

**IMPACTS OF ECONOMIC
INTEGRATION ON THE
COMPUTER SECTOR
IN MEXICO AND THE
UNITED STATES**



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Summary of Impacts of Liberalization and Economic Integration

Impacts on information technology (IT) use in Mexico

- Liberalization has had the expected impacts on IT use: it has led to more competition, resulting in lower prices, which has led to more IT use.
- Mexico's accession to NAFTA has encouraged use by opening up some Mexican economic sectors (e.g., banking, government procurement, retail, manufacturing) to competition from U.S. companies, who have introduced IT as a competitive tool in Mexico. Mexican companies have followed suit, increasing investments and upgrading their IT capabilities.

Impacts on Mexico's computer industry

- Liberalization has hurt locally-owned PC makers, most of which lost business, were bought out, or went out of business.
- On the other hand, liberalization did not lead foreign computer makers to abandon production in Mexico even though they could have just served Mexico from the U.S. Instead, given Mexico's membership in NAFTA, its location, its cheap labor and the adequate pool of engineering skills it offers, three key vendors, IBM, Hewlett-Packard, and Acer have expanded Mexico's role as a production base. In addition an important number of foreign suppliers and contract manufacturers such as Solectron, Dovatron, Flextronics, Jabil Circuit and Avex have established plants in Mexico in the last few years. The substantial, but not so publicized devaluation the peso experienced during 1998 –of about 30 per cent— made it even more profitable to invest in this country. For some companies, the effects of this devaluation were stronger than NAFTA as a luring factor. As a result, thousands of new jobs have been created in the computer and electronics industries, and advanced production technologies have been transferred to Mexico.
- The electronics and computer industries still operate mostly as maquiladoras, importing parts and components and assembling final products. NAFTA and liberalization of the local market haven't changed that. Linkages to domestic Mexican suppliers are rare, little production is for the local market, and locally-owned companies are largely absent.
- The lack of a national IT policy has hurt Mexico's ability to create backward linkages, to develop local suppliers, or to develop a local software and services industry. An exception to this is a supplier development program operated at the national level by the Ministry of Trade and Industrial Promotion (SECOFI). The Jalisco State government and CANIETI (the IT industry association) are trying to create a true industry cluster in the Guadalajara area, but the effort is hampered by the lack of federal support. In order for Mexico to benefit from its geographical location and its membership in NAFTA, it needs to develop policies aimed at creating national capabilities and improve the information infrastructure.

Impacts on the US computer industry

- For US companies, NAFTA has helped support North America as a base of operations in competition with Asia, especially since the Asian crisis has cut production costs there. For the US computer industry, NAFTA has been a boon by linking North America together as a more integrated regional market and production platform, benefiting from low-cost production in Mexico to complement high value activities in the US.
- Liberalization has expanded the Mexican computer market, and the main beneficiaries have been US companies in the hardware, software and services markets.
- The failure to expand NAFTA has led some companies to serve the Latin American market from Mexico, which has free trade agreements with other countries in the region.

I. INTRODUCTION

Market liberalization and economic integration have been global economic trends in the 1980s and 1990s, reaching from Latin America to Eastern Europe, China, India and beyond. Following the advice of economists and technocrats at home and abroad, countries around the world have lowered trade barriers, encouraged foreign investment, and undertaken comprehensive deregulation and privatization programs.

Mexico is a prime example of this trend. It has dramatically opened and liberalized its economy over the past fifteen years, responding at first to the pressures of the 1982 debt crisis, then moved toward economic integration globally and regionally by joining the GATT in 1986 and NAFTA in 1994. The Mexican government has lowered barriers to foreign investment and trade, privatized most state enterprises, and deregulated sectors such as telecommunications, petrochemicals, finance and transportation.

The computer industry is one case in which policy shifted from protection to liberalization. In the 1980s, Mexico's computer industry was governed by a government policy that limited participation of foreign companies, requiring them to establish joint ventures and produce in Mexico in return for market access. Importation of most new computer equipment was prohibited or tightly restricted. The policy began to shift after a confrontation with IBM over ownership of a new plant in Guadalajara. As an outcome of that dispute, the government backed off its restrictions on foreign equity, but still required foreign subsidiaries to meet targets for local content, exports and R&D. However, in 1990, the computer sector was almost completely liberalized by means of a new presidential decree. Most restrictions on computer imports were removed, and requirements for local content, exports and R&D were eliminated.

