* We thank the help of Carlos Enrique Cardoso in preparing the manuscript and the statistical materials.

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NÚMERO 72

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MEXICO'S NATIONAL INNOVATION SYSTEM IN THE 1990S: OVERVIEW AND SECTORAL EFFECTS

Introduction

The signature of NAFTA to begin in January 1994 has been only the formal culmination of an openning process, which in the Mexican case, had been initiated a decade earlier. The joining of GATT in 1986 was probably the most important measure initiating this phase to open up the Mexican economy in order to reinsert it more competitively into the international economy.

While domestic industry was abruptly exposed to competition from abroad, also technology policy was changed towards a more liberal tone. The response of the innovation and technology transfer system to these changes is still very moderate up to date, as we will show. Funding for science and technology has remained insufficient and highly dependent on public funds, there is a very limited utilization of the public technological infrastructure by private enterprises, and the nurturing of learning between domestic users and producers of technology and other innovative activities is very weak given the limited scope of their relations.

This chapter is divided in three sections. Firstly we offer an updated overview of gross S&T efforts showing how limited they are and the extent of reliance on public funds. The second section introduces some qualitative estimates of the weakness of the system, stressing in particular the very weak technological linkages impinging upon the learning potential of the country. A final section produces detailed evidence on the type of adjusment experienced in some of the leading industries along the restructuring and opening period. For a few industries the response seems positive, but for most of the nationally controlled sectors the result has been a downgrading technological adjustment. The overall result of changes due to the modernization agenda seem far less promising than anyone anticipated.

A. The R&D system in the early 1990s[1]

The review of Science and Technology policy undertaken by the OECD[2] during 1993 clearly stated the very poor conditions of the Mexican R&D system. These conditions remain today essentially the same. Here we summarize the OECD review updating most of the figures, though without altering their basic conclusions.

[1]Most of this section follows Chapter II.A in Unger, 1995.

[2]OECD-DSTI/STP, 1994, p. 11, "Review of National Science and Technology Policy: México II: Examiners' Report".

1. Funding S&T Iinsufficient

All through the 1980s and 1990s R&D expenditure has been insufficient and the participation of the private sector has remained extremely modest. Total national spending in Science and Technology for 1991 was estimated in $1351 millions of US dollars, a poor proportion of only 0.48% of GDP[3] (Table 1).

Later estimates of spending on experimental or applied R&D for 1993 arrive to a larger monetary figure of about US$1959 millions, though keeping the measure of the effort at a modest 0.32% of GDP.[4]

During most of the 1980's S&T spending deteriorated. From 1980 to 1989, the Federal Government Expenditures on S&T declined at an average annual rate of 3.1%. Lately, between 1989 and 1993, spending in this area grew at an average yearly rate of 27.8 % (current prices). The net effect however, is that the ratio of Federal Government Expenditure on S&T to GDP has declined from 0.46% in 1981 to 0.41% in 1993 (Table 2).

Human resources devoted to Science and Technology activities are also quite insufficient under any reasonable comparison. The proportion of engineers and scientists is 9.4 per 10,000 of the labor force. This ratio compares very unfavorably with, for instance, 35.9 per 10,000 of the labor force in the U.K. and 68.8 per 10,000 in Japan. In 1991 there were a total 57,016 individuals engaged in R&D activities in Mexico. Only 40% of these were scientists or engineers, the other 60% were technicians and support personnel (Table 3). The recent Program for Industrial Modernization (1996) recognizes the importance of engineers in developing the technological system of the country and calls for a new approach to put them at the center of industrial policy, but the time lagg to redress social inertia in favor of engineering and the hard sciences may prove substantial. Some more radical initiatives probably will need to be tried.

2. S&T Highly Dependent on Public Funds

Mexico's R&D system shows very limited participation of the private sector. On the total for 1991, 77% were federal government expenditures and only 23% was spent by the private sector. In 1984, the private sector's share of total national spending in S&T was even less at around 15% (Table 4). The latest estimate for 1993 declined

[3]An earlier OECD estimate has credited a lower effort of only 0.33% of R&D to GDP in 1991. See OECD, 1994, p.142. The figures on Science and Technology usually overestimate the measure of innovative efforts due to the inclusion of most of the higher education spending, but they are useful for international comparisons.

