the same technology as the biggest aerospace industries in the world. Thus teams involved in projects will no longer be required to build replicas of each model developed, in real size or in scale, for tests – a significant saving of project time and costs. This system allows the designer to accomplish a "virtual tour" in each section of the aircraft, perform tests and model structures, for example. CRV technology can be applied in several areas such as in design and manufacture, human model simulation, marketing (some sales were confirmed after the buyers made the virtual tour within the aeroplane), design review, hangar manufacture, kinematics, ergonomics and corporate presentation, among others. This system also allows the certification authorities to better evaluate the aircraft as it is being built.

All these changes had a significant impact on the labour force. Figure 3 below shows the evolution of Embraer's workforce over the 1990s, particularly the significant reduction in the number of employees during the crisis period. With recovery in the second half of the 1990s, the employment level increased again. It is important to highlight what happened with employment of more qualified personnel. During the restructuring phase, although the Technology and Engineering Department, considered the strategic nucleus of the company, was spared from outsourcing, many engineers and highly qualified technicians were laid off. Obviously, with their departure the knowledge accumulated over the years was lost. Due to the high training costs and recycling time it takes for one (aeronautical) engineer to be able to act in other areas, when the sector boomed again in the late 1990s it was not easy to re-employ them. [19]

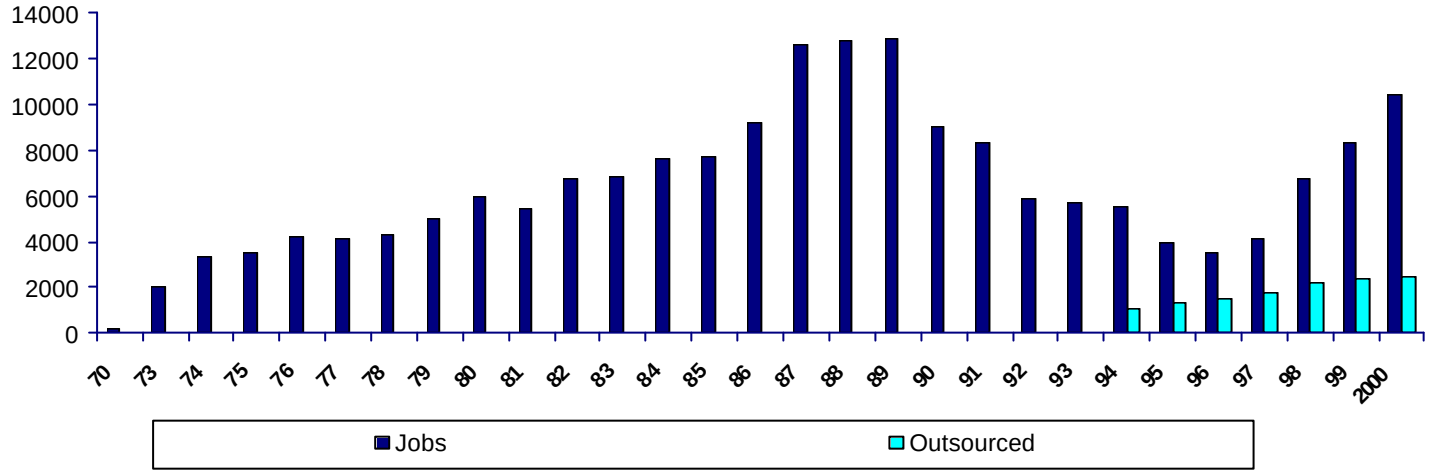
However, with the recent recovery of the sector many engineers and technicians have returned to Embraer. On the other hand, many services such as cleaning, catering, security, certain areas of information technology (IT), pilot and other employee training, transportation and some services associated with the design all started to be outsourced. The outsourcing of indirect activities resulted in savings of approximately US$ 80 million. In the first semester of 2000, Embraer had 9,000 direct employees. Of these, 1,500 (16.7 per cent of the total) were engineers, and, according to estimates of the local metal workers' union, outsourced activities accounted for 4,000 jobs.

It is expected that investments in the new family of regional jets will raise sales to US$ 4 billion over the next four years, making Embraer is one of the few Brazilian brands to enjoy prestige and a dynamic participation in the medium- and high-tech world market. It plans to invest in a new plant, to be located in the city of Gavião Peixoto, in the area of Araraquara, where military aircraft production lines, new versions of jets for corporate use and the construction of a test runway for Embraer aeroplanes will be located. The investment is expected to generate 3,000 new jobs. Two equipment and component suppliers, Tamesa and CMB, have confirmed their installation of two new plants near the new Embraer factory. Close proximity to one university (Unesp) and to the engineering school of another (São Carlos Federal University) was taken into consideration for the choice of location, as was the availability of local fibre optic infrastructure, and fiscal incentives.

[19] Also, given the crisis that affected the entire Brazilian economy in the 1990s and the few R&D activities in most Brazilian industries, many engineers had great difficulty in finding a new technical job. Indeed, there are several reported cases of qualified engineers from Embraer changing their occupation and downgrading their activities (working as salespersons, for instance). Some managed to be hired by other companies, some created their own businesses and others were recruited by foreign aerospace firms and migrated.

The final net results of these changes in the aircraft innovation system are difficult to measure. However, it is fair to say that it has probably had mixed results. With the prospect of production, growth and development of new products, it is estimated that 4,000 new jobs (both direct and indirect) will have been created during the period 2000–2002.

Figure 3. Embraer: Total employment, 1970-2000



Source: Embraer

CHAPTER V

CREATING LOCAL SYSTEMS OF INNOVATION FOR AIRCRAFT PRODUCTION IN SÃO JOSÉ DOS CAMPOS

This chapter discusses the role – real and potential – of the local innovation system of São José dos Campos in Embraer's strategy. As a result of the high growth of the aircraft sector, the Vale do Paraiba region (composed of the towns of Caraguatatuba, Cruzeiro, Guaratinguetá, Taubaté and São José dos Campos) accounted for more than 15 per cent of the country's exports in 1999. This region has been named "The Technology Valley" because it has the largest concentration of high-tech industries in Brazil.

The São José dos Campos region hosts several plants belonging to local and multinational firms that are of strategic importance in global and local production chains. These firms include: Embraer and Avibrás in the aerospace business, Volkswagen, Ford and General Motors in the auto industry, Ericsson in telecommunications, and the petrochemical plant of Petrobrás. In less than 40 years a local production and innovation system geared towards the production of aircraft has been developed. This chapter discusses some aspects of this system, in particular local institutions that provide R&D infrastructure, firms that supply goods and services to Embraer and recent institutional arrangements being introduced in the region that are geared towards increasing local capabilities.

1. Scientific and technological infrastructure

The successful creation of an aircraft cluster in the São José dos Campos region is largely the result of the Government's efforts to create a robust scientific and educational infrastructure aimed at meeting the high-skills requirements of the aircraft industry. The Technological Airspace Centre (CTA) and National Institute of Space Research (INPE) are the leading institutions in this area. The CTA, which is a branch of the Department of Research and Development (DRD) of the Ministry of Aeronautics, consists of four institutes: the Aeronautic Technology Institute (ITA), which is a teaching organization; the Aeronautic and Space Institute (IAE); the Institute of Advanced Studies (IEA); and the Institute of Industrial Liaison (IFI). In 2000, CTA employed approximately 4,000 researchers to work on development projects for the aeronautic, space and defence systems in the areas of advanced materials, physics, chemistry, electronics and computer sciences. Computer simulations, a wind tunnel, and soil and flight tests complement basic research. As most research is linked with industry, CTA has acquired capabilities in metrology, quality, standardization, reliability and R&D management. INPE is designed to conduct research in space and atmospheric sciences and space applications. It offers graduate and post-graduate programmes and has research programmes for satellites and their sub-systems, including tests, tracking and control integration.[20]

[20] The Technological Airspace Centre (CTA) and National Institute of Space Research (INPE) are leading educational institutes located in São José dos Campos, offering graduate and post-graduate courses in different areas of the aerospace sector to 600 and 130 students respectively. ITA has post-graduate programmes in

The region also hosts other important training institutions, such as a local branch of SENAI (National Industrial Learning Service), which is part of the National Confederation of Industry (CNI) and is geared towards providing training for workers. A partnership agreement between SENAI and Embraer provides training to 40 students per semester until 2010. The objectives of this youth apprenticeship programme are to train young relatives of Embraer employees in the fields of mechanics and electronics in order for them eventually to be employed by Embraer. In return, Embraer will build a modern telematics laboratory at the SENAI branch in São José dos Campos.

2. Locally subcontracted small and medium-sized enterprises

As mentioned earlier, Embraer designs and develops aircraft projects and integrates and assembles systems, structures, the fuselage and components. It was also pointed out that the competitive strategy of Embraer is based on coordinating a global network of risk partners, world suppliers and local subcontractors.

Apart from the risk partners already discussed, Embraer has about 450 to 500 supplier companies for the ERJ-145 programme. Most of first-level suppliers are located abroad. Up to 2001, about 95 per cent of the suppliers were located abroad: 73 per cent in the United States, 25 per cent in Europe and the remaining 2 per cent in other countries. Of 43 first-level suppliers, there is only one Brazilian firm, EDE that produces the main landing gear (table 1.13).

In the ERJ-170/190 programme the total number of suppliers was reduced to 40 companies, most of which are located abroad (95 per cent). As Embraer designs new forms of relationship with suppliers, United States firms are losing their share (53 per cent), while Japanese firms are now participating (8 per cent) and European firms (27 per cent) and companies of other countries (8 per cent) are gaining relative importance (table 1.14).

aeronautical and mechanical engineering, electronics and computer science, airspace infrastructure, industrial engineering and organization, and physics. Since its inception in 1961, some 830 students have graduated with master degrees, 110 with doctoral degrees, and 120 specialists. INPE offers post-graduate courses in meteorology, remote sensoring, space engineering and technology, applied computing, space geophysics and astrophysics. It has produced 690 graduates with a master degree and 150 with PhDs since it was set up in 1968. On a smaller scale, human resources for the cluster have also been provided by the Mechanical Engineering School of University of São Paulo - São Carlos (USP), the University Vale do Paraiba (UNIVAP) and the Federal University of Minas Gerais, which also offers graduate courses for engineers, specializing in aeronautics.

Table 1.13. First-level suppliers for the ERJ-145/140/135 programme

Class and suppliers (Distribution %)	Components supplied	Country
Hardware (4%)		
Electrical		
E.G. & G. Rotron	Electronic compartment and cooling fans	United States
Matrix	Connectors	United States
Mechanical products	Circuit breakers	United States
Raychen	Wires and cables	United States
Vickers	Hydraulic pumps	United States
Eaton-MSC	Buttons	United States
ECE	Contact points and fuses	United States
ABG Semca	Pressurization equipment	France
AIIied Signal	GPWS/wind shear detector, pneumatic start-up and CVR/FDR	United States
Mechanical		
B.F.Goodrich	Wheels and brakes	United States
Goodyear	Tires	United States
EDE	Main landing gear	Brazil
Liebherr	Auxiliary landing gear and flap control	Germany
Mason	Aerodynamic brake stick	United States
Aviac	Stick pusher. pedal adjustment actuator and fire shut-off valve	France
Crane. Hydro Aire	Brake controls	United States
Raw material (2%)		
Alcoa	Aeronautical aluminium	United States
Equipment (60%)		
Allison	Motor AE 3007	United States
Lord	Motor front	United States
Eros	Crew oxygen	France
Rosemount	Ice detector and stall protection	United States
Sextant	Altimeter and speed indicator	France
Sicma	Pilots Seats	France
Sierracin	Windshield and bad weather window	United States
Struthers Dunn	Relay	United States
Systron Donner	Fire detector	United States
Technofan	Fan	France
Vibro-Meeter	Central maintenance computer and motor vibration monitoring	Switzerland
Parker Hannifin	Hydraulic, fuel and flight command systems	United States
Eldec	Proximity sensor	United States
Grimes	Warning units, alarms and illumination	United States
Hamilton Standard	Air conditioning and pneumatic system	United States
Honeywell	Avionics	United States
Jet Electronic	Altitude indicator and emergency battery	United States
Lucas Aerospace	Power generation	United States
Marathon Power Technologies	Batteries	United States
Pacific Scientific	Fire extinguisher	United States
Avtech	Communication with passengers	United States
Metallic structures (34%)		
Gamesa	Wings, engine nacelles, wing fairings/fuselage junction and main landing gear doors	Spain
Enaer	Horizontal and vertical empennage	Chile
Sonaca	Luggage compartment service and main doors, front section and pylons	Belgium
Sundstrand/ Labinal	APU, APIC	United States/France
Norton	Radome	United States

Source: Estimates supplied by Embraer.

Roughly, the relative weight of inputs for the production of Embraer's aircraft is as follows: 60 per cent equipment (e.g. engines, avionics and air-conditioned systems), 34 per cent metallic structures (subsets, wings and careenage), 4 per cent electric components (wires, cables and systems) and mechanic systems (e.g. brakes and wheels) and 2 per cent basic inputs (e.g. aluminium, titanium, kevlar and carbon fibre). Risk partners are responsible for 36 per cent of the total (in value terms), international suppliers for 57 per cent and national suppliers, mostly small and medium-sized enterprises (SMEs), for 7 per cent. Considering the final cost of the aeroplane, the local content is approximately 4 per cent, distributed in the following way: 2 per cent consists of engineering services, usinage and manufacture of composite materials by local SME and 38 per cent is the value added by Embraer (e.g. wages, product development and depreciation). [21]

Perhaps of greater significance is the fact that the growing importance of Embraer and the way its strategy has been designed are attracting several firms to locations near Embraer's manufacturing plants. Embraer already buys several important services (e.g. engineering, software, management, thermal treatment), avionics and other industrial inputs from its local suppliers. Inter-firm relationships established in this region present different levels of integration and commercial and technological transaction flows, but with a high degree of vertical integration and coordination. Today, the local aircraft industrial cluster comprises approximately 40 SMEs organized around Embraer.

Most local suppliers are locally owned and were set up by Embraer's former employees and fostered by Embraer itself. These local SMEs (e.g. Cemic, Akros, Digicon, Elebra, Eleb, ETA, Mectron, Neuron-Eletrônica, Fibra Forte, Aeroserv, Qualitas, N&N, Tectlecom and Alltec) depend on local R&D centres and participate in the aircraft production chain through a direct subcontracting system with Embraer. There are also some other local suppliers that participate in the production chain through subcontracting with other risk partners. Table 1.15 shows some examples of firms in the São José dos Campos area, in Campinas (70 kms. from São José) and Porto Alegre in the south of Brazil, that are subcontracted by Embraer and its risk partners to provide high quality technical services and manufactured goods.

There are also some important firms that are part of the productive chain, supplying parts, component and technical services, that are located in other Brazilian regions, such as GE/Celma (Petrópolis – RJ), Aeronaut and Aeroeletrônica (Porto Alegre – Rio Grande do Sul), Rolls Royce (São Bernardo do Campo-SP), and NEIVA which belongs to Embraer (Botucatu – SP). All this important network of highly competitive firms has originated from policy design rather than from market forces.

[21] The definition of the local content index follows BNDES criteria. Relative shares were calculated taking as the base the final price of an aeroplane in 2000. Financial information was taken from Arthur Andersen's accounting reports for 2000 and 1999. For details see Bernardes (2000).

Table 1.14. First-level suppliers of the ERJ-170/190 programme

Category and suppliers (Distribution %)	Component	Country
Hardware (4%)		
Electric		
BFGoodrich	Smart probe	United States
BFGoodrich	Stick shaker	United States
BFGoodrich	TAT	United States
BFGoodrich	Windshield wiper	United States
Hamilton Sundstrand	Electric system	United States
Raychem	Wires & cables	United States
Eaton	Push buttons	United States
Mechanical		
Liebherr	Landing gear	Germany
Barber Colman	Windshield heater	United States
Parker	Flight controls	United States
Pacific Scientific	Fire protection system	United States
GEAE - GE Aerospace	Power plant (engine & nacelles)	United States
Air Industries	Mechanical hardware	United States
AHG	Mechanical hardware	France
Fairchild	Mechanical hardware	United States
Pentacon	Mechanical hardware	United States
Textron	Mechanical hardware	United States
Equipment (60%)		
Parker	Fuel system	United States
Hamilton Sundstrand	Air management system	United States
Chelton	Static discharger	United Kingdom
AVTECH	Passenger address system	France
Honeywell	Avionics	United States
Chelton	Antennas VHF	United Kingdom
Sensor	Antennas VOR/ILS	United States
Allied Signal	EGPWS	United States
Allied Signal	SSCVR / FDR	United States
Air Precision	Clock	France
Parker Hydraulics	Hydraulic systems	United States
Vibrometer	EVM	Switzerland
Hexcel	Composite material	United States
Pilkington Aerospace	Pax window transparencies	United States
PPG Industries, Inc.	Windshield transparencies	United States
Honeywell (Grimes)	External and cockpit lighting	United States
IDD	Lighted acrylic panelling	United States

Table 1.14. First-level suppliers of the ERJ-170/190 programme (continued)

Category and Suppliers (Distribution %)	Component	Country
Raw materials (2%)		
Alcoa Mill Products	Aluminium plates & sheets	United States
Corus	Aluminium plates & CTS	Germany
VSMPO	Titanium plates & sheets	Russian Federation
Alexco	Aluminium extruded shapes	United States
Pechiney Aviation	Aluminium extruded shapes	France
Alcoa Forged Products	Aluminium forged parts	United States
Otto Fuchs	Aluminium forged parts	Germany
Neuvant	Aluminium forged parts	United States
Structures (34%)		
Kawasaki	Wing stub	Japan
Kawasaki	Fixed leading edge	Japan
Kawasaki	Fixed trailing edge	Japan
Kawasaki	Pylon	Japan
Kawasaki	Control surfaces	Japan
Latecoere	Centre fuselage I	France
Latecoere	Centre fuselage III	France
Latecoere	Doors	France
C&D	Interior	United States
Sicma	Pilot / co-pilot seats	France
Gamesa	Rear fuselage	Spain
Gamesa	Horizontal empennage	Spain
Gamesa	Vertical empennage	Spain
Akaer	CFII / wing fuselage fairing project	Brazil
Kaiser	Throttle / autothrottle	United States
Sonaca	Centre fuselage II	Belgium
Sonaca	Slats	Belgium
NMF	Wing skins	United States
Saint Gobain	Radome	United States
Hamilton Sundstrand	APU/tail cone	United States
Tools and Manufacturing Services		
Dynamic Solutions	Tool project	Brazil
Matrinor S.L.	Fairing tools	Spain
(Several Companies)	Tools Manufacturing	Brazil

Source: Estimates supplied by Embraer

Table 1.15. Local firms subcontracted by Embraer and its risk partners

Firms	Region	Subcontractors	Type of Activities Subcontracted
Aeroserv	RSJC	➢ Embraer ➢ Gamesa ➢ Sonaca	➢ Assembling and structural services ➢ Aircraft configuration services ➢ Aircraft configuration services
Akros	RSJC	➢ Embraer ➢ Latecoere ➢ Sonaca	➢ Project engineering services ➢ Project engineering services ➢ Project engineering services
Aeromot	Porto Alegre RGS-	➢ Cyclone	➢ Complex technologies and structural assembling in metallic and composites materials, superficial and thermal treatment.
Dynamics Solutions Engenharia	Campinas	➢ Embraer ➢ Hamilton Sundstrand ➢ Latecoere ➢ Gamesa	➢ Tool engineering ➢ Technical support ➢ Engineering services ➢ Engineering services and technical support
Serco Engenharia	RSJC	➢ Embraer ➢ Latecoere ➢ Sobraer	➢ Engineering services ➢ Engineering services ➢ Engineering services

RSJC = Region of São José dos Campos
Source: Bernardes (2000)

3. Support institutions

Thus, for decades support institutions have played a key role in the creation of Embraer, as well as in the development of the São José dos Campos aircraft innovation system. These have included several municipal, state and federal agencies, especially those at the Ministry of Aeronautics, the Brazilian Socio-economic Development Bank and FINEP, the agency for technological development of the Ministry of Science and Technology.

What follows is a description of the initiatives introduced in the 1990s, when, in the absence of federal programmes, most of the institutional support involved basically municipal and state as well as private agencies. In 1992, the Pólo Vale Foundation was set up with the objective of fostering the setting up of technology-intensive SMEs. It had the support of the Commercial and Industrial Association of São José dos Campos (ACI) in partnership with the city government of São José dos Campos, and the government-sponsored service to support SMEs, Sebrae and Univap (the University of Vale do Paraíba). Its institutional mission was to create and manage a technological cluster in the area through a programme for incubating technology companies. In 1993, the Pólo Vale Foundation signed a protocol of intent with the Ministry of Science and Technology (MCT) whereby it would become the local branch of the Softex programme – the most important programme of the federal Government aimed at fostering the establishment of software firms.

The Foundation was disbanded at the end of 2001 because of financial problems, even though it had produced some positive results. These included:

1. The setting up of a new venture in February 2000 by Petrobras' Revap (Henrique Lage Refinery), which resulted from the merging of five SMEs from the oil, chemical, biotechnology, instrumentation and industrial automation industries.
2. The setting up in 1993 of a firm of 10 employees in the aerospace sector, Engenharia Qualitas, specializing in the production of software and programming projects, quality control, aircraft maintenance and systems logistics for the aeronautical sector (see box V),

Box V. A success story in Pólo Vale

Initially dedicated to the domestic civil and military aviation market, Engenharia Qualitas has signed contracts with foreign companies such as Aertec of Spain for the implementation of an airport maintenance system. In the domestic market, the firm has customers in the civil aviation market, including Helibras (the helicopter producing firm), Embraer, and Pantanal Linhas Aéreas, a local carrier. In 1999, it signed a contract with Embraer for an estimated US$ 100,000 to develop systems for maintenance engineering and monitoring of costs for its entire fleet. In the aviation defence segment its main customer is the army. Sales reached approximately 500,000 real in 1999 and 1 million real in 2000.

Source: Authors

In 1998, the Foundation for Research Support of the State of São Paulo (Fapesp) allocated about US$ 30 million, over a period of six years, to support basic research and industry/university linkages. Fiscal incentives, such as local tax rebates, were also offered to new investments. These actions are strategic since a majority of the new enterprises are SMEs that are in no condition to meet operational requirements and, furthermore, have fragile self-financing structures.

In 1997, the municipal government of the city set up an agency – the Economic Development Secretariat (SDE) – with the objective of fostering local development and attracting new productive investment to the area. It targets the aerospace sector in particular, and it has developed (jointly with Embraer) a plan for the setting up of an aeronautical industrial complex. It is organized in an area of 200,000 m^2 where some 15 companies will be set up.

SDE and Embraer, with the support of the Federation of Industries of the State of São Paulo (FIESP), are also developing another project, a consortium for exporting, comprising SMEs in Paraíba Valley that supply parts and components to Embraer. Firms participating in the export consortium specialize in the areas of milling, metal processing, sub-assembly and treatment of materials. The main objectives of the consortium are both to make exports feasible by minimizing fixed costs and to increase the domestic production of components in the aeronautical supply chain. Twenty-six SMEs that potentially could take part in that consortium have been identified and 17 have been selected to participate in the pilot phase (see table 1.16). As a result, a new venture has been created: High Technology Aeronautics (HTA). It is estimated that there is an export potential of between US$ 7 and 10 million/year, and that 35-40 per cent of the idle capacity of these firms could be used for manufacturing for

export. The local government, together with the companies and entrepreneurs and workers associations, has been playing a major role in the promotion and development of the infrastructure for logistical and technology projects, which are strategic to the aeronautical production system. Also under way is a project with FIESP for the modernization of the Port of São Sebastião.

Also worthy of mention is the Programme for Expansion of the Brazilian Aerospace Industry (PEIAB), which was established by Embraer itself with the aim of strengthening the local aeronautical chain and raising the domestic content from the current 37 per cent to 50 per cent of value added. The programme is designed to focus on motivating partners to: (i) boost industrial capacity in Brazil, by setting up their own industrial units there or in association with national companies; and ii) contract parts of their industrial packages with Brazilian companies, offering and supporting those that are presently Embraer suppliers. The idea is to develop programmes with the federal, state and municipal authorities aimed at bringing to Brazil manufacturing and technological capacity currently not available in the country.

Table 1.16. Firms participating in the High Technology Aeronautics (HTA) Venture

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Firms	Origin of capital	Localization in the state of São Paulo	Area
Akaer	Local	São José dos Campos	Project engineering
Alltec	Local	São José dos Campos	Composites
Autômota Industrial	Local	Taubaté	Parts and components
Carpini & Marques Indústria	Local	Caçapava	Parts and components
Compoende Equipamentos para Ensaios e Serviços Especializados	Local	Tremembé	Project engineering
Elaine Ferreira Pereira	Local	São José dos Campos	Parts and components
LEG- Engenharia e Comércio	Local	São José dos Campos	Parts and components
LS Neves & Cia	Local	São José dos Campos	Parts and components
Metinjo Metalização Industrial Joseense	Local	São José dos Campos	Parts and components
Mirage	Local	São José dos Campos	Parts and components
New Plotter Engenharia	Local	Caçapava	Project engineering
Poly Cad Engenharia e Comércio de Informática	Local	São José dos Campos	Project engineering
SPU Indústria e Comércio de Peças	Local	Caçapava	Parts and components
Status Usinagem Mecânica	Local	São José dos Campos	Parts and components
Tecplas Indústria e comércio de Fibras	Local	São José dos Campos	Composites
Aeroserv	Local	Jacareí	Parts and components

Source: HTA - High Technology Aeronautics

The Association of the Brazilian Aerospace Industries (AIAB) was set up in 1993 with the objective of promoting a long-term policy of competitiveness for the sector. It is an organization of 25 firms targeting local technology development. In 1998, it produced a document on policies of competitiveness for the Presidency of the Republic, and in 1999, it presented a project for technological development to the Programme for Support of Technologic-Scientific Development (PADCT) of the Ministry of Science and Technology.

This project, which was approved, identified critical technologies and opportunities for businesses and is being implemented through partnerships between universities and local firms.

The local union, the Metallurgical and Engineers Union, has also been taking an active part in discussions on the direction of regional development, the processes of technological restructuring, privatization and its impact on skills. In turn, the institutional apparatus is geared to support research, basic, intermediate and higher technical education, and the formation of an associated technology culture for high-tech production. The local educational institutions have been able to meet the demand for highly skilled personnel. Their physical proximity to supplying companies and assemblers is also a positive factor. All this produces an industrial and innovative atmosphere that is extremely favourable to technological development.

The São José dos Campos area also enjoys logistical advantages due to its strategic location on the Presidente Dutra Highway between the two main centres of economic development in Latin America. It is 84 km from São Paulo and 321 km from Rio de Janeiro, has a 38 km natural gas pipeline delivery network and a 31 km optic fibre network at the disposal of companies located along the Presidente Dutra Highway. There is a basic band telecommunications station for transmission of voice, data and images, offering services such as international video-conferencing. Moreover, nearby are the Ports of São Sebastião (111 km), Santos (160 km), and the Port of Conchas on the Tietê-Paraná River is approximately 300 km from this area. The modernization of the São José dos Campos airport located 120 km from the capital of São Paulo, now being licensed to receive international cargo, was another important development for the region. Estimates are that monthly exports though the new airport could reach 2,000 tons, while imports could reach 1,000 tons. This corresponds to two daily flights of a Boeing 747-400 cargo aircraft.

4. Recent changes: Attracting foreign suppliers

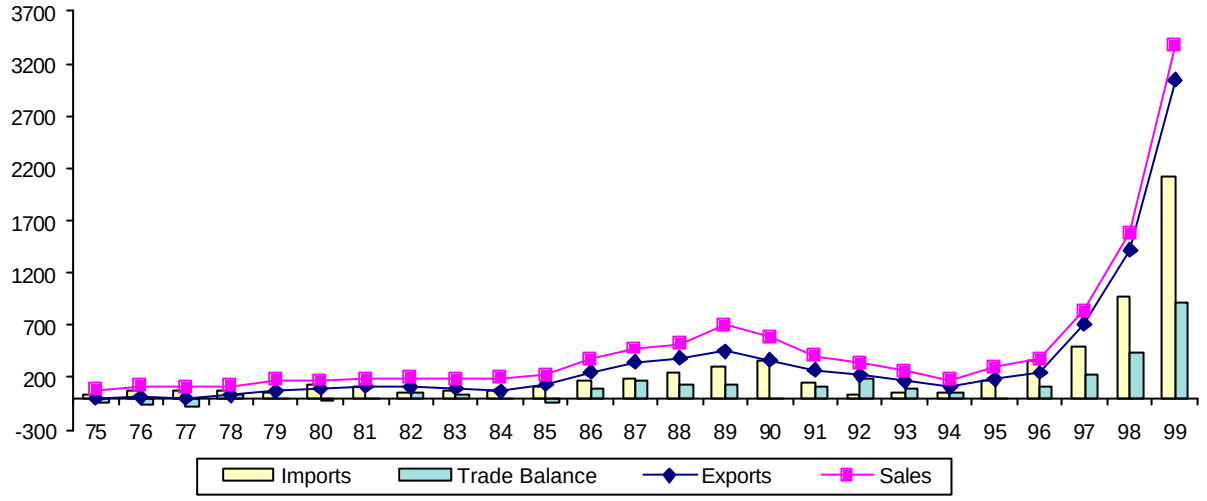
Embraer's overall strategy has resulted in successful sales and export performance over the years, as already discussed; imports also account for a large share of overall production, consistent with the worldwide trend in this industry. In the past, imports represented 60–70 per cent of production. More recently, however, with the rapid increase in production and world sales, an improvement in the trade balance has been observed, as shown in figure 4 below.

The *new supply policy* of Embraer has three main objectives:

1. Domestic production of parts, components and sub-systems, through the attraction of partner companies of the ERJ-170/190 programme to the vicinities of the São José dos Campos plant;
2. Reduction in the number of external and local suppliers, establishing new norms and parameters for the composition and integration of its supply chain. The ERJ-145 programme had around 400 suppliers, while the new ERJ-170/190 family will have approximately 40 suppliers; and
3. Building new types of supply relationships and managing flows between the suppliers of systems, parts, components, structures and technological services, through a pattern of "technological packages".

Figure 4

Embraer: Sales, exports, imports and trade balance, 1975-1999
(Million real)



Source: Embraer

In practical terms, the first-level suppliers will be responsible for the aggregation of a group of sub-systems that will make up a "technological package" of the aircraft, to be supplied and integrated into the final phase of the assembly line at Embraer.

The historical experience of technology transfer by Embraer to national suppliers has brought mixed results. The AMX programme is a case in point. During the 1980s, Embraer had identified and nurtured, through the special PIC programme (Industrial Supplementary Programme) of the Ministry of Aeronautics (Maer), about 20 domestic companies (among them, Elebra, Tecnasa, Aeroeletrônica, GE/Celma, Rolls Royce motors, EDE, Modata, ABC dados, Pirelli, Engetronic), mostly located in the area of São José dos Campos, to supply components and electronic systems for the consortium between Embraer and the Italian company Aermacchi. At present, of the initial group of companies only four remain: Elebra, Aeroeletrônica, GE/Celma, and Tectelcom (formerly Tecnasa, presently under bankruptcy proceedings). In this case, there was a deliberated regression in technological development, as well as losses in technological know-how and international markets.

The new Embraer philosophy and technological strategy is focused mainly on the essential competencies. In the past, software and technological systems were developed largely within the company but now they are ordered, purchased or developed jointly with "soft houses". One example is Fibra Forte, a small company (of five employees) located in the São José dos Campos area, staffed with ex-employees from Embraer, which develops the engineering software used in the management of project activities.

The development of the new family of Embraer jets – ERJ-170, ERJ-190-100 and ERJ-190-200 – opened up opportunities for attracting new foreign investment and foreign companies in Brazil. The transfer of some suppliers of the programme to the area of São José dos Campos, close to the company's factory, is part of its strategic plan to operate under a *just-in-time/kanbam*[22] philosophy from the year 2001 onwards.

Information supplied by Embraer confirms that 17 of its international partners are interested in setting up local subsidiaries in Brazil to benefit from the proximity to Embraer (see table 1.17 in Annex); these companies include:

- C&D Interiors, one of risk partners of the ERJ-145 programme;
- Parker, which has a factory in Jacareí where it produces systems for the automobile industry;
- The German company Liebherr, which reached an agreement with the Equipment Division of Embraer (EDE) for opening a new company, ELEB, in São José dos Campos; and
- Latecoere that has already signed contracts with companies located in São José dos Campos for the supply of engineering services and technical support.

The report of the Embraer PEIAB team estimates that the new investment already confirmed will result in the direct generation of 1,850 new local jobs with forecasted annual sales of US$ 320 million. In this new stage, industrial investment of the order of US$ 280 million is planned: US$ 80 million in engineering services, generating 250 jobs; US$ 150 million in local production of parts, creating 1,000 jobs; and US$ 50 million for the installation of partners in Brazil, resulting in another 600 new jobs (see box VI).

Box VI. Potential for local production

Embraer believes there are several intermediary products (and technologies) that could be manufactured locally, which at present are imported. Among them,

- Sub-set and structure assembly (fuselage rings and wing);
- Connection bars, autoclave services, thermoforming and vinyl gluing;
- CNC stamping of 4 and 5 axes, acrylic moulding and plate anodizing;
- Milling, tapestry and manual impregnation;
- Chemical finishing; and
- Special processes: Shot-pin conforming.

As for technical services, in general, Embraer estimates that local production could be developed in the areas of:

- Project engineering in general;
- Systems and process controls, administration and use of equipment;
- Architecture and integration of mechanical and electronic systems, for example; and
- Quality and instrumentation services and software, among others.

Source: Embraer

[22] Kanbam: methodology of production optimisation.

CONCLUDING REMARKS: THE POLICY PERSPECTIVE

Today, Embraer is one of the few Brazilian companies with ample capabilities for innovation in the complete technological learning process. It accords great importance to the process of consolidation of technological knowledge, its transformation and dissemination through the company's communication channels. In addition, Embraer has highly qualified personnel through the mechanisms of learning-by-doing, especially in the manufacturing process, in the assembly of fuselages and in systems' integration. The dynamics of learning uses complex products, new materials, software and avionics resulting both in efficient operating practices and more effective maintenance and adaptation, which in turn result in product improvements. And finally, it promotes learning-by- interacting that derives from the interaction and institutional administration between the partners and the suppliers linked by information, goods and services.