This series of policy shifts has changed the nature of both computer production and use in Mexico. The mainframe industry has always been led by foreign companies, but the PC market was initially led by small local startups such as Printaform, Electronica Zonda and Wind. After IBM opened its Guadalajara plant in 1986, it took the lead in the protected domestic market, as it faced little competition from other foreign PC makers. When the market was opened in 1990, however, IBM's market share dropped as it faced competition from U.S. and Asian companies. This competition drove prices down and PC sales grew rapidly. However, it led to the demise of many locally-owned PC makers, who were unable to compete with new foreign competitors.

Since 1994, developments in the Mexico's computer sector have been driven in part by economic integration under the North American Free Trade Agreement (NAFTA), which has created new incentives for both production and use of computers. NAFTA has encouraged production because its local content provisions give advantages to companies that produce in North America rather than Asia or elsewhere. It has stimulated use by lowering tariffs on computers, and by attracting more U.S. companies to enter many sectors of the Mexican market, bringing with them their heavy emphasis on information technology (IT) as a competitive weapon. The peso crisis of 1994 interrupted the growth of IT investment in Mexico, but the market rebounded quickly and by 1997, spending exceeded pre-crisis levels.

While liberalization has had some salutary effects on computer production and use, Mexico has suffered in the 1990s from the lack of any coherent IT policy aimed at developing national capabilities or improving linkages with the global computer industry. IT use is hampered by high telecommunications costs and poor infrastructure, the near absence of computers in public schools, and relatively low levels of government computerization.

Mexico's computer industry is highly fragmented. IBM, Hewlett-Packard and Acer all produce for the local market and for export, but they mostly import components and equipment, due to an absence of local suppliers. The major contract manufacturers concentrate on assembly of imported parts for re-export to the U.S. market, and have only begun to develop linkages to local computer production. However, the CMs do produce for companies such as HP, Compaq and Ingram Micro in the United States. Computer and components production by locally-owned companies is very limited, while the booming maquiladora sector operates as a pure export enclave, with almost no linkages to the local market or to local suppliers. There are some promising local software and IT services companies, but they are hampered by a lack of capital and are relegated to niche markets to avoid competing directly with foreign companies.

Mexico's location next to the world's largest IT market and producer, as well as its membership in NAFTA, give it an advantage that most other countries would envy, yet it has done little to develop policies to capitalize on its position. This is partly due to a prevailing ideology of laissez faire that guides government policy, and partly due to concerns that Mexico should not be seen as pulling jobs out of the U.S., but it is largely a result of the fact that IT is simply not very high on the policy agenda. Unlike countries such as Singapore, Ireland, Taiwan, or Malaysia, there has been no emphasis placed on IT by top government leaders, and there has been no "champion" of technology policy such as Al Gore in the U.S. or Lee Kuan-Yew in Singapore. Efforts by state governments and the Mexican Investment Board to attract multinationals have been successful, but there is no coordinated national strategy to develop the infrastructure, human resources or technology base to support computer production.

The history of the computer industry has shown the dangers of excessive or misguided government intervention in many countries, including Mexico in the 1980s, but it has also shown that no country has become a leading producer or user of IT through a pure free market approach either (see Flamm, 1987; Anchoroguy, 1989; Fransman 1990; Dedrick and Kraemer, 1998). While Mexico's laissez faire approach of the 1990s certainly removed some barriers created by the earlier nationalistic approach, it has not led to the development of many of the capabilities or much of the infrastructure needed for the computer industry or computer use to thrive. In order for Mexico to develop a more integrated, diversified computer industry, it will need to develop policies aimed at creating those capabilities.