[4]This is applied R&D expenditures which is not the same as S&T expenditures, as noted in the previous footnote (Gasto en Investigacion y Desarrollo Experimental =GIDE). See Conacyt, (1996), p.98. The change in emphasis in one or the other as reporting criteria is common when a new Administration takes office, and this time has not been the exception.

again the business enterprises financed R&D to a poor 10% ($358.2/ $3566.2 millions of *nuevos pesos*; Conacyt, 1996, p.38).

Funding not only has been limited and under public budget, but has also been an acute concentration of S&T efforts in very few sectors and scientific areas that have been able, due to benefits of tradition, to accumulate some scientific capabilities. The larger part of basic research infrastructure, both equipment and human capital, is concentrated in a handful of the larger State universities and several government research centers. This fact is reflected in the figures of human resources engaged in R&D. In 1991, 50% of the total scientific and technical personnel engaged in R&D was working in government S&T institutions, 49% in higher education institutions (of which 47.5% was employed in State financed Universities) and only 1% was working in industry and private non profit institutions (Table 5).

The concentration of efforts, of course, is not bad per se. What is indeed troublesome is that the sectors and scientific areas of concentration do not pertain to a purposeful targeting of priority activities; rather, they show the inertia from the past when scientists defined a broad spectrum of sciences to foster without a major sense of specialization, not to mention their assessment of relevance for the global pressures now faced by the productive sector.[5]

As a counter part to public funding deficiencies, there is also very little private capacity to perform R&D, as shown above. This is most acute at small and medium size firms that comprise 98% of all manufacturing establishments, but it also applies for large ones as shown in a 1991 survey (see ENESTYC 1992): R&D was 0.7% for large establishments, barely above the average 0.6% for all the sample including firms of all sizes (Conacyt, 1996, p.72). This measure of R&D is likely to be overestimated since only a few of the larger enterprises, about a dozen or so industrial firms belonging mostly to national conglomerates, have given evidence of developing technological capabilities to compete internationally. Likewise, only a proportion of this type of firms have set up or formalized their own R&D divisions or technology centers (Table 6). On the contrary, for many of them, survival to the international exposure has meant to apply drastic measures of "downgrading" as we showed elsewhere (Unger, 1994).

Among many other factors that may relate to the poor economic and cultural background of Mexican entrepreneurs, one of their crucial problems commonly mentioned by the firms and foreign observers alike (see the OECD Report of 1994) is the lack of adequate financial funding for R&D projects: commercial banks do not have the experience nor the will to evaluate risky projects involving technological components. Here seems to surface again a field calling for some kind of

[5]Earlier indications of this debate can be traced back to 1970 when Conacyt was created. See Ciencia y Desarrollo, 1982.

Government involvement, though the Program for Industrial Modernization of 1996 has largely ignored the specifics of financing.

B. Users and Producers of Technology: The Weakness of the System

The need to have stronger relations between users and producers of science and technology inputs has been detected since the early writings of the "dependency" school. Regardless of the wide spectrum of radicalism associated to many writers of that school, for those addressing the issue of development of Science and Technology there was a common cry for the need to foster the links between users and producers.[6] The topics remain of importance today, whether they be technology transfer, property rights or the supply of capital goods, and we have certainly witnessed a revival of the user-producer case, albeit more evident in regard to studies of the European industrial economies.[7] Here we will argue that most of the Mexican industries still show a very poor system of domestic user-producer relations by the hand of an excessive level of dependence on imported sources of technology.

3. Technological infrastructure and private enterprises.

Technology transfer has commonly been a subtle code for imports of technology.[8] Only recently the development of local linkages in the demand of technology from local institutions has appeared as a crucial priority for research and policy making. During earlier years meanwhile, technology institutions (TIs) –mainly government funded institutions as seen above– developed largely in isolation from industry. As a result there are very few TIs in Mexico, the majority of which were created without much connection to specific market demands for technology, most noticeably –but not only– the Government funded TIs. To date there is almost no TIs industry linkages, as we aim to show with the evidence collected for several sectors from another study.[9]

First of all one needs to differentiate among sectors with respect to their sensitivity for the various types of technical changes that may give raise to technology needs. There are sectors subjected to changes in process technology,

[6]See for instance the papers in the special issue on Science and Technology of The Journal of Development Studies, October, 1972.