The cycle of technological innovation is now perceived as a business dynamic not exclusively restricted to the routines of R&D. This is because the technological learning processes have demonstrated the importance of interdependency and intercommunication. In other words, the organization needs to create an interdependence between technical production, human resources, financial, economic and marketing spheres while at the same time also satisfying market demands. This implies the merger of many functional activities at Embraer. A further strategic change for Embraer is needed, based on implementing a management model that emphasizes learning, innovation and knowledge. In this respect, studies for the implementation of a project for creating a "corporate university", i.e. a private university owned by the firm that will graduate scientists and engineers with the appropriated skills to its needs, has already been initiated under the responsibility of the human resources department.

The focus adopted by the new administration is characterized by sophisticated analysis using indicators of performance, profitability, client satisfaction, and the monitoring of change and future market transformations. This requires the establishment of a set of formalized and institutionalized mechanisms to generate, register, analyse and interpret information that is considered strategic and vital in the context of high competition, swift obsolescence of the technological frontiers and market uncertainty. The competitive strategy of the company has been articulated mainly through studies concerning aircraft demand conducted by outside consulting companies. In 1998, a Market Intelligence area was created with the aim of internalizing these studies within the culture and competitive strategy of Embraer itself. Basically, they include the study of market trends through the quantification of the global demand of aircraft using "top down" technical analysis, which consists of evaluating elements such as fleet size, number of aeroplanes in operation and fleet condition, sales development, backlog, sold and undelivered units, and sales forecast. The other method for quantification uses the "bottom up" approach, and consists of a direct approach to the customers, and their real interest in a new product.

Embraer is responsible for the employee training, technical monitoring and for the technological learning processes of its subcontractors. It does this by sending Embraer engineers to them to impart the necessary know-how (see box VII).

Box VII. Cooperative of Engineering Services (SERCO)

The 1995 experience of the Cooperative of Engineering Services (SERCO), comprising ex-employees of Embraer and other previously State-owned firms in the military area (such as, Avibras and Engesa), is one of the most interesting in São José dos Campos. The services rendered by the Cooperative provided a crucial alternative for Embraer's survival, since there was a surplus of professionals on the market due to the crisis in the civil aerospace and military defence sector in the first half of the 1990s. SERCO is made up of work nuclei organized by segments of commercial performance; it consists of eight services nuclei distributed among the cooperative partners: aerospace and infrastructure, quality and human resources, civil works, safety and occupational medicine, machinery and IT structures, electro-electronics, industrial automation and export and import services.

According to a study conducted by Mendonça (1997:44), in 1996 SERCO had 130 cooperative partners registered in the municipal government as autonomous professionals. The Cooperative signed contracts with multinational corporations that participated in the ERJ-145 programme, rendering design services and development inspection. Embraer hired services from this Cooperative, ranging from microfilming of drawings and documents to maintenance and checking of documents. The monthly average revenue was in the range of US$ 250,000 in 1996. With the sustained recovery of the aeronautical sector, SERCO's revenue grew twentyfold reaching a total of US$ 5 million in 1998. The substantial growth of this Cooperative is related mainly to the boost it received from Embraer and its suppliers and from the global air transport sector, at which the services that meet the requirements of new markets, such as IT and electronic documents processing, are aimed.

Source: Authors

Embraer's successful strategy of competition and innovation in the 1990s occurred during a period rupture in government support for CTA and other local technological institutions. The Brazilian Government cut down its resources for government-sponsored science and technology institutions and this had some impact on the local innovation system. As a matter of fact a problematic cooperation pattern has emerged between Embraer and the local R&D institutions. Embraer's cooperation and research relationships with CTA used to be more organic in the days of total government control, but currently are limited to aircraft certification and approval. Even with other universities, such as the São Carlos School of Engineering and the Polytechnic School, contacts are only on an informal basis, contrasting with European and North American experiences where a more structured relationship of firms and R&D centres is found.

In the 1990s Embraer managed to capture an important share in the world market for aircaft and became a member of a very select club of competitive firms in this sector in a period when the Brazilian federal Government's policy towards the industrial sector was almost non-existent. Without entering into a wider discussion about general industrial policy, it is important to note that all the successful experiences of the aircraft industry point to large

government support in several different ways. This is the case with Boeing and McDonnell Douglas of the United States, the Airbus European Consortium and the Canadian firm Bombardier.

However, there was an important Brazilian Government programme, which helped Embraer in the 1990s. Besides the virtues of the ERJ-45, its price and financing scheme were important in American Eagle's decision to purchase the aircraft. The sales operation had the support of credit lines provided by the Brazilian Economic and Social Development Bank (BNDES) through its Finamex programme for export financing. The financing arrangement was the decisive factor in the success of the deal, covering up to 100 per cent of the value of the operation at internationally comparable interest rates and with a repayment period of up to 15 years. The loan of US$ 1 billion granted by BNDES for the export of 40 ERJ-145 aircraft was the largest ever approved in the entire history of the bank. This scheme was part of a government export support programme – Programa de Financiamento às Exportações (PROEX) created by the Government of Brazil on 1 June 1991, by Law 8187/91. It provides export credit to Brazilian exporters, either through direct financing or interest equalization payments. Under the direct financing scheme, the Government lends a portion of the funds required for the transaction. Under interest equalization, underlying legal instruments provide that the National Treasury "grants to the financing party an equalisation payment to cover, at most, the difference between the interest charges contracted with the buyers and the cost to the financing party of raising the required funds (Resolution 2380/97 of the Brazilian Central Bank, 25 April 1997).

The success of Embraer and the use of these policy mechanisms led to a dispute between Embraer and Bombardier wherein Bombardier accused the Brazilian Government of subsidizing the manufacture of aeroplanes. On 18 June 1996, Canada requested consultations with Brazil at the World Trade Organization (WTO), under Article 4 of the Agreement on Subsidies and Countervailing Measures and Article 4 of the Understanding on Rules and Procedures governing the Settlement of Disputes, regarding "certain export subsidies granted under the Brazilian PROEX to foreign purchasers of Brazil's Embraer aircraft". [23]

The possibility for the type of investment outlined in Chapter V materializing is certainly dependent on some important changes in government industrial policy. The federal Government has been allowing state governments to compete almost entirely through the offer of fiscal incentives (tax breaks or significant reductions in the state level taxes), without any interference by the central authorities, to attract foreign firms to their regions. However, such competition between the state governments plays limited role in attracting the type of new investment needed by Embraer.

In order to analyse policy alternatives it is useful to discuss briefly the role that the Government played in supporting Embraer's establishment. The federal Government supported Embraer's sales through a programme of financing its exports. As a developing country firm, Embraer had experienced difficulties finding international banks and financial institutions willing to provide the financial engineering needed to sell aeroplanes. In this type of market, sales tend to be coupled with a financing package. The importance of the programme of financing exports (PROEX) of the Brazilian National Economic and Social Development Bank (BNDES) was that it not only provided the financial package, but also, and equally important, a framework under which local interest rates were equated with

[23] See Canada's request for consultations at WTO (WTO document WT/DS/46/1).

international interest rates. As mentioned above, this kind of incentive was heavily contested at the WTO by Embraer's immediate competitor Bombardier of Canada and by the Canadian Government.

The other significant policy initiative of the federal government, that partly helped Embraer, has been the fiscal incentive to stimulate technological upgrading. Under this policy, industrial and agricultural firms are allowed to rebate the outstanding income tax on account of *R&D* expenditures and the value added tax on equipment acquired for *R&D* activities, as well as accelerated depreciation allowance for equipment and instruments acquired for *R&D*.

There are also some credit lines by Finep, the technology bank of the Ministry of Science and Technology, but this is not an excellent option, given the high interest rates that characterize the Brazilian financial system. As already mentioned, there have also been several attempts both from the state of São Paulo and from the city of São José dos Campos to provide help.

One of the more important policy mechanisms that could help the development of the local innovation system would be a series of mechanisms to foster the growth of small high-technology firms around Embraer. In fact all major competitors of Embraer benefit from this type of support provided it is not inconsistent with WTO rules.

It may be concluded that federal policies and state actions contributed to the success of the modern phase of the Brazilian aircraft industry. The federal Government offered solid and continuous support to Embraer at the time when it was a government-controlled enterprise through budgetary allocation of sufficient financial resources for S&T infrastructure and procurement. To a large extent, it was through procurement that technological learning was made viable and feasible. This government policy, particularly that of the Ministry of Aeronautics, imposed on outside partners associated with Embraer the requirement of local production to foster people-to-people technology transfer.

In Embraer's present situation as a private company, the federal Government continues to support Embraer's sales through its programme of export financing and it has been able to implement a supporting programme, namely the Programme for Expansion of the Brazilian Aerospace Industry.

In terms of international trade rules, civil aircraft is also the subject matter of a plurilateral Agreement on Trade in Civil Aircraft, part of the Tokyo Round Agreements of the General Agreement on Tariffs and Trade (GATT), that applies only to its signatories. Brazil is not a signatory of the Agreement but it has observer status. Due to the fact that civil aircraft is subject to this plurilateral agreement, certain provisions of the Agreement on Subsidies and Countervailing Measures (SCM Agreement) (Article 6.1 (a) and (d)- Serious Prejudice -, and Article 8.2 (a) Non-Actionable Subsidies)[24] did not apply to civil aircraft. However, the provisions of these Articles have lapsed on 31.12.1999. Subsidies otherwise applied to the aircraft industry are subject to compliance with the provisions of SCM Agreement.

Finally, Embraer's experience in cooperative agreements involving transfer of technology could be considered an interesting example of successful acquisition of technological knowledge in conformity with international trading rules.

[24] Article 6.1 (a) and (d) – Serious Prejudice – and Article 8.2 (a) Non-Actionable Subsidies of the WTO SCM Agreement explicitly exclude civil aircraft from these provisions.

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ANNEX

Table 1.17. Partners of the ERJ/170/190 Programme Intending to Invest or to Settle in Brazil

COMPANY	Country of origin	Supply	Contractual commitment	% National Supply	Status
Parker Hannifin Corporation	USA	Flight Control, Fuel and Hydraulic System	Installation of plant close to Embraer	15%	The company will count with its local subsidiaries in SP and Jacareí. It evaluates the construction of a new building in São José dos Campos
Hamilton Sundstrand	USA	Power System/ APU. Tail Control System, Air Control System	Seeking new opportunities and domestic partners	2%	Establishment of an office in Brazil; Contract signed with Dynamic in Campinas for rendering of engineering services and technical support in the amount of Real$ 180,000 until Dec/2000.
General Electric Aircraft Engines	USA	Motor/Nacelle	Group assembly	2%	GE controls Celma, and is analysing the viability of assembling motors and rendering maintenance and repair services. It is also studying the conditions for purchase of motor components directly from Celma or Brazilian companies.
Latecoere	USA	Central Fuselage I Central Fuselage III / Doors	Production of parts and/or engineering services in Brazilian companies	5%	Establishment of Latecoere do Brasil. Has entered contracts with Dynamic in Campinas, for rendering of engineering services and technical support of US$ 160,000 until Dec/2000. Signed a contract with Suprisul - São José dos Campos - for lease of IT equipment, total in the amount of US$ 425,000. Contract with Akros (S.J. dos Campos) for rendering of engineering services US$ 690,000/year for 5 years. It is evaluating the companies Aeroserv and ELEB (S.J. dos Campos) as part of its network of suppliers.
Gamesa Aeronáutica	Spain	Rear fuselage and Empennage	Use of Brazilian companies for material purchase and/or services limited to US$500,000/yr.	--	The company evaluates new national companies for the supply of composite materials for the ERJ-170/190. It maintains a contract with Dynamic in Campinas for the allocation of engineering equipments and technical support over US$ 7,000 until Dec/2000.
Liebherr	Germany	Landing gear	Production of the Landing gear	38%	Entered a joint venture with EDE (former division of Embraer) forming a new called company ELEB.
Sobraer S.A. (Brazilian subsidiary of Sonaca S.A.)	Brazil	Slat/Central Fuselage II (Manufacture)	Production of parts and/or engineering services in Brazilian companies	--	Implantation of an industrial unit in S.J. dos Campos. Sobraer will accommodate the junction of the pylons in the rear fuselage supplied for the ERJ-135/145 programme and its final assembly, in a process that will be transferred progressively from the Belgian head office to the Brazilian subsidiary. Presently made in Belgium, the final

					assembly of its segments supplied for the ERJ-135/145 programmes is made possible through services rendered by a contract signed with Serco (S.J. dos Campos), foreseeing the use of 35 employees/month for 1 year, with a total of 50,000 work hours. It studies the viability of the production, in Brazil, of approximately 250 milled parts of the Central Fuselage II of the ERJ-170/190 programme.
C&D Aerospace	USA	Interior	Installation of a Plant in the Area of São José dos Campos	10% in the first year and 20% starting from the second year	C&D do Brazil was Established in 2000, in Jacareí. Their activities will begin with support to the ERJ-135/145 programme, foreseen to begin of production of Overhead Bins and PSU structures for first quarter of 2001. The accumulated investments in industrial plant, improvements, equipment and personnel and development of infrastructure are estimated at US$ 3,100,000.
Kawasaki	Japan	Wing (fixed leading edge, fixed trailing edge, pylon, control surfaces	Studying partnerships with domestic companies	4%	Kawasaki is analysing the feasibility of looking for domestic partners to reach a 4% national content.
Honeywell	USA	Avionics	Expansion of the repair workshop at Embraer and intention of establishing support centre for operators of Latin America	--	Installation of support centre for training of operators in Latin America
NMF	Canada	Covering panels	Factory implantation in Brazil.	--	The decision to install a plant in Brazil depends on the minimization of the tax burden. Company studies point to investments of US$ 18,000,000 in the implantation of the Brazilian factory.
Figeac Aero	France	Supply of Covering Panels and Wing Rib	Implantation of a subsidiary in Brazil	--	The intention of the company is to invest US$ 12,000,000 in the assembly of a subsidiary in Brazil for the supply in partnership with Embraer of Covering Panels and Wing Ribs.
Aeromot/Cyclone Aviation Products Ltd.	Israel	Implementation of new technologies in aviation production	Investment in new technologies together with national companies	--	A contract was signed between Cyclone and the Brazilian Aeromot (Rio Grande do Sul) for the implementation of technologies for structural assembly of metallic and composite materials, milling forming of metallic plates, superficial and thermal treatments. Investments of around US$ 10,000,000 to US$ 15,000,000 are planned.
Goodyear	USA	Tires	Reactivation of the industrial park for the	--	Reactivation of its industrial unit in São Paulo, seeking initially to meet the ERJ-135/145 programme, and later, the expansion for

			production of tires for the aeronautical industry		supply to the ERJ-170/190 programme. The intention is to produce about 20 different sizes of tires to meet the aircraft requirements of Embraer, such as: Brasília, AMX, ALX and Tucano. The production expectation is around 25,000 tires a year in 2003, with a sales forecast of US$ 6,000,000.
Pilkington Aeroespace	USA	Production of Transparencies / windows	Adaptation of an industrial unit in São José dos Campos	--	The company is adapting an industrial unit in São José dos Campos, seeking initially the production transparencies /windows for the ERJ-135/145 programme, and later, the expansion for supply to the ERJ-170/190 programme. This unit has a built area of 1,950 m2, where it intends to have from 60 to 70 employees dedicated to the aerospace sector. The technology transfer should occur, according to Embraer, in a year.
Elano Corporation	USA	Project and Manufacture of tubes and metallic ducts for aviation engines and air conditioning systems and aircraft pressurization	Establishment of partnerships with Brazilian companies, or installation of own subsidiary in Brazil	--	The Elano company is subsidiary of GE Aircraft Engines. With the objective to meet to the needs of the Embraer programmes, Elano intends to establish partnership with Brazilian factories, or in case of viability, invest in the establishment of own subsidiary in place that is economical and logistically more viable to meet the Embraer programmes.
Labinal	USA	Supply of Electric Cabling	In phase of viability studies	--	Labinal is accomplishing viability analyses for the establishment of partnership with Brazilian company or installation of a subsidiary in Brazil.

Source: Embraer - PEIAB Brazilian Aerospace Industry Expansion Plan

A Case Study of the Pharmaceutical Industry in India

INTRODUCTION

The decade of the 1990s has been significant for India in terms of the changes in policy orientation directed at its economy. From the relatively inward looking policies in place till the end of the 1980s, the policy regime adopted in 1991 sought to break down the walls of protection behind which Indian industry had developed in the past. The biggest challenge for Indian industry posed by the new regime arose from the need to adopt measures that would improve its competitive strength.

This study focuses on the performance of the pharmaceutical industry, a sector that has been able to meet the challenges posed by the new policy regime with a degree of success. The success that this industry experienced in the 1990s was, however, built on a foundation that was laid in the 1970s. During this phase, the Government provided a policy environment to the industry, which was defined through a mix of instruments. The prime objective of the policy framework was to develop a viable domestic industry with adequate participation of Indian entrepreneurs. A key instrument for the realization of this objective was the policy aimed at building up the technological sinews of the industry.

The impact of the policies adopted through the three decades covering the 1970s to the 1990s is analysed in this paper in three chapters. While the first two chapters present a broad overview of the performance of the industry, the third chapter provides a case study of the leading Indian enterprise in this industry, namely Ranbaxy Laboratories. The case of Ranbaxy Laboratories shows how the Indian pharmaceutical industry performed through the changing policy regime.

CHAPTER I

HISTORICAL OVERVIEW OF THE INDIAN PHARMACEUTICAL INDUSTRY

The pharmaceutical industry in India has evolved through three phases over the past 50 years. The first was the period prior to 1970, when the industry was relatively small in terms of production capacities. The second phase spanned the late 1970s to the early 1990s, a period during which the industry experienced policy-induced growth. In its third phase, during the 1990s, much of the regulatory structure that the Government had imposed during the previous two decades was dismantled.

Even as late as the mid-1970s, India had a relatively small pharmaceutical industry, with a total production of just over US$ 600 million. During the subsequent four years, the total output of the industry more than doubled, the major contribution being made by formulations, which accounted for 85 per cent of total production. Table 2.1 shows the production figures for the two broad segments of the industry: bulk drugs and formulations.

Table 2.1

Indian pharmaceutical industry in the 1970s: Production (US$ million)

Years	Bulk drugs	Formulations	Total
1974/75	111.1	493.7	604.8
1975/76	155.2	668.6	823.8
1976/77	167.4	781.3	948.7
1977/78	187.7	1 029.9	1 217.6

Source: Based on GOI, Ministry of Chemicals and Fertilizers, *Annual Report* (various years).

An overwhelmingly large share of installed capacity in the Indian industry was in the small-scale sector, with approximately 2,400 of a total of 2,524 units belonging to this sector in the mid-1970s. Of the remaining units, 43 were affiliates of foreign firms in which the parent firms' share in equity holdings exceeded 40 per cent. These foreign affiliates were deemed to be "foreign-controlled" firms in accordance with the guidelines that were laid down by the Foreign Exchange Regulation Act of 1973 (commonly known as FERA). According to FERA, any firm registered in India was to be treated as "Indian" as long as its foreign equity holding did not exceed 40 per cent.

The 43 foreign firms in the Indian pharmaceutical industry had a disproportionately high share in total production in the mid-1970s. They produced 42 per cent of bulk drugs and formulations put together and about 38 per cent of the bulk drugs produced by the Indian industry.[25]

[25] GOI, Drug Policy, 1978.

1. The policy regime since the 1970s

The decade of the 1970s marked a turning point in the development of the Indian pharmaceutical industry as a result of three critical policy initiatives taken by the Government: the Drugs Price Control Order (DPCO), which was adopted in 1970; adoption of the new Patents Act, which became effective in 1972; and adoption of a new drug policy in 1978. The framework for the new drug policy was provided in the Report of the Committee on Drugs and Pharmaceutical Industry (commonly known as the Hathi Committee). Complementing these policy initiatives was yet another piece of legislation, the Foreign Exchange Regulation Act (FERA) of 1973, which aimed at reducing the share of foreign equity in enterprises registered in India. The above-mentioned policy initiatives were taken with two broad objectives in view: (i) to develop a strategy for the expansion of the domestic pharmaceutical industry by relying essentially on Indian enterprises, and (ii) to establish a structure for keeping the prices of drugs within affordable limits.

The first step towards evolving a comprehensive policy regime for the Indian pharmaceutical industry was taken by the setting up of the Hathi Committee in 1974. The Committee had an exhaustive mandate that aimed at the realization of the two broad objectives mentioned above. The Hathi Committee presented its recommendations in 1975.

2. The new drug policy of 1978

The new drug policy announced by the Government in 1978 had the following five broad objectives: (i) to develop a strong Indian sector with the public sector playing a leading role; (ii) to channel the activities of the foreign firms in accordance with the national priorities and objectives; (iii) to deepen the production base of the domestic industry by ensuring that the production of drugs took place from as basic a stage as possible; (iv) to encourage research and development and improve the technological sinews of the industry; and (v) to provide drugs to consumers at reasonable prices.

A. Expansion of capacities and the role of foreign firms

The 1978 Drug Policy guided the expansion of the Indian industry through two means: (i) by providing incentives to Indian drug manufacturers by relaxing the provisions of the licensing policy, and (ii) by imposing conditions on foreign-controlled firms to ensure that they created linkages within the economy.

Indian enterprises were given two major incentives. First, these enterprises were allowed to produce formulations up to 10 times the value of bulk drugs. The Indian drug manufacturers were thus allowed to produce a relatively higher proportion of non-basic drugs in a regime that laid emphasis on the production of bulk drugs. Further, to encourage consumption of indigenously produced bulk drugs, only such formulation capacity was

sanctioned in which the formulation turnover was based on a ratio of 2:1 between indigenous bulk drugs and imported bulk drugs.

Foreign firms[26] on the other hand faced relatively tighter controls in respect of their expansion in production of formulations. Three conditions were imposed on the foreign drug firms intending to expand their operations in India. These were: (i) the ratio between production of bulk drugs and formulations allowed in their output mix was 1:5, as against 1:10 allowed to the Indian firms; (ii) licences to foreign firms were provided only if the firms agreed to supply 50 per cent of their production of bulk drugs to non-associated formulators; and (iii) foreign firms producing formulations based on imported bulk drugs and intermediates had to start manufacturing from the basic stage within two years. The policies in respect of the foreign firms were thus aimed at utilizing the strengths of these firms for creating linkages within the industry for fostering an increase in downstream capacities.

The Drug Policy of 1978 was adopted during the phase when the Government was implementing the Foreign Exchange Regulation Act (FERA) of 1973, which aimed at reducing foreign holding in enterprises that were not of strategic importance for the country. According to FERA, foreign holdings up to 40 per cent were allowed in any enterprise registered in India. The shadow of FERA fell on the pharmaceutical industry as well. The Drug Policy of 1978 provided that firms which did not use high technology while producing bulk drugs or formulations had to reduce their foreign holding to 40 per cent, if the share of foreign holding was higher.

B. Emphasis on technology and R&D

As regards technology, the new drug policy had two stated objectives: (i) to develop local R&D facilities, and (ii) to import technology wherever necessary.

The local R&D facilities were to be developed in two ways: first, by using the facilities available with the public-funded organizations, which included the public sector production units and national laboratories; and second, through obligations imposed on foreign firms. In the case of foreign firms that had a drugs turnover of more than US $ 6.2 million (Rs 50 million) a year, the Drug Policy imposed two obligations. These were: (i) to have R&D facilities in India in which the capital investment would be at least 20 per cent of their net block, and (ii) to spend at least 4 per cent of their sales turnover as recurring expenditure on R&D facilities.

The public sector units were expected to develop a strong design and engineering component to bolster their R&D facilities, so that processes that they may have developed could be indigenously tested and scaled up with the necessary complement of indigenous design and engineering skills. The public sector units were also directed to set aside at least 5 per cent of their net turnovers for R&D activities.

Alongside development of indigenous capabilities, the new Drug Policy emphasized the role that technology imports could play in the technological upgrading of the pharmaceutical industry in India. With respect to agreements for technology transfer entered into by public sector units, the policy stated that efforts should be made to ensure that the import of technology would provide for horizontal transfer of technology. This emphasis on

[26] The Drug Policy of 1978 did not provide a clear definition of foreign firms. This category of firms presumably comprised those that had a majority foreign holding.

technological upgrading was crucial for an industry in which less than 40 of the firms engaged in production activities during the mid-1970s[27] had R&D units that were recognized by the Government.[28]

C. Price control regime

The pharmaceutical industry in India had been subjected to rigorous price controls since 1970 through the adoption of the Drugs Price Control Order or DPCO (henceforth DPCO '70). DPCO '70 was aimed at fulfilling two objectives. The first and more obvious objective was to ensure that drugs were available at reasonable prices in India. The second was to create an incentive structure for the domestic producers so as to encourage them to produce new formulations and to use, as active ingredients, new drugs that were products of original research in India. Besides covering the above-mentioned formulations, DPCP '70 also gave the Government the power to fix the minimum price of essential bulk drugs. The latter objective was in fact built into the larger policy framework evolved through the Drug Policy of 1978 as indicated earlier.

A modified DPCO was adopted in 1979 (henceforth DPCO '79), which had three significant changes from DPCO '70. These were: (i) the number of bulk drugs under price control was reduced from 347 to 163; (ii) non-essential formulations were excluded from price control; and (iii) all small-scale units with an annual turnover of less than US $ 1.22 million (Rs. 10 million) were exempted from the purview of price control. One of the major effects of DPCO '79 can be seen from the manner in which the small-scale sector expanded in the Indian pharmaceutical industry.[29]

The policy regime for the pharmaceutical industry in India was revised during 1986/87. Although the broad parameters of policy, defined by the Drug Policy of 1986, remained largely unchanged, a new DPCO was introduced in 1987, which reduced the number of drugs under price control: the number of bulk drugs under price control was reduced to 145. Accordingly the new price control regime remained valid both for drugs that were used in the National Health Programmes monitored by the Ministry of Health, and for other essential drugs that were identified by a group of experts.

3. Modifications to the drug policy

The changed orientation of the Indian economy since 1991, with emphasis by the policy makers on market forces, had implications for the drug policy. Modifications to the drug policy were adopted in 1994, followed by the adoption of the revised DPCO in 1995, which aimed at freeing the industry from the limitations imposed by government regulations. The following were the key elements of the new drug policy:

[27] In the mid-1970s, more than 2,500 firms were engaged in the production of pharmaceuticals.
[28] This information was obtained from R&D statistics produced by the Department of Science and Technology, Government of India.
[29] A recent estimate shows that there are more than 8,000 small-scale units in operation, see GOI, *Annual Report 1999-2000*: 2.

(i) The licensing requirement was abolished for all bulk drugs, with three exceptions: (a) identified bulk drugs which were the exclusive preserve of the public sector units, (b) bulk drugs produced by using recombinant DNA technology, and (c) bulk drugs requiring *in-vivo* use of nucleic acids;

(ii) Conditions stipulating mandatory supply of a percentage of bulk drug production to non-associated formulators were abolished;

(iii) Limitations on the use of imported bulk drugs were removed;[30]

(iv) Foreign holdings of up to 51 per cent of the total equity were allowed, as against the ceiling of 40 per cent earlier;

(v) New drugs, developed through indigenous R&D efforts were excluded from price control for 10 years from the commencement of commercial production; and

(vi) The scope of price control was limited to two categories of drugs: (i) those for which there were at least 5 bulk drug producers and 10 formulation producers, with none having a market share exceeding 40 per cent, and (ii) genetically engineered drugs produced by recombinant DNA technology.

The policy regime adopted for the pharmaceutical industry in India thus changed from one in which the industry was subjected to government controls in the 1970s to one that was almost completely guided by market forces two decades later. This changed scenario can be best understood by looking at the sharply declining number of bulk drugs under price control since 1970, the year in which the first DPCO was introduced in the country (see table 2.2).

Table 2.2

Bulk drugs under price control (1970 to 1995)

Year of introduction of the Drug Price Control Order	Number of drugs under price control
1970	347
1979	163
1987	145
1995	74

Source: Indian Credit Rating Agency (ICRA), 1999.

While the declining role played by the DPCO has been an important factor in the growth of the pharmaceutical industry, particularly in recent years, as the evidence provided below indicates the Patents Act of 1970 provided the initial impetus for the industry to take firm roots in India. This Act contained several provisions that were directly responsible for the development of the pharmaceutical industry in India.

[30] This in effect removed "local content regulation" in respect of the pharmaceutical industry.

4. The Indian patent system

In 1970, India adopted a new Patents Act (henceforth Patents Act, 1970), which became effective from 1972. The Patents Act, 1970 replaced the Patents and Designs Act of 1911. Its adoption marked more than two decades of intense debate amongst policy makers for evolving a patent regime that best suited India's development needs. The key issues figuring in this debate were high prices for drugs and the abuse of patent monopoly by foreign patent holders, especially in the case of pharmaceuticals. It was therefore not totally unexpected when the most important changes in the patent system ushered in by the Patents Act of 1970 were in respect of drug inventions.

There were three provisions in Act that affected the pharmaceutical industry. These were: (i) patents could be taken only for processes and not for products; (ii) the patent term was five years from its being granted or seven years from application, whichever was shorter;[31] and (iii) automatic licences of right could be issued three years after the granting of the patent. It could be argued that these three provisions had the combined effect of almost denying any patent rights to inventors seeking patent protection in India for their inventions involving pharmaceuticals. First, the process patent regime adopted by India encouraged reverse engineering and development of alternative processes for the products patented in other countries. Secondly, the reduction of the duration of the patent term, coupled with the fact that the Patents Office took on average four years to grant a patent, meant that the patentee did not enjoy patent monopoly for more than a year. And, finally, the provision relating to automatic license of right meant that anyone interested in exploiting the patented process involving a drug could do so, of course after obtaining the concurrence of the patentee.

It was therefore quite clear that the Patents Act of 1970 was intended to restrict the rights of the patent holders especially in the area of pharmaceuticals. With a “weak” patent regime, the foreign inventors had very little incentive to take out patents in India. Consequently, there was a decline in the number of foreign drug patents in India after the Act became effective. This might have had a negative impact on technology transfer, but at the same time it also left the Indian firms free to produce alternative processes for the drugs that were not patented in India.

The process patent regime was adopted in keeping with the argument that such a regime would encourage innovations in India, which had limited technological capabilities and financial resources for carrying out R&D activities. Support for this view was provided by evidence from several developed countries, which had also adopted process patent regimes when their pharmaceutical industries were at the nascent stage.[32]

One of the most obvious indicators of success achieved by the Indian pharmaceutical industry in the period since the adoption of the Patents Act of 1970 has been the shortening of the time lag between the introduction of a drug in the global market by the inventor and the marketing of the same drug in the Indian market, as indicated in table 2.3**.**

The table shows that the Indian firms have been able to progressively shorten the time lag between the introduction of a drug by the inventor and its introduction in the Indian

[31] For all other inventions, the patent term was 14 years from the date of application.
[32] Countries such as Japan and Italy moved from process to product patent regimes only in the 1970s.

market. However, estimates of the share of patented drugs in the overall sales of the pharmaceutical industry vary widely. The Indian Drug Manufacturers' Association (IDMA) estimated the value of drugs marketed in India with valid United States patents for the period June 1990 to July 1991 at 21.47 per cent of the total pharmaceutical market (IDMA, 1992). Redwood (1994) estimated this, on the basis of 500 top selling brands whose patents were still effective in Europe, at 11 per cent for the year 1993.

The overall impact of this mix of policies was favourable for the industry. This is evident in the relative performance of the pharmaceutical industry in the industrial sector as a whole, and also by the performance of the pharmaceutical industry in the 1990s, when it had to face external competition in the liberalized policy regime adopted by the Government.

Table 2.3

Time lag between introduction of a new drug in the world market and its introduction in India

Drug	Introduced in (year)		Time lag before introduction in India (years)
	World market by the inventor	Indian market by domestic companies	
Ibuprofen	1967	1973	6
Salbutamol (anti-asthmatic)	1973	1977	4
Mebendazole (anti-helminthic)	1974	1978	4
Rifampicin (anti-TB)	1974	1980	6
Cimetidine	1976	1981	5
Naproxen (anit-rheumatic)	1978	1982	4
Bromhexin (anti-hypertensive)	1976	1982	6
Captopril (anti-hypertensive)	1981	1985	4
Ranitidine (anti-ulcer)	1981	1985	4
Norfloxacin (anti-bacterial)	1984	1988	4
Ciprofloxacin (anti-bacterial)	1985	1989	4
Acyclovix	1985	1988	3
Ciprofloxacin	1985	1989	4
Astemizole	1986	1988	2
Larazepam	1977	1978	1

Source: Keayla (1997).

CHAPTER II

IMPACT OF THE POLICY REGIME ON THE DEVELOPMENT OF THE PHARMACEUTICAL INDUSTRY

1. Effects of active policy intervention

The changes that took place in the Indian pharmaceutical industry in the phase following the adoption of active policy intervention by the Government were, in many ways, quite significant.

Two sets of figures are provided in tables 2.4 and 2.5. The first gives details of the production of bulk drugs and formulations by the pharmaceutical industry in India. The second pertains to the performance of the pharmaceutical industry as compared to the other major sectors of Indian industry considering their respective profitability ratios.

Table 2.4

Production performance of the Indian pharmaceutical industry during the 1980s (US$ million)

Years	Bulk drugs	Formulations	Total
1980/81	305.2	1 526.1	1 831.3
1981/82	333.8	1 656.1	1 989.9
1982/83	364.9	1 755.7	2 120.6
1983/84	351.5	1 742.7	2 094.2
1984/85	331.8	1 607.9	1 939.7
1985/86	336.3	1 572.5	1 908.8
1986/87	363.2	1 696.9	2 060.1
1987/88	370.3	1 813.0	2 183.3
1988/89	395.2	2 263.4	2 658.6
1989/90	394.4	2 107.7	2 502.1

Source: Organization of Pharmaceutical Producers of India (OPPI).

Table 2.4 shows that the pharmaceutical industry grew by a third in dollar terms during the 1980s. The impetus for growth during this period came from the formulations, the production of which went up by almost 40 per cent. Bulk drugs production, on the other hand, increased by less than 30 per cent. The more important aspect of the increase in output of the industry was that it was more pronounced in the second half of the decade. While bulk drugs production increased twice as fast in the second half of the decade as compared to the first, production of formulations grew more than sixfold in the second half as compared to the first.

Clearly, it was in the latter half of the 1980s that the pharmaceutical industry started consolidating. Another noteworthy point is that this take-off in bulk drugs production in the country was in keeping with the expectations of the Drug Policy of 1978.