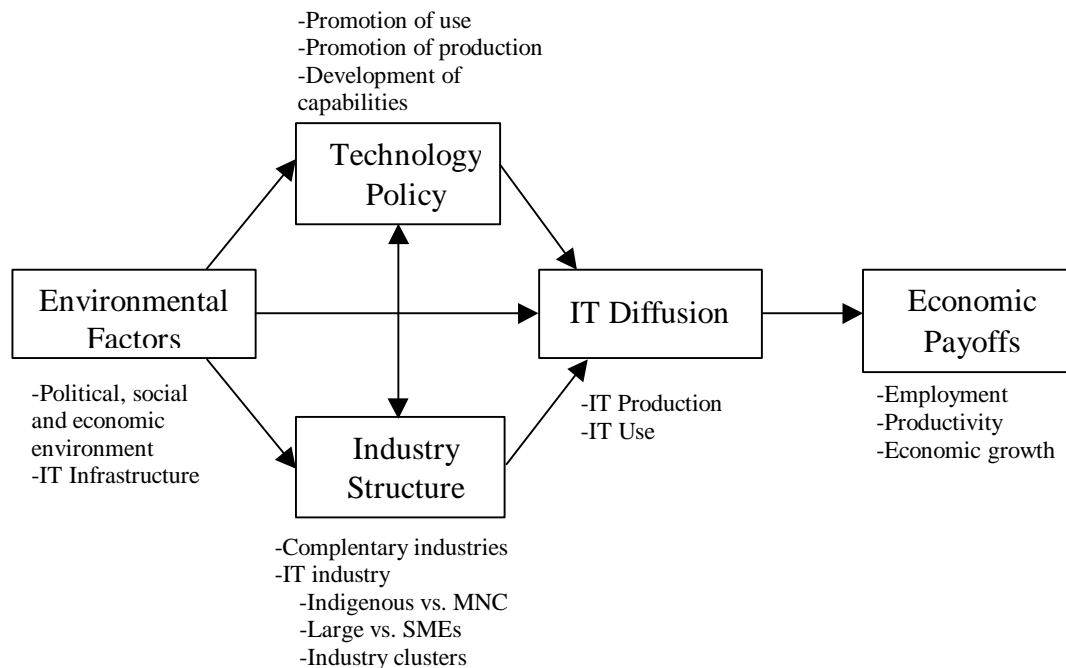
Analytical Framework

This paper presents a critical analysis of Mexico's experience with computers using the framework presented in Figure 1. Moving from left to right, it posits that environmental variables such as the economy and infrastructure, along with industry structure, influence computer production and use both directly and through the mediation of government policy. Environment, industry structure, and policy are closely interrelated, as policy choices alter the

economic incentives and influence industry structure, and these factors in turn shape the range of policy choices available and the outcome of those choices for computer diffusion. Also, there is a feedback from computer diffusion to environment, industry structure and policy. Over time, the success or failure of computer diffusion in the economy and of development of a national computer industry will change the environment and affect ensuing technology policy.

As shown in Figure 1, the *environment* includes economic factors that affect computer production and use, political forces that affect the policymaking process, and the quality of a country's IT infrastructure, including human resources, telecommunications and R&D capabilities. *Industry structure* refers to the character of firms that comprise the computer industry and the nature of their value chains (suppliers, business partners, customers). *Technology policy* represents the strategic choices a nation makes about support for promotion of computer production and use, as well as the development of national capabilities such IT skills and infrastructure. *IT diffusion* includes the spread of computer use throughout the economy and the development of domestic hardware, software and services industries. Finally, it is expected that IT production and use will have *economic payoffs* in the form of employment, productivity and economic growth.

Figure 1. Framework for Analysis



The detailed analysis which follows is organized according to this framework. The first section discusses *environmental factors* affecting the production and use of computers. The next section describes the *industry structure* of Mexico's computer and electronics industries. The third section recounts the history of *technology policies* related to the production and use of computers, considering the reasons why particular policy choices were made and the effects of those policies. The fourth section looks at the *diffusion of computer production and use* in Mexico over time and compares the level of use and production to selected other countries. The

final section draws conclusions about Mexico's experience with computers, especially regarding the impacts of economic liberalization, and the prospects for the future.

II. ENVIRONMENT

A. Political Environment

Mexico has been governed by the Institutional Revolutionary Party (PRI) since 1929, the longest continuing rule of any political party in the world. Political power is shared between the Legislative and Executive branches, but for most of that long period, the PRI exercised absolute control over the Mexican Congress, which acted as little more than a rubber stamp agency for the president. Mexican presidents not only possess great power while in office, but have traditionally selected their own successors.

The PRI's power has been bolstered by its close alliance with national labor unions and its control over state enterprises, both of which have been counted on to get workers to the voting booth and to vote for the party's candidates. This has begun to change during the 1990s, as new political options have been opened to workers and public officials, and dissent has increased among PRI members, giving rise to the emergence of new political factions inside the party.