[7]The most direct reference is Lundvall, 1988. In the Mexican context, see the special issue compiled by G. Dutrenit in Comercio Exterior, 1994.

[8]As a gross indication of the importance of technology transfer, the survey of manufacturing firms estimated a 2.5% of income spent on technology transfer. The same survey estimates R&D of 0.6% (see Conacyt, 1996, p.72).

[9] The study was sponsored by The World Bank and the IDRC-Canada and is reported at lenght in Unger, 1995.

others more to product design and innovations, others are overruled by production complexity, and there are still others where R&D/best practices are at the heart of technical change.

Secondly, the access to technological innovations (or to keep pace with technical changes if preferred) is a consequence of the type of technical change and of the structure and ownership characteristics of the industry, which in turn determine the potential role for independent TIs.

At the risk of oversimplification, we can expect that R&D sensitive and product innovating industries have the access to technical changes limited to their own R&D capabilities, including the need to attract foreign participation either as direct investment or as Joint Ventures (JV). TIs are not a major source of this kind of innovations that have to be under close control of the firms themselves. Most process technology, on the contrary, can be obtained through licences and patent rights, which offer certain scope for the screening services of TIs, mainly services of use for small and medium size firms that may not have substantial technical in-house capacities. Other services of TIs for these industries may involve standard and quality tests, training schemes and organizational systems, though we found much less of these cases in Mexico than we originally anticipated. Finally, the acquisition of machinery and specialized plant designs involves specialized suppliers, most usually foreign producers supplying imported technology incorporated into the machines and equipment.

In sum, technology institutions that ought to facilitate the use of the predominantly public infrastructure existing in Mexico are for the most part cut off the real demand conditions. Their potential role is very limited. Given that these limits on the demand side are also aggravated by major inefficiencies in the way they develop[10], the result is a very poor system of technological linkages within the country.

4. Users-producers network of learning

The changes in relation to technology policy, liberalizing imports and foreign investment played a decisive role in keeping very weak, and probably in further weakening, the links between Mexican users and producers of technology and technology intensive products. Those policy changes reflected the liberalizing goals of the 1990s, calling for less restrictions in those areas as we have documented elsewhere (see Unger, 1995, chapter II).

The most direct results can be seen in the very poor development of local sources of technology as argued above for technology institutions. The coverage

[10]The characteristics of TIs are described extensively in Chapter V of the report to The World Bank. It may suffice here to say that they are very few, highly inefficient in resolving industry needs, and still rather independent of the markets in defining their activities.

ratio of technology receipts to technology payments has remained around 20% all through the 1990s, while the deficit of the technology balance of payments increases every year (see Conacyt, 1996, p.73).

Another expression of the limited technological development of Mexico is found in the specialization of industry in mature segments that rely on imports of technology related products. The latter effect is suggested by the analysis of trade flows following Pavitt's typology of industries according to the sources and importance of technological innovations. On the whole, the recent restructuring and specialization of Mexican industry has had serious drawbacks for the technological development of the country.[11] The specialization of industry has led to a duality of competitive conditions: a few scale intensive and mature industries (many also resting on natural resource advantages) have become highly competitive to export, while the majority of other industries remain separated from this small group and quite behind the international standards to compete.

The result is that the industrial dynamism rests now in the exports of a few mature sectors, which for the most part and in spite of a few notable exceptions to be further noted below, are of moderate interest for the longer term in an innovation led perspective. Furthermore, many of these mature activities are also deprived of substantial linkages to other activities. In fact, these very same sectors also concentrate larger proportions of imports, which grow hand by hand with exports. Increasing the import content of Mexican industry was in some instances taken to the extreme of turning industrial firms into mere commercializing activities. The associated loss of industrial and technological capabilities in that process may prove substantial in a not distant future.