Table 2.5 and figure 5 below show the relative profitability of the firms in the pharmaceutical industry. Two sets of data have been used to compare the relative profitability ratios. The first set of data is from the annual survey conducted by the Reserve Bank of India (RBI) using data from public limited companies. Table 2.5, and, more clearly, figure 5, show that the firms belonging to the pharmaceutical industry in the sample used by the RBI have been registering profitability ratios consistently higher than the non-pharmaceutical firms in almost the entire period from 1970/71 to 1999/00. What is important is that while the non-pharmaceutical firms taken as a whole have experienced a declining trend in their profitability ratios (profits after tax to net worth) during the 1990s, the profitability ratios in the pharmaceutical industry have seen a rising trend.

Another set of data presented in table 2.6 along with the associated figure 6 compares the profitability ratios of the firms in the pharmaceutical industry with those in other major industrial sectors of the Indian economy during the 1990s. Unlike in the earlier exercise where the data for the non-pharmaceutical firms were presented in an aggregate manner, this exercise provides the data for the firms belonging to each of the larger segments of the Indian industry. Data for this exercise have been taken from a database comprising major firms in the Indian corporate sector.

The data compares the profitability ratios (defined as profits after tax as a percentage of the net worth) of the firms in the pharmaceutical industry with five of the largest sectors in Indian industry during the 1990s. Three of the sectors included in the data set faced declining rates of growth in the latter half of the decade, which turned negative in the closing years of the 1990s. The firms belonging to the pharmaceutical industry too faced a declining profitability ratio from the middle of the decade, but witnessed a turnaround in their profitability ratios in the last year of the decade.

Table 2.5

Profitability ratios of the drugs and pharmaceutical industries (percentage)[33]				
Years	Gross profits to sales		Profits after tax to net worth	
	Pharmaceutical	All industries	Pharmaceutical	All industries
1970/71	17.8	10.3	16.5	11.2
1971/72	16.2	10.0	16.4	10.5
1972/73	15.5	9.5	15.6	10.3
1973/74	14.9	12.0	15.2	14.3
1974/75	13.6	12.7	14.1	16.4
1975/76	13.0	9.2	12.0	8.2
1976/77	14.2	9.0	14.6	7.9
1977/78	14.2	9.0	16.5	8.3
1978/79	14.5	9.5	16.1	8.8
1979/80	13.5	10.1	17.0	8.3
1980/81	10.8	9.8	12.9	6.6
1981/82	10.4	9.3	14.0	6.4
1982/83	11.0	8.7	14.4	6.9
1983/84	9.7	7.9	8.8	5.7
1984/85	9.9	8.8	10.7	5.8
1985/86	9.0	8.8	11.5	5.8
1986/87	8.6	8.3	11.4	5.4
1987/88	8.3	8.6	11.2	4.3
1988/89	9.1	8.9	15.9	7.8
1989/90	9.6	10.2	17.5	10.7
1990/91	10.4	11.6	16.0	13.9
1991/92	9.9	11.9	14.3	12.0
1992/93	10.3	11.0	16.1	8.7
1993/94	11.3	11.9	15.2	4.0
1994/95	13.3	13.0	17.8	3.5
1995/96	11.5	14.3	19.6	14.5
1996/97	13.8	12.9	16.1	9.8
1997/98	13.9	13.0	15.7	8.8
1998/99	14.5	11.7	16.3	6.9
1999/00	16.2	11.8	19.5	7.6

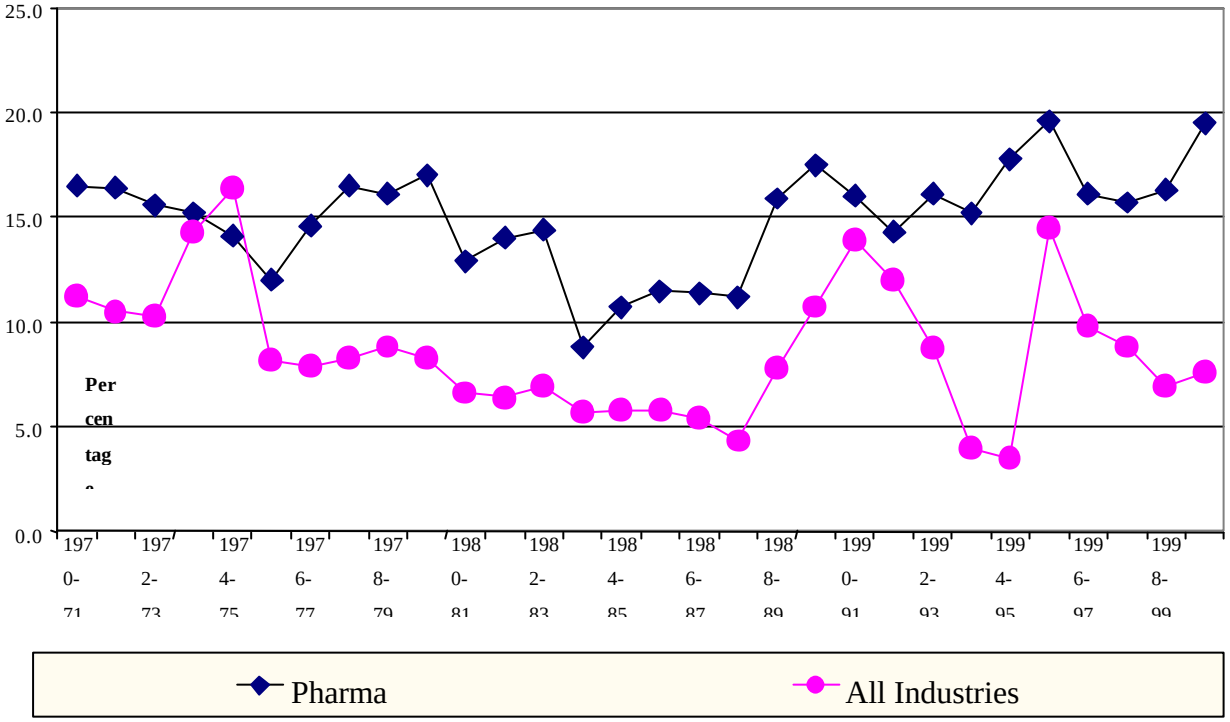
Source: RBI, *Finances of Public Limited Companies*, various issues.

Notes: (1) The number of companies varied from year to year. For instance, the number stood at 46 in 1970/71 while in 1997/98 the number of selected companies was 69.
2) The above ratio pertains to the financial performance of non-government, non-financial public limited companies based on the audited annual accounts of selected companies.
3) The selected companies for this study, for instance in 1997/98, accounted for 30.3 per cent in terms of paid-up capital.
4) It needs to be noted that while for most years the companies selected were mainly medium and large public limited companies, for some years a few small companies were also included.
5) Companies whose paid-up capital is about US $ 12,000 using the 1999/2000 exchange rate, or Rs.0.5 million or above, were included under medium and large public limited companies.

[33] Although the number of companies included in the survey has varied, there is no sampling bias in favour of any industry, and the data are therefore quite reliable for the purpose of this exercise.

Figure 5

Profitability of pharma and non-pharma industries in India: Profit after tax to net worth



Source: RBI, *Finances of Public Limited Companies*, various issues.

Table 2.6

Profitability of industries in India (1989-2000)[34]

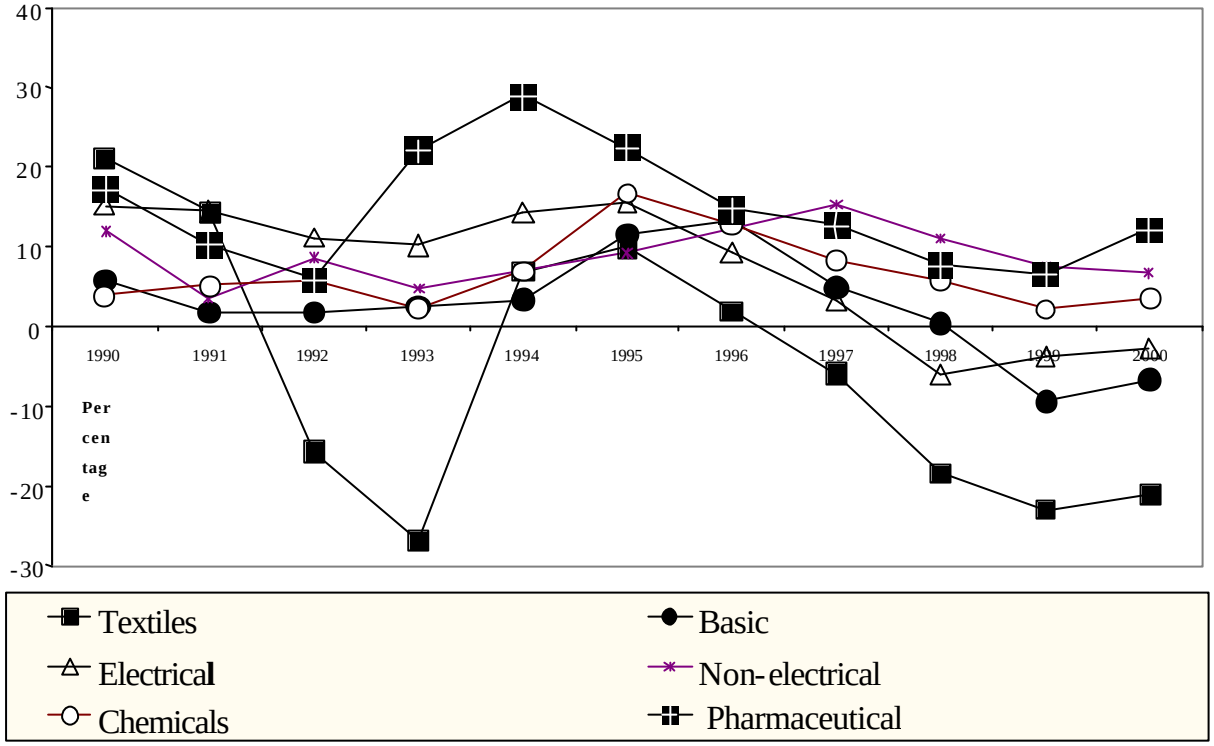
Sectors	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	1990/1995	1996/2000
Profit after tax /net worth														
Textiles	-105.2	21.12	14.45	-15.6	-26.7	6.97	10.01	2.01	-5.8	-18.4	-22.9	-21	1.7	-13.2
Basic metals	225.31	5.79	1.86	1.73	2.62	3.47	11.64	13.46	5.03	0.6	-9.37	-6.6	4.5	0.6
Electrical equipment	60.3	15.12	14.51	11.15	10.33	14.37	15.6	9.32	3.37	-5.9	-3.67	-2.7	13.5	0.1
Non-electrical equipment	117.07	12.04	3.72	8.75	4.69	7.03	9.24	12.36	15.32	11.06	7.72	6.82	7.6	10.7
Chemicals	9.49	3.87	5.2	5.91	2.48	7.2	16.9	12.99	8.37	5.92	2.39	3.6	6.9	6.7
Pharmaceutical	30.68	17.35	10.39	6.01	22.22	28.96	22.55	14.81	12.89	7.85	6.66	12.3	17.9	10.9

Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database (2000).

[34] As in the earlier data set, firms have been included in the data set with no explicit bias and hence the sample is quite reliable for the purpose of this study.

Figure 6

Comparative profitability of Indian industries



Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database (2000).

2. Performance of the pharmaceutical industry during the 1990s

The 1990s witnessed the strongest performance of the Indian pharmaceutical industry on several fronts. Not only did the industry exceed its output expansion of the previous decades, but it actually became a net foreign exchange earner. This performance followed the change in the policy orientation of the Indian economy that took place in 1991. This industry thus took advantage of the unshackling of the industrial sector during the 1990s from the controls imposed by the Government. The rapid opening up of what had been largely an insulated economy to international trade and investment brought about a swift response from the leading firms in the pharmaceutical industry. The following discussion, as well as the case study of the largest Indian pharmaceutical firm, Ranbaxy Laboratories, highlights the key facets of the response of the industry to the changed economic environment.

A. Production

That the decade of the 1990s was the phase in which the Indian pharmaceutical industry took off is clearly evident from the production trends. Between 1990/91 and 1999/00, the industry grew twice as fast as it had during the preceding decade. Table 2.7 presents the annual production of bulk drugs and formulations.

Table 2.7

Production performance of the Indian pharmaceutical industry in the 1990s (US$ million)

Year	Bulk drugs	Formulations	Total	Share of the pharmaceutical industry in the manufacturing sector
1990/91	417.0	2 193.8	2 610.8	2.4
1991/92	395.7	2 110.6	2 506.4	2.8
1992/93	443.7	2 315.0	2 758.7	2.9
1993/94	432.9	2 262.8	2 695.7	3.2
1994/95	483.8	2 529.2	3 013.0	3.1
1995/96	561.9	2 814.0	3 375.9	2.8
1996/97	616.9	2 961.6	3 578.6	3.2
1997/98	722.3	3 323.3	4 045.7	3.0
1998/99	763.0	3 363.6	4 126.6	na
1999/00	877.3	3 706.9	4 584.1	na

Note: Totals may not add up because of rounding off of numbers
Sources: 1. Department of Chemicals and Petrochemicals, *Annual Report* (various years). 2. Organization of Pharmaceutical Producers of India (OPPI) and UNIDO, *International Yearbook of Industrial Statistics.*

The production of bulk drugs rose from US$ 417 million in 1990/91 to more than US$ 877 million in 1999/00, showing a compound growth rate of 8.6 per cent. The production of formulations, on the other hand, increased from nearly US$ 2,194 million to US$ 3,707 million during the same period, showing a growth rate of 6 per cent. The share of bulk drugs in total drug production increased from 16 per cent in 1990/91 to 19 per cent in 1999/00. If we divide the decade into two five-year periods, we find that in the first period the growth rate of bulk drugs production was less than 4 per cent, and this increased substantially to nearly 12 per cent in the second period. In the case of formulations production, while the growth rate for the first five-year period was 3.6 per cent, it was twice as much in the second five-year period.

The market structure of the Indian pharmaceutical industry can be characterized as "long tailed" (i.e. there are a small number of large firms and a large number of small

firms).[35],[36] The Indian pharmaceutical industry consists of a large private sector, which can be further divided into the large Indian private sector, foreign-controlled companies (FCCs)[37] in India, and small private sector firms. There are also five public sector units in this industry. The public sector concentrates on the production of bulk drugs and has almost no presence in formulations. The Indian private sector is active both in the production of bulk drugs and formulations. The FCCs import most of their bulk drug requirements and formulations into the country, their focus being the domestic market. The small firms concentrate mainly on lower-end therapeutic drugs and formulations and depend on imports for meeting their bulk drug requirements, but there is a part of this category that produces bulk drugs.[38]

B. Exports

The Indian pharmaceutical industry turned into a net earner of foreign exchange on its trade account in 1988/89, and this surplus kept increasing throughout the 1990s. The export performance of the pharmaceutical industry is all the more remarkable given that it has been the only one amongst the major industrial sectors to have consistently generated trade surpluses in recent years, with total exports increasing from US$ 448.4 million in 1990/91 to US$ 1,540.1 million in 1999/00 (see table 2.8).

Total exports of pharmaceuticals showed a compound growth rate of nearly 15 per cent during the 1990s. This was built around an 18 per cent growth in the export of formulations and a 14 per cent growth of bulk drugs. A notable feature of the export performance of the two broad segments of the industry was that while exports of formulations performed relatively better in the first half of the decade, export of bulk drugs expanded rapidly during the second half, the period when growth in world trade had declined quite significantly.

The impressive growth in exports witnessed during the 1990s meant that an increasingly larger share of total production was being exported, particularly during the second half of the decade (see table 2.9). This is a particularly significant development in a country where the major industrial sectors have been largely inward looking.

[35] "There are about 250 large units and about 8,000 small scale units in operation…" in the pharmaceutical industry, Government of India (GOI), *Annual Report 1999-2000*: 2. The Reserve Bank of India defines a small firm as a firm with a paid-up capital of less than Rs. 500,000 (approximately US$ 150,000) and firms with more than this amount of paid-up capital are categorized as medium and large (RBI, 1995).

[36] In 1994, industrial licensing in this sector was abolished (GOI, *Annual Report, 1994-95*).

[37] FCCs were identified as firms having more than 25 per cent foreign equity holding.

[38] About 30 per cent of the total bulk drug production is accounted for by the small-scale sector. (GOI, *Annual Report, 1998-99*: 624).

Table 2.8

Indian pharmaceutical industry: Exports (US$ million)			
Years	Bulk drugs	Formulations	Total
1990/91	236.2	212.2	448.4
1991/92	317.7	245.6	563.3
1992/93	158.0	372.5	530.5
1993/94	174.1	429.9	603.9
1994/95	242.3	479.9	722.1
1995/96	349.4	630.6	980.0
1996/97	446.2	708.2	1 154.4
1997/98	598.4	875.7	1 474.1
1998/99	669.9	774.4	1 444.3
1999/00	na	na	1 540.1

Source: Department of Chemicals and Petrochemicals, *Annual Report;* and Organization of Pharmaceutical Producers of India (OPPI).

Table 2.9

Shares of exports in the total production of the pharmaceutical industry (1990/91 to 1999/00)			
Years	Total exports (US$ million)	Total production (US$ million)	Shares (percentage)
1990/91	448.4	2 610.8	17.2
1991/92	563.3	2 506.4	22.5
1992/93	530.5	2 758.7	19.2
1993/94	603.9	2 695.7	22.4
1994/95	722.1	3 013.0	24.0
1995/96	980.0	3 375.9	29.0
1996/97	1 154.4	3 578.6	32.3
1997/98	1 474.1	4 045.7	36.4
1998/99	1 444.3	4 126.6	35.0
1999/00	1 540.1	4 584.1	33.6

Note: Totals may not add up because numbers have been rounded off.
Source: Department of Chemicals and Petrochemicals, *Annual Report;* and Organization of Pharmaceutical Producers of India (OPPI).

The export performance of the pharmaceutical industry during the 1990s came after the industry experienced rapid expansion in exports during the 1980s. However, it should be pointed out that the increase in exports during the earlier decade took place from a very low

base.[39] A noteworthy feature of the exports of pharmaceuticals is the significant presence of bulk drugs (see table 2.10). The share of bulk drugs in the total exports of pharmaceuticals from India shows a rising trend from the mid-1990s, an indicator that the industry has been consolidating its production in the relatively higher technological segments. What is more, developed countries have been the major export destinations of bulk drugs while the export destination of formulations have been developing countries (Government of India, *Annual Report, 1992-93*: 4).

Table 2.10

Shares of bulk drugs and formulations in total exports
(percentage)

Years	Bulk drugs	Formulations
1990/91	52.7	47.3
1991/92	56.4	43.6
1992/93	29.8	70.2
1993/94	28.8	71.2
1994/95	33.5	66.5
1995/96	35.6	64.3
1996/97	43.4	56.6
1997/98	40.6	59.4
1998/99	46.4	53.6

Source: Department of Chemicals and Petrochemicals, *Annual Report*; and Organization of Pharmaceutical Producers of India (OPPI)

The bulk drug exports from India are mostly in the generic category[40] (i.e. those drugs on which patents have expired).[41] Significant advantages are gained by being the first entrant in this market (Lanjouw, 1998:16). The Indian firms managed to gain experience in the production of generic drugs by the reverse engineering process and by acquiring production capabilities based on indigenously generated technologies,[42] activities that were possible because of the process patent regime adopted in the country. This is the principal reason for the growth of exports of generic bulk drugs from India during the 1990s. With their ability to develop generic drugs, Indian firms had the opportunity to export drugs to the larger markets in the developed world when the patents on the products had expired.[43]

[39] Exports increased from about US$ 50 million in 1980/81 to close to US$ 410 million in 1988/89, Department of Chemicals and Petrochemicals/OPPI.

[40] In 1998 the generic market accounted for 47 per cent of the prescriptions market (CRISIL, 2000: 30).

[41] EXIM Bank (1991), discussing the exports of the bulk drugs, Ibuprofen, Ampicillin and Amoycillin Trihydrate, noted that the exports of these products took off after their patents expired.

[42] The Annual Report of the Department of Chemicals and Petrochemicals had this to say: "...Indian research has led to cost effective production of a wide range of products such as Myethyldopa, Paracetamol, Ibuprofen, Aspirin, Ampicillin, etc. and a host of other items. The process improvement achieved in these areas is internationally competitive, with the result that most of these products have found markets even in advanced countries like the USA, Germany, etc. May all of the Indian companies have the technology for cost effective production of a variety of items" (GOI, *Annual Report, 1993-94*: 2).

[43] Between 1991 and 1995, 19 of the top 50 pharmaceutical products lost their patent protection (EXIM Bank, 1991); As Jayaram, Venugopal and Bhagat (2000) have noted, these are "… drugs that accounted for sales of

The expansion of the market for generic drugs in the United States that took place after the mid-1980s resulted directly from the enactment of the Waxman-Hatch Act in 1984.[44] The requirement for fresh clinical trials for generic drugs existing till then was replaced with the much simpler and less expensive "bio-equivalence" and "bio-availability" tests.[45] Consequently, the share of generic drugs increased from 18 per cent in 1984 to as much as 47 per cent in 1998 (CRISIL, 2000: 30). A firm can reap the full benefits of this growing popularity of generic drugs if it markets its drug formulations in the United States market. Only a few Indian firms are involved in this activity at present. These Indian firms have applied for about 60 Abbreviated New Drug Applications (ANDAs) (Does this have to be capitalized?) and have obtained marketing approval for some of them.

The successful entry of Indian firms into developed country markets is also because of the advantage they have of low production costs (Lanjouw, 1998: 17); in the competitive market for generic drugs, low costs are a distinct advantage. The Indian firms have also started paying attention to good manufacturing practices, and their production facilities have been approved by the Food and Drug Administration (FDA) of the United States and the Medicines Control Agency (MCA) of the United Kingdom (ICRA, 1999).

C. Imports

Total imports of drugs and pharmaceuticals rose from US$ 335 million in 1990/91 to US$ 799 million in 1999/00. Bulk drugs and formulations were imported in the ratio of 6:1 at the beginning of the decade. By the end of the decade, the ratio had declined to 4:1, as seen in table 2.11.

Imports of intermediates and bulk drugs rose from US$ 296.5 million in 1990/91 to US$ 641.3 million in 1999/00, showing a compound growth rate of 8.9 per cent. Imports of formulations increased from US$ 48.5 million to US$ 157.9 million during the same period, showing a growth rate of 14 per cent. The share of intermediates and bulk drugs in total drug imports declined from 85.9 per cent in 1990/91 to 80.2 percent in 1999/00, the average being 86.3 per cent for the whole period.

nearly US$ 90 billion in 1995. An unprecedented number of drug patents are set to expire between 2002 and 2005."

[44] See Grabowski and Vernon (1986).

[45] "Bio-equivalence tests refer to the tests conducted on a sample of persons to test the similarity between the original drug and the re-engineered drug. Bio-availability tests are also aimed at testing the similarity, but here the similarity is examined in terms of the presence of the drug in the bloodstream after different time intervals. Since the bio-equivalence and bio-availability tests are conducted on a relatively smaller number of persons and against a lesser number of parameters, the total cost and time involved are considerably less than in the case of the original drug trials" (ICRA, 1999: 133).

Table 2.11

Indian pharmaceutical industry: Imports (US$ million)			
Year	Intermediates and bulk drugs	Formulations	Total
1990/91	296.5	48.5	345.0
1991/92	312.8	42.3	355.0
1992/93	392.7	46.1	438.8
1993/94	337.2	45.4	382.6
1994/95	381.1	55.1	436.3
1995/96	658.4	83.3	741.7
1996/97	638.0	97.4	735.3
1997/98	671.4	118.4	789.8
1998/99	627.3	130.9	758.1
1999/00	641.3	157.9	799.2

Note: Totals may not add up because numbers have been rounded off
Source: Organization of Pharmaceutical Producers of India (OPPI).

D. Research and development

The pharmaceutical industry is a technology-intensive, science-based industry, with biotechnology playing an ever-increasing role in its development – a feature of the industry that has grown in importance in recent years.

Ballance, Pogany and Forstner (1992) have presented a typology of the world's pharmaceutical industries. They identified 10 countries (all of them developed) as "countries with a sophisticated pharmaceutical industry and a significant research base". The next group of 17 countries was identified as "countries with innovative capabilities". India is one of the countries in this group. While these countries are not active in discovering new molecular entities they have the technological capability to either develop innovative processes or improved formulations of already discovered drugs.

Although India has been attempting to develop new drugs, its record is far from impressive. For example, during the period 1956 to 1987 there were only 13 cases of invention of new chemical entities in India (Mehrotra, 1989:1061). In the late 1990s there were some new molecular discoveries by the private sector firms, Ranbaxy and Dr. Reddy's (CRISIL, 2000: 40).[46] The other area where the Indian firms seem to have succeeded is in new drug delivery systems (NDDS). This research involves "modifying an existing molecule to develop more user friendly dosage forms of medicines" (CRISIL, 2000: 21). Ranbaxy has developed an NDDS for ciprofloxacin (see chapter III, below) and the firm Wockhardt is reported to have applied for three patents for new drug delivery systems. Apart from this, Indian firms are active in developing new processes for known molecules. Again Ranbaxy is

[46] Ranbaxy had discovered a new molecule for benign prostatic hypertrophy and another one for asthma. Dr. Reddy's had discovered a new molecule for anti-diabetics. Wockhardt is reported to have applied for three patents for new chemical entities in the area of anti-infectives (*Financial Express*, March 8, 2000).

the most successful firm in this area and was granted 24 new process patents in the United States between 1990 and 2000; Dr. Reddy's and Cadila are other Indian firms with patents in the United States.

Internationally, the pharmaceutical industry has gone through two stages in the pre-molecular biology era. These can be broadly classified as "random drug discovery" (this approach entails screening of natural or chemically derived compounds for possible therapeutic activity) and "drugs by design" (resulting from advances in knowledge, such as in pharmacology and cell biology, which led to more sensitive screening mechanisms).[47] The Indian pharmaceutical industry does not seem to have progressed beyond the "random drug discovery" mode in whatever new drug discoveries it has made.[48]

The Indian pharmaceutical industry spends about 1.8 per cent, on average, of its sales on R&D (see table 2.12). This is higher than the average for Indian industry, which is around 0.7 per cent. The reported R&D expenditure by pharmaceutical firms grew at a compound growth rate of 6.7 per cent during the period 1990/91 to 1999/00.

A key aspect of technological change in the pharmaceutical sector in India is the close interaction between private sector firms and publicly funded laboratories of the Council for Scientific and Industrial Research (CSIR). The three laboratories that are most active in drugs research are the National Chemical Laboratory (NCL) located in Pune; the Central Drug Research Institute (CDRI) located in Lucknow; and the Indian Institute of Chemical Technology (IICT) located in Hyderabad.

The Government offers various incentives in the form of tax concessions and exemptions of specific products from the purview of price controls to encourage firms to engage in R&D. The pharmaceutical industry is eligible for weighted deduction for R&D expenses up to 150 per cent. Three categories of drugs are exempt from price controls for specific periods. These are: (a) drugs using processes developed through indigenous R&D effort, for a period of five years; (b) drugs using a new drug delivery system developed indigenously and approved for marketing, for a period of five years (GOI, *Annual Report, 1993-94*); and (c) new products developed in India, for a period of 10 years (GOI, *Annual Report, 1994-95*).

[47] Henderson, Orsenigo and Pisano (1999).

[48] Henderson, Orsenigo and Pisano (1999), while studying the impact of molecular biology on the pharmaceutical industries in the United States, Europe and Japan come to the conclusion that firms, which have graduated from "random drug discovery" to "drugs by design" were found to move on to molecular biology more often than firms that did not. The Indian pharmaceutical firms, if they are into drug invention, seem to be in the "random drug discovery" mode.

Table 2.12

Reported R&D expenditure by Indian pharmaceutical firms (1990/91 to 1999/00)[49]		
Year	US$ million	R&D expenditure as percentage of sales
1990/91	36.5	1.30
1991/92	29.4	1.40
1992/93	37.0	1.50
1993/94	39.8	1.90
1994/95	44.6	2.00
1995/96	45.5	1.80
1996/97	51.5	1.90
1997/98	56.0	1.90
1998/99	61.2	2.00
1999/00	73.6	1.90

Source: Department of Science and Technology *Research and Development in Industry*; and Organization of Pharmaceutical Producers of India (OPPI).

With a view to furthering the industry-government linkages in R&D activities, the Government appointed a Pharmaceutical Research and Development Committee, which submitted its report in November 2000. The Committee explored the possibility of developing institutional linkages in the pharmaceutical sector in order to improve the capacity of Indian industry to develop new drug molecules. In what appears to be a rather ambitious target, the Committee recommended that 20 new molecules, capable of being patented in the United States, should be developed by the pharmaceutical industry by the year 2005 (GOI, 2000).

E. Knowledge partnerships

In the transition from process development to applied and basic research, there has been a growing realization in the Government and industry that India must seek to leverage collective wisdom. Such leveraging implies intense networking between academia, government and industry. Such networking allows the funnelling of intellectual and other resources towards significant incremental progress.

This objective led to the creation of a world-class training and research institute, the National Institute of Pharmaceutical Education and Research (NIPER) at Chandigarh. The idea was mooted by the industry to create a world-class infrastructure for pharmacy education and research. The institute has been set up with government funds along with contributions from the industry. Today, apart from its regular activities of running academic courses at the masters, doctoral and post-doctoral levels, NIPER is interacting with several Indian companies, transnational corporations (TNCs) and international organizations such as the

[49] This data is based on a survey of all the in-house R&D centres that are registered with the Department of Scientific and Industrial Research. The overall response rate is not reported, but it seems to be around 60 per cent. As no adjustment is made for non-reporting, and as the number of firms registering their in-house R&D units increases from year to year, this data is not strictly comparable over time; but it can be taken as indicative.

World Health Organization (WHO), Tropical Prevention of Conception and Disease, Rush University, Chicago. (TOPCAD), the World Bank and the United Nations Industrial Development Organization (UNIDO). It is also conducting training programmes for drug regulators from various parts of the world and for members of the Indian industry.

The other dimension of this partnership among academia, government and industry is the alliance between industry and national laboratories/universities. It is believed that, on the one hand companies should educate themselves on scientific research and, on the other, the scientists should become familiar with the world of business. Laboratories such as the Central Drug Research Institute (CDRI), National Botanical Research Institute (NBRI) and Centre for Indian Medicinal and Aromatic Plants (CIMAP) have been in existence for several years. However, until recently, each laboratory or institute worked in isolation. Only in the 1990s, was it recognized that significant results could be achieved by welding together the individual capabilities of these institutions in specific, time-bound projects and programmes. Companies are now collaborating not only with Indian laboratories and universities, but also with foreign universities. For instance, Ranbaxy Laboratories has collaborated with the University of Bath for a Gastro-Retentive drug delivery system. This collaboration has helped Ranbaxy file two United States patents. Similarly, Indian companies, such as Dr. Reddy's Laboratories, are partnering with TNCs such as Novartis and Novo Nordisk for co-developing drugs.

The Government has launched several schemes for promoting this networking. These include:

a) *The Drugs and Pharmaceuticals Research Programme.* Initiated in 1994/95 by the Department of Science and Technology, Government of India, this programme aims to promote R&D in the drugs and pharmaceuticals sector. The scheme intends to enhance the capabilities of the Indian drugs and pharmaceuticals industry in the development of new drugs by synergizing the strengths of national institutions and the drug industry. Under this programme, R&D in all systems of medicine is promoted including *Ayurvedic* (herbal), *Unani & Siddha*, which are all indigenous systems of health care. It has three fields of activities: (i) bringing together the scientific expertise existing in the country's research institutions and industry on a joint platform through projects; (ii) establishment of mechanisms and linkages to facilitate the development of new drugs by Indian industry and research institutions; and (iii) creating state-of-the-art infrastructure facilities at par with international standards for the benefit of the Indian industry and other users. The programme is jointly funded by the industry and the Government.

A list of the firms and institutions participating in this programme is provided in table 2.13.

b) *Technology Development Board*. With a view to encouraging the development and commercialization of indigenous technologies and adaptation of imported technology for wider applications, the Government constituted the Technology Development Board (TDB) in September 1996. The Board provides equity and/or soft loans to industrial units and private research institutions. Since its formation, the Board has signed 67 agreements for providing financial assistance amounting to a total of US $ 71.62 million. Important TDB-financed projects relating to drugs and pharmaceuticals financed are listed in table 2.11.

c) *Programme aimed at Technological Self-Reliance (PATSER).* This is a scheme implemented by the Department of Scientific and Industrial Research (DSIR), whereby

networking among the scientific facilities available at the National Laboratories and the industry is promoted through partial financial assistance. It has been in operation for about a decade. So far over 80 projects have been supported under this scheme including some projects concerning R&D in the field of drugs and pharmaceuticals. Table 2.12 provides a summary of these projects.

d) *New Millennium Indian Technology Leadership Initiative (NMITLI).* This is another successful example of a public-private partnership for technology development. The initiative involves about 100 institutions, and the projects under NMITLI were selected keeping in view the Indian pharmaceutical industry's strengths and weaknesses. For instance, the drug development project for combating tuberculosis (TB) has been initiated because TB is not only a challenge for developing countries, including India, but also because India has the potential to emerge as a leader in drug development in this area. The project is being implemented through inter-institutional collaboration with special areas of focus in each of these: the Centre of DNA Fingerprinting in Hyderabad and the Bose Institute in Kolkata have developed targets for the disease (a part of the organism that the drug can attack); the Central Drug Research Institute (CDRI), Lucknow, will screen these targets for drugs; the Indian Institute of Science (IIS), Bangalore, is developing a model for testing the drug for latent tuberculosis, a stage in the onset of the disease when there are no symptoms; the National Institute of Immunology, Delhi, is developing a delivery system for the drug; and the Regional Research Laboratory in Jammu is examining whether its bio-enhancer (a drug that enhances the effect of another) can be used for tuberculosis. Lupin, with its long-term interest in tuberculosis, is the industrial partner that will take the drug to the market.

The above analysis reveals that “knowledge partnerships” are increasingly considered efficient, sustainable and reliable in the pharmaceutical sector in India.