In summarizing this section, we may add that the context of depressed investment in S&T was further aggravated by the vast majority of the firms which reacted, by and large, very conservately to the driving measures of public adjustment, privatization and imports competition. Most of them shifted their attention to their basic sources of comparative advantage, rather than investing in technological upgrading efforts. Such a context is, expectedly, poorly conducive for industrial firms to engage in major technology development nor acquisitions, which in turn limited the development and use of technological institutions in the country. Some more concrete evidence is extended below for a few sectors studied in detail.

C. Technological effects of restructuring at the firm level.

In general we can say that exposing Mexican industry to international competition has led to consolidate the mature segments within industries. In spite of this general

[11]The overall effect of industrial restructuring is probably best shown in the composition of export and imports grouped according to Pavitt's typology: scale intensive and suplier dominated industries account for 86% of export and 60% of imports in 1994. Estimates taken from Unger, 1996

trend, some differences and a few successful experiences can be highlighted to illustrate the changes that took place.

First of all one has to recognize that effects for the firms may be very different depending on the sector, type of firm and the business environment they face. The findings of previous studies, such as the one we conducted for petrochemicals and machine tools (Unger, 1994), suggest substantial differences between sectors and also some differences between firms within each sector, particularly in the way that technology issues related to the liberalizing measures enforced in recent years. That is also evident among the motor firms, as we found in another study (Ramírez, 1995).

For firms in the petrochemical industry, the main technological issues derive from changes in the international markets of chemical products. Basic petrochemicals, intermediate chemicals, and finished products (specialities) face different and changing market conditions. In the industry, new internationally competitive projects require to adopt international economies of scale, which in turn suppose large gestation and construction periods for each plant. The feasibility study of these projects is then based on longer term projections of international demand and supply. These world market projections may change very dramatically within few years, as we have been able to witness in interviewing the major players in Mexican industry.

By the end of the 1980's, most firms considered more promising the markets for finished-specialities products than intermediates. This assumption involved to leave behind the production of traditional commodities and invest heavily in R&D and in new plants in order to capture the more profitable "specialities" markets. During the last five years or so the results have been very different, since the rapid openning of the Mexican market left Mexican firms exposed to immediate competition from abroad, thus precluding their development of complex specialities. At the same time, some of the traditional plastics and fibers have regained internationally major market shares to the advantage of the more traditional producers of mature products.

As a result of these international and domestic trends, the Mexican technological leaders into the "specialities" up-grading route, that is those investing in R&D and commiting themselves more firmly to technological development, are now in difficulty, especially if they did not have a foreign partner sharing the risk.[12]

The recently successful firms, on the other hand, see their future in consolidating the basic and intermediate petrochemical chains which are both less

[12]One of the most clear examples of firms that faced difficulties due to their previously more aggresive industrial and technological strategy is Resistol, one of the companies listed in Table 6. It then adjusted later to a more moderate approach, one we could refer as downgrading at the firm level, even if not in comparison with others in the industry. The survival strategy for this firm has included sacrificing the search for break-through specialities.

technologically demanding and more profitable in the near term. They invest in R&D, but much less than the others both in terms of quantity and of quality.[13] The rules of international competition are anticipated to apply in the domestic market of the future as well, and these rules are set forth by large vertically integrated chemical conglomerates that may use transfer pricing in order to obtain a profitable return for their integrated operations.

Relatedly, some of the most promising areas may involve increasing their vertical integration up-stream, arriving to final consumer goods that may be less subjected to cost competition and more to product differentiation. This is the case of a firm with long tradition in the fibers business that only recently decided to enter the clothing line. And other still more promising new ventures may relate not so much to the development of new products but rather to their commercial exploitation of down-to-earth environmental concerns: recycling of plastics, sewage and other water treatment, biotechnology applications to chemicals pollution, and the like. In all these cases, the result is not to up-grade their industrial capabilities, but the contrary.

For the machine tool producers the effects of international competition are less evident than in petrochemicals. Domestic demand is the driving force of machine producers, and although such demand is highly dependent on new fixed investment, the rythm of activity that we observed in machine producers showed some laggs with respect to the trends of total investment. This meant that some machine tool firms did not see their production reduced but several years after the 1982 collapse of most other domestic markets.