However, as is evident from the tables (tables 2.13, 2.14 and 2.15), even in India[50] R&D efforts are largely concentrated on diseases like cancer, diabetes and cardiovascular problems. Only a handful of projects are being implemented for fighting tropical diseases and TB. This is one of the major concerns of the Indian Government.

[50] India accounts for nearly one-third of the global TB burden and every year there are more than 2 million new TB cases. Approximately 500,000 people die from this disease each year, more than 1,000 every day and one every minute. The spread of HIV/AIDS would increase the number of TB cases and deaths.

Table 2.13

Industry/Institutional Alliance

Industries:

1. Spic Pharma
2. Dr Reddy's Foundations
3. Ranbaxy Laboratory Ltd
4. Dabur Research Foundation
5. Zandu Pharmaceuticals Works Ltd.
6. Recon Ltd.
7. Bharat Biotech International Ltd.
8. Cadila Healthcare Ltd.
9. Indian Herbs Research and Supply Co. Ltd.
10. Arya Vaidya Sala
11. Cadila Pharmaceutical Ltd.
12. Glenmark Pharmaceuticals Ltd.
13. Alembic Ltd.
14. Lupin Laboratories Ltd.

Institutions:

1. Indian Institute of Chemical Technology
2. Central Drug Research Institute
3. Centre for Biotechnology
4. Regional Research Laboratory
5. Regional Research Laboratory
6. National Chemical Laboratory
7. Indian Institute of Chemical Biology
8. Centre for Cellular & Molecular Biology

Academia:

1. Indian Institute of Science
2. University of Hyderabad
3. University Department of Chemical Technology
4. All India Institute of Medical Sciences
5. Tamil Nadu Veterinary & Animal Science University
6. Delhi University
7. Indian Institute of Technology
8. Seth G.S. Medical College & KEM Hospital

Note: A large number of these projects are on Anti-cancer agents, Anti-infectives agents and new Anti-virals.

Source: Ministry of Science and Technology, Department of Science and Technology, December 2000

Table 2.14

Drug and pharmaceutical project financed by the Technology Development Board

S.No (1)	Company (2)	Product (3)	Field of application (4)	Total Project Cost (US$ m) (5)	TDB support (US$ m) (6)
1.	M/s Shantha Biotechnics Private Ltd.	Hepatitis B Vaccine	Hepatitis B control	5.05	1.7
2.	M/s Shantha Biotechnics Private Ltd.	Interferron alfa-2	Treatment of viral Hepatitis C	4.88	0.24
3.	M/s Bharat Biotechnic International Ltd.	Recombinant vaccine for Hepatitis B	Hepatitis A control	2.44	0.65
4.	M/s Bharat Biotechnic International Ltd.	Streptokinase through recombinant route	Activator for Myocardial infraction	4.7	2.2
5.	M/s Alpha Amines Private Ltd.	DL-2 Amino Butanol	Intermediate for manufacture of ethambutol – an anti-TB drug	1.04	0.5
6.	M/s Ranbaxy Laboratories Ltd.	Development of *Cefuroxime Axetil*	Anti infective drug	0.62	0.23
7.	JKDPL	4th generation *cephalosporins* antibiotics-*cefixime*	Respiratory and other infections	0.64	0.3
8.	Manukirti Biogems Private Ltd.	Reagent for detection of bacterial endotoxin	Detection of bacterial contamination	0.13	0.06
9.	Mark Medicines Private Ltd.	Concentrate of living lactic acid bacteria	Suppressing development of pathogenic flora in intestine	5.31	1.4
10.	Shantha Marine Biotechnology Private Ltd.	Extraction of *beta - carotene*	Natural source of vitamin A	0.01	0.7
11.	Medicorp Technologies India Ltd.	Manufacture of *fluconazole, enalapril maleate, itraconazole and omeprazole*	Anti-fungal, anti-hypertension and anti-ulcer drugs	3.40	1.06
12.	ACL Chemicals Ltd.	Extraction of *beta-carotene* from algae	Vitamin A precursor	0.57	0.18
13.	Gland Pharma Ltd.	Manufacture of *enoxaparin*	Anti-coagulant in bypass and other surgeries	1.54	0.7

Source: Department of Science and Technology

Table 2.15

Drug and Pharmaceutical R&D Projects under PATSER

S.No.	Project item	Executing agencies	Total project cost (US$ m)	DSIR's share (US$ m)
1.	Development of a process of manufacturing *Pyrazinamide* – an anti-T.B. drug	SPIC, and IICT	1.04	0.43
2.	Scale up process for development of *Lyposonal Amphotericin B* used for *Kala Azar*	Lifecare Innovations Private Ltd.	0.29	0.1
3.	Development of novel resins for use in solid phase organic synthesis and combinatorial chemistry	M/s Bharavi Industries Pvt. Ltd.	0.13	0.04
4.	Controlled released formulation of *Nimesulide*	M/s Ajanta Pharma Ltd., Mumbai	0.29	0.12
5.	Pilot scale manufacture of hyaluronic acid formulations	M/s Gland pharma Ltd., Hyderabad	0.27	0.09
6.	Development of technologies for 3-*Chloro methyl-D3-Cepham Ester* from *Pen-G*	M/s SPIC and CECRI	0.29	0.13

Source: Technology Development Board (TDB), Annual Report, 2000-2001 and Technology Development Board-Enabling Commercialisation.

F. Technology transfer

During the 1990s policies relating to transfer of technology have been liberalized in the form of easier procedures, removal of restrictions on royalty or technical fee payments, removal of restrictions on inclusion of restrictive clauses in arrangements, and no scrutiny for repeated imports, among others. However, all these measures have failed to increase the number of collaboration agreements in the Indian pharmaceutical industry. According to Narsalay (2000), there were a total of 187 technical collaboration approvals in the drug industry during 1991-1999, which constituted 3.1 per cent of all the technical collaboration agreements approved during that period. This is a very small figure for such a technology-intensive sector.

Foreign technical collaboration has not been as important for the export market as for the domestic market; many small and medium firms enter into technical collaboration with foreign firms to cater mainly to the domestic market. One of the reasons ascribed to this low

level of transfer of technology in the Indian pharmaceutical industry is the relatively weak patent system that currently exists in India in respect of pharmaceuticals. As mentioned earlier, the Indian Patents Act, 1970, follows a process patent regime, which is due to be dismantled in 2005, in keeping with India's commitments under the World Trade Organization (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). It is only when a product patent regime is in place that its impact on the number of technical collaboration agreements can be assessed.

G. Foreign direct investment

Controls over the operations of foreign enterprises that were imposed largely through the Foreign Exchange Regulation Act (FERA) in 1973, were rapidly reduced through the 1990s.

In 1994 the Government allowed foreigners to hold up to 51 per cent of the equity capital of enterprises registered in India. This change in policy led many firms, which had reduced their foreign shareholdings in the 1970s to 40 per cent or less to meet the requirements of FERA, to increase the foreign share to 51 per cent (for a list of firms which increased their foreign equity to 51 per cent, see GOI *Annual Report, 1993-94*).[51] However, apart from the increase in foreign stakes of some of the major firms operating in India, the pharmaceutical sector was not among the major beneficiaries of FDI inflows during the 1990s; it accounted for only 0.4 per cent of total FDI approvals during the period 1991-1999, amounting US$ 260 million (Narsalay, 2000).[52]

It has often been contended that India's failure to attract FDI is due to its relatively weak patent regime. According to Tancer and Josyla (1999), the 10-year transition period that India has opted for in order to introduce product patents in fulfilment of its obligations under TRIPS has affected the inflow of FDI in the pharmaceutical sector. The real interest of foreign firms in the Indian market will be better assessed only after India starts giving product patents in pharmaceuticals from 2005. Reporting on disinvestments in the pharmaceutical sector by the firms, Nicholas, Merind, Roche, and Searle, the GOI *Annual Report, 1993-94* gives the following reasons: "... the pricing system, lack of patent protection, advantages in entering into licensing arrangements with local India firms rather than direct investment..." (p. 4).

The above discussion shows the benefits for the Indian pharmaceutical industry resulting from the policy environment since the beginning of the 1970s. It is clear that the instruments of policy introduced by the Government during this phase suited the industry, a fact borne out by its performance over time. While the more protected environment in the 1970s and 1980s helped the domestic enterprises to establish their presence in the industry, the adoption of an open economy framework in the 1990s encouraged the leading firms to expand their overseas operations. The latter aspect can be best understood by analysing the performance of the leading firms in the industry. The next chapter therefore presents a case study of the success of Ranbaxy Laboratories, the largest of the wholly Indian-owned enterprises.

[51] These are Glaxo, E Merck, Reckitt & Colman, Procter & Gamble and Hoechst.
[52] This figure is obtained by using the average rupee-dollar exchange rate for the period.

CHAPTER III

THE SUCCESS OF RANBAXY LABORATORIES

Ranbaxy Laboratories has been one of the best performers in the Indian pharmaceutical industry during the past decade, a period that has witnessed an opening up of the Indian economy to external competition. The firm, which was established in 1961, has emerged as the largest enterprise among the wholly Indian-owned pharmaceutical firms in terms of sales turnover. In more recent years, the overall performance of the firm has been even more impressive. This is corroborated by an annual survey of the leading firms in the Indian corporate sector. According to the most recent edition of the survey, which covered 266 firms, Ranbaxy Laboratories ranked the highest among the pharmaceutical firms included in the sample (see table 2.16).

Table 2.16

Ranking of the leading pharmaceutical firms among the best performing firms in India

Company	Rank in 2000	Rank in 1999
Ranbaxy Laboratories	18	26
Novartis India Ltd	43	92
Cipla Ltd	46	70
Dabur India Ltd	54	65
Glaxo India Ltd	68	93
Aurobindo Pharma Ltd	74	147
Wockhardt Ltd	79	na
Rallis India	83	134
Sun Pharmaceuticals	92	na
Dr Reddy's Laboratories Ltd	100	118
Hoechst Marion Roussel Ltd	105	150
Torrent Pharmaceuticals Ltd	130	167
Bayer India Ltd	169	203
Cadila Healthcare Ltd	176	na
Orchid Chemicals and Pharmaceuticals Ltd	198	154
Smithkline Beecham Pharmaceuticals India	205	185

Note: The ranking was based on parameters: net sales, earnings before interest, depreciation, tax and amortization, net fixed assets, market capitalization, return on capital, number of employees, and sales to net fixed assets.
Source: *Business India*, 27 November to 10 December 2000.

The performance of Ranbaxy Laboratories can be better understood by analysing the changes observed in three sets of variables since the beginning of the 1990s. The first pertains to the size of the enterprise and includes variables such as equity capital and assets. The second set includes variables that provide an idea of the magnitude of the operations of the enterprise. And finally, the third set of variables helps explain the foreign exchange transactions of the enterprise during the past decade.[53]

1. Performance of the firm in the 1990s

A. Growth in size

The following three variables are considered for assessing the growth of the enterprise during the 1990s: (i) equity capital, (ii) net worth, and (iii) gross fixed assets. In addition to using more commonly used variables for commenting on the size of an enterprise (i.e. equity capital and fixed assets), net worth has also been taken into account. Net worth includes the undistributed profits of an enterprise and provides an indication of its growth potential.

Table 2.17 presents the figures for the above-mentioned variables over the past decade. From a modest US$ 5.3 million in 1990 the equity base of the company had increased to more than US$ 27 million by the end of the decade. Measured in constant dollar value,[54] the equity base of the firm increased more than 5 times, its gross fixed assets increased more than 6 times, and its net worth rose almost 14 times.

The performance of Ranbaxy Laboratories over the past decade can be divided into two distinct phases, 1990-1994 and 1995-1999. The first four-year phase was one in which the firm experienced phenomenally high rates of growth in all spheres. The second phase, although marked by a considerable slowing down of expansion, can be considered the period of consolidation for the firm. Thus the size of the firm increased at widely varying rates in the two halves of the 1990s. The compound rates of growth of the three variables are shown in table 2.18.

[53] The data used for the analysis were taken from the Prowess Database on the Indian corporate sector, which has been developed by the Centre for Monitoring Indian Economy (CMIE) as well as from the Annual Reports of Ranbaxy Laboratories. Additional information was obtained from discussions held with the firm's senior managers.

[54] US$ 1was Rs. 19 in 1990 and Rs. 42 in 1999.

Table 2.17

Size of Ranbaxy Laboratories (1989/90 to 1999) (US$ million)			
Year	Gross fixed assets	Equity capital	Net worth
1989/90	29.0	5.3	23.9
1990/91	36.8	5.0	27.9
1991/92	38.3	5.9	24.4
1992/93	60.4	8.3	47.5
1993/94	65.3	11.0	63.8
1994/95	94.8	13.7	204.8
1995/96	126.2	12.6	231.0
1996/97	152.3	13.8	317.3
1997/98	168.7	13.7	320.1
1999*	183.5	27.3	331.2

Note: Until 1998, Ranbaxy followed the accounting year April to March. After 1997/98, the accounting year was changed to the calendar year.
Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database 2000

Table 2.18

Compound rates of growth in size of Ranbaxy Laboratories in the 1990s (percentage)			
Years	Gross fixed assets	Equity Capital	Net worth
1990-1994	22.5	20.0	27.8
1995-1999	18.0	18.8	12.8

Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database 2000

B. Growth in the size of operations

The size of operations of Ranbaxy can be measured using four variables: total income, sales, value added and profits. While for total income, sales and value added the gross figures are taken, for profits the figures taken are net of taxes and depreciation. Table 2.19 presents the trends observed in these variables during the 1990s.

Of the three indicators of performance included in the table, profits have registered the most impressive increase over the period. While total income and sales of the firm increased by a factor of 3 and the gross value added increased by a factor of 4, the profits of the firm increased more than 16 times.

Table 2.19

Size of operations of Ranbaxy Laboratories (1989/90 to 1999) (US$ million)				
Year	Total income	Sales	Profits after tax	Gross value added
1989/90	150.0	116.6	2.8	23.7
1990/91	169.3	137.3	6.7	26.7
1991/92	162.7	129.5	6.3	25.6
1992/93	219.1	175.8	13.4	40.6
1993/94	223.0	189.0	20.2	47.8
1994/95	282.1	226.8	35.1	71.5
1995/96	309.9	248.2	40.0	83.8
1996/97	352.7	319.8	44.7	109.9
1997/98	386.6	339.3	44.3	109.9
1999	472.5	367.0	45.5	104.6

Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database 2000

The four sets of variables taken together make the analysis of the performance of Ranbaxy Laboratories quite interesting. The comparable increases in total income and sales of the firm during the period under consideration indicate that the manufacturing activities remained as important for the firm at the end of the period as they were at the beginning of the period. The higher increase in gross value added of the firm as compared to that in the total sales implies a deepening of the production process internally as well as an improvement in the utilization of its production facilities. It can further be inferred from table 2.19 that the growth of value added observed through the 1990s was reflected in the increase in net profits recorded by the firm.

A better understanding of the performance of Ranbaxy Laboratories described above can be had by looking at the compound growth rates of the above-mentioned variables in the two halves of the decade (see table 2.20).

Table 2.20

Compound rates of growth in the operations of Ranbaxy Laboratories in the two halves of the 1990s (Percentage)				
Years	Total Income	Sales	Profit after tax	Gross value added
1990-1994	10.4	12.8	63.9	19.2
1995-1999	13.7	12.8	6.7	10.0

Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database 2000

Table 2.20 reveals that in the two halves of the 1990s the performance of Ranbaxy Laboratories was a study in contrast. The contrast in the growth of profits of the firm is particularly striking. Net profits of the firm increased more than sevenfold during the first phase (1990-1994), which was reflected in a compound growth rate of nearly 64 per cent, as shown in the table. The second phase (1995-1999) on the other hand, saw profits register only a modest increase. Consequently, the growth of net profits was less than 7 per cent. Although this rate can be considered quite impressive, given the overall performance of the industrial sector in India, the high standards set by the firm in the early 1990s makes this performance look rather ordinary.

The growth of gross value added of the firm during the two halves of the 1990s also showed considerable variation which, in the period 1990-1994, increased annually by 19 per cent, while in the second half of the 1990s, compound growth dropped to about 10 per cent.

Two factors could have contributed to these striking contrasts in the annual growth rates of Ranbaxy Laboratories in the two halves of the 1990s. The first is that both net profits and gross value added started moving upwards from relatively small bases at the beginning of the decade. This was particularly so for net profits which were a mere US$ 3 million in 1989/90. The second factor that could explain the slowing down of the firm towards the end of the decade was the process of consolidation that was under way. This in part could be explained by the fact that the total income or sales of the firm did not slow down as sharply as did the net profits. The latter argument can be further supported by the external transactions of the firm, which had improved consistently throughout the decade.

C. Foreign exchange transactions

The successful forays made by the larger firms like Ranbaxy Laboratories in the international market was the key factor behind the rapid growth of exports of the pharmaceutical industry, particularly during the 1990s. Throughout this decade Ranbaxy Laboratories maintained a steady increase in its net foreign exchange earnings (see table 2.21).

The single most important aspect of the foreign exchange transactions of Ranbaxy Laboratories is the remarkable turnaround that the firm experienced after the early 1990s when its net foreign exchange earnings were negative. The rise in net foreign exchange earnings was mainly due to the firm's ability to maintain a consistently high rate of increase in foreign exchange earnings. Thus even though the foreign exchange spending of the firm was growing at a reasonable rate, its increase in foreign exchange earnings was able to more than compensate for the growth in foreign exchange spending. Table 2.22 shows the broad composition of foreign exchange earnings of the firm.

Table 2.21

Ranbaxy's foreign exchange transactions (US$ million)			
Year	Foreign exchange earnings	Foreign exchange spending	Net foreign exchange earnings
1989/90	22.3	24.7	-2.4
1990/91	32.7	34.0	-1.3
1991/92	36.6	35.2	1.4
1992/93	53.6	45.5	8.1
1993/94	70.6	45.2	25.4
1994/95	97.1	69.2	27.9
1995/96	120.2	94.8	25.4
1996/97	146.1	90.9	55.2
1997/98	150.4	98.8	51.6
1999	191.5	96.7	94.8

Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database 2000

Table 2.22

Composition of Ranbaxy's foreign exchange earnings (US$ million)			
Year	Goods exports	Services	Total earnings
1989/90	21.7	0.5	22.2
1990/91	31.9	0.9	32.8
1991/92	35.7	0.9	36.6
1992/93	52.2	1.4	53.6
1993/94	69.1	1.4	70.5
1994/95	94.4	2.7	97.1
1995/96	113.8	6.4	120.2
1996/97	141.5	4.6	146.1
1997/98	n.a	n.a.	n.a.
1999	170.9	20.6	191.5

Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database 2000

The composition of foreign exchange earnings of Ranbaxy Laboratories shows an interesting pattern. Although export of goods was an overwhelmingly large component of its foreign exchange earnings throughout the decade, its export of services increased quite significantly in the later years. This was mainly because of the firm's entry into the market for technology. In 1999 there was evidence of the firm's potential in this market when it registered a phenomenal growth in its services exports.

This was primarily because of the licensing agreement that Ranbaxy Laboratories entered into with Bayer AG for a new drug delivery system involving the blockbuster antibiotic *ciprofloxacin.*

Ranbaxy Laboratories looked increasingly to the international market for expansion of its operations. Representing the strongest segment existing in the Indian pharmaceutical industry, Ranbaxy Laboratories undertook international expansion during the 1990s, clearly a response to the policy changes that the Government introduced from the beginning of the decade. This can be better understood by looking at the percentage of the domestic market sales and exports in each of the major product groups of the firm in the most recent year for which the data are available (see table 2.23).

Table 2.23

Ranbaxy Laboratories: Market distribution of products of different therapeutic groups in 1999 (US$ million)

Therapeutic groups	Domestic sales	Exports	Total	Share of exports (percentage)
Anti-infectives/antibiotics	84.9	40.8	125.6	32.4
Gastrointestinal tract	12.2	8.8	21.0	41.8
Nutritionals/multivitamins/ haematinics	12.9	6.9	19.8	34.8
Analgaesics	11.5	3.8	15.3	24.8
Dermatologicals	12.6	0.1	12.7	0.9
Cardiovasculars	6.8	1.1	7.8	13.6
Orthopaedics	6.8	0.0	6.8	0.2
Central nervous system	5.2	0.3	5.4	4.7
Others	7.3	8.8	16.1	54.7
Total	160.1	70.5	230.6	30.6

Source: Ranbaxy Laboratories, *Annual Report 1999.*

Almost a third of the major products of Ranbaxy Laboratories have been marketed internationally. This figure can be considered quite significant in view of two objective realities that face the firm. First, the domestic market is itself very large, and second, the increasing exports have not been as motivating a factor for the Indian firms given that the overall orientation of policy has remained essentially inward looking for a considerable period of time.

2. The technology factor in the performance of Ranbaxy Laboratories

The initial forays of Ranbaxy Laboratories into R&D activities began in the late 1970s. However, it was not until the late 1980s that the firm made some progress in this area through the development of a novel process for Cefaclor. One of the major advantages that Ranbaxy had as it sought to build its R&D base was the favourable policy environment provided by the Patents Act of 1970.

Eli Lilly owned the drug, Cefaclor, through a patent that the firm had obtained in 1979. This antibiotic was one of the best selling drugs in 1980s. Ranbaxy started work on developing a new seven-stage process for the production of Cefaclor in 1989. After spending nearly US$ 1.1 million (Rs.20 million) on a three-year project, Ranbaxy emerged as the only other manufacturer of Cefaclor besides the patent holder, Eli Lilly. Not only did Ranbaxy produce the product successfully; but it also managed to obtain high yields from its process. In 1993, Eli Lilly and Ranbaxy Laboratories agreed to set up two joint ventures in India. One was to conduct research in India and the other, to market Eli Lilly's products in the South Asian market. These joint ventures had yet another significance – it was the first time in its 30-year existence that Ranbaxy Laboratories entered into a joint venture with a foreign firm.

Ranbaxy Laboratories has a clearly articulated strategy to compete in the global markets, the key element of which is technology. There are two facets of this strategy. In the first instance the firm has made optimum use of its own R&D capabilities built up over the past two decades. The second facet is the strategic alliances it has tried to build with other firms in the pharmaceutical industry, both of foreign and Indian origin. The R&D structure built by the firm has four dimensions. These are: (i) development of abbreviated new drug applications, (ii) novel drug delivery systems, (iii) development of new processes, and (iv) new drug discovery and research. In the following sections the R&D expenditures of the firm during the decade of the 1990s and the main features of its R&D activities are discussed.

A. Growth of in-house R&D activities in the 1990s

Table 2.24 presents the R&D expenditures of Ranbaxy Laboratories from 1992/93 to 1999.

The two kinds of expenditure of Ranbaxy Laboratories during the 1990s, as shown in the above table, indicate contrasting tendencies. In the earlier years, capital expenditure was relatively greater, which is a pointer to the establishment of R&D facilities by the firm. However, since the middle of the decade, capital expenditure has declined quite significantly. Such has been the magnitude of the decline, that in 1999 capital expenditure on R&D was no more than a fourth of the level of spending in 1993/94. In sharp contrast, current expenditure on R&D has increased rapidly and at a rate far exceeding that of the decline in capital expenditure. Between 1992/93 and 1999, current expenditure on R&D increased more than four times.

Table 2.24

R&D expenditures of Ranbaxy Laboratories (1992/93 to 1999) (US$ million)			
Year	Capital expenditure	Current expenditure	Total
1992/93	3.4	2.6	6.0
1993/94	8.2	2.9	11.1
1994/95	5.7	5.9	11.6
1995/96	5.8	7.2	13.0
1996/97	4.3	9.6	13.9
1997/98	3.2	10.1	13.3
1999	1.7	11.4	13.1

Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database 2000

The increase in the R&D expenditure can be seen more clearly from table 2.25, which shows the contrasting growth rates of the three components of such expenditure by the firm.

Table 2.25

Growth rates of the three components of R&D expenditure by Ranbaxy Laboratories			
Years	Capital Expenditure	Current expenditure	Total expenditure
1992/93 to 1999	Negative	27.9	13.9

Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database 2000

A better picture of the R&D expenditure of the firm can be had by looking at this expenditure in conjunction with the sales turnover figures (see table 2.26). The R&D intensity of the firm through the 1990s has been showing a somewhat mixed picture. While the ratio of current spending as a percentage of sales turnover has been registering a steady increase, the ratio of total spending on R&D to sales has been declining since the middle of the decade. Interestingly, the highest ratio of total R&D spending to sales was registered in 1993/94, which was during the period when the firm started to use R&D spending as a strategy to meet the challenges posed by the new policies adopted by the Government in India. The R&D spending of the firm in the later years, however, indicates that the initial thrust appears to be wearing out. This is a pointer to the fact that the firm needs to give more attention to its R&D activities if it is to remain true to the epithet of a research-oriented firm.

Table 2.26

R&D intensity of Ranbaxy Laboratories		
Year	Current expenditure/sales (percentage)	Total expenditure/sales (percentage)
1992/93	1.5	3.4
1993/94	1.5	5.9
1994/95	2.6	5.1
1995/96	2.9	5.3
1996/97	3.0	4.3
1997/98	3.0	3.9
1999	3.1	3.6

Source: Centre for Monitoring Indian Economy (CMIE), Prowess Database 2000

B. Areas of R&D spending of Ranbaxy Laboratories

Among the four dimensions of R&D activities that Ranbaxy Laboratories has focused on, two have been quite prominent in terms of the results obtained. These are: (i) development of abbreviated new drug applications, and (ii) development of new processes. However, in more recent years, the two other areas have also shown considerable promise.

(i) Abbreviated new drug applications

By focusing its activities in this area, the firm has been able to make the maximum use of its position as a leading generic drug producer in an ever-growing Indian market. Utilization of this core competence of the firm has resulted in the development of several formulations and alternative processes. More importantly, the firm has obtained approvals for its products as abbreviated new drug applications (ANDAs) in the United States (see annex table I for details). The development has taken place alongside the steps taken by the firm to obtain patents for the novel processes it has generated

The ANDAs were the creation of legislative action in the United States through the Drug Price Competition and Patent Restoration Act of 1984 (more commonly known as the Waxman-Hatch Act). Under this Act, a generic product needed only to be shown to be a "bio-equivalent" to a patented drug in order to obtain marketing approval after the original patent, and the market exclusivity granted therein, had expired. The Waxman-Hatch Act provides that a generic drug can be considered as a bio-equivalent if the rate and extent of absorption of the drug do not show a significant difference from the rate and extent of absorption of the patented drug.

In the past two years, there has been a quantum jump in approvals for ANDAs received by the firm. Three ANDA approvals were obtained by the firm in the first half

of 1999. The products that were approved belonged to the antibiotics therapeutic group, the traditional area of strength of the firm. By the first quarter of 2000, Ranbaxy Laboratories was seeking approvals for 26 ANDAs and had received approval for eight molecules. Among the products that received approval during this period was Ranitidine, one of the largest selling anti-ulcer drugs in the world market.

(ii) Development of new processes

This is an area where Ranbaxy Laboratories has developed considerable expertise, given the patent regime in India that allowed patenting of process patents in the area of chemicals, including pharmaceuticals. However, despite the fact that the present Indian Patents Act was adopted in 1970, it was not until the late 1980s that Ranbaxy Laboratories started applying for patents. The first patent was applied in the United States in 1988, followed by patent filing under the European Patent Convention; the firm did not file for patents in India before 1990.

The patenting activity of the firm has started increasing in recent years (see annex tables II to V). Data for the Indian filings were not available before 1995, but from 1996 to 1999 the firm filed 40 patent applications in India.

(iii) Novel drug delivery systems

The activities of Ranbaxy Laboratories centering on the development of novel drug delivery systems (NDDS) received a significant fillip as a result of a tie-up in 1999 with Bayer AG, the Germany pharmaceutical giant, involving one of the new generation antibiotics, *ciprofloxacin*. The firm was able to improve on the product, which was developed by Bayer AG and is under patent protection until 2003. Instead of the multiple-dose-a-day therapy that the Bayer formulation was offering, Ranbaxy Laboratories was able to produce a one-a-day formulation. This product improvement promised greater patient compliance, and was therefore considered to be a major step forward. The significance of this improvement was reflected in the terms of the licensing agreement between Ranbaxy Laboratories and Bayer AG. Under the agreement, Ranbaxy Laboratories was to receive US$ 65 million from Bayer over a four-year period, with an initial payment of US$ 10 million. The agreement allowed Bayer AG to have the worldwide marketing rights for *ciprofloxacin*, except in India and the countries of the Commonwealth of Independent States (CIS) where Ranbaxy Laboratories would have the marketing rights. The product is due to undergo phase III of clinical trials in the United States to be marketed there from 2002..

(iv) New drug discovery

Ranbaxy Laboratories has recently entered the most challenging area for pharmaceutical firms, that of new drug discovery. The firm has discovered three molecules, which are at various stages of development. The first product, discovered in 1998, is at the clinical trial stage; the second molecule was discovered in 2000 and went into clinical trials by the end of that year; and the third molecule is at an advanced stage of development. Having developed these molecules, the firm has now planned for the development of at least one new molecule every 12 to 18 months.

The R&D activities of Ranbaxy Laboratories show a distinct trend towards improvement of the company's technological intensity of operations. While emphasis in the earlier phase was on development of generics, in more recent years it has been on the development of new chemical entities. This transition to developing new chemical entities has two advantages. First, the Indian industry should look to better infusion of technology and an enhanced rate of introduction of new drugs. Secondly, and more importantly, this leading firm in Indian industry looks better prepared to face the challenges posed by the post-TRIPS patent regime.

CONCLUDING REMARKS

The production and export performance of the Indian pharmaceutical industry during the 1980s, and especially during the 1990s, has been impressive. The industry has carved a niche for itself in the international market as a supplier of low-cost and good quality generic bulk drugs. The foundations for a competitive pharmaceutical industry were laid during the 1970s in the policy regime, which encouraged the growth of domestic pharmaceutical firms. The other major objective of the policy regime was to keep prices low.

The Patent Act, 1970 played a major role in the development of the technological capability of Indian firms. By reducing the patent term, granting only process patents for drug inventions and bringing these inventions under automatic compulsory licences, it became unattractive for foreign firms to take patents in India, as evidenced in the lower number of foreign patent applications in the pharmaceutical sector. This gave the Indian firms the opportunity to copy technology and first cater to the domestic market, and later, when the patent expired, to export. This might have had a negative impact on technology transfer, but the Act became a useful tool for enabling Indian enterprises to make an entry into previously uncharted territory.

The process patent regime was adopted with a view to encouraging innovations in a country like India, which had limited technological capability and financial resources to devote to R&D. The shorter patent term was adopted to keep a "softer" monopoly in an area like drugs, which are essential for human life. In a similar vein, the provision relating to licences of right was introduced to encourage competition in the pharmaceutical industry.

Because of the fact that the patents law in force grants only process patents in the case of pharmaceuticals and a relatively short patent term, the Indian firms could gain experience through a reverse engineering process, acquiring production capabilities based on indigenously generated technologies. This gave Indian firms the opportunity to export drugs to the larger markets in the developed countries when the patent on the products had expired. This is the principal reason for the growth of exports of generic bulk drugs from India during the 1990s.

The policy regime for the pharmaceutical industry in India shifted from subjecting the industry to strict government control in the 1970s to freeing it almost completely to allow market forces to guide it in the 1990s. The major policies applied since the 1970s have gradually moved towards greater accordance with new international rules that entered into force in the mid-1990s.

India has chosen to opt for introducing a product patent regime in pharmaceuticals only from 2005. The Indian Patent Regime adopted in the 1970s would have been inconsistent with the WTO TRIPS Agreement. Under this agreement, patents are required not only for processes but also for products. Moreover, the terms of protection available shall not end before 20 years from the filing date. Additionally, the

TRIPS Agreement establishes detailed conditions for compulsory licensing or government use of patents without the authorization of the patent owner[55].

Regarding R&D, the Government has offered incentives to firms that engage in R&D. The incentives have taken the form of tax concessions and exemption from the purview of price controls. Although the WTO Agreement on Subsidies and Countervailing Measures (SCM Agreement) identified assistance for R&D as non-actionable subsidies, under certain circumstance these provisions applied only for a period of five years, beginning from the date of entry into force of the Agreement; thus they now fall under the category of actionable subsidies.

Moreover, until 1994, the drug policy provided that firms which did not use high technology while producing bulk drugs or formulations had to bring down their foreign holding to 40 per cent to be considered Indian firms. On the basis of that regulation, foreign firms faced a relatively tighter regime as regards production of formulations; they were also obliged to have R&D facilities in the country and to spend at least 4 per cent of their sales turnover as recurring expenditure on R&D facilities. Those requirements could have been inconsistent with the obligation of national treatment of regulations under Article III of the GATT 1994.

Technological change in the pharmaceutical sector in India also benefited from institutional support. The publicly funded laboratories of the Council for Scientific and Industrial Research (CSIR) were active in drugs research and had close links with private sector firms, thereby overcoming the common problem of non-interaction with industry. In particular, "knowledge partnerships" funnelled intellectual resources towards incremental progress.

However, the overall impact of this mix of policies was favourable for the industry. This is evident in the relative performance of the pharmaceutical industry in the industrial sector as a whole, and of the performance of the pharmaceutical industry in the 1990s, when it surpassed that of all other major industrial sectors in India. In a phase where most industries were devising strategies to meet the challenges posed by the opening up of the Indian economy, the pharmaceutical industry was in a league of its own. Since the 1970s, government policy initiatives were aimed at increasing the production of bulk drugs in India from as basic a stage as possible. This objective had been largely achieved by the year 2000. Presently, India is self-sufficient in up to 70 per cent of bulk drugs and almost all formulations.

The proactive government policies and the global developments in the pharmaceutical sector helped change the mindset of Indian drug manufacturers. Moreover, the contribution of industry visionaries[56] also greatly helped the development of the pharmaceutical sector.

[55] See for more details UNCTAD (1996).

[56] Persons such as Dr. Parvinder Singh of Ranbaxy and Dr. Anji Reddy of Reddy's Laboratories have been path breakers for the Indian pharmaceutical industry. When most Indian companies were content with production based on reverse engineering, Dr. Singh and Dr. Reddy had the foresight to recognize that the future of the industry lay in greater emphasis on R&D. They realized the necessity for untying this industry from the protectionist regime that had condemned it to low levels of competitiveness.

A new pharmaceutical policy announced in February 2000 aims at preparing the industry for the post 2005 period, when a new patent regime would come into force in the country. The new policy seeks to strengthen indigenous research, calls for better quality assurance, aims to ensure abundant availability of essential drugs and seeks to create a framework for the drug industry to promote new investment and encourage the development of new technologies.
The following are the key changes introduced in the new policy:

a) Industrial licensing for all bulk drugs, their intermediates and formulations is abolished except in the case of bulk drugs produced by the use of recombinant DNA technology, bulk drugs requiring *in-vivo* use of nucleic acids as the active principles, and specific cell-/tissue- targeted formulations.
b) Foreign investment of up to 100 per cent is permitted through the automatic route except for those items requiring industrial licensing.
c) Automatic approval of foreign technology agreements is given except for the drugs requiring industrial licensing.
d) The Pharmaceutical Research and Development Support Fund (PRDSF) is established.
e) The scope of price control is limited to only two categories of drugs: (i) those that have a turnover of a value of more than US $ 5 million and a market share greater than 50 per cent, and (ii) those that have a turnover of US $ 2 to 5 million and a market share greater than 90 per cent. This means, with respect to turnover, that 17 per cent of the total bulk drug market will be under price control, down from 38-40 per cent earlier.

The policy reflects the Indian Government's intentions to reorient this sector, enabling it to meet the challenges and harness the opportunities arising from the liberalization of the economy and the impending advent of the product patent regime.

In the medium term, the growth prospects for Indian firms are very encouraging. With a number of important drugs going off patent in the next decade, there will be enough room for the Indian pharmaceutical industry to expand. In comparison, long-term prospects are uncertain; they depend on the capacity of the Indian pharmaceutical industry to direct resources into R&D and discover and develop new molecular entities, and on how fast the industry can introduce molecular biology into its research programme.

The strategy adopted by the leading firms, such as Ranbaxy Laboratories, offers some hope for the industry. Particularly significant from the long-term point of view has been the growing presence of this firm in the larger markets, a presence built on the technological strength of the firm that was initially developed through joint ventures. Over the years, the joint ventures have given way to strategic alliances with some of the leading firms in the global market, which holds promise for the future of the industry.

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ANNEX

Table I. Approvals for abbreviated new drug applications (ANDA) obtained by Ranbaxy Laboratories in the United States

Appl No	Active Ingredient	Dosage Form Route	Strength
074975	ACYCLOVIR	Capsule; Oral	200MG
074980	ACYCLOVIR	Tablet; Oral	400MG
074980	ACYCLOVIR	Tablet; Oral	800MG
065016	AMOXICILLIN	Capsule; Oral	250MG
065016	AMOXICILLIN	Capsule; Oral	500MG
065021	AMOXICILLIN	Tablet, Chewable; Oral	125MG
065060	AMOXICILLIN	Tablet, Chewable; Oral	200MG
065021	AMOXICILLIN	Tablet, Chewable; Oral	250MG
065060	AMOXICILLIN	Tablet, Chewable; Oral	400MG
065059	AMOXICILLIN	Tablet; Oral	500MG
065059	AMOXICILLIN	Tablet; Oral	875MG
064156	CEFACLOR	Capsule; Oral	EQ 250MG BASE
064156	CEFACLOR	Capsule; Oral	EQ 500MG BASE
064166	CEFACLOR	Powder For Reconstitution; Oral	EQ 125MG BASE/5ML
064165	CEFACLOR	Powder For Reconstitution; Oral	EQ 187MG BASE/5ML
064164	CEFACLOR	Powder For Reconstitution; Oral	EQ 250MG BASE/5ML
064155	CEFACLOR	Powder For Reconstitution; Oral	EQ 375MG BASE/5ML
065018	CEFADROXIL/CEFADROXIL HEMIHYDRATE	Tablet; Oral	EQ 1GM BASE
065007	CEPHALEXIN	Capsule; Oral	EQ 250MG BASE
065007	CEPHALEXIN	Capsule; Oral	EQ 500MG BASE
065053	DOXYCYCLINE	Capsule; Oral	EQ 100MG BASE
065053	DOXYCYCLINE	Capsule; Oral	EQ 50MG BASE
075556	ENALAPRIL MALEATE	Tablet; Oral	10MG
075556	ENALAPRIL MALEATE	Tablet; Oral	2.5MG
075556	ENALAPRIL MALEATE	Tablet; Oral	20MG
075556	ENALAPRIL MALEATE	Tablet; Oral	5MG
075226	ETODOLAC	Tablet; Oral	400MG
075226	ETODOLAC	Tablet; Oral	500MG
065062	MINOCYCLINE HYDROCHLORIDE	Capsule; Oral	EQ 100MG BASE
065062	MINOCYCLINE HYDROCHLORIDE	Capsule; Oral	EQ 50MG BASE
065062	MINOCYCLINE HYDROCHLORIDE	Capsule; Oral	EQ 75MG BASE
075523	NALOXONE HYDROCHLORIDE; PENTAZOCINE HYDROCHLORIDE	Tablet; Oral	EQ 0.5MG BASE; EQ 50MG BASE
075439	RANITIDINE HYDROCHLORIDE	Tablet; Oral	EQ 150MG BASE
075439	RANITIDINE HYDROCHLORIDE	Tablet; Oral	EQ 300MG BASE
075000	RANITIDINE HYDROCHLORIDE	Tablet; Oral	EQ 150MG BASE
075000	RANITIDINE HYDROCHLORIDE	Tablet; Oral	EQ 300MG BASE

Source: US, Federal Drug Agency Orange Book <**http://www.fda.gov**>

Table II. Patent applications made in India by Ranbaxy Laboratories

Date of filing	Gazette Notification	Title
July 30, 1996	March 15, 1997	A novel process for manufacturing a key intermediate of simvastatin
June 13, 1996	March 15, 1997	A novel process for the preparation of 8-chloro-6-(2-fluoro-phenyl)-1-methyl-4h-imidazo (1 5a) (1 4) benzodiazepine (midazolam)
April 9, 1997	Dec. 5, 1998	A novel process for the preparation of cefpodoxime acid
March 4, 1999	June 12, 1999	A novel process for the preparation of cephem compounds
November 13, 1997	Jan. 2, 1999	A process for the synthesis of 1-(4-arylpiperazine-1-yl)-(i)-(2 5-dixopipedidin-1-y1) alkanes as a adrenoreceptor blockers useful for hypertension and benign prostatic hyperplasia (bph)
November 13, 1997	Jan. 2, 1999	A process for the synthesis of 1-(4-arylpiperazine-1-yl)-(i)-(2 6-dixopipedidin-1-y1) alkanes as a adrenoreceptor blockers useful for hypertension and benign prostatic hyperplasia (bph)
May 23, 1997	Dec. 5, 1998	A process for the preparation of a stable oral pharmaceutical composition
September 14, 1998	Feb. 27, 1999	A process for the preparation of a controlled drug delivery system containing pseudoephedrine and a long acting antihistamine
March 19, 1999	June 12, 1999	A process for the preparation of a novel coating composition
September 14, 1998	Feb. 27, 1999	A process for the preparation of a once-a- day pharmacokinetic profile of ciprofloxacin
Dec. 29, 1997	Jan. 2, 1999	A process for the preparation of a stable oral pharmaceutical composition containing a substituted pyridysulfinyl benzimidazole
May 13, 1997	Dec. 5, 1998	A process for the preparation of an oral pharmaceutical composition containing quinolone antibacterial agents.
September 29, 1997	Jan. 2, 1999	A process for the preparation of cefuroxime axetil in an amorphous form
June 6, 1997	Dec. 5, 1998	A process for the preparation of ranitidine capsules
October 22, 1998	March 20, 1999	A process for the synthesis of derivatives of monosaccharides as novel cell adhesion inhibitors
Jan. 15, 1999	June 5, 1999	A process for the synthesis of derivatives of monosaccharides as novel cell adhesion inhibitors
Jan. 25, 1999	June 12, 1999	An improved process for the preparation of cephem sulphoxides
October 28, 1997	Jan. 2, 1999	An improved process for the preparation of statins from their corresponding acids
October 28, 1997	Jan. 2, 1999	An improved process for the preparation of statins from their corresponding acids
May 2, 1997	Dec. 5, 1998	An improved process for the preparation of z-phenylacetamido desacetoxycephalosporanic acid

Table II (continued)

Jan. 25, 1999	June 12, 1999	Derivativers of monosaccharides as novel cell adhesion inhibitors
Dec. 4, 1998	March 27, 1999	I- (4arypiperazin-1-y1) -a-(n (a w dicorboximididoi-alkanel useful as uro-selective a adrenocept or blockers
April 25, 1997	Dec. 5, 1998	Improved process for the preparation of lovastatin
June 5, 1997	Dec. 5, 1998	Improved process for the preparation of mevinolinic acid or its salt
July 31, 1998	Feb. 20, 1999	Process for preparing a highly pure, predominantly amorphous form of cefuroxime axetil
March 18, 1996	Jan. 18, 1997	Process for producing cephalosporin antibiotics
May 6, 1997	Dec. 5, 1998	Process for the manufacture of ranitidine hydrochloride form i
March 19, 1999	June 12, 1999	Process for the preparation of a bioavailable oral dosage form of cefuroxime axetil
November 13, 1995	July 27, 1996	Process for the preparation of a pharmaceutical composition in the form of a layered tablet containing two active ingredients with different release profiles.
Jan. 12, 1998	Jan. 9, 1999	Process for the preparation of cephalexin hydrochloride monohydrate in an amorphous form
March 30, 1998	Feb. 6, 1999	Process for the preparation of ceruroxime from ceruroxime axetil
Jan. 21, 1997	Dec. 5, 1998	Process for the preparation of controlled release drug formulation containing diltiazem
June 1, 1998	Feb. 20, 1999	Process for the preparation of crystalline (z)-2-(2-tert butoxycarbonylprop-2-oxyimino)-2-association with n, n-dimethylformamide
Jan. 10, 1996	Jan. 4, 1997	Process for the preparation of modified release matrix formulation of cefaclor/cephalexin
November 22, 1995	July 27, 1996	Process for the preparation of novel pharmaceutical composition in effervescent form.
September 19, 1997	Jan. 2, 1999	Process for the preparation of oral controlled drug delivery system containing gas generating components
November 13, 1996	July 27, 1996	Process for the preparation of pharmaceutical tablet comprising rabutudube as core coated with a polymeric film.
Jan. 21, 1997	Dec. 5, 1998	Process for the preparation of simvastatin from lovastatin or mevinolinic acid
Dec. 4, 1998	March 27, 1999	Process for the preparation of stafies solid pharmaceutical compositions containing enalapril maleate.
May 8, 1998	Feb. 6, 1999	Process for the preparation cefpodoxime acid

Source: Technology Information, Forecasting and Assessment Council (TIFAC), Ekaswa-Database on Patent Applications.

Table III. Patents granted to Ranbaxy Laboratories in the United States

Date of Filing	Date of Issue	Patent Number	Title
Oct. 28, 1988	Feb. 20, 1990	US4902447	Process for the production of alpha-6-deoxytetracyclines and hydrogenation catalyst useful therein
Oct. 28, 1988	Nov. 27, 1990	US4973719	Process for the production of alpha-6-deoxytetracyclines
Feb. 9, 1990	Feb. 5, 1991	US4990636	Process for the production of alpha-6-deoxytetracyclines and hydrogenation catalyst
April 13, 1989	March 5, 1991	US4997959	Process for the production of alpha-6-deoxytetracyclines
March 7, 1990	Dec. 3, 1991	US5070195	Ring-opening process for preparation of 2-chlorosulfinyl azetidinones
May 6, 1991	Oct. 27, 1992	US5159071	Process for the manufacture of 7-amino-3-exomethylene-3-cepham-4-carboxylic acid
Feb. 18, 1993	April 25, 1995	US5347000	Process for the preparation of 2-chlorosulfinylazetidinone
April 21, 1993	Sept. 13, 1994	US5410044	Process for preparing Z and E-rotamers of 3-hydroxy cephem derivatives
June 24, 1994	April 15, 1997	US5536830	Process for P-nitrobenzyl ester cleavage in cephalosporin
June 24, 1994	Dec. 9, 1997	US5621120	Process for the manufacture of form 1 ranitidine hydrochloride
May 30, 1995	July 16, 1996	US5696275	Process for the manufacture of pharmaceutical grade ranitidine base
May 1, 1996	Feb. 9, 1999	US5728401	Effervescent ranitidine formulations
Oct. 9, 1996	May 26, 1998	US5756729	Process for the manufacture of 8-chloro-6 (2-fluorophenyl)-1 methyl-4H-imidazo [1,5a] [1,4] benzodiazepine (midazolam)
March 13, 1997	June 9, 1998	US5763646	Process for manufacturing simvastatin from lovastatin or mevinolinic acid
March 13, 1997	June 9, 1998	US5763653	Key intermediates in the manufacture of simvastatin
April 16, 1997	March 17,1998	US5792874	Process for the manufacture of 8-chloro-6-(2-flourophenyl)-1-methyl-4H-imidazo[1,5A][1,4] benzodiazepine
Aug. 26, 1997	Aug. 11, 1998	US5869649	Process for producing cephalosporin antibiotics
Dec. 17, 1997	Sept. 7, 1999	US5917058	Process of lactonization in the preparation of statins
April 6, 1998	Aug. 17, 1999	US5939564	Process of lactonization in the preparation of statins
April 22, 1998	June 29, 1999	US5948440	Modified release matrix formulation of cefaclor and cephalexin
May 9, 2000	June 17, 1998	US6060599	Process for the preparation of cefuroxime axetil in an amorphous form
June 13, 2000	Dec. 4, 1997	US6074669	Controlled drug delivery system for diltiazem
July 4, 2000	July 21, 1998	US6083950	1-(4-arylpiperazin-1-yl)-.omega.-[n-(alpha,omega.-dicarboximido)]-alka nes useful as uro-selective .alpha.1-adrenoceptor blockers
July 18, 2000	Dec. 2, 1998	US6090809	1-(4-arylpiperazin-1-yl)-.omega.-[n-(.alpha...omega.-dicarboximido)]-alkanes useful as uro-selective .alpha.1 -adrenoceptor blockers

Source: Delphion Intellectual Property Network: <http://www.delphion.com>

Table IV. Applications made under the European Patent Convention (EPC) by Ranbaxy Laboratories

Date of Filing	Date of Issue	Patent Number	Title
Oct. 27, 1989	April 3, 1991	EP366565A3	Process for the production of alpha-6-deoxytetracyclines and hydrogenationcatalyst useful therein
April 3, 1989	Oct. 16, 1991	EP391005B1	Process for the production of alpha-6-deoxytetracyclines
May 11, 1995	Aug. 19, 1998	EP694540B1	Process for the manufacture of form 1 ranitidine hydrochloride
May 11, 1995	July 1, 1998	EP697411B1	Process for the manufacture of pharmaceutical grade ranitidine base
March 13,1996	Dec. 2, 1998	EP745603B1	Process for p-nitrobenzyl ester cleavage in cephalosporin
March 13,1997	Nov. 12, 1997	EP806424A1	Process for producing cephalosporin antibiotics
June 13, 1997	April 15, 1998	EP835874A2	A process for the manufacture of 8-chloro-6-(2-fluorophenyl)-1-methyl-4h-imidazo 1,5a)(1,4) benzodiazepine (midazolam)
June 13, 1997	June 10, 1998	EP835874A3	A process for the manufacture of 8-chloro-6-(2-fluorophenyl)-1-methyl-4h-imidazo (1,5a)(1,4) benzodiazepine (midazolam)
April 29, 1997	Sept. 16, 1998	EP864560A1	Key intermediates in the manufacture of sinvastatin
July 4, 1997	Sept. 16, 1998	EP864569A1	Process for manufacturing simvastatin from lovastatin or mevinolinic acid
Feb. 28, 1997	March 24, 1999	EP902681A1	Inhibition of selectin binding (See WO09731625)
March 30, 1998	June 23, 1999	EP923934A1	Modified release matrix formulation of cefaclor and cephalexin
Dec. 7, 1998	Nov. 10, 1999	EP955297A1	An improved process of lactonization in the preparation of statins
Dec. 7, 1998	Dec. 1, 1999	EP960620A1	A stable oral pharmaceutical composition containing a substituted pyridylsulfinyl

Source: Delphion Intellectual Property Network: <http://www.delphion.com>

Table V. Applications made under the Patent Cooperation Treaty (PCT) by Ranbaxy Laboratories

Date of Filing	Date of Issue	Patent Number	Title
July 16, 1999	Feb. 3, 2000	WO005205A1	Arylpiperazine derivatives useful as uroselective alpha1-adrenoceptor blockers
Jan. 26, 1999	Feb. 3, 2000	WO005206A1	Arylpiperazine derivatives useful as uro-selective alpha-1-adrenoceptor blockers
Jan. 10, 2000	July 20, 2000	WO042053A1	Derivatives of monosaccharides as cell adhesion inhibitors
Jan. 10, 2000	July 20, 2000	WO042054A1	2,3-o-isopropylidene derivatives of monosaccharides as cell adhesion inhibitors
March 8, 2000	Sept. 14, 2000	WO053609A1	Process for the preparation of cefuroxime
Oct. 26, 1999	Sept. 28, 2000	WO056266A2	Taste masking coating compositions
March 17, 2000	Sept. 28, 2000	WO056286A1	Process for the preparation of a bioavailable oral dosage form of cefuroxime axetil
May 3, 2000	Nov. 9, 2000	WO066116A2	Stable solid pharmaceutical compositions containing enalapril maleate
May 5, 2000	Nov. 16, 2000	WO068234A2	Process for the preparation of cefpodoxime acid
June 7, 2000	Dec. 21, 2000	WO076479A1	Taste masked compositions
June 7, 2000	Dec. 21, 2000	WO077006A1	Process for the preparation of 1,8-disubstituted-1, 3, 4, 9tetrahydropyrano (3,4-b)-indole-1-acetic acid esters in a hydroxylic solvent
June 7, 2000	Dec. 21, 2000	WO077017A1	Novel amorphous form of clarithromycin
Feb. 28, 1997	Sept. 4, 1997	WO9731625A1	Inhibition of selectin binding
Jan. 26, 1999	Dec. 2, 1999	WO9961022A1	A stable oral pharmaceutical composition containing a substituted pyridylsulfinyl benzimidazole
Jan. 27, 1999	Dec. 23, 1999	WO9965919A1	Process for the preparation of cefuroxime axetil in an amorphous form

Source: Delphion Intellectual Property Network: <http://www.delphion.com>

A Case Study of the Automotive Industry in South Africa

INTRODUCTION

This paper reviews the development of the automotive industry in South Africa, from a highly protected, inward-focused industry to one with a marked export orientation, able to compete effectively in global markets. The Motor Industry Development Programme (MIDP), which reversed the import-substitution programmes that had shaped the industry from the early 1960s, played a significant role in this turnaround. Institutional support also contributed significantly to innovation and technological development to meet the high technical standards necessary to compete in international markets. The extensive foreign ownership of both vehicle and component manufacturers facilitated the transfer of skills and organizational development and provided access to international markets.

The study is organized in the following way. Chapter I discusses the factors that have shaped the formation of technological capability in the South African automotive industry. The chapter reviews the origins of the industry; the evolution from import-substitution polices to those more export oriented, including the ownership patterns, the location of the industry, and the importance of foreign direct investment (FDI); and finally, the aspects that attracted foreign automotive producers during the 1990s. Chapter II analyses the performance of the South African automotive industry, both qualitatively and quantitatively. The quantitative assessment includes the investment behaviour of the assemblers, and the market and export performance. The qualitative assessment focuses on the inter-firms relationships, the learning processes and the levels of labour productivity of the automotive industry. Chapter III concentrates in policies and institutions supporting the automotive industry in South Africa. It reviews the Motor Industry Development Programme and its recent modifications, and provides a critique of the programme. With respect to institutional support, the chapter discusses the role played by the South African Bureau of Standards in reaching international standards and enhancing quality. Chapter IV presents the stories of the successful integration into the global markets of two South African firms, Bosal Automotive and Volkswagen of South Africa. The concluding remarks highlight the characteristics of the South African automotive industry and the key policy aspects that have helped integrate the industry into global networks.

CHAPTER I

FACTORS SHAPING TECHNOLOGICAL CAPABILITY IN THE AUTOMOTIVE INDUSTRY

1. Origins of the automotive industry in South Africa

The South African automotive industry dates back to the 1920s when Ford and General Motors established assembly plants in the country, in 1924 and 1926 respectively. The result was acceleration in new car sales from about 13,500 units to 20,500 units between 1925 and 1929. The onset of the Great Depression in the 1930s halted the expansion of the industry until 1938/39 after which car sales picked up. A third assembly firm, the National Motor Assembly of Johannesburg, entered the market in 1939.

In the aftermath of the Second World War, the South African automotive industry grew further and even faster. In 1945, the assembly plants, Motor Assemblers and Car Distributors Assembly, were established in Durban and East London respectively. The Chrysler Corporation established a plant in Cape Town, closely followed by South African Motor Assemblers and Distributors in Uitenhage in 1948 and later by the British Motor Corporation in Cape Town in 1955 (Onyango, 2000). All these assembly plants assembled completely knocked down (CKD) imported kits.

The domestic market expanded rapidly and the production of cars reached 87,000 units in 1960, a level higher than in any other developing country at the time. Currently, the automotive industry in South Africa consists of 8 light vehicle assemblers (see table 3.1) and 11 producers of medium and heavy commercial vehicles. Toyota is the major producer (in terms of market share) of both cars and light commercial vehicles.

2. From import substitution to export orientation

From the early 1960s South Africa adopted import-substitution policies.[57] For the automotive industry these took the form of local content programmes (either by mass or value), augmented by high tariff barriers and direct import controls. These policies effectively built an anti-export bias into the automotive industry. Coupled with the small domestic market, this protection resulted in high dependence on local inputs and a proliferation of vehicle models. Short, high-cost production runs were the result.

[57] These policies were geared towards an attempt to build local industries behind protectionist walls to replace imports. Essentially, the Government sought to gradually replace imported manufactures by indigenous output. Tariffs were key to providing protective barriers so that local industries could grow and develop

Table 3.1. Light vehicle assemblers operating in South Africa

Assembler	Ownership	Makes	Capacity (units)	Domestic market share 1999 (per cent)
Automakers	Nissan Fiat Sankorp	Nissan Fiat	75 000	9
BMW (SA)	BMW AG	BMW	40 000	8.4
Delta	GM Domestic	Opel Isuzu	75 000	11
SAMCOR	Ford Motor (90 per cent)	Ford Mazda	70 000	13.3
Land rover	BMW AG	Landrover	10 000	1
Daimler Chrysler	Daimler Chrysler	Mercedes Honda # Mitsubishi	40 000	9.9
Toyota	TMC Wesco	Toyota	120 000	23.6
VW (SA)	VW AG	VW Audi	100 000	22.6

Source: Onyango (2000)

In the late 1980s, the development model based on industrial import substitution was beginning to show considerable limitations. In 1989 there was a shift in policy to address the problems of an inward-focused industry that had low-volume production and associated high costs, through the introduction of Phase VI of the local content programme. It allowed firms to include exports as part of their local content requirement. The MIDP was introduced in 1995 to improve competitiveness through the adoption of market-based policies, and this was instrumental in bringing about the process of industrial restructuring necessary for successful integration into global markets. It introduced a more rapid rate of reduction in tariffs than that required by South Africa's World Trade Organization (WTO) obligations.

In 1998, a recession year, the eight light-vehicle producers assembled 301,000 units, of which 8.4 per cent were exported. With falling protection in the 1990s, import levels began rising: they accounted for 18.2 per cent of locally produced vehicles in 1998, as shown in table 3.2.

Table 3.2. Automotive production and sales in South Africa ('000 units)

	Production	Sales (domestic)	Exports
1990	343	335	10
1991	315	308	10
1992	293	284	13
1993	308	298	16
1994	313	308	15
1995	389	387	16
1996	394	421	12
1997	364	399	20
1998	313	351	26

Source: Black (1998)

3. Ownership patterns

A distinctive feature of the South African auto industry is its particular ownership structure. All assemblers are now wholly or partly owned by their respective parent companies in Japan, the United States or Europe. The associated corporate governance structures have significant implications for technology transfer and integration of the industry into global markets. For instance, local producers, through the networks and supply chains of their "parent" companies, are able to access new technologies and tap into existing markets.

Ford and General Motors (United States firms) entered the South African market in the 1920s, but they disinvested during the period of sanctions in the 1980s. However they subsequently reinvested in South Africa and established close links with local firms (Samcor – now renamed Ford Motor Company – and Delta). Daimler Chrysler, Volkswagen (VW) and BMW (German firms) wholly own their South African subsidiaries and the local firms are well integrated into the global automotive network. Volkswagen (South Africa) is the country's major exporter of vehicles. It has benefited from the lack of capacity in the global group, and, as a result, has obtained large export orders (e.g. 60,000 VW Golf 4 vehicles a year to Europe). In the case of United States firms (such as Ford and General Motors), Nissan of Japan and the German-based firms, the links with South African firms are through franchise partnerships.

4. Location of the industry

The South African automotive industry is located in three geographic clusters: Port Elizabeth/East London, Durban/Pinetown and Pretoria/Johannesburg.

Geographic proximity facilitates inter-firm interaction, in this case specifically between vehicle assemblers and components manufacturers. Local firms produce a range of components, from leather car seats to tyres and catalytic converters, which are used by the local auto industry and are also exported mainly to Germany and the United Kingdom (Galloway, 2000). Located close to the Port Elizabeth/East London cluster is the major test facility of the South African Bureau of Standards (SABS). This is one of the key support institutions for the automotive industry, providing testing facilities for the industry's products. Indeed a symbiotic relationship has developed between the industry and the SABS that supports technological developments in the industry. The SABS has cooperated with individual firms in the development of the test facility and of technical standards, which are necessary for local vehicles and components to meet the demands of international markets.

5. Foreign direct investment

The South African automotive industry has attracted substantial foreign direct investment (FDI) in both automotive assembly and component production. FDI has often involved greater commitment by a parent company to the local company. This has led to associated positive spillovers such as technology transfer, human capital development, learning processes in organizational development and access to export markets. Human capital development has included, for example, transfer of managerial skills, which in turn has led to organizational development. The supply linkages between the auto and components producers have been instrumental in supporting the improvements in quality standards required for a successful integration into the world market. Moreover, links into the global automotive chains of the parent companies have underpinned the good export performance of the 1990s; they have assisted in the development of internationally competitive vehicle assemblers and components producers.

6. Attracting foreign automotive producers in the 1990s

The Japanese and the American auto producers, buoyed by the collapse of the apartheid regime in 1994, have invested quite substantially in the South African automotive industry. Since 1996 Toyota (Japan) and Nissan (Japan) have invested over US$74.6 million and US$77.6 million respectively, in the purchase of shares in the local subsidiaries, which in turn has allowed the local subsidiaries room for upgrading plant and equipment that generates further production capacity. Prior to 1996, the Japanese were restricted from entering the South African market due to the latter's apartheid policies. The American auto producers, Ford and General Motors, have also recently invested in the South African industry: up to US$62.68 million and US$77.6 million respectively, since 1995. These investments were more a case of reinvesting in the country since both these companies had disinvested during the height of the apartheid regime. Now the attraction is to develop the production capacity in South Africa and use that as a launching pad into the rest of the African region.

The three big German auto manufacturers, BMW, Volkswagen and Daimler-Chrysler, have always maintained a presence in South Africa. Huge investments by these companies

over the past five to six years have been motivated largely by their desire to capitalize on the opportunities presented within the framework of the Motor Industry Development Programme (MIDP) (discussed in detail later in the paper). Daimler-Chrysler invested US$163.6 million in 1998 for the expansion of the existing Eastern Cape plant where top-of-the-range Mercedes Benz vehicles are produced. BMW has invested US$149 million since 1996 for the expansion of production capacity at its plant near Pretoria where the 3-Series vehicles are now being produced. Since BMW had an existing plant in South Africa, and since the BMW market share in South Africa is larger than its share in Germany, it made business sense to invest in its existing facility as opposed to opening a new plant in a new location. Volkswagen, with the aim of using the incentives provided by the MIDP to tap into overseas markets, launched a US$149 million investment in 1998 to increase production capacity and upgrade its workshop facilities. Volkswagen in South Africa is now currently exporting Golf 4 cars to Europe.

CHAPTER II

PERFORMANCE OF THE SOUTH AFRICAN AUTOMOTIVE INDUSTRY

This chapter reviews, both qualitatively and quantitatively, the performance of the automotive industry in South Africa. The review is based on a number of surveys and other data sources (Black, 2000 and 1998; Onyango, 2000; Barnes, 1998; Department of Trade and Industry, 2000).

1. Quantitative assessment

With respect to the quantitative assessment, the focus is on investment in plant and equipment, R&D, human capital development, and other related expenditures. Furthermore, the assessment deals with issues related to market research, marketing activities as well as export performance in terms of products exported, export earnings and export markets.

A. Investment

The investment behaviour of assemblers is influenced by a number of industry-specific factors. The importance of economies of scale in automotive production means that the increasingly competitive environment exerts some pressure on firms to increase production as a way of reducing unit costs (Black, 1998). Given the small size of the domestic market, such a scenario may require that the parent company create export opportunities for the South African subsidiary, and invest accordingly. Key investment decisions are made outside South Africa by the global parent, and therefore short-term profitability in a minor South African subsidiary is likely to be of much less concern than medium-term market prospects and strategic considerations related to market share and the location logic of global production networks.

Investment has been rising in both the assembly (table 3.3) and component industries. Some firms such as BMW and Volkswagen have embarked on major expansion, with new investment and export plans. While FDI inflows into the South African economy totalled a moderate US$6.57 billion during the period 1995-1997, the automotive industry was the third largest recipient (after telecommunications and food and beverages). In the assembly industry, apart from plant upgrades and expansions that have created new production capacity, a significant trend has been the purchase of majority or minority stakes by the parent company, such as the purchase by Toyota Motor Corporation (TMC) of Toyota SA. The investments made in plants have not, however, reached the level of the massive investments that have been made in emerging market economies such as Brazil, Thailand, Argentina and Eastern Europe (Black, 1998).

Table 3.3. Investments in plant and equipment by vehicle manufacturers

Year	Vehicle assembly (US$ current)
1990	330 million
1991	332 million
1992	390 million
1993	181 million
1994	214 million
1995	338 million
1996	354 million
1997	324 million
1998	516 million

Note: The data in this table is presented in US$; the exchange rate is approximately US$1= 8.30 rand.
Source: National Association of Automobile Manufactures of South Africa (NAAMSA), 1999

South African firms, historically benefited with a protected trade regime, have been slow in adopting modern techniques and more flexible forms of production that have become standard practice amongst the major players in the international automotive industry. This is unsurprising if one looks at patterns of R&D expenditures that show a very small, albeit growing, commitment to R&D investment.

Average R&D expenditure as a percentage of sales amongst the sampled firms is differentiated between exporting firms and non-exporting firms. Exporting firms tend to spend significantly large amounts on R&D (2.55 per cent of total sales) as compared to the 0.95 per cent of the non-exporting firms. Collaboration between motor assembly firms and the South African Bureau of Standards, as well as the engineering faculties of academic institutions such as the Universities of Cape Town and Stellenbosch, have been of particular significance in, for example, the development and testing of engines and catalytic converters.

Transfer of technology and other spillovers have been significant features associated with the investment in local subsidiaries by parent companies. Investment in Toyota SA by TMC (Japan) has resulted in the upgrading of plant and equipment to meet internationally competitive standards. Technologies previously unavailable in South Africa have now spread across the automotive industry; this has brought benefits such as superior product design, transfer of skills (know-how) and relevant machinery. These developments, although progressing slowly, are geared towards reducing average *lead* times and average *throughput* time (measured in days). A number of manufacturers have adopted multi-shift or double-shift production (especially for export), thereby introducing greater flexibility into production organization (*Cape Times*, 23 March 2001).

B. Market performance

Net profits before tax of the light vehicle assemblers increased from a rather low base of US$ 113.10 million in 1992 to a record level of US$ 561.94 million in 1995 (table 3.4). Since then, profits have dipped precipitously, and the industry incurred large aggregate losses in 1997 and 1998. Indeed the significant volumes of imported vehicles led to much greater price competition and lower margins, which added to the pressures of stagnating sales volumes (Black, 1998).

Table 3.4. Aggregate profit performance of vehicle manufacturers

Year	Net profit before tax (US$ current)
1992	113.10
1993	185.45
1994	321.66
1995	561.94
1996	120.93
1997	(118.91)
1998	(59.81)

Source: Department of Trade and Industry, 1999

Economic performance and profitability in the component industry have also fallen sharply. This is highlighted by the fact that average employment levels per sampled firm declined 14 per cent between 1995 and 1997, and turnover in real terms stagnated over the same period (Barnes, 1998). In a subsequent survey of 21 component firms, conducted by the *Department of Trade and Industry* in 1997, Black (1998) reported that the sampled firms' profits fell by 74.6 per cent during 1996 from their record levels of 1995. The prominent contributing factors were falling margins, resulting from pressure applied by vehicle manufacturers, and the increasing desire of the vehicle manufacturers to use imported components (see table 3.6).

C. Export performance

Automotive exports from South Africa expanded dramatically from just US$ 121.15 million in 1988 to approximately US$ 2.45 billion in 1999, of which just over US$ 0.81 billion was accounted for by vehicles. In unit terms, light vehicle exports increased from 11,400 units in 1992 to approximately 58,000 units in 1999. The main destination for vehicle exports is to Africa. However exports to non-African markets are likely to be the fastest growing in the short term, and will consist mainly of passenger cars. Volkswagen has a large contract to export Golf 4 vehicles to the United Kingdom and BMW exports its 3-Series vehicles to Australia and a number of Asian markets. As table 3.4 indicates, there has been a

major expansion in production of a wide range of components, especially of products such as leather seating material, catalytic converters, wheels, tyres and exhaust pipes.

The prime objective of the import-export complementation scheme is to assist component suppliers to generate high volumes, which make them more efficient and able to compete in the domestic market against imports. Under this scheme, import duty on components and vehicles may be offset by import rebate credit certificates derived from the export of vehicles and components.[58] This is expected to support the development of more volume-based products for global consumption. While this objective has been achieved in part, it is clear that the bulk of export expansion has not been by "traditional" component suppliers, but by a rapidly emerging new group of mainly foreign-owned firms, frequently with links to vehicle manufacturers. The major links of these firms are with the global networks of the parent companies.