The machine tool producers still surviving in the 1990s are of two kinds:

a) small firms producing simpler standard machinery, where keeping close contact with a disperse variety of consumers becomes a competitive determinant; and

b) subsidiaries of large TNCs suppliers of specialized machinery and components for the replacement market that may have more to sell when the users decide to extend the life of older machinery rather than replacing them with new machines.

Some of these producers have initially suffered the penetration of low cost imported machine tools after the liberalization of 1985. The main competitors were imports from South East Asia (Taiwan and Singapore) and China. After a few years however, imported machines are on the whole discredited as of lower quality and less reliable to repair and maintain. For the very few competing Mexican producers the results of that experience are very reassuring. They now feel very confident to keep their competitiveness provided they stick firmly to their domestic traditional consumers.

[13] In those firms (Idesa and Primex in particular) R&D accounts for less than 1% of sales and R&D, while main efforts are devoted to improve efficiency in known processes.

Perhaps the most serious technological result in this sector is that local producers see the scope of their production confined to the standard mature segments of machine tools. There is not a need to upgrade the profile of their product-mix, neither they believe that they could close the technology gap with foreign producers of more advanced equipment. In so far as machine tools and other capital goods remain to be considered important vehicles of technological development and a source of benefitial externalities for other parts of the economy, the quality of the capital goods that one country chooses to produce is not a free value decision (Krugman, 1986; Harris, 1991).

Other technological effects are of minor importance. Imports of technology by the machine tool producers themselves has never been substantial, neither technology transfers nor equipment. Training, R&D, new organizational technologies, and the like are not of importance and have not been directly impacted in any substantial degree by the new environment of the early 1990s.

The motor industry (MI) experience can be seen in a different perspective. Nowadays, this industry exhibits a dual pattern of specialization in which Northern plants produce for export, while those in the South are concentrated on supplying the domestic market. Transactions between these two types of plants are minimal.

A critical aspect of this spatial pattern lies on the way firms are linked to their parent companies. Plants in the North rely much more on imports than those in the South, because of their more integrated nature of activities to the conglomerate, including intensive intra-firm trade. All but 10 per cent of the total value of Northern plants' transactions take place among the supplier-assembler circuit and parent companies. This explains why motor firms have increased their exports while raising the ratio of imports to production of manufacturing in the last years.[14]

With the exception of some producers of "principal components" in the South, the largest Northern plants have turned to be the main benefitiaries of this spatial division.[15] Their uncomparable productive success is particularly due to the implementation of radical organizational changes. They are leaders in upgrading automation levels and have led the adoption of new managerial approaches by transforming greatly the traditional relations between capital and labour.

These changes, which grossly fit into the industrial goals pursued by the government since 1982, have allowed the MI to become the core of Mexico's export led programme. The MI is, along with the maquiladoras, the largest exporter and

[14]For the whole manufacturing sector, this ratio grew from 7.3% in the period 1982-1986 to 13.2% in 1990. The leading export firms were responsible for this boom; for instance, the autoparts industry incresaed its imports to output ratio from 49.2% in 1982 to 120.7% in 1990 (Arjona and Unger, 1996).

[15]By contrast, the Southern plants are the net lossers of this division. After the opening of the economy, many small producers went out of bussiness mainly because of the increasing integration of their main client, the largest first-tier suppliers. This integration reduced the small producers 'chances to survive since the first-tier suppliers tended to concentrate their purchases on their affiliates with the purpose of increasing scale economies, thereby reducing costs.

value-added generator in manufacturing. They contribute 60%t of the country's total exports. But in contrast with the petrochemical and machine tools cases, the exports projects of the MI are led by a handful of subsidiaries of foreign-based multinationals.

In particular, the six US Big Three facilities located in the North after 1981, account for the majority of the MI's exports.[16] They are organized around flexible complexes practicing and using effectively the most advanced Just in Time (JIT) manufacturing systems in Mexico. In fact, the Big Three assembly plants have lately recorded the highest levels of productivity and quality in manufacturing due mainly to their efficient JIT suppliers networks.[17]

The placement of these plants in Northern Mexico is a result of the headquarters' strategy to make Mexico the most important "consolidation centre" in Latin America. The development of prototypes in Northern plants to be later implemented around the world, as well as the production in Mexico of models that were usually made in the USA and Canada, are successful proofs of such a strategy. This new role of the six facilities has been recently fostered by the headquarters decision to enter technological agreements with Mexican partners only if they are concerned with "simultaneous engineering".