In June 2000, the changes to the MIDP included a productive asset allowance (PAA), which became effective as of 1 July 2000 (see appendix 1 for further detail). This involves a non-tradable duty credit, calculated at 20 per cent of qualifying investments, which is made available to manufacturers for five years. Assemblers are able to use this duty credit to import vehicles, maintaining the range of imported products offered to the consumer. Assemblers are encouraged to assemble vehicles for the local market through an allowance of up to 27 per cent of the components of locally produced cars to be imported duty free (*Business Day*, 2 June 2000).

Table 3.5 shows the rise in total automotive exports over an 11-year period. The industry supplying leather seat covers supplies the bulk of BMW's global requirements, and it is an important supplier to a significant number of other foreign vehicle manufacturers. The industry is labour-intensive, and a sizeable tanning industry has developed to support it. The catalytic converter industry, which is capital-intensive, currently supplies more than 10 per cent of the total world supply, and is set to expand even further.[59] It has reached the critical mass, requiring investment in inputs such as the ceramic substrate, where the required investment is much larger than for the relatively simple coating and canning process. A major advantage of the industry is that 90 per cent of the precious metal content in the catalytic converter is included in the valuation of exports that are eligible for import rebate.

[58] The significance is that it enables exporters to earn import credits, which they can then use to source components at close to international prices.
[59] See case study of Bosal later in the paper.

Box VIII. Toyota's production and exports

The largest vehicle producer in the country, Toyota SA, has responded to the need for closer integration into global production networks by expanding its export programme. For the first time, the South African company will embark on large-scale production of components to feed into the Toyota Motor Corporation (TMC) global production network.

Under this new programme, Toyota SA is entering into a joint venture with TMC and Cataler Corporation of Japan to produce catalytic converters for use in TMC's products. This new venture aims to become the fourth source of exhaust catalysts for the Toyota global manufacturing network. Production of exhaust catalysts started in the latter half of 2001, and annual production is geared to rise to more than one million units per year. The new facility will make use of Toyota's patented advanced catalytic converter technologies, therefore involving quite significant technology transfers, where previously there were none.

Source: Toyota (SA)

Table 3.5. Total component exports (US$ current)

	1995	1996	1997	1998	1999	Per cent of 1999 total
Catalytic converters	107.77	134.72	181.52	276.36	421.14	26.6
Stitched leather covers	283.05	292.79	225.00	337.09	309.50	19.5
Tyres	60.8	68.82	74.34	90.54	104.75	6.6
Silencers/exhaust pipes	21.11	39.53	32.82	89.63	98.03	6.2
Road wheels/parts	48.61	52.79	70.65	81.09	84.92	5.4
Engine parts	31.11	31.86	61.95	70.91	62.78	4.0
Wiring harnesses	11.38	21.39	29.56	37.64	49.83	3.1
Automotive tooling	71.94	64.88	67.17	46.55	43.28	2.7
Glass	13.61	16.51	22.83	20.36	24.09	1.5
Radiators	21.38	24.88	20.22	19.64	18.20	1.1
Ignition/starting equipment	1.11	3.72	6.52	8.54	15.41	1.0
Filters	3.61	9.76	11.96	13.09	13.94	0.9
Transmission shafts, cranks	8.05	8.83	1.52	11.27	13.93	0.9
Brake parts	6.38	6.74	8.48	13.82	12.95	0.8
Shock absorbers	10.55	12.33	12.17	11.45	12.62	0.8
Batteries	14.72	13.95	19.13	14.36	11.14	0.7
Car radios	1.94	0.93	6.30	8.54	11.96	0.7
Clutches/shaft couplings	4.44	4.88	7.17	9.27	8.85	0.6
Other components	195.00	154.41	122.82	203.45	268.52	16.9
TOTAL	916.66	941.86	1 031.96	1 363.6	1 585.90	100

Source: Department of Trade and Industry (1999).

Table 3.6 Automotive exports
(Fob values, US$ current)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Components	53.5	115.4	153.8	269.2	379.3	515.2	583.3	916.7	941.9	1 032.0	1 363.6	1 585.9
Vehicles	67.7	88.1	146.5	150.8	144.5	176.1	193.1	250	174.4	314.6	420.9	840.3
TOTAL	121.2	203.5	300.3	420	523.8	691.3	76.4	4 200	116.3	1 346.6	1 784.5	2 426.2

Source: Department of Trade and Industry, 1999 and 2000

While South African automotive exports into the Southern African Development Community (SADC)[60] have increased rapidly, this has been at a slower rate than total automotive exports. For example, light vehicle exports to SADC accounted for 12 per cent of the total in 1999, a sharp decline from the 64 per cent share in 1996. For medium and heavy commercial vehicle exports, which have not grown significantly in volume terms, Africa remains the dominant market, although the SADC share declined from 89 per cent in 1996 to 60 per cent in 1999. Two reasons account for this. First, the collapse of the Zimbabwean market and the raising of tariff barriers in response to economic problems have slowed sales into South Africa's major regional market. Secondly, light vehicle exports from South Africa have been increasing at a very rapid pace to markets such as Australia and Europe, reflecting the increasingly important role played by South African operations of firms such as BMW and VW in the global strategy of their parent companies

The growth in exports to Europe (see table 3.7) is a direct result of local subsidiary firms accessing the traditional markets of the parent companies. The investments of global automotive producers in local operations have facilitated the inclusion of these local firms into the "parent" company's global supply networks and markets.

The export performance of the South African auto industry has improved significantly in the 1990s for two reasons:

(i) The import-export complementation arrangements[61] of Phase VI of the local content programme and the MIDP have powerfully assisted export expansion, in particular by facilitating the integration of South Africa as a supplier of selected components into the global networks of the major vehicle producers. Ford's Port Elizabeth engine plant has been designated the sole supplier of 1.3-litre engines to Europe and Asia, with the first shipment at the end of 2001, and SA Trim has a contract to produce all leather car seats for BMW (Cape Times, 17 May and box 2 later in this paper). In this sense,

[60] SADC is a regional economic bloc consisting of 14 countries in southern and eastern Africa. South Africa is by far the largest member country with the most diversified industrial base.
[61] This is a scheme that allows import duty rebates based on exports. Essentially, this enables assemblers to use import credits to source components at close to international prices, therefore providing a strong incentive to assemble locally.

integration is happening more rapidly with the major producing countries, especially Germany, than within the southern African region itself.

Table 3.7 Destination of South African light vehicle exports by value
(percentage)

Country/Region	1996	1997	1998	1999
Germany	-	5	25	57
United Kingdom	3	2	15	13
Australia	11	19	15	10
Mozambique	9	9	7	4
Taiwan Province of China	-	5	4	3
Zimbabwe	36	18	8	2
Zambia	7	6	6	2
Malawi	9	7	4	2
Kenya	9	5	3	1
Mauritius	1	1	1	1
Ghana	-	-	1	1
Other	15	13	4	3
European Union (EU)	4	7	41	70
SADC	64	46	27	12

Source: Department of Trade and Industry (2000)

(ii) A second driver of export expansion has been falling protection and limited domestic market growth possibilities, which have forced firms into the export market. A significant share of this export expansion has been destined for SADC, a process that has accelerated since the advent of democracy in South Africa and the dropping of sanctions. Although recently the rate of growth in the SADC market has been declining for reasons mentioned earlier.

Table 3.8. Destination of medium and heavy commercial vehicle exports
(percentage by value)

Country/Region	1996	1997	1998	1999
Mozambique	14	19	23	28
United States	-	-	4	27
Malawi	19	19	12	16
Zambia	12	12	7	6
Zimbabwe	36	25	17	4
United Kingdom	-	3	-	4
Belgium	-	-	1	3
United Rep. of Tanzania	6	3	4	2
Angola	-	4	1	2
Dem. Rep. of the Congo	-	1	1	1
Kenya	6	3	7	1
Other	9	11	24	5
SADC	89	82	66	60
North America	-	1	8	30
EU	-	3	2	8

Source: Department of Trade and Industry (2000)

2. Qualitative assessment

A qualitative assessment of the performance of the automotive industry requires focusing on the nature of inter-firm relationships in the industry, learning processes within firms, and increasing labour productivity, among other factors.

A. Inter-firm relationships

It is interesting to note the blend of cooperation and competition that exists among firms in the automotive industry. Vehicle assemblers compete with one another, sometimes through fierce price competition, while cooperative relationships are found between vehicle assemblers and components producers. Table 3.9 shows the extent of support provided by vehicle manufacturers to local components manufacturers. It appears as if such linkages (or support) are declining. This is possibly explained by increased import competition, as tariff barriers have fallen.

Table 3.9 Purchases of original equipment components by vehicle manufacturers

Year	Local purchases (US$ current)	Imports (US$ current)	Total purchases (US$ current)	Local content (per cent)
1994	1 525	2 100	3 625	42
1995	1 863	2 575	4 438	42
1996	1 546	2 332	3 879	40
1997	6 641	10 380	3 958	39

Source: DTI Survey, 1998

Another interesting perspective regarding inter-firm relationships is provided by a survey of components producers (Barnes, 1998). Barnes asked firms whether they consulted with their suppliers when designing new products, and whether their customers assisted them to improve quality. Tables 3.10 and 3.11 suggest that there is a great deal of inter-firm cooperation, to the extent that most firms in the sample seem to cooperate with their suppliers and customers on matters of product development and quality. Barnes suggests that this cooperation involves collaboration on design and product specifications. Also involved in this collaboration are the SABS and testing facilities at various universities (e.g. Stellenbosch).

Table 3.10 Do you consult with your suppliers when designing new products?

	Exporters	Non-exporters
YES	7	21
NO	1	3

Source: Barnes (1998)

Table 3.11 Do your important customers assist you with quality control?

	Exporters	Non-exporters
YES	8	22
NO	0	2

Source: Barnes (1998)

The relationships between parent (foreign) and local firms are particularly important, both for assemblers and components manufacturers. Through the franchise modality of involvement with South African firms, the parent companies are engaged in technical support,

training programmes and financial commitment in terms of investment. Barnes (1999) found that these links were fostered by the following factors:

- Levels of foreign ownership and investment have been increasing and trade, especially exports, expanding. Direct equity stakes by Nissan and Toyota could be the forerunner of direct Japanese investments in the component industry.

- Until the early 1990s, with the exception of the German companies (Mercedes, BMW and Volkswagen), all local assembly operations were domestically owned and operated under licence. This has changed substantially, and much closer links have developed between the local firm and the overseas parent (box 2).

- Ford and General Motors have taken substantial equity stakes, with Ford recently increasing its stake to 90 per cent in Samcor (now renamed Ford) that produces Ford and Mazda vehicles.

- Political acceptability (of South Africa) and an automotive policy that encourages exports and, therefore, specialization, have given strong encouragement to parent companies to increasingly incorporate their South African interests into their global networks.

- There has also been significant foreign investment, particularly by German firms, in the component industry in areas such as tyres, catalytic converters, engines, seating and axle assemblies.

- Certain South African automotive firms have subsidiaries in the region and South Africa tends to act as regional headquarters to foreign firms with interests in southern Africa. Examples include South Africa's US$ 33 million investment in the Afinta Motor Corporation of Swaziland for the assembly of medium to heavy commercial vehicles, and a US$1.04 million investment by Nissan (SA) in the Quest assembly plant in Zimbabwe for the manufacture of a range of Nissan vehicles (*BusinessMap,* 2000, unpublished data).

Box IX Expansion at BMW (SA)

BMW (SA) has benefited greatly from its close association with the parent company in Germany. Substantial amounts of investment in plant and equipment, technology transfer and improved access to international markets of the parent company have been some of the factors associated with its rise in production and exports. The South African manufacturer is currently fulfilling a US$ 652 million export order of the 3-Series BMW vehicles to BMW markets all over the world that were traditionally served by the BMW parent company in Germany. These markets include the United Kingdom, Japan, Australia, the United States, Hong Kong (China), New Zealand, Taiwan Province of China and Germany. Each of the exported vehicles has a domestic component percentage of at least 60 per cent. In addition to the export of cars, SA Trim, a BMW-owned producer of leather seating, has an export contract worth 1 billion rand to supply leather seat covers to all BMW markets around the world. It is these kinds of "parent-subsidiary" linkages that are very important for providing access to international markets.

Source: BMW (SA)

B. Learning processes

Work organization – the manner in which production/assembly is structured – is important for achieving and maintaining a competitive edge in the automotive industry. South African automotive producers have been relatively slow in adopting the "lean production" methods that have contributed to the expansion of the Japanese automotive industry and to the success of Japanese transplants in the United States and the United Kingdom (Black, 1994). Broadly defined, "lean production" not only includes production, but also linkages to suppliers and to the distribution system.[62] In the South African industry, low education levels of the labour force and a legacy of shopfloor conflict seem to impose constraints on the introduction of a production system which is essentially dependent on a much more motivated workforce. South African firms appreciate the need to introduce more automation but are again constrained by the absence of policies that would create both high levels of training (multi-skilling) and commitment from the workforce. Therefore, marginal gains from the introduction of more automation are limited as they depend on a workforce that is committed and sufficiently skilled to handle the automation. Although automation is a significant method for improving labour productivity, in lower-wage countries such as South Africa and Brazil, it is indeed likely that automation may be introduced more for reasons of improving quality than to lower costs (see Krafcik J, 1989).

[62] "Lean production" is a system that was pioneered by Toyota in the early 1980s, which has as its main elements: continuous improvement, teamwork, flexibility and close relationships between producers, suppliers and the distribution network.

C. Labour productivity

In general, the automotive industry in South Africa suffers from low levels of labour productivity. South African firms are on average not as competitive in terms of their operational dynamics as their more aggressive European counterparts (see table 3.12); they nevertheless still possess a labour-cost advantage (see table 3.13), which suggests that there is potential for South African firms to improve their competitiveness and expand production. However, there are some firms that are very competitive and have been able to achieve high levels of labour productivity. This point is supported by table 3.12, which shows that regarding quality (customer returns and internal defects) and human resource development, in particular, some individual South African firms are more competitive than their European counterparts, but perform much worse on an industry average.

A low skill base, both at the managerial and at the shop floor level, is a key constraint in the automotive industry. Almost all surveyed firms (94 per cent) agreed that the lack of sufficient skills and/or the high cost of the available small pool of skills had affected productivity and competitiveness levels. Surprisingly though, average levels of expenditure on training in the industry are quite low (compared with other industries in South Africa). On average, firms spend 1.4 per cent of their total remuneration costs on training. This is a factor that also contributes to the low labour productivity in the industry.

South African firms actually have a labour cost advantage over their European counterparts that to some extent compensates for the lower average output per employee. Although this may suggest that operational competitiveness is lacking in the South African automotive industry, it does not rule out the potential for future improvements.

Box X. Learning German in South African assembly plants

An interesting learning process that is currently in practice at the BMW and Daimler-Chrysler plants in South Africa is language instruction. Local managers and shop floor workers are benefiting from lessons in the German language from hired experts who have been instrumental in improving the literacy levels at these plants. Since there is an increasing German involvement in the operations of the local subsidiaries, and since local managers and workers now deal more often with German supply networks and markets, providing German lessons improves coordination and flexibility within the individual firms, and between the firm and its supply networks and markets.

Source: Authors

Table 3.12 Average competitiveness benchmark findings for firms in South Africa and Western Europe, including an outline of the best performing firms, 1997

Market driver	Measure	South Africa Average	South Africa Best	W. Europe Average	W. Europe Best
COST CONTROL	Raw material stock: days	44	4.2	15.1	7.5
	Work in progress: days	9.9	3	7.6	1.8
	Finished goods stock: days	15.2	0.2	6.7	3.2
Quality	Internal defects: percentage	4.4	0.4	3.4	0.9
	Customer returns: (parts per million)	20 285	38	265	50
Human resource development	Absenteeism: percentage	6.8	2.5	5.4	4.1
	Labour turnover: percentage	9.9	2.0	9.5	4.0
	Expenditure on training as a percentage of remuneration	1.4	2.7	2.0	2.6
Innovation	R&D expenditure as a percentage of turnover	0.8	2.0	5.4	12.5

Source: Barnes (1999)

Table 3.13. South African vs. European firms' output/average remuneration costs per employee

Firm	Output per employee (US$)	Average remuneration costs per employee (US$)	Remuneration costs as a percentage of employee output
South African firms	34 426	6 149	17.9
European firms	136 393	25 559	18.7
South African as a percentage of European figures	25.2	24.1	95.7

Source: Barnes (1999)

CHAPTER III

SUPPORTING THE AUTOMOTIVE INDUSTRY: POLICY AND INSTITUTIONS

Institutional support and selective policy interventions have played an important role in the development of an internationally competitive industry in South Africa. In this chapter we focus on the role of the Department of Industry and the South African Bureau of Standards. The former was responsible for the local content programmes, and at present it is responsible for the Motor Industry Development Programme (MIDP), which involves formulating, implementing and monitoring the MIDP. The South African Bureau of Standards has been instrumental in substantively influencing the restructuring of the automotive industry and its integration into the global economy. It is a statutory organization responsible for the development and publication of standards, certification and testing of standards. As such, it is important for technology transfer and innovation in terms of both product and process development.

1. Motor Industry Development Programme (MIDP)

From a policy perspective, the automotive industry in South Africa has been driven by a series of local content programmes, very high tariff protection, and, more recently, the Motor Industry Development Programme that runs until 2007. The MIDP has marked a shift from import substitution to export orientation.

In 1960, the domestic content of a locally assembled vehicle was only 20 per cent. This prompted the introduction of the first of a series of local content programmes in 1961, resulting in a rapid rise of local content to 52 per cent on a mass basis by 1971. Later phases of the programmes increased local content requirements to 66 per cent for all light vehicles.[63] The main objective behind these programmes was to minimize the use of scarce foreign currency. Phase VI of the local content programme, introduced in 1989, marked a substantial change of direction. It was the first attempt to address the problems of an inward-oriented, severely fragmented industry with low volume output and associated high unit costs. Under this programme, local content was to be measured not just by the value of domestically produced components fitted to locally assembled vehicles, but also on a net foreign exchange usage basis. In other words, exports by an assembler counted as local content and enabled it to reduce actual local content (to a minimum of 50 per cent) in domestically produced vehicles. Exports, especially of components, grew extremely rapidly and gave assemblers greater flexibility in their sourcing arrangements.

In 1995, Phase VI of the local content programme was replaced by the Motor Industry Development Programme. It was introduced after a comprehensive consultative process

[63] This requirement was introduced under Phase III of the local content programme in 1971 and was extended to light commercial vehicles in Phase V, introduced in 1980.

involving all industry stakeholders. This consultative process continues through the Motor Industry Development Council. The MIDP continued the direction taken by Phase VI and entrenched the principle of export complementation. However, it went a step further by abolishing local content requirements and introducing a tariff phase-down at a more rapid rate than was required by South Africa's WTO obligations.

The MIDP consists of two parts:
- Light Vehicle Programme; and
- Medium and Heavy Vehicle Programme.

A. Light Vehicle Programme

The Light Vehicle Programme covers passenger vehicles, mini buses and light commercial vehicles. To participate in the Programme, assemblers have to be registered vehicle assemblers and have to undertake completely knocked down (CKD) assembly of vehicles. The key elements of the programme are as follows:

- The excise-duty-based local content system, which applied under Phase VI, has been replaced by a tariff-driven programme;[64]

- There is no minimum local content requirement;

- Tariffs are being phased down to 40 per cent for light vehicles and to 30 per cent for components by 2002 (see table 3.14);

Table 3.14 Import duty phase-down for light vehicles and components under the MIDP

Year	Vehicles	Components
1995	65.0	49.0
1996	61.0	46.0
1997	57.5	43.0
1998	54.0	40.0
1999	50.5	37.5
2000	47.0	35.0
2001	43.5	32.5
2002	40.0	30.0

Note: Tariffs for each year are applicable from 1 January.
Source: DTI, 2000

[64] This implies that a single tariff will apply to all components as opposed to the previous system under which each component had its own excise duty.

- Manufacturers of light vehicles are entitled to a duty free allowance (amounting to 27 per cent of the wholesale value of the vehicle) for the import of original equipment components;

- Import duty on components and vehicles may be offset by import rebate credit certificates derived from the export of vehicles and components.[65] The value of the certificates is equal to the net foreign currency earnings of the exports, that is the FOB export value less foreign currency usage in the manufacture of exported products. The prevailing duty on components (table 3.14) applies to the balance.

- The programme also contains a provision for additional duty free allowance, which is a facility granted to vehicle manufacturers assembling vehicles for the domestic market. The facility allows for up to 27 per cent of the components of locally produced cars to be imported duty free.

The Department of Trade and Industry conducted a mid-term review of the MIDP recently. While the MIDP is perceived by the South African Government as having had a generally positive effect in terms of increasing exports and improving productivity, a number of changes were introduced, effective from July 2000, as follows:

a) The MIDP has been extended to 2007 in order to provide a long-term planning environment;

b) Tariffs on imported light vehicles will be reduced from 2003 by 2 percentage points per annum, to 30 per cent in 2007. Tariffs on original equipment (OE) components will be reduced from 2003 by 1 percentage point per annum, to 25 per cent in 2007;

c) The small-vehicle incentive is being phased out as it is seen as having served its purpose;

d) The duty free allowance on imported components is being maintained at 27 per cent;

e) The import rebate credit facility for component exports is being reduced from the current 1:1 ratio to 1:0.6 by 2007;

f) The ratio of exports of components exported versus CBU (Completely Built Up) light motor vehicle imports is being adjusted from 1:0.75 to 1:0.6 by 2003 to encourage component manufacture; and

g) A productive asset allowance (PAA) has been introduced to encourage investment (see appendix 1 for details).

B. Medium and Heavy Vehicle Programme

At the introduction of the MIDP in 1995, the South African Government adopted the view that medium and heavy vehicles were key items of capital equipment and should be available at competitive prices. Protection was therefore sharply reduced. Although this industry was

[65] The significance is that it enables exporters to earn import credits, which they can then use to source components at close to international prices.

not subjected to a formal mid-term review, it was decided to investigate the rebate provision for drive train components (automatic diesel engines, gearboxes and drive axles) and the duty for assembled vehicles. Amendments, which came into effect in July 2000, include the following (see appendix 2 for further details):

a) The rate of duty on medium and heavy motor vehicles is to remain at 20 per cent;

b) The rebate on drive train components is to be amended to provide a full duty rebate;

c) The duty protection afforded to tyres is to remain at 15 per cent; and

d) The rate of duty on original equipment components is to be reduced from 30 per cent to 25 per cent from 2002 to 2007, by 1 percentage point per annum, as in the case of light vehicles. OE components can, however, be imported with a full duty rebate.

A survey of components producers (Barnes, 1998) shows that firms are well aware of the demands placed upon them, both in terms of the Phase VI Programme and the MIDP. They highlighted the need to significantly improve plant efficiency, expand investment and exports, and enhance technological capabilities. Firms indicated that customer demands drove the innovation process at the firm level. In particular, they mentioned the role of domestic customers in this process, while exporting firms emphasized the key role of international customers.

C. A critique of the MIDP

The MIDP is widely regarded as being successful, especially with respect to increasing investment and exports. This is consistent with the overall macroeconomic framework of Growth, Equity and Redistribution (GEAR) in South Africa that seeks to encourage renewed growth and sustainable development through investment and exports. Although the MIDP is sector-specific, the rationale behind it is not confined to the automotive sector.

Although the incentives that form part of the MIDP have been successful in encouraging exports, there have been complaints from other automotive producers in the southern African region (especially Zimbabwe), who find it difficult to compete with South African automotive products because the import-export complementation programme virtually subsidizes South African exports into the region. A study of the automotive industry in Zimbabwe by Muradzikwa (1999) revealed for the first time that Zimbabwe components producers view the MIDP as an obstructive framework that runs against the concept of fair trade.

Incentives, whether they are MIDP related or not, are almost always problematic. Firms are willing and sometimes able to abuse incentive facilities to their best advantage but to the detriment of the other more needy firms in the industry/economy. For instance, firms utilize incentives under the pretext of wanting to expand exports although they would have exported anyway even without the incentives. In this case, the incentives have not really achieved their objective. However, there is no evidence to suggest that such practices are happening with the MIDP pack of incentives.

2. South African Bureau of Standards (SABS)

The role of institutional support has been very important in South Africa, especially in terms of ensuring standards for the international market and enhancing quality competition. Institutions such as the South African Bureau of Standards (SABS), Department of Trade and Industry (DTI), and various research and academic institutes, all have a part to play in enhancing the competitiveness of the automotive industry.

The SABS plays a critical role, especially for firms wanting access to international markets. Goods are inspected, tested and analysed in terms of compulsory specifications, and are tested in accordance with numerous international test methods. Individual firms may also set standards against which products can be tested by the SABS. Commodities that do not meet the specified requirements are rejected, or even destroyed. For instance, the SABS destroyed a consignment of some 3,000 sets of brake pads that did not comply with compulsory specifications. Testing and certification facilities at the SABS are increasingly being considered as a passport to export opportunities for South African companies, and collaboration between the SABS and various automotive firms has been an encouraging feature in the industry's quest for international competitiveness.

Collaboration between the SABS and automotive firms has led to the establishment of various testing and certification facilities. One such example is the EuroType Test Centre (Pty) Ltd, a state-of-the-art laboratory that can perform vehicle emissions testing to the most exacting European, American and Japanese environmental requirements. Although South Africa manufactures and exports more than 1.5 billion rand worth of catalytic converters each year, it is the only major country in the world that does not require any control over the poisonous gases emitted by motor vehicles. Vehicles manufactured in South Africa for export to countries with strict air pollution requirements therefore need to be tested before leaving the country; hence the strategic importance of the EuroType Test Centre (see box 4).

Box XI. Euro Type-Test Centre

The EuroType Test Centre is a 30-million-rand investment in the Eastern Cape located near the Port Elizabeth/East London automotive cluster. It is critical for the export programmes of firms wanting to make inroads in international markets. The specifications of the facility include fuel temperature control, oil temperature control, combustion and transition control. The Centre has already secured contracts from Daimler-Chrysler and BMW to perform vehicle emission testing for all their export vehicles so as to be competitive in international markets. As the Managing Director of BMW, Ian Robertson has correctly asserted, "The EuroType Centre is invaluable in our efforts to penetrate additional overseas markets where international emission testing is a legal requirement".

Source: SABS

CHAPTER IV
SUCCESSFUL INTEGRATION INTO GLOBAL MARKETS: THE STORIES OF TWO FIRMS

In addition to the snapshots of firm experiences documented in the boxes in the paper thus far, the experiences of two firms are examined here in greater detail with a view to highlighting their success in integrating into global markets.

1. Bosal Automotive: innovating for global integration

Bosal Automotive produces a range of products from precision tubing, including exhaust systems, catalytic converters, tow bars, roof racks, jacks and warehouse racking systems. The Belgian parent company has 30 manufacturing plants in countries including the Netherlands, Canada, Mexico, the United States, and the Czech Republic, in addition to its South African plant. It also has 50 distribution plants around the world. Bosal's South African plant has been operating for more than 40 years.

Bosal has its group Research and Engineering Centre at Lummen, Belgium, with satellite centres at Ann Arbor, Michigan (United States), and Pretoria, South Africa. The key areas of activity include research, advanced engineering, product development, manufacturing and industrial development to cover the whole spectrum, from new product development to pilot production. These activities are aimed at developing new product models striving for leaner production, lower cost and shorter lead-time targets. Research into product innovation includes lightweight exhaust systems, weight reduction programmes for existing product lines and development of innovative technology. The company's exhaust plant in South Africa was awarded the QS 9000 Achievement Quality Award by the SABS in September 2000. Ford, General Motors and Chrysler determined the international quality standard, which is based on criteria of cost reduction, reduction of inspections required and consistency of quality. Bosal was the first South African exhaust manufacturer in South Africa to achieve this standard.

Also in September, 300,000 Daewoo cars of the Republic of Korea were fitted with South African manufactured catalytic converters. An agreement between Daewoo and Catalytic Converter Industries, a subsidiary of Bosal Automotive, for these converters followed an earlier order of 17,000 converters, indicating that Daewoo was convinced of the quality of the South African product. Bosal automotive engineers worked closely with their counterparts in Daewoo to develop a catalytic converter to meet the specific requirements of the Korean car manufacturer. This transfer of knowledge and cooperation in this venture has seen the development of a relationship of trust between the two firms in that the contract will continue for the duration of the model's life.

The South African firm has demonstrated its ability to meet the high technical standards of the international market place. This has involved adoption of manufacturing technology, organization and systems, which meet international best practice, with the

assistance of Daewoo. Skills development programmes were also undertaken and additional jobs created in a region of South Africa, which faces a daunting unemployment problem.

2. Volkswagen of South Africa: export-led skills development and employment creation

Volkswagen of South Africa (VWSA) is the largest foreign employer in South Africa, directly employing 6,500 workers. Employees receive extensive education and training opportunities, ranging from basic literacy and skills training to assistance with tertiary education.

Exports of VW vehicles have grown rapidly over the past six years. In 1994, VWSA began a three-year contract to export its Jetta models to China in a deal worth over US$ 208.33 million in foreign exchange earnings. In 1997, 6,000 VW vehicles were exported to Europe, Australia and Africa, and in 1998, VW (SA) exported 5,000 "generation three" Golf Gti vehicles to the United Kingdom in a deal worth US$ 72.7 million. The South African manufacturer currently has an export order for 68,000 Golf 4 vehicles to Europe, making VW the biggest vehicle exporter in Africa. This Golf 4 deal is worth US$ 746 million, and a total of US$ 22.39 million in capital expenditure has been undertaken to upgrade plant, tooling and equipment at the VW Uitenhage plant within the Port Elizabeth/East London cluster. Over 1,000 new jobs have been created to meet this large export order and more than US$1.49 million has been invested in training for employees working in the export programme. Such skills development has the potential to improve labour productivity and competitiveness, and this in turn provides a sound base for further export expansion and integration into the global markets.

These two success stories of firms illustrate that from being isolated in a South African market by high protection barriers, it is possible within a relatively short period of time (just over a decade) to become integrated into global markets and to be able to compete on the basis of the exacting standards of these markets. This has been achieved through the policy support of the MIDP and through greater market access that is related to the global auto producers investing in local subsidiaries.

CONCLUDING REMARKS

The automotive industry in South Africa has evolved from a highly protected, inward-focused industry to one with a marked export orientation, able to compete effectively in global markets. A number of specific characteristics of the South African automotive industry have contributed to its integration into international markets. Those characteristics include extensive foreign ownership of both vehicle assemblers and components manufacturers; close links with parent companies; and effective linkages between assemblers and component manufacturers. Links with parent companies have facilitated technology and skill transfers, as well as organizational development, and they have provided access to international markets; at the same time linkages between assemblers and components manufacturers have been instrumental in driving technological development and setting industry standards.

At present the South African automotive industry is facing the challenges of competitive international markets. Given the history of tariff protection, this is not easy. Current developments in the industry suggest an increasing trend towards integration into global production networks and this has already resulted in various benefits for the local industry in terms of technology transfer and related spillovers.

Guided by the MIDP, which is an industry-specific policy approach, the automotive industry is striving to develop a competitive advantage. As has been indicated by firm-specific experience, different routes to integration into the global markets are possible. Competitive advantage may be built on technological development (either in terms of product or process), productive and organizational efficiency and quality standards.

The key factors that have assisted in integrating the industry into global networks have been the incentives provided under the MIDP, falling tariff protection that has increased import competition, the supportive role of institutions such as the SABS, and access to international markets through the parent company. Supported by these factors, the vehicle assemblers have positioned themselves to compete globally by embarking on intense export-driven manufacture of vehicles and components.

The components producers, however, have enjoyed relatively fewer benefits. The rapid decline in protection that has left the industry exposed to surging import competition, and the fact that vehicle assemblers are able to source components from overseas directly under the import/export complementation scheme of the MIDP, have worsened their situation.

South Africa has been gradually adjusting its automotive industry support programmes, which have powerfully assisted export expansion, to make them compatible with WTO rules. For example, the import-export complementation scheme of the local content programmes would have been found inconsistent with the WTO Agreements that entered into force in 1995. In particular, local content programmes are included in the illustrative list of the Trade-Related Investment Measures (TRIMs) Agreement, as measures that are inconsistent with the obligation of national treatment provided for in paragraph 4 of Article III of GATT 1994. Therefore the South African authorities eliminated local content requirements in 1995.

Moreover, the excise-duty-based local content system would have qualified as a subsidy. The excise duty is a financial contribution by the Government in the form of fiscal incentives, which confers a benefit to the recipient and is specific to an industry. Thus it fits the definition of an actionable subsidy under the WTO Agreement on Subsidies and Countervailing Measures. Furthermore, for a subsidy to be actionable, the Subsidies Agreement requires the determination of adverse effects on the interests of another Member. Adverse effects include injury to the domestic industry of another Member, nullification or impairment of benefits accruing directly and indirectly to another Member under GATT 1994 – in particular the benefits of concessions bound under Article II of GATT 1994 – and serious prejudice to the interests of another Member.

Because of the high integration of the South African automotive industry with parent companies, it is unlikely that adverse effects may have occurred, at least in the form of injury to the domestic production of another Member or by way of nullification or impairment of benefits accruing directly and indirectly to another Member under GATT 1994. In this case, those adverse effects may have arisen from the displacement or impediment of imports of a like product of another Member into the market of the subsidizing Member. However, other automotive producers in the southern African region have seen their ability to compete with South African automotive products undermined by the fact that the import complementation programme virtually subsidizes South Africa's exports into the region. In this case, adverse effects may take the form of injury to the domestic production.

Export-import complementation schemes are used by other developing countries in the context of regional integration processes, such as in the cases of the Southern Common Market (MERCOSUR)[66] and the Andean Community[67] in Latin America. These automotive regimes include, in addition to the aim of establishing a competitive sector integrated into the global market, the objectives of regional free trade and regional integration.[68]

[66] See website: www.mercosur.org.uy: MERCOSUR/CMC/DEC N° 04/01, *Política Automotriz del Mercosur*
[67] See www.comunidadandina.org: *Convenio de Complementación en el Sector Automotor*
[68] For details on exports, see United Nations/CEPAL (2001), *La Inversión Extranjera en América Latina y el Caribe*. Chile, 2002.

APPENDICES

Appendix 1: Productive Asset Allowance

To encourage investment in plant modernization a new support package has been introduced in the form of a productive asset allowance (PAA), effective from 1 July 2000.

Government policy has sought to encourage greater scale economies, and, in line with world trends, certain South African-based manufacturers are moving towards common platform engineering[69] with a reduced number of component suppliers.