Such a strategy has involved assemblers and a handful of Mexican innovative suppliers in certain experiments of product design and development since 1990. The most relevant example is a joint venture between Chrysler and six Mexican firms to design an engine. The association has proven to be very successful.[18]

Unfortunately this strategy has been limited to those suppliers which have agreed joint ventures with TNCs or acquired licenses to upgrade their technological and organizational levels (see table 7). We found that 12 first-tier suppliers concentrate nearly 40% of total sales and 85% of exports in the autoparts industry (excluding engines). Eight out of these are placed in the Northeast of Mexico and are single producers of engine blocks, iron-and aluminium heads, windscreens, plastic parts, suspensions, and so on (Ramírez, 1995).

For other minor producers, the chances of supplying the outward-oriented plants are limited to the extent that they depend on their links with the first-tier

[16] On average, the Big Three exports accounted for two-thirds of the MI's total revenue (US $7bn.) between 1993 and 1995. This means that these subsidiaries contribute over 20 per cent of the foreign exchange elicited by the manufacuring sector, the largest foreign-exchange providers in Mexico after Pemex.

[17] According to Shaiken (1994), Ford-Hermosillo and Ford-Chihuahua have recorded the highest productivity and quality standards in the North America auto market. The former, for instance, was acknowledged by Ford Motor Co. as the plant with the highest levels of quality within the Ford global network in 1988. More recently, this plant registered 1406/TGW (things gone wrong) defectives points per auto, against an average 1520 points for the rest of the corporation's plants.

[18] The success story is quoted by an observer: "[Chrysler] expects that Mexican firms will take the lead in the product design of engines in the future" (Morales, 1994, p. 10).

suppliers. In practice, the major suppliers decide how many other suppliers will be incorporated into their network. National suppliers contracted by outward-oriented plants may not have affiliates elsewhere and are, therefore, in disadvantage when in competition with transnational suppliers who can provide parts for the motor companies in different countries. Only a few Mexican companies can successfully survive as independent suppliers, resting on their monopolistic position in the domestic market.

By all accounts we can conclude that the opening of the MI has partially upgraded the technological levels of a few suppliers, even if the technological sophistication of the Big Three factories has not produced substantial spillovers. In fact, the location of the six assemblers has concentrated even more the production and technological resources in the hands of the biggest suppliers (both national and international). Thus, it would be venturous to say that the MI for export can be a solid base or a counterbalance to other sectors, as to lead the development of a National System of Innovation in Mexico.

Perhaps the most damaging effect of the adjustment policies in these sectors, as much as in most other parts of the economy, has been to reduce their concern with the long run and the extended development of long term technological capabilities. Short term opportunities appear more profitable, even when they demand some upgrading adjustment of suppliers in the near network. Other profitable areas include commercializing options rather than fabrication, and most of all financial ventures. The long run is a difficult bet for the short-sighted private sector of countries that have just past through adjustment experiences.

TABLE 1. MEXICO. NATIONAL EXPENDITURES ON SCIENCE AND TECHNOLOGY, 1991

Sector of Financing	Sector of Performance	Millions U.S. Dlls.	Ratio/Total %	Ratio/Sector %	Ratio/GDP %
Federal Government [1/]		1050	78	100	0.36
	Government Agencies	722	54	69	
	Higher Education	328	24	31	
Private Sector [2/]		301	22	100	0.12
	Business Enterprise	291	21	97	
	Higher Education	10	1	3	
Total		1351	100		0.48

SOURCE: [1/] SHCP, Federal Treasury Account, 1991.
[2/] Conacyt, estimates based on INEGI Surveys

TABLE 2. FEDERAL EXPENDITURES ON SCIENCE & TECHNOLOGY, MEXICO 1980-1993
(Millons of Dollars)