The PAA is a non-tradable duty credit calculated at 20 per cent for the qualifying investment in productive assets, which will be spread equally over five years. Assemblers can utilize this duty credit against CBU imports only, which will sustain the range of products being offered to the consumer but not necessarily locally produced. Marginal low volume products could therefore be discontinued and production capacity focused on higher volume products for global consumption.

Components manufacturers who are being encouraged by these assemblers to invest in new plants and tooling to support their own expansions will be awarded the same PAA as noted above, with the provision that 80 per cent of the duty saved be passed on to the component manufacturer. The 20 per cent remaining duty saved by the assemblers on such investments will serve as encouragement for strategic investments in components to supply local assembly plants. What this means for the components manufacturers is that they have access to duty free imports (either of machinery and equipment, or of components that are produced in low and unprofitable volumes in South Africa) measured as 20 per cent of the value of productive investments made by the manufacturers. This would enable the components manufacturers to access inputs and technologies at world prices, thereby increasing their potential competitiveness. To qualify, assemblers must submit a detailed business plan to the Director General of the Department of Trade and Industry, which is considered according to strict criteria on a case-by-case basis for the most recent investments in the industry. Companies, which received support through the now discontinued Tax Holiday Scheme, or any other investment support, will not be considered.

[69] A situation whereby a single chassis (platform) is used to produce different makes of the same model of vehicle. For instance, BMW uses a single chassis (platform) to produce the 3-Series that has six models: 316i, 318i, 320i, 323i, 325i, and the 328i.

Appendix 2: Mid-Term Review: Amendments to the Medium and Heavy Vehicle Programme

Date	Duty	Extent of rebate			
	OE Components	Drive-train components	Tyres	Cabs/bodies	Other components
1 Jan 2000	35 %	Full duty less 15 per cent	Full duty less 15 %	Full duty	Full duty
1 Jul 2000	35 %	Full duty	Full duty less 15 %	Full duty	Full duty
1 Jan 2001	32.5 %	Full duty	Full duty less 15 %	Full duty	Full duty
1 Jan 2002	30 %	Full duty	Full duty less 15 %	Full duty	Full duty
1 Jan 2003	29 %	Full duty	Full duty less 15 %	Full duty	Full duty
1 Jan 2004	28 %	Full duty	Full duty less 15 %	Full duty	Full duty
1 Jan 2005	27 %	Full duty	Full duty less 15 %	Full duty	Full duty
1 Jan 2006	26 %	Full duty	Full duty less 15 %	Full duty	Full duty
1 Jan 2007	25 %	Full duty	Full duty less 15 %	Full duty	Full duty

Note: The extent of the rebate on cabs of an integrated load-body design and panel vans/buses under rebate item 317.07 as well as the CKD definition for these vehicles as set out in Chapter 98 is to be further investigated to ensure that these vehicles comply with the CKD definition applicable to light motor vehicles.

Source: DTI Press release, 2000

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Part III

International Dimension

The Case Studies in the Light Of Multilateral Rules

INTRODUCTION

The three case studies[70] on transfer of technology for successful integration in the global economy, namely the aircraft industry Embraer – in Brazil, the pharmaceutical industry in India and the Automotive Industry in South Africa, were analysed at the UNCTAD Expert Meeting on Best Practices on Transfer of Technology.[71] Experts agreed that the studies show that national policies have played a crucial role in enhancing capacity building, promoting investment in research and development (R&D) and fostering exports. However, in order to extract relevant lessons for other developing countries, national policies have to be viewed from the perspective of the commitments made by the country Members under the WTO Agreements.

The case studies covered by this analysis refer to policy measures that may have a bearing on the rights and obligations accruing on account of WTO rules, more particularly those contained in the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), the Agreement on Trade-Related Investment Measures (TRIMs) and the Agreement on Subsidies and Countervailing Measures (SCM). The multilateral rules that came into force in the mid-1990s changed the scope and the extent to which Governments can apply their policies in certain areas of productive activity. Consequently, following the entry into force of the WTO Agreements, Governments adjusted their policies to make them compatible with the provisions contained in these agreements.

Hence, it is worth analysing each one of these Agreements, focusing on provisions concerned with the policies followed by the Governments in the different case studies, with a view to attempting to identify the relevance of WTO rules for particular policy efforts related to technological capacity building in the sectors covered by the studies.

In addition to the agreements already mentioned, rules under the General Agreement on Trade in Services (GATS), the plurilateral Agreement on Government Procurement and provisions referring to home country measures, as well as the ongoing negotiations under the mandate of the Fourth Ministerial Conference, may affect the design of national policies aimed at promoting investment and technological innovation.

This part is organized as follows: chapter I provides a brief review of the case studies from the perspective of the national policies adopted for the different sectors and the adjustment that these policies underwent in order to make them compatible with the commitments assumed by WTO Members as a result of the Uruguay Round of Multilateral Trade Negotiations. Chapter II presents the main provisions of the WTO Agreements that are relevant to the policy instruments identified in the case studies. It covers provisions of the TRIPS, the TRIMs and the SCM Agreements, as well as the aspects of the ongoing negotiations related to them. Provisions under other agreements that may be relevant in promoting technological capacity building are also included. Finally, Chapter III concentrates

[70] See Part II.

[71] UNCTAD/UNDP Global Programme on Globalization, Liberatization and Sustainable Human Development: Best Practices in Transfer of Technology. Meeting on Transfer of Technology for Successful Integration in the Global Economy. Geneva, 11 to 12 April, 2002.

on the institutional aspects that contribute to making sectoral policies yield their intended result, and presents preliminary policy considerations.

CHAPTER I

MAIN POLICY INSTRUMENTS IDENTIFIED IN THE CASE STUDIES

1. Main policy instruments in the case study of Embraer

Major policies in the establishment and development of the Brazilian aircraft industry were government support and technology strategy. The Brazilian Government had continuously supported technological capacity building in the sector since the setting up of the Aeronautic Technology Centre (CTA) in 1945 and, soon after, of the Aeronautics Technological Institute (ITA). The aim of these institutions was to train high-quality engineers with a view to establishing, developing and acquiring skills and capabilities in aircraft manufacture. The ultimate goal was the setting up of a national aircraft industry, for which the previous development of the requisite resources and technological capabilities was necessary. The CTA and the ITA played a central role in that strategy.

As discussed in part II, after the setting up of the national company as a government-controlled enterprise, the Brazilian Government offered solid and continuous support to Embraer through the allocation in its budget of sufficient financial resources to science and technology infrastructure, procurement and tax incentives and benefits. The Government supported a coherent and continuous technological policy targeting Embraer and several institutes of the Aeronautic Technology Centre and promoting an intense interaction among those institutes and Embraer. This allowed Embraer to develop a technological learning process and, consequently, to obtain an uncommon competitive position compared with the position in other developing countries.

Additionally, the technology strategy envisaged the acquisition of "technology autonomy" entailing "the capacity to understand the whole technological cycle of aircraft production by developing and manufacturing". Consequently, Embraer's initial plans encompassed manufacture of aeroplanes through aircraft projects designed and conceived locally by local engineers and technicians. Since Embraer's early stages, licence and cooperation agreements with foreign companies were essential for supplying the civil and military domestic markets. These agreements, as well as sales agreements with airline operators, including technical assistance and aircraft maintenance, and agreements for the manufacturing of complex components by order, had a significant impact on the development of Embraer's human resources capabilities. In some agreements, the Brazilian Government made it mandatory that Embraer's employees would get skills upgrading in engineering. In fact, it was through procurement that technological learning was made viable and feasible to a great extent. This government policy, particularly that of the Ministry of Aeronautics, imposed on outside partners associated with Embraer the requirement of local production to foster people-to-people technology transfer.

Although, Embraer’s successful strategy of competition and innovation in the 1990s occurred during a period of rupture in government support for CTA and other local technological institutions, the company was able to cope with this situation in part because of the technological capacity built during the previous stages. The cycle of technological

innovation is now perceived as a business dynamic not exclusively restricted to the routines of R&D. As a result of this strategy, throughout the 1990s Embraer increased its participation in the world market for aircraft and became a prominent actor in a very competitive environment.

Even in those days as a private company, Embraer continued to be supported by the Federal Government through a programme of export financing. Coming from a developing country, Embraer had experienced difficulties finding international banks and financial institutions willing to finance the sale of its aeroplanes. In this type of market the sale of a good is coupled with a financing package. In this sense, the programme of financing exports (PROEX) of the Brazilian National Economic and Social Development Bank (BNDES) not only provides the financial package but also, most important, has a scheme of interest rates equalization under which the financing party is granted equalization payments to cover, at most, the difference between the interest charges contracted with the buyers and the cost to the financing party of raising the required funds.[72]

The other significant policy initiative of the Federal Government that partly affected Embraer is the fiscal incentive to stimulate technological upgrading. Under this policy, industrial and agricultural firms are allowed to reduce the outstanding income tax on account of R&D expenditures and the value added tax on equipment acquired for R&D activities and accelerated depreciation of equipment and instruments acquired for R&D.

2. Main policy instruments in the case study of the pharmaceutical industry

The policies followed for the pharmaceutical industry in India evolved from subjecting the industry to strict government control in the 1970s to freeing it almost completely to allow market forces to guide the sector in the 1990s. The government policies for the sector were gradually brought in to consonance with the new international scenario following the entry into force of the WTO Agreements.

Development of the pharmaceutical industry was the result of a mix of policies put in place by the Government in different time periods and institutional technological building.

In the 1970s and 1980s, the Indian national drug policy was based on expansion of domestic manufacturing capacities through development of local R&D facilities or import of technology; the price controls, used to keep drugs affordable to the masses; and the existing patent regime. Expansion of capacities was encouraged by incentives to the Indian drug manufacturers and imposing conditions on the foreign-controlled firms. This policy helped to create the manufacturing and technological capabilities needed for competitive drug production.

In the 1990s, the new drug policy aimed at freeing the industry from the limitations imposed by government regulations, which was in keeping with the market-oriented reforms introduced in 1991. Foreign investment policy was liberalized, price controls were drastically reduced and local content requirements were removed. Thus, the pharmaceutical industry

[72] Resolution 2380/97 of the Brazilian Central Bank, 25 April 1997.

showed impressive growth in terms of production, exports and imports, as well as R&D expenditure (see tables 2.7, 2.8, 2.11 and 2.12 in the study).

The Indian patent regime, modified in the 1970s, was one of the main policy instruments playing a major role in the development of the technological capability of the Indian firms. In respect of pharmaceutical inventions, the Patents Act, 1970, provided a reduced patent term (five years from grant or seven years from the date of filing, whichever is shorter), granted only process patents, and subjected pharmaceutical inventions to "licences of right" – a form of automatic licence granted for patents in the field of drugs and medicines with a stipulation that a maximum of 4 per cent royalty be paid to the patentee by the licensee. The process patent regime was adopted with a view to encouraging innovation in a country such as India with limited technological capability and scarce financial resources to devote to R&D. This patent regime thus gave the Indian firms the opportunity to produce patented drugs through reverse engineering in order to meet the needs of the domestic markets in the first instance and later to export the drug to the larger markets in the developed countries when the patent on the product had expired.

The Indian Government also provided specific support to pharmaceutical firms that engaged in R&D. This support took the form of tax concessions and exemption from the purview of price controls.

As highlighted in part I, the pharmaceutical industry is a science-and technology-intensive industry, and drug companies compete primarily on the basis of the products they can bring to the market, which are the result of their own R&D efforts. That explains the importance of the patent system and reverse engineering for this industry. Institutional support and interaction between private sector firms and publicly funded laboratories that are active in drugs research have been crucial for technological change in the Indian pharmaceutical industry. The Indian Government has launched several programmes aimed at promoting R&D in drugs and pharmaceuticals, which are considered efficient, sustainable and reliable in the pharmaceutical sector in India. These programmes support intense networking between academia, government and industry for facilitating the funnelling of intellectual resources towards significant incremental progress.

3. Main policy instruments in the case study of the automotive industry

The automotive sector has evolved from being a highly protected, inward-focused sector to being market-export-oriented and able to compete in foreign markets. Specific characteristics of the South African automotive industry, including extensive foreign ownership, close links with parent companies and effective linkages between assemblers and components manufactures, have contributed to its integration into international markets.

From the policy perspective, the automotive industry in South Africa has been driven by a series of local content programmes, very high tariff protection, and recently, by the Motor Industry Development Programme (MIDP), which will run until 2007 and has marked an about-turn from import substitution to export orientation.

The incentives provided under the MIDP, decreasing tariff protection that increased import competition, the supportive role of institutions such as the South African Bureau of

Standards (SABS) and access to international markets through the parent company were key factors assisting in integrating the industry into global networks.

During the 1960s and the 1970s, the local content programme increased local content requirements by up to 60 per cent for light vehicles. In 1989, a substantial change was introduced to address the problems of an inwardly oriented industry. Under phase VI of the local content programme, local content was to be measured not just by the value of domestically produced components but on a net foreign exchange usage basis. In other words, exports by an assembler counted as local content and enabled it to actually reduce local content in domestically produced vehicles to a minimum of 50 per cent.

The MIDP, introduced in 1995, continued to enhance the principle of export complementation but went even further. It abolished the local content requirements and introduced a tariff phase-down at a more rapid rate. The system where each component had its own excise duty based on local content was changed to a tariff driven programme where a single tariff applies to all components. Tariffs are phasing down to 30 per cent for light vehicles and to 25 per cent for components by 2007. Manufacturers of light vehicles are entitled to a duty-free allowance (27 per cent of the wholesale value of the vehicle) for importing original equipment components. A duty-free allowance for up to 27 per cent of components to be imported duty-free is also granted to manufacturers assembling vehicles for the domestic market.

A scheme of import-export complementation applies to the importation of vehicles and components. Under this scheme, import duties on components and vehicles may be offset by import rebate credit certificates derived from the exports of vehicles and components. The value of the certificates is equal to the net foreign currency usage in the manufacture of exported products. The prevailing component duty applies to the balance. The significance of the system is that it enables exporters to earn import credits, which they can use then to source components at close to international prices.

The next chapter reviews the national policies adopted in the case studies in the light of the provisions of the relevant WTO Agreements, as well as the current multilateral negotiations on these issues.

CHAPTER II

SELECTED PROVISIONS OF THE WTO AGREEMENT RELEVANT TO THE IDENTIFIED POLICY INSTRUMENTS

1. Provisions of the TRIPS Agreement

The basic principles of the TRIPS Agreement, as in GATT, are non-discrimination features, prominently national treatment and most-favoured-nation (MFN) treatment. Article 7 states the objective of the Agreement: "[T]he protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conductive to social and economic welfare, and to a balance of rights and obligations". The obligations under the Agreement include giving protection to intellectual property rights (IPRs) as per the scope and term of protection specified therein. The IPRs covered by the Agreement are the following: copyright and related rights, trademarks, including service marks, geographical indications, industrial designs, patents, layout designs (topographies) of integrated circuits, and undisclosed information, including trade secrets.

As per the TRIPS Agreement, patent protection must be available for inventions for at least 20 years from the date of filing and for both products and processes, in all fields of technology. Members have the option to exclude certain inventions from patentability for specified reasons or subject matters. Specified reasons include protection of public order or morality, or human, animal or plant life or health, or to avoid serious prejudice to the environment. Specified subject matters include diagnostic, therapeutic and surgical methods for treatment of humans or animals, plants and animals, and biological processes for the production of plants or animals. Members may provide for limited exceptions to the rights of patentees, such as those for educational or research purposes not involving commercial benefits.[73] Governments are further allowed to issue "compulsory licences",[74] permitting a competitor to produce the product or use the process under licence, subject to certain specified conditions. However, no grounds are specified, thus leaving it open to Members to issue such licences on any grounds, subject to meeting the conditions outlined in Article 31 – "Other Use Without Authorization of the Right Holder".

When the WTO Agreement took effect in 1995, developed countries were given one year to ensure that their laws and practices conformed with the TRIPS Agreement. Developing countries and, under certain conditions, transition economies were given five

[73] Article 30 of the TRIPS Agreement.
[74] "Other Use Without Authorization of the Right Holder" Article 31 of the TRIPS Agreement.

years and least developed countries (LDCs) 11 years.[75] If a developing country did not provide product patent protection in a particular area of technology when the TRIPS Agreement came into force – 1 January 1995, it has up to 10 years to introduce such protection. However, if a WTO Member did not extend product patents protection for pharmaceutical and agricultural chemical products as on 1 January 1995, it had to provide a means through which patent applications could be filed from that date, although the patent did not need to be granted until the end of the transitional period. Further, exclusive marketing rights should be granted for those products subject to the applicants' meeting two specified conditions: (a) the applicant had filed for and obtained a patent in the territory of another WTO Member after 1 January 1995; and (b) the applicant had obtained marketing approval in that other Member. Such marketing rights are available for a five-year period after obtaining marketing approval, or until the product patent is granted or rejected, whichever is shorter. Table 4.1 summarizes the main dates in the application of the provisions of the TRIPS Agreement.[76]

Taking note of the provisions under Article 65 "Transitional Arrangements", the Indian Government chose to delay the extension of product patents to drugs and medicines until 2005. As has been indicated, the Indian patent regime granted only process patents for drugs and medicines. The regime left the Indian firms free to produce alternative processes for the drugs, which were not under patent protection in India. However, under this "weak" patent regime, there was a decline in the number of foreign drug patents in India ever since the Patents Act, 1970, became effective. Foreign inventors had very little incentive to take out patents in India.

The Patents Act, 1970, might have had a negative impact on transfer of embodied technology, although necessary technological capabilities were built up in the domestic industry through domestic policy initiatives, and alternative processes were developed for patented drugs. Under these initiatives, Indian firms were able to produce drugs for the domestic market at prices much lower than those of the proprietary products.

The Doha WTO Ministerial Conference in November 2001 adopted a Declaration on the TRIPS Agreement and Public Health (the Declaration) stressing that the TRIPS Agreement does not and should not prevent Members from taking measures to protect public health and affirming that it can and should be interpreted and implemented in a manner supportive of WTO Members' right to protect public health and to promote access to medicines for all. This Declaration points out the right of WTO Members to use, to the full, the provisions in the TRIPS Agreement that provide flexibility, and recognizes that these include the following: the right of each Member to grant compulsory licences and to determine the grounds upon which such licences are granted; and the freedom to establish its own regime for exhaustion of IPRs – which is the basis for parallel imports-without challenge, subject to the MFN and national treatment provisions of Articles 3 and 4 of the TRIPS Agreement. Another flexibility so recognized by the Declaration is that in applying the customary rules of interpretation of public international law, each provision of the TRIPS Agreement shall be read in the light of the objects and purpose of the Agreement as

[75] This provision for LDC Members has now been extended until1 January 2016 with respect to pharmaceutical products, for applicability or enforcement of the rights relating to patents and undisclosed information.

[76] For a detailed examination of the TRIPS Agreement and its implications for developing countries, see UNCTAD (1996).

expressed, in particular, in its objectives[77] and principles.[78] Mention should be made the Appellate Body in the Canada-Patent Term case clarified the fact that these two articles –7 and 8, respectively had not yet been interpreted in the WTO.[79] The Declaration should inform any future interpretation of the objectives and principles of the TRIPS Agreement.

The Declaration also recognized the difficulty faced by developing countries with insufficient or no manufacturing capacities in the pharmaceutical sector to take advantage of compulsory licensing, since Article 31 (f) of the TRIPS Agreement states that products made under such a system must be supplied predominantly for the domestic market. This applies directly to countries that can manufacture drugs – it limits the amount they can export when the drug is made under compulsory licence. This has an indirect impact on countries unable to make medicines and therefore desiring to import generics. They would find it difficult to find countries that supply them with drugs made under compulsory licensing. The Ministers instructed the Council for TRIPS to find a solution to this problem before the end of 2002.[80] It was after intense discussion that WTO member Governments agreed to allow any member country to export pharmaceutical products made under compulsory licences within a certain terms set out in the Decision of 30 August 2003.[81]

Accordingly, all WTO member countries are eligible to import under this Decision, but 23 developed countries are listed in the decision as announcing voluntarily that they will not use the system to import. A number of other countries announced separately that if they use the system it would only be for emergencies or extremely urgent situations. The decision covers patented products or products made using patented processes in the pharmaceutical sector, including active ingredients and diagnostic kits.

It should be noted that the decision takes the form of an interim waiver, which allows countries producing generic copies of patented products under compulsory licences to export the products to eligible importing countries. It is understood that this waiver would last until the TRIPS Agreement is amended. Therefore, countries with manufacturing capacities in the pharmaceutical sector, including developing countries such as India, would benefit from this decision that gives due effect to a compulsory licence issued by another Member for the production of goods intended for the market of that Member. In this case, generic drugs would be manufactured under a foreign license for exporting to the Member issuing the licence, not for supplying the domestic market.

[77] The objectives of the Agreement, contained in its Article 7, are that the protection and enforcement of IPRs should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations.

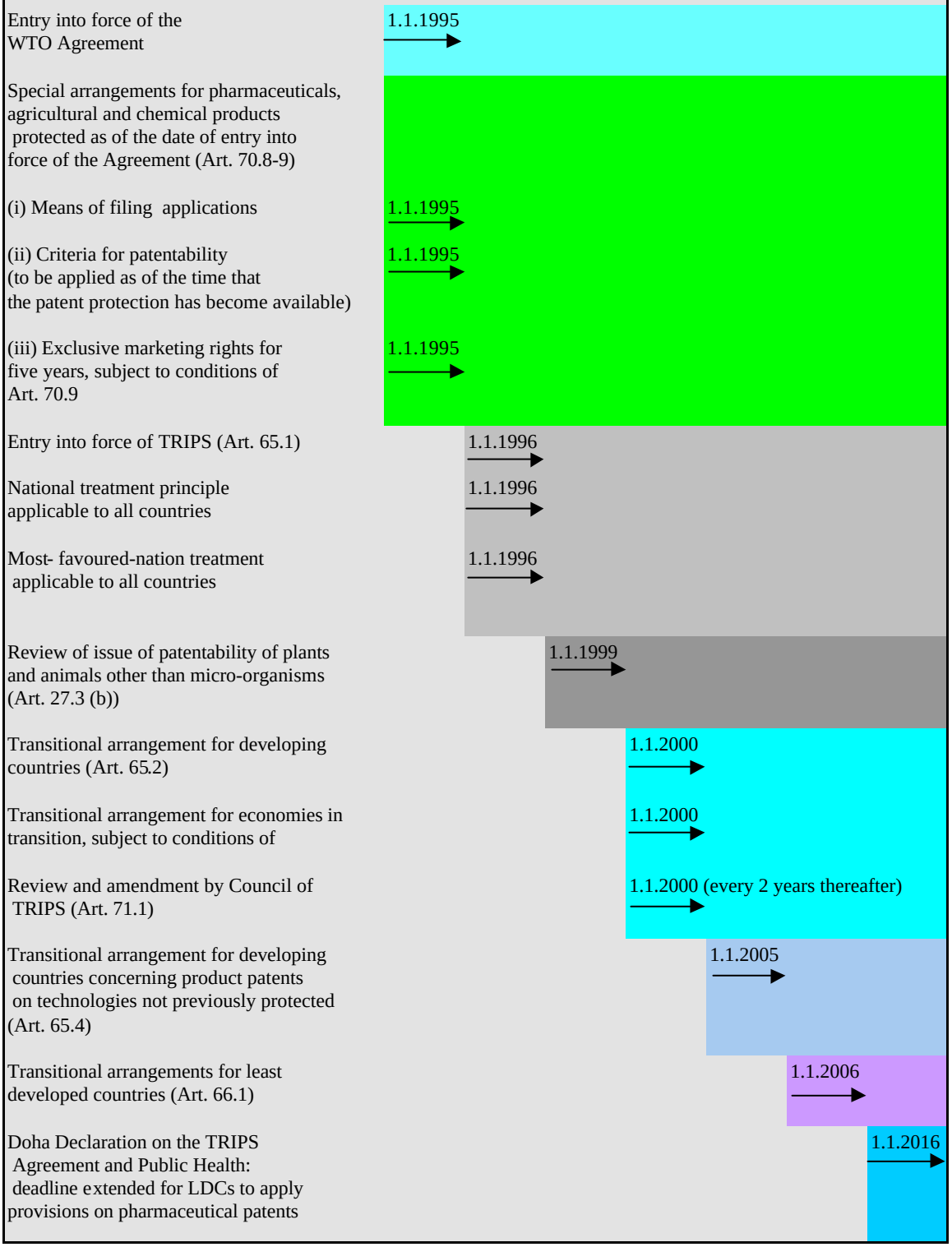
[78] The principles of the Agreement, contained in its Article 8, *inter alia* allow Members, in formu lating or amending their laws and regulations, to adopt measures necessary to protect public health and nutrition, and to promote the public interest in sectors of vital importance to their socio economic and technological development.

[79] See Report of the WTO Appellate Body. Canada-Terms of Patent Protection, paragraph 101, "...findings in this appeal do not in any way prejudge the applicability of Article 7 and Article 8 of the TRIPS Agreement in possible future cases with respect to measures to promote the policy objectives of the WTO Members that are set out in those Articles. Those Articles still await appropriate interpretation."

[80] See also Love (2002).

[81] Implementation of Paragraph 6 of the Doha Declaration on the TRIPS Agreement and Public Health, Ge neral Council, Decision of 30 August 2003.

Table 4.1
Main dates in the application of the TRIPS Agreement



Note: Based on UNCTAD (1996, Table 2).

On the demand side, since least-developed countries (LDCs) are the countries that need the most to acquire pharmaceutical products to cope with their health problems, the

Declaration on the TRIPS Agreement and Public Health reaffirmed the commitment of developed country Members to provide incentives – home country measures (HCM) – to their enterprises and institutions to promote and encourage technology transfer to such countries pursuant to Article 66.2 of the Agreement. Also, the Ministers agreed that the LDCs will not be obliged, with respect to pharmaceutical products, to implement or apply Sections 5 – Patents – and 7 – Protection of Undisclosed Information – of Part II of the Agreement or to enforce rights provided under these Sections until 1 January 2016, without prejudice to the right of least developed country Members to seek other extensions of the transition periods as provided for in Article 66.1 of the TRIPS.

The impact of the Declaration on the TRIPS Agreement and Public Health on the policy space available to developing countries such as India need to be clarified after the ongoing negotiations have been concluded. However, there should still be sufficient scope for policy intervention by developing countries in times of public health crises. In fact, even developed countries have resorted to such policy intervention in time of need.[82]

2. Provisions of the TRIMs Agreement

The TRIMs Agreement recognizes that certain investment measures can cause trade-restrictive and distorting effects. It states in Article 2 that no Member shall apply any measure that is inconsistent with the provisions of GATT 1994 Article III, paragraph 4 – NationalTreatment – or Article XI – General Elimination of Quantitative Restrictions. The Illustrative List of inconsistent measures in the Annex to the TRIMs Agreement includes measures which require particular levels of local purchases by an enterprise ("local content requirements") or which restrict the volume or value of imports that an enterprise can purchase or use to an amount related to the level of products it exports ("trade balancing requirements"). A developing country is free to deviate temporarily from the provisions of Article 2 to the extent permitted by Article XVIII of GATT 1994 – Governmental Assistance to Economic Development –, the Understanding on the Balance-of- Payments Provisions of GATT 1994 and the Declaration on Trade Measures taken for Balance of Payments Purposes adopted on 28 November 1979.[83]

Developing country Members were given a five-year period following the entry into force of the Agreement for eliminating all non-conforming TRIMs, and LDCs were allowed a

[82] For example, US regulation H.R. 3235 of 2001, in the wake of the anthrax crisis, allowed generic companies to export medicine or other health care products that are needed in order to address global public health emergencies, when the legitimate rights of the patent holder are protected in the export market.

[83] See the interpretation of the provisions of Article XVIII of GATT and the related Understanding and Declaration given by the WTO Panel and Appellate Body in the dispute India – Quantitative Restrictions on Imports of Agricultural, Textile and Industrial Products. In this respect, there is a view that the conditions and procedures for the application of Article XVIII: B of GATT have been made so stringent that developing countries are finding it difficult to take any action under it. See the Indian intervention in the Minutes of Meeting of the WTO Dispute Settlement Body, held from September 22 to 24 1999: …"The Appellate Body has also made some other important rulings which, India believed, had curtailed the scope of the developing country Members' substantive rights under Article XVIII:B". …. "The Appellate Body's interpretation had the consequence that stricter requirements were imposed on developing countries than on developed countries"…. This was supported and added to by Cuba, the Dominican Republic, Egypt, Indonesia, Jamaica, Malaysia, Philippines and Sri Lanka in the same meeting.

period of seven years for eliminating such measures (Article 5.2 of the Agreement). Article 5.3 states that the Council for Trade in Goods may extend the transition period for the elimination of TRIMs for a developing country, including LDCs, which demonstrates particular difficulties in implementing the provisions of the Agreement. Table 4.2 summarizes the main dates in the application of the TRIMs Agreement.

South Africa's import substitution policy for the automotive industry took the form of local content programmes. The Government sought to replace imported manufactures by indigenous output; thus, tariffs provided protective barriers for local industries to grow and develop. With the entry into force of the WTO Agreements, that policy was brought into line with the Agreements, and local content programmes were abolished and replaced by a tariff phase-down at a more rapid rate than required in terms of South Africa's WTO obligations.

Such local content programmes would have been found inconsistent with the TRIMs Agreement, on the ground that they were measures inconsistent with the obligation of national treatment, and therefore included in the illustrative list of the Annex of the Agreement. The local content requirements have been commonly used in many countries to foster the development of local automotive industries. They implied discrimination against imported goods and in favour of domestic goods.

Similarly, India adopted a local content programme in its drugs policy in 1978, and continued it until 1994, when it was phased out to bring it into compliance with the TRIMs Agreement. Brazil, on the other hand, adopted a strategy of 'technological autonomy', rather than local content requirement. It achieved its goal by insisting upon "local production"[84] for supplying the domestic market for aeroplanes, so that the technology is "learnt" by local engineers, and later applied for domestic production. For example, in the cases of MB-326 and Piper aeroplanes, Brazil insisted on the suppliers setting up production bases in Brazil rather than supplying planes from their home production.

It is worth noting that the Decision on Implementation-related Issues and Concerns adopted at the Doha Ministerial Conference took note of the request by some developing country Members for the extension of the five-year transitional period and urged the Council for Trade in Goods to consider positively the requests for extension by LDCs of the seven-year transition period under Article 5.3 of the TRIMs Agreement or Article IX – Decision Making – of the WTO Agreement. The latter provides that the Ministerial Conference may decide the waiver of an obligation imposed on a Member by the WTO Agreement or any of the Multilateral Trade Agreements. However, except for one Member,[85] no LDCs has notified any TRIM since 1995, and hence there is no effective extension facility of TRIMs for LDCs. Furthermore, most of the TRIMs for which extension is being sought are from the automobile sector. Thus, many developing and least developed Members question the utility of this facility.

Article 9 of the TRIMs Agreement provides that, not later than five years after the date of entry into force of the WTO Agreement, the Goods Council shall review the operation of the TRIMs Agreement, and as appropriate, propose to the Ministerial Conference

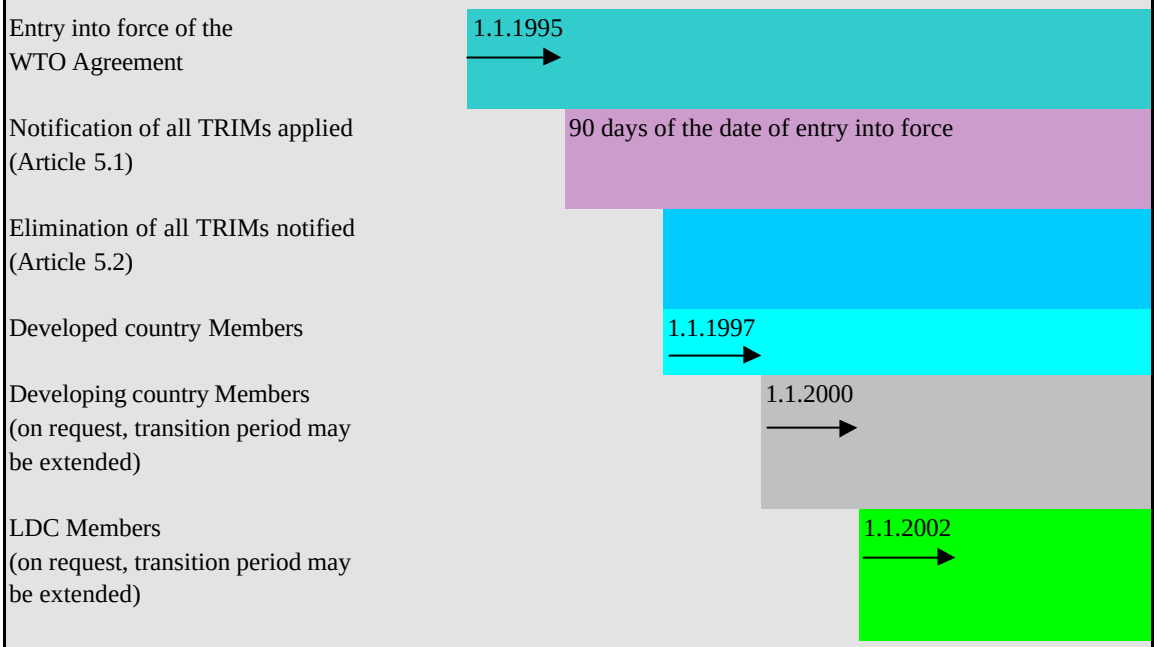
[84] Laying down the conditionality of establishing local production by itself does not violate GATT disciplines, even if the production is for export purposes. Violation occurs if any specific discipline, such as Articles III – National – Treatment and on Internal Taxation and Regulations – and XI – General Elimination of Quantity Restrictions – of GATT, or the SCM Agreement, is violated.

[85] Uganda. See TRIMs notifications at <www.wto.org>

amendments to its text. Such a review, although begun, has not finished yet. Many developing countries are making a point in this review that those of the disciplines in the TRIMs Agreement that may close off development options may have to be reviewed and the Agreement tailored to the stage of development of a WTO Member.

Table 2

Main dates in the application of the TRIMs Agreement



Note: Doha Decision on Implementation took note of the request from some developing country Members for the extension of the five-year transitional period and urged the Council for Trade in Goods to consider positively the requests by least-developed countries of the seven-year transition period.

Source: UNCTAD.

3. Provisions of the SCM Agreement

The Agreement addresses multilateral disciplines on grant of subsidies and the use of countervailing measures. Multilateral disciplines regulate the provision of subsidies, establishing whether a Member may provide a subsidy or not. They are enforced through invocation of the WTO dispute settlement mechanism. Countervailing measures offset injury caused by subsidized imports, which may be applied by a Member after an investigation. The Agreement states that a subsidy is a financial contribution or income or price support by a Government or any public body within the territory of a Member, which confers a benefit on the recipient. Export subsidies defined in Article 3.1 are prohibited *per se* and are deemed to be specific subsidies *ipso facto.* As for other subsidies, only specific subsidies as defined in Part I, Article 2–Specificity, that is those that are specifically provided to an enterprise or industry or group of enterprises or industries, are subject to provisions in the Agreement related to prohibited or actionable subsidies, or to countervailing measures.

The Agreement defines three categories of subsidies: those that are prohibited and those that are actionable, that is subject to challenge or to countervailing measures, and non-actionable subsidies that escape countervailing measures. Prohibited subsidies (Article 3) include export subsidies and import substitution subsidies because they affect trade directly and are most likely to have adverse effects on the interests of other Members. Actionable subsidies (Part III) include production subsidies. They are subject to challenge through the multilateral dispute settlement or through countervailing action, in the event that they cause adverse effects for the interests of other Members.

Adverse effects (Article 5) involve injury to the domestic industry of another Member; nullification or impairment of benefits accruing directly and indirectly to other Members under GATT 1994, in particular the benefits of concessions bound under Article II of GATT 1994; and serious prejudice to the interests of another Member.

Concerning countervailing measures, according to Article 10 – Application of Article VI of GATT 1994, it may only be imposed pursuant to investigations to determine the existence of a subsidy injury within the meaning of Article VI of GATT 1994 as interpreted by the Agreement and a causal link between the subsidized imports and the alleged injury.

The provisions of Part II or III may be invoked in parallel with the provisions of Part V; however, with regard to the effects of a particular subsidy in the domestic market of the importing Member, only one form of relief (either a countervailing measure, if the requirements of Part V are met, or a countermeasure under Articles 4 or 7) shall be available.

Non-actionable subsidies (Article 8) involved assistance for research activities, assistance to disadvantaged regions and assistance to promote adaptation of existing facilities to new environmental requirements. However, provisions relating to non-actionable subsidies lapsed on 31 December 1999.

Developed countries not otherwise eligible for special and differential treatment were allowed three years from the date the Agreement entered into force to phase out prohibited subsidies that they notified within 90 days of the coming into force of the WTO Agreement for that Member. LDCs and Members with a GNP per capita of less than $1,000 per year listed in Annex VII – Developing Country Members referred to in paragraph 2(a) of Article 27 of the Agreement are exempted from the prohibition on export subsidies and have eight years and five years, respectively, to phase out import-substitution subsidies. Other developing countries have an eight-year period to phase out their export subsidies and five years to phase out import-substitution subsidies. Table 4.3 sets out these special and differential provisions in tabular form.

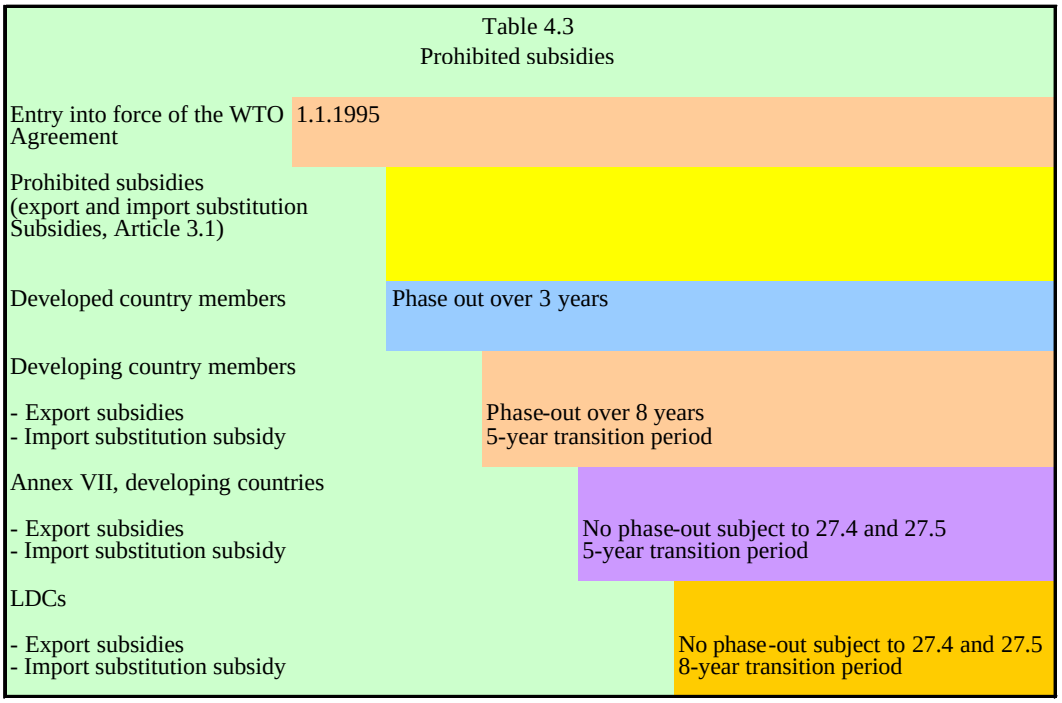
The SCM Agreement (Article 27.9) significantly restricts remedial action available under Article 7 against actionable subsidies granted by developing country Members. While remedial action can be taken against developed country Members on the basis of nullification and impairment of tariff concessions or other obligations under GATT 1994, for developing country Members an additional condition is to be satisfied, namely that the subsidy also displaces or impedes imports of a like product of another Member into the market of the subsidizing Member or unless injury to a domestic industry in the market of an importing Member occurs. The only exception to provisions under Article 27.9 is that of serious prejudice as defined in Article 6.1 of the Agreement, which no longer applies as the latter provision has since lapsed. Additionally, certain subsidies related to developing country

Members' privatization programmes are not actionable multilaterally. With regard to countervailing measures, developing country Members' exporters are entitled to more favourable treatment with respect to termination of investigations where the level of subsidization or volume of imports is small.

The Fourth Ministerial Conference, held in Doha, approved the procedures for extensions of the eight-year period granted to some developing countries for phasing out their export subsidies under Article 27.4 – Special and Differential Treatment of Developing Country Members – of the Agreement. The programmes eligible for extension are export subsidy programmes in the form of full or partial exemptions from import duties and internal taxes, which were in existence not later than 1 September 2001 and which are provided by developing country Members whose share of world merchandise export trade was not greater than 0.10 per cent and whose total gross national income for the year 2000 as published by the World Bank was at or below $20 billion.

In addition, the Doha Decision on Implementation-related Issues and Concerns established that GNP per capita, for the purpose of Annex VII of the Agreement, should be measured in constant 1990 US dollars and for three consecutive years.

Table 4.3
Prohibited subsidies



Note: UNCTAD.

Moreover, the Ministerial Conference took note of the proposal to treat as non-actionable subsidies measures implemented by developing countries with a view to achieving legitimate development goals, such as regional growth, technology research and development funding, production diversification and development, and implementation of environmentally sound methods of production. This proposal was included in the negotiations on outstanding

implementation issues, which are part of the Work Programme established by the Doha Ministerial Declaration. During the negotiations on implementation issues, Members were urged to exercise due restraint with respect to challenging such measures. Provisions of the agreement on non-actionable subsidies applied for a period of five years beginning with the entry into force of the WTO Agreement and covered subsidies provided by developed and developing country Members.

In the light of the above considerations, the excise duty rebate based on local content programme applied by the South African Government appeared to fit the definition of prohibited subsidy given in the Agreement since it was contingent upon the use of domestic over imported goods. Consequently, the South African authorities replaced it in 1995 by a tariff-driven programme. The same conclusion would apply to the provision of subsidies upon export performance (Article 3 Prohibited Subsidies). The rebate in excise duty is a revenue that is otherwise due and is forgone or not collected by the Government and thus is a form of fiscal incentives, that confers a benefit on the recipient and is specific to an industry. Therefore, it would appear as an actionable subsidy under the WTO SCM Agreement. However, the SCM Agreement requires for a subsidy to be actionable, in addition to specificity, the determination of adverse effects on the interests of other Members (Part III, Article 5 – Adverse Effects).

Because of the high degree of integration of the South African automotive industry with parent companies, it is unlikely that adverse effects may have occurred at least in the form of injury to the domestic production of other Members or by way of nullification or impairment of benefits accruing directly and indirectly to other Members under GATT 1994. In this case, adverse effects may have arisen from the displacement or impediment of imports of a like product of another Member into the market of the subsidizing Member (serious prejudice).

However, other automotive producers in the Southern African region have complained that their ability to compete with South African automotive products is undermined by the fact that the import-export complementation programme virtually subsidizes South Africa's exports into the region. In this case, adverse effects may take the form of injury to the domestic production.

It should be borne in mind that, to be actionable, a production subsidy needs to be specific. Furthermore, the mere fact that a certain form of government assistance does not qualify for non-actionable treatment under the Agreement does not restrict the ability of Members to provide such assistance. An example of such government assistance is the assistance through institutional support aimed, say, at ensuring quality standards. Institutions such as the South African Bureau of Standards played a crucial role in enhancing quality competition, especially for firms waiting for access to international markets.

It should be noted that developing country enterprises in the small and medium-size sector could benefit from the provisions qualifying specificity in the SCM Agreement. As per Article 2.1 (b), specificity shall not exist where the granting authority or the legislation establishes objective criteria or conditions governing the eligibility for and the amount of subsidy, provided that the eligibility is automatic and that such criteria and conditions are clearly spelt out and strictly adhered to. As per footnote 2 of the Agreement, criteria, which are economic in nature and horizontal in application, such as number of employees or size of enterprise, are objective criteria. Most developing countries determine the nature of a small

and medium-size enterprise based on the number of employees or the size of the enterprise; a production subsidy that is transparently and automatically available to such enterprises will not be considered to be specific, and hence not subject to provisions relating to actionable subsidies.

The Brazilian Government's programme for financing exports (PROEX) was heavily contested at WTO under the SCM Agreement by Embraer's immediate competitor Bombardier and by the Canadian Government. The latter claimed that PROEX confers an export subsidy, which is defined as a prohibited subsidy by the Agreement.

Following a request by Canada, the WTO Panel established pursuant to the Dispute Settlement Understanding (DSU) found the payments through PROEX to be subsidies contingent upon export performance within the meaning of Article 3.1 (a) – Prohibition of subsidies contingent upon export performance, including those illustrated in Annex I – of the Agreement.[86] Embraer's export sales of regional aircraft were coupled with the financing facilities provided by PROEX. As mentioned, the main feature of PROEX is a mechanism for interest rate equalization. Under this mechanism, an equalization payment is provided to cover the difference between the interest charges contracted with the buyer and the cost to the financing party of raising 90 ninety days.

The Appellate Body[87] upheld the findings of the Panel, including the conclusion that Brazil had failed to demonstrate that the export subsidies for regional aircraft under PROEX were not used to secure a material advantage in the field of export credit terms within the meaning of item (k) of the Illustrative List of Export Subsidies of the Annex I of the Agreement. The first paragraph of item (k) considers to be a prohibited subsidy the grant by Governments of export credits at rates below those which they actually have to pay for the funds so employed, or the payment by them of all or part of the costs incurred by exporters or financial institutions in obtaining credits, in so far they are used to secure a material advantage in the field of export credit terms.

Following the recommendation of the Panel and the Appellate Body, Brazil took certain measures (PROEX II) in compliance with these recommendations. Canada contested the consistency of the measures with the rulings of the Panel and Appellate Body under Article 21.5 – Surveillance of Implementation of Recommendations and Rulings-of the Dispute Settlement Understanding. The Panel and Appellate Body again ruled in favour of Canada. Canada also obtained authorization from the DSU for countermeasures worth C$ 344.2 million.

Brazil again revised the financing programme to bring it into compliance with the rulings. It reviewed the interest equalization system of PROEX under PROEX III. On Canada's recourse for a second time to Article 21.5 of DSU, the Panel(26 July 2001).[88] concluded that the PROEX III programme is not inconsistent with the SCM Agreement on the basis of the view that it is legally possible for Brazil to operate the PROEX III programme in a such a way that it will (a) not result in a benefit being conferred on producers of regional aircraft and hence not constitute a subsidy within the meaning of Article 1.1 of the Agreement (i.e. definition of subsidy as a financial contribution by a Government that confers a benefit the recipient); or (b) result in a benefit being conferred on producers of regional aircraft, but

[86] See Report of the Panel, WT/DS46/R.
[87] See Report of the Appellate Body, WT/DS46/AB.
[88] See Report of the Panel, WT/DS46/2.

conform to the requirements of the safe haven of the second paragraph of item (k), in which case it would not constitute a prohibited export subsidy within the meaning of Article 3.1 of the Agreement. The second paragraph of item (k) of Annex I provides that if a Member is a party to an international undertaking on official export credits to which at least 12 original Members of the Agreement are parties as of 1 January 1979,[89] or if in practice a Member applies the interest rates provisions of the relevant undertaking, an export credit practice which is in conformity with those provisions shall not be considered an export subsidy prohibited by the Agreement.

This dispute shows that developing countries have to acquire more skills in devising financing programmes for large-value exports in such a way that they are not deemed to be subsidies under the SCM Agreement, particularly when the provisions of the second paragraph of item (k) of the Illustrative List at Annex I of the Agreement limit it mainly to an arrangement developed by OECD for and by its Members, which may not take into account the special circumstances under which credit facilities operate in developing countries.

It should be noticed that civil aircraft are also the subject matter of a plurilateral Agreement on Trade in Civil Aircraft that applies only to its signatories. Brazil is not a signatory to the Agreement but has observer status. Since civil aircraft are subject to this plurilateral agreement, certain provisions of the SCM Agreement (Article 6.1 (a) and (d)–Serious Prejudice – and Article 8.2 (a)–Non-Actionable Subsidies) did not apply to civil aircraft. However, these provisions lapsed on 31 December1999, unless revived as per the mandate of the Doha Ministerial Declaration.[90] In any case, export subsidies and credits that are otherwise inconsistent with the SCM Agreement,[91] and are applied to the aircraft industry, have been held to be incompatible with the obligations of Members under the WTO Agreement in the Brazil-Aircraft and Canada-Aircraft cases by the Dispute Settlement Body of the WTO.[92]

Finally, different developing countries get different levels of special and differential treatment under the SCM Agreement, and it would be helpful to identify these before framing or continuing to apply subsidies in their domestic policies. For example, in respect of export subsidies, Article 27.2 – Special and Differential Treatment of Developing Country Members of the SCM Agreement divides developing countries into two types: LDCs and countries with a GNP per capita of less than US$1,000 which are exempted from the application of Article 3.1 (a), and others that are so exempted only for eight years subject to certain conditions specified in Article 27.4. Brazil fell into the latter category and failed to satisfy the contingent conditions in the aircraft case. Amongst the other countries in the case studies, South Africa also falls into this category, while India falls into the former category as its GNP per capita is below US$ 1,000.

[89] It refers to the OECD Arrangement on Guidelines for Officially Supported Export Credits

[90] It refers to the proposal to treat measures implemented by developing countries with a view to achieving legitimate development goals as non-actionable subsidies. This proposal was included in the negotiations on outstanding implementation issues. See section 4 below.

[91] See also 1999 USTR Annual Report March 2000, in particular "While the 1979 GATT Agreement on Trade in Civil Aircraft was not strengthened through renegotiation during the Uruguay Round, civil aircraft was brought under the stronger disciplines of the WTO SCM Agreement. This was the objective of the U.S. aerospace industry, whose competitors have in the past benefited from huge government subsidies."

[92] See Canada–Measures Affecting the Export of Civilian Aircraft, Report of the Appellate Body (WT/DS70/AB/R) and Report of the Panel (WT/DS70/R). See also Canada–Export Credits and Loan Guarantees for Regional Aircraft, Report of the Panel (WT/DS222/R). Both at <www.wto.org/disputes>.

4. Other relevant provisions

In addition to the provisions examined, there are a number of others that may have some relevance with regard to the policy instruments identified in the case studies. Among them are the following.

A. Rules related to government procurement

Regulations relating to the procurement of goods and services by a Government, through its departments and agencies, for its own use are outside the scope of WTO rules for goods and services. There is no multilateral agreement on government procurement. Instead there exists a plurilateral Agreement on Government Procurement signed by only 25 Members. Its purpose is to open up this business as much as possible to international competition; to make laws, regulations, procedures and practices regarding government procurement more transparent; and to ensure that they do not protect domestic products or suppliers, or discriminate against foreign products or suppliers. The new Agreement, which took effect on 1 January 1996, extends coverage to services, procurement at the sub-central level (i.e. states, provinces, departments and prefectures) and procurement by public utilities.

The Doha Declaration provides that a multilateral agreement on transparency in government procurement will be negotiated starting after the Fifth Session of the Ministerial Conference, subject to an explicit consensus on the modalities of the negotiations.[93] Negotiations shall take into account participants' development priorities, especially those of LDCs, and will be limited to the transparency aspects, and therefore will not restrict the scope for countries to give preferences to domestic supplies and suppliers. The outcome will be separated from the plurilateral Agreement on Government Procurement.

As pointed out in the case study of Embraer, government procurement was a means by which the Brazilian Government provided support to Embraer during its stage as a government-controlled enterprise. It was through its procurement policy that technological learning was made viable and feasible to a great extent. This policy imposed the requirement of local production in associations of Embraer with outside partners for supplying the local market in order to acquire technology and, in particular, design and manufacturing capabilities. Manufacture cooperation agreements and sales agreements signed with other firms made it mandatory that Embraer received technological training in different areas, including design, integration of components and maintenance. After privatization, Embraer continued its policy of strategic alliances and active collaboration – this time, however, under the new idea of spreading the high risks associated with big projects among partners, both clients and suppliers.

Government procurement has been used by all countries as one macroeconomic management tool to help deal with economic imbalances such as inflationary pressures or

[93] The Chairman's understanding on the issue, delivered at the time of adopting the Doha Ministerial Declaration, indicates that such an explicit consensus would also give each Member the right to take position on modalities that would prevent negotiations from proceeding after the Fifth Ministerial Conference until that Member is prepared to join in an explicit consensus. See www.wto.org/development agenda

unemployment problems.[94] Regarding technological capacity building, government procurement could be an effective policy instrument in defining the pattern of demand for technology, as well as its transfer, diffusion and development, especially in countries where purchases by the public sector represent a significant proportion of goods and services imported.[95] A public-procurement strategy could be used to help developing countries' firms expand their international market through cooperative agreements with foreign firms for supplying the domestic market and improve conditions under which transfer of technology takes place. Such a strategy may also comprise promoting consulting and engineering capabilities. The supply of this kind of services plays a strategic role in economic growth and development. Consulting and engineering design services determine the technological dimension of investment projects and help to establish forward and backward linkages in the national economy with local R&D activities and the capital goods sector.[96]

B. Provisions related to transfer of technology

A number of provisions in the WTO Agreements, in particular those referring to the need for transfer of technology to take place between developed and developing countries, rely on national measures to be operational – home country measures.[97],[98] In principle, they remain a unilateral and discretionary decision by developed countries to transfer of technology. However, Article 66.2 of the TRIPS Agreement, for example, stipulates that "developed country Members shall provide incentives to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to least-developed country Members in order to enable them to create a sound and viable technological base". Institutions in developed countries in charge of implementing such measures include outward investment agencies, development aid departments and technology research centres. Some of these measures are aimed at promoting FDI, and others are specifically adopted to ensure transfer of technology and skill acquisition. The Doha Implementation Decision emphasized the mandatory nature of Article 66.2 and requested developed country Members to submit prior to the end of 2002 detailed reports on the functioning in practice of the incentives provided to their enterprises for the transfer of technology pursuant to their commitments under Article 66.2.

There are some other provisions in the WTO Agreements that provide special treatment to developing countries for getting different types of assistance from developed

[94] See UNCTAD (1989).
[95] See UNCTAD (1997).
[96] See UNCTAD (1993).
[97] For a detailed explanation on these measures, see "Home Country Measures", UNCTAD series on issues in international investment agreements. Also see **"**International arrangements for transfer of technology" (TD/B/COM.2/37); "International arrangements for transfer of technology: best practices for access to and measures to encourage transfer of technology with a view to capacity building in developing countries, especially in least developed countries" (TD/B/COM.2/EM.9/2); "Report of the Expert Meeting on International Arrangements for Transfer of Technology: Best Practices for Access to and Measures to Encourage Transfer of Technology with a view to Capacity Building in Developing Countries, especially in Least Developed Countries" (TD/B/COM.2/33); and *Compendium of International Arrangements on Transfer of Technology: Selected Instruments* (UNCTAD/ITE/IPC/Misc.5).
[98] For an overview of national initiatives and measures in developed countries for favouring transfer of technology to developing countries, see "Initiatives and Measures Promoting Transfer of Technology: Home Country Measures Facilitating Access to Technology by Developing Countries", UNCTAD/DITE/IPCB (forthcoming).

countries to meet standards in the WTO and increase their competitiveness. For example, the Agreement on Technical Barriers to Trade (TBT Agreement) provides for technical assistance, on request, to developing countries for establishment of national standardizing bodies, regulatory bodies or bodies for the assessment of conformity with technical regulations, and participation in international standardizing bodies (Article 11 – Technical Assistance to Other Members). Developed countries have the obligation to take into account the special development, financial and trade needs of developing countries in the preparation and application of their technical regulations, standards and conformity assessment procedures, as well as to provide specific time-limited exceptions to the applicability of such standards to the products of developing countries (Article 12 – Special and Differential Treatment of Developing Country Members). Similar provisions also exist in the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). The Doha Ministerial Decision on Implementation-related Issues and Concerns reiterates some of these obligations of developed countries in respect of the TBT Agreement, and determines the time-limited exception for application of sanitary and phytosanitary measures to products as six months, subject to certain conditions under the SPS Agreement.

Questions remain to what extent these provisions were implemented to transfer technology to developing countries. Since access to technology is crucial to successful integration into the world market, it was no surprise that, under strong demand from developing countries, the WTO Ministers decided in Doha to establish a Working Group on Trade and Transfer of Technology to examine how transfer of technology takes place in practice and if specific measures might be taken within the WTO to encourage such flows of technology.

C. General Agreement on Trade in Services

Finally, there are also some provisions of the General Agreement on Trade in Services (GATS) that might be considered when designing support policies. The GATS covers all internationally traded services, including all the different ways of providing an international service: (a) services supplied from one country to another, officially known as "cross-border supply"; (b) consumers or firms making use of a service in another country, officially known as "consumption abroad"; (c) a foreign company setting up subsidiaries or branches to provide services in another country, officially known as "commercial presence"; and (d) individuals travelling from their own country to supply services in another, officially known as "presence of natural persons".

It is worth noting that, as in the case of goods, general most-favoured-nation (MFN) treatment of non-discrimination applies to all services, which means that if a country allows foreign competition in a sector, equal opportunities in that sector should be given to service providers from all other WTO Members. However, temporary exemptions were allowed for countries that already had preferential agreements in services with trading partners. These exemptions will normally last no more than 10 years.

However, it should be pointed out that while national treatment is a general principle in the GATT and the TRIPS Agreement, in GATS it only applies where a country has made a specific commitment, and exemptions are allowed. Individual countries made commitments to open markets in specific sectors, which appear in schedules that list the sectors being opened, the extent of market access being given in those sectors, and any limitations on national

treatment. Those commitments are bound like bound tariffs. They can only be modified or withdrawn after negotiations with affected countries, which would probably lead to compensation.

Mention should also be made of the diversity in the provision of services that is reflected in the GATS Annexes. The Annex on movement of natural persons deals with negotiations on individuals' rights to stay temporarily in a country for the purpose of providing a service. The Annex on financial services provides that Governments have the right to take measures to protect investors, depositors and insurance policy holders and to ensure the integrity and stability of the financial system. Since the telecommunications sector is an underlying means of providing other economic activities (i.e. electronic money transfers), the Annex on telecommunications states that Governments must ensure that foreign service suppliers are given access to the public telecommunications networks without discrimination. Negotiations on basic telecommunications ended in 1997 and national commitments took effect from January 1998. The Annex on air transport services excludes traffic rights and directly related activities from GATS's coverage. However, it establishes that the GATS applies to aircraft repair and maintenance services, selling and marketing of air transport services and computer reservation services.

Rules dealing with subsidies, as well as rules regarding government procurement and safeguard measures, are not included in GATS Agreement. These rules are part of ongoing negotiations. However, subsidies granted to services should meet the requirements of most-favoured-nation treatment, unless an exemption is specifically sought in the Member’s schedule of commitments. Furthermore, a work programme for proposals and subsequent discussions on subsidies in services has been agreed to in the ongoing negotiations, and Members will need to closely follow these proposals and discussions in order to protect their interests. Another set of ongoing negotiations concerns rules on the requirements that foreign service providers have to meet in order to operate in a market. The focus is on qualification requirements and procedures, technical standards and licensing requirements.

CHAPTER III

INSTITUTIONAL SUPPORT AND POLICY CONSIDERATIONS

1. Institutional aspects

The case studies show that government support could be in the form of institutions that help companies in acquiring technological capacity or competitive edge, without directly subsidizing their production efforts or flouting non-discrimination rules of the WTO in general.

In the case of the Indian pharmaceutical industry, the building of R&D capacities was aided by publicly funded R&D organizations, such as the Council for Scientific and Industrial Research (CSIR), which permitted the use of their facilities. The Indian Government fostered technological change through close interaction between private sector firms and publicly funded laboratories of the CSIR – the National Chemical Laboratory (NCL), the Central Drug Research Institute (CDRI) and the Indian Institute of Chemical Technology (IICT), all three of them are very active in drugs research.

To further the industry government linkages in R&D activities and facilitate transition from process development to applied and basic research, the Indian Government supports an intense networking between academia, government and industry. Such networking allows the channelling of intellectual and other resources towards significant incremental progress and enhances the capabilities of the Indian drugs and pharmaceuticals industry in the development of new drugs by synergizing the strengths of national institutions and the drug industry. The Government has launched several schemes for promoting this networking jointly funded by the industry and the Government.

The other aspect of this knowledge partnership has been the creation of the National Institute of Pharmaceutical Education and Research (NIPER). The Institute was set up under the initiative of the private sector, which wanted a world-class training and research institute, with government funds together with contributions from the industry. The NIPER interacts with Indian companies, transnational corporations and international organizations, and conducts training programmes for drug regulators from various parts of the world and for members of the Indian industry.

The role of institutional support has been very important in South Africa also, especially in terms of ensuring standards for the international market and enhancing quality competition, through institutions such as the South African Bureau of Standards (SABS) and other research and academic institutes. The South African Government complemented its selective policy interventions in the automotive sector with institutional support through the SABS, whose action has been instrumental in the restructuring of the automotive industry and integrating it into the global economy. This organization is responsible for the development and publication of standards, and certification and testing of standards, and plays an important role in technology transfer and innovation in terms of both product and process development.

Also, collaboration between motor assembly firms and the engineering faculties of academic institutions such as the Universities of Cape Town and Stellenbosch, has been of particular significance in, for example, the development and testing of engines and catalytic converters.

Again, the successful establishment of an aircraft industry in Brazil has been largely due to government efforts to create a robust scientific and educational infrastructure. The origins of this industry can be traced back to the setting up of the Aeronautic Technology Centre (CTA) first and soon after of the Aeronautics Technological Institute (ITA), with the aim of training high-quality engineers and developing and acquiring skills and capabilities in aircraft manufacture. The establishment of Embraer as a State-owned enterprise was a natural outcome of these earlier developments.

The local institutions that provide R&D infrastructure to the manufacturing cluster in the São José dos Campos region, geared towards fulfilling the skills requirements of the aircraft industry and increase local capabilities, encompass the CTA and its institutes – the Aeronautic Technology Institute (ITA), which is a teaching organization; the Aeronautic and Space Institute (IAE); the Institute of Advanced Studies (IEA); the Institute of Industrial Liaison (IFI); and the National Institute of Space Research (INPE). The CTA is a branch of the Department of Research and Development (DRD) of the Ministry of Aeronautics and is a research institution linked with industry. The INPE is designed to conduct research in space and atmospheric sciences and space applications.

R&D and other institutional support are very common in the developed countries also.[99] Moreover, a sound publicly funded infrastructure for creating technological capacities and competitiveness across the board would not be treated as a specific subsidy.

2. Policy considerations

This section is an attempt to highlight some of the possibilities available to developing countries in designing industrial policies in conformity with WTO rules. Developing countries are not a homogeneous block. They exhibit a wide range of diversity in their needs and interests and, most important, in their stages of development. However, multilateral rules may offer a menu of measures aimed at fostering development in accordance with such diversity.

Most of the WTO Agreements contain specific provisions for developing countries, including longer periods for implementing agreements and commitments or measures to increase trading opportunities for developing countries. However, many of these periods, such as the ones for meeting the obligations under the TRIMs and TRIPS Agreements and use of subsidies contingent upon the use of domestic over imported goods, have expired, and some, such as the grant of product patents and prohibition of export subsidies, will be expiring soon. Nevertheless, the Fourth Ministerial Conference in Doha agreed that special and differential provisions should be reviewed with a view to strengthening them and making them more precise.

[99] The average of national public sector spending on R&D for the 15 EU member countries in 1993 was 39.7 per cent. The equivalent figures were 39.6 per cent for North America, 19.6 per cent for Japan and 36.2 per cent for the OECD as a whole. See OECD (1996, p.239).

Moreover, the Doha Implementation Decision addresses many problems faced by developing countries in implementing the current WTO Agreements. Issues include balance-of-payments provisions, agriculture, sanitary and phytosanitary measures, subsidies, textiles and clothing, technical barriers to trade, trade-related investment measures, rules for customs valuation, and rules of origin. The Decision also instructs the Committee on Antidumping Practices to strengthen the special and differential provisions in the Anti-dumping Agreement, particularly its Article 15 – Determination of Injury. Negotiations on outstanding implementation issues are part of the WTO Work Programme.

As a result, decisions were taken with regard to the extension of the transition periods for implementing obligations under the TRIPS, the TRIMs and the SCM. More important, it was agreed that the proposal to treat as non-actionable subsidies measures implemented by developing countries aimed at achieving development goals will be addressed as an outstanding implementation issue, and therefore be part of the Work Programme.

Overall, the Doha Ministerial Declaration stresses that the Ministers sought to place the needs and interest of developing countries at the heart of the Work Programme with a view to ensuring the increased participation of the developing countries in the multilateral trading system. They recognized the vulnerability of LDCs and the structural difficulties they face in the global economy, and committed themselves to addressing marginalization of LDCs in international trade.

With respect to the obligations of developed countries, the Declaration reaffirms that the provisions of Article 66.2 of the TRIPS Agreement – HCM – are mandatory. The Ministers also launched tariff-cutting negotiations on all non-agricultural products, which include reduction or elimination of tariff peaks, high tariffs and tariff escalation, as well as non-tariff barriers, particularly in respect of products of export interests to developing countries. These tariff-cutting negotiations are relevant for developing countries' market access as tariff peaks and tariff escalations maintained by developed countries often abound in products of their export interest. With regard to LDCs' products, Governments committed themselves to the objective of duty-free, quota-free market access and to considering additional measures to improve market access for these exports.

It should be highlighted that subsidies on services are not currently covered by the GATS, and this leaves the Governments the discretion to apply them according to their needs, provided that requirements for MFN treatment are met, unless an exemption is specifically sought in the Member's schedule of commitments. In the same way, government procurement is not subject to multilateral rules and in some cases could serve the aim of technological capacity building.

Embraer's experience with cooperative arrangements involving technology transfer is an example of how transfer of technology could be made feasible in consonance with the development objectives. The case study also shows the role of technological change in capacity building. The concept of technology includes not only "embodied" technology (i.e. equipment), but also "dis-embodied" technology (i.e. knowledge). Thus, under this new concept of technology, cooperative arrangements that include acquisition of know-how and training process are appropriate devices for acquisition of technological autonomy and skills. Embraer's case, particularly after the dispute with Canada, also shows that once the industry has become internationally competitive, finding WTO-compatible solutions becomes an achievable objective for Governments also.

Even for reverse engineering of processes, substantial investment in terms of skills and R&D is required. The Indian pharmaceutical industry could find this a feasible option because the Indian market is very large and allows economies of scale to flourish. Gradually, Indian firms achieved international competitiveness, and could continue to grow despite withdrawal of WTO-incompatible measures that helped them reach levels of productivity in the first place. Today, that industry is targeting developed markets successfully,[100] and it may become difficult for the competitors to create barriers[101] without falling foul of the WTO principles of non-discrimination.

In any case, to remain competitive in the global market place, the industry has to get into joint ventures or other forms of partnerships with other players in the market. This is best exemplified, among the case studies here, by the South African auto industry. Through the franchise modality of involvement with South African firms, the parent companies are engaged in technical support, training programmes and financial commitment in terms of investment.[102]

Finally, in spite of the constraints restricting policy space on account of the stricter disciplines under the WTO system, national policies can still play a crucial role in enhancing capacity building, promoting investment in R&D and fostering exports in developing countries, provided that such policies are drawn up fully taking into account the flexibilities available in the WTO rules, optimal use of the special and differential treatment provisions built into the Agreements and active participation in the ongoing negotiations to protect existing policy space. In addition, institutional support by the Government, particularly for scientific research and standards, could play an important role in enabling developing country industry to take up market challenges from a position of strength.

[100] Some of the Indian generics manufacturers such as Ranbaxy, Dr Reddy's laboratory and Cipla are besting the other laboratories in acquiring selling exclusivity in just-off-patent drugs in the US market. See "Pill stop: US generics market" in *The Economic Times*, 10 July 2002.

[101] In what could constitute an exclusive pharmaceutical trade bloc between the US, EU and Japan, participants in the International Conference on Harmonization (ICH) conveyed to their developing country counterparts at the International Conference of Drug Regulatory Authorities, held in Hong Kong (China) from 24 to 27 June, 2002, that regulatory authorities would reject any application for marketing of drugs that does not conform to a "common technical document" introduced by ICH. It is a moot point how non-ICH members could be excluded from such approvals. See "Pharma trade bloc to keep Indian drugs out of US, EU markets" in *The Economic Times*: 8 July 2002.

[102] See Barnes, (1998), quoted in the study.

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