Year	FES&T [1/]	GDP	FES&T/GDP %	Government Expenditure [2/]	FES&T/Govt. Exp. %
1980	836	194,775	0.43	50,528	1.66
1981	1,145	250,005	0.46	73,571	1.56
1982	715	170,574	0.42	46,274	1.54
1983	472	148,779	0.32	35,334	1.33
1984	646	175,667	0.37	42,566	1.52
1985	653	184,432	0.35	41,145	1.59
1986	454	129,535	0.35	28,129	1.62
1987	395	141,442	0.28	28,698	1.38
1988	467	173,512	0.27	32,983	1.42
1989	596	206,923	0.27	35,983	1.58
1990	725	244,508	0.30	41,073	1.77
1991	1,050	287,737	0.36	49,514	2.12
1992	1,143	329,076	0.35	55,912	2.04
1993	1,454	355,931	0.41	67,218	2.16

[1/] Federal Spending on Science & Technology.
[2/] Total Public Sector (not including debt service).
SOURCE: SPP, Federal Treasury Accounts 1980-1990. SHCP, Federal Treasury Accounts 1991-1992. SHCP, Federal Budget. Banxico, 1992 Annual Report.

TABLE 3. MEXICO. SCIENTIFIC AND TECHNOLOGICAL PERSONNEL, 1991

Sector	Scientists & Engineers	Technicians	Support Personnel	Total
Federal Government	11,304	9,043	8,139	28,486
SEP-Conacyt System	1,059	847	762	2,668
IMP	816	343	144	1,303
ININ	378	302	272	952
IIE	795	636	572	2,003
INIFAP	1,528	1,222	1,100	3,850
LANFI	80	64	58	202
IMSS	1,081	865	778	2,724
ISSSTE	297	238	214	749
Health Secretary	1,254	1,003	903	3,160
Others	4,016	3,523	3,336	10,875
Higher Education	11,125	8,900	8,010	28,035
Public Universities	10,756	8,605	7,744	27,105
UNAM	2,641	2,113	1,109	5,863
UAM	1,609	1,287	1,158	4,054
IPN	1,233	986	888	3,107
Autonomous University of Chapingo	555	444	400	1,399
Technical Institutes System	248	198	179	625
Others	4,470	3,577	4,010	12,057
Private Universities	369	295	266	930
ITESM	213	170	153	536
Others	156	125	113	394
Business Enterprises	155	124	112	391
Peñoles Industriales	109	87	78	274
HYLSA	15	12	11	38
Petrocel S.A.	10	8	7	25
Others	21	17	16	54
Private Non Profit	41	33	30	104
Sonora College, A.C.	18	14	13	45
Alfa Cultural Center	12	10	9	31
Research Center for Development	9	7	6	22
Other	2	2	2	6
Total	22,625	18,100	16,291	57,016

SOURCE: Conacyt-OIKOS, Preliminary Results Inventory of Institutions and Resources Devoted to Scientific and Technological Activities 1990-1991.

TABLE 4.MEXICO. NATIONAL EXPENDITURES ON SCIENCE AND TECHNOLOGY, 1984-1991

Sector	1984	1989 (Millions of Dollars)	1991	1984	1989 (Percentages)	1991
Federal Government	646	569	1,050	85.0	76.9	77.7
Private Sector [a/]	114	171	301	15.0	23.1	22.3
Total	760	740	1,351	100.0	100.0	100.0

[a/] Estimated figures.
Source: Inter-American Development Bank; INEGI and SPP, Mexico.

TABLE 5. MEXICO. PERCENTAGES OF SCIENTIFIC AND TECHNOLOGICAL PERSONNEL, 1991

Sector	Scientists & Engineers	Technicians	Support Personnel	Total
Federal Government	50.0	50.0	50.0	50.0
SEP-Conacyt System	4.7	4.7	4.7	4.7
IMP	3.6	1.9	0.9	2.3
ININ	1.7	1.7	1.7	1.7
IIE	3.5	3.5	3.5	3.5
INIFAP	6.8	6.8	6.8	6.8
LANFI	0.4	0.4	0.4	0.4
IMSS	4.8	4.8	4.8	4.8
ISSSTE	1.3	1.3	1.3	1.3
Health Secretary	5.5	5.5	5.5	5.5
Others	17.8	19.5	20.5	19.1
Higher Education	49.2	47.2	49.2	49.2
Public Universities	47.5	47.5	47.5	47.5
UNAM	11.7	11.7	6.8	10.3
UAM	7.1	7.1	7.1	7.1
IPN	5.5	5.5	5.5	5.5
Autonomous University of Chapingo	2.5	2.5	2.5	2.5
Technical Institutes System	1.1	1.1	1.1	1.1
Others	19.8	19.8	24.6	21.2
Private Universities	1.6	1.6	1.6	1.6
ITESM	0.9	0.9	0.9	0.9
Others	0.7	0.7	0.7	0.7
Business Enterprises	0.7	0.7	0.7	0.7
Peñoles Industriales	0.5	0.5	0.5	0.5
HYLSA	0.1	0.1	0.1	0.1
Petrocel S.A.	0.0	0.0	0.0	0.0
Others	0.1	0.1	0.1	0.1
Private Non Profit	0.2	0.2	0.2	0.2
Sonora College, A.C.	0.1	0.1	0.1	0.1
Alfa Cultural Center	0.1	0.1	0.1	0.1
Research Center for Development	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0

SOURCE: TABLE 3

TABLE 6. MEXICAN COMPANIES AND THEIR R&D ACTIVITIES, 1993

Company	Sector [e]	Sales [e] (Thousands of new *pesos*)	Assets [e] (Thousands of new *pesos*)	Personnel [e]	R&D Unit [c]	R&D Activity [d]
Industriales Peñoles [a]	Mining	2285009	3629861	10382	Center for Researchd and Technological Development	Metals, Minerals and Chemicals
Vitro Corporativo [a]	Glass	*	*	*	Six R&D divisions	Glass and Botting Manuf. Non Metallic New Materials, Metallurgy, Machinery, Industrial Equipment.
Grupo Industrial Resistol [c]	Petrochemicals	646435	650947	2244	Grupo IRSA, Center for Research and Technology Development	Polymers (Rubber, Plastics, Additives)
Celanese Mexicana S.A. [b]	Petrochemicals	2903011	4275816	8278	Technology Research and Development Center	Chemical Products
Hylsa [b]	Iron and Steel	2505414	4104116	4997	*	Steel
Grupo Condumex S.A de C.V. [a]	Electronics & Manufacturing	2409865	2599631	12028	Condumex Research and Development Center	R&D on Materials, Metallurgy, Electric Testing, Machinery and Tools
Richold Quimica	Chemicals	*	*	*	Research and Development Departament	Polymers
CYDSA [a]	Chemicals	2559509	4470113	12381	Different Research Units	Chemicals
Comercial Mexicana de Pinturas	Chemicals	*	*	*	Polymers Research Center	Polymers

SOURCE: [a] Expansion. September 1, 1993. [b] Expansion. August 18, 1993. [c,d] Data gathered from companies by phone. [e] SOURCE: [a, b, c]

TABLE 7. THE AUTOPARTS FIRMS: A SAMPLE UPGRADING EXPORTERS 1993

Firm	Ranking (sales)	Ownership	Production (Q) (US millons)	Export (X) (US millons)	X/Q	Technology: Source	Technology: Purpose
Renault Autoparts Industries	1	French	120	120	1.00	Renault HQ	Components for own makes
VITROFLEX	2	Mexican 90% American 10%	95	85	0.89	FORD Glass Division	JV. Engineering support for sales of windscreens in Mexico and US
CARPLASTIC	3	American	85	80	0.94	FORD PTDP Division	License to produce dashboards
CIFUNSA	4	Mexican	69	56	0.81	a) Italian company b) FORD's affiliate	Process reorganization License to automate the premachining and smelting
TREMEC	5	Mexican & American	65	15	0.23	Autoparts American Co.	License to produce automatic transmissions
METALSA	6	Mexican 88% American 12%	54	24	0.44	A.O. Smith	JV. Assistance for production of chasses and side rails (sales in Mexico and US)
RASSINI	7	Mexican	515	43	0.83	Autoparts American Co.	License to produce spring suspensions
NEMAK	8	Mexican 85% Italian 15%	36	19	0.53	TEKSID	JV. to enhance quality and productivity of aluminium heads
Total			575.5	442*	0.77		

* This figure accounted for 65% of the autoparts industry exports (excluding engines) in 1993

SOURCE: Ramírez (1995)

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