The hegemony of the PRI was first seriously challenged in the 1988 presidential election, when Cuauhtémoc Cárdenas, taking advantage of the growing national discontent with the PRI, led a wide opposition movement organized as the National Democratic Front. Many observers and opposition parties believed that Cárdenas actually won the close election, but PRI candidate Carlos Salinas was elected amidst charges of election fraud.

Salinas promised from the outset a thorough political reform concomitant with the economic reform agenda he presented as the backbone of his government program. His political reforms failed to match his economic reforms however, and he followed traditional practices such as handpicking the PRI's presidential candidate in 1994 rather than opening the process up to broader participation. However, his economic successes and populist policies helped make him one of Mexico's most popular presidents in recent decades.

Salinas' historical achievements on the economic front, such as the signing of NAFTA and Mexico's admission to full membership in the OECD, seemed to assure him a grand *finale* for his regime in 1994. However, the Zapatista uprising in Chiapas on January 1st of that year and the political turmoil it entailed foiled Salinas' intentions of extending *de facto* his political power beyond his time in office.

In this context, 1994 was marred by the murder in March of Luis Donaldo Colosio, Salinas's hand-picked candidate, and that of José Francisco Ruiz Massieu, PRI's Secretary General and Salinas' brother-in-law, in September. Ernesto Zedillo was chosen by Salinas as a stand-in for Colosio and won the presidential elections of that year. Since then, Mexico has endured a drastic devaluation of the peso just weeks after Zedillo's inauguration on December 1st; a severe economic crisis and eventual recovery; an ongoing guerrilla movement in Chiapas; the

conviction of Carlos Salinas's older brother, Raúl, on charges of conspiracy in the murder of Ruiz Massieu.

The power of opposition parties has continued to grow as the PRI has struggled with its own scandals and internal strife. The conservative National Action Party (PAN) was able to win the governorships in a number of northern states and the left-of-center Democratic Revolution Party (PRD) took control of numerous municipal governments in various states in central Mexico. Furthermore, in July 1997 the PRI lost its long standing majority in the Chamber of Representatives (*Cámara de Diputados*) thus ending seven decades of undisputed domination over the Mexican Congress. The ruling party not only lost its control of the legislative branch, but also its political grip on Mexico's capital city, as Cuauhtémoc Cárdenas became the first elected head of government of Federal District (the position was previously a political appointment).

More governorships have fallen to the PAN in the last two years, including major states as Jalisco, Chihuahua, and Guanajuato. The PRD in turn has continued to expand its presence and political power, especially with Cárdenas' accession to power in the Federal District, with more seats in the district's legislative body, and with the triumph of its candidates in other states, most notably in Baja California Sur and Zacatecas in 1999. Also, Congress has begun to take a more active role in the policy-making process since 1997 by challenging for the first time many major presidential initiatives.

As the 2000 federal elections draw near, the PRI has promised a more democratic process for choosing its candidate, but whoever is nominated will face strong competition from the PRD and PAN candidates, surely Cuauhtémoc Cárdenas and Vicente Fox, respectively. The decline of the PRI may lead to a more democratic future, but in the meantime the Zedillo administration has still to struggle to respond to serious problems such as crime, corruption, drug trafficking and the Chiapas rebellion.

Constitutionally, Mexico is a federal republic, but power is highly concentrated in the central government and its bureaucracy, which collects most of the country's taxes and controls the key decisions as to how funds are allocated and spent. In the past, the Ministry of Trade and Industrial Promotion (SECOFI) had a large role in shaping trade and industrial policy, but the liberalization of the Mexican economy and the decision to join the GATT and NAFTA have greatly curtailed its influence. The impact on the computer and electronics industry has been to abandon Mexico's strategy of promoting domestic production and technology development in favor of a hands-off policy approach. Whatever the outcome of the 2000 election, there is little likelihood of a major shift in economic policy away from liberalization and North American integration. It is possible, however, that a new government would embrace a more active technology and industrial policy approach, especially considering that for the first time in 70 years opposition parties have a real chance of winning the election and taking power.

B. Economic Environment¹

Building on the foundations laid by the revolutionary governments over the previous three decades, in 1940 Mexico inaugurated an era of rapid growth and overall prosperity that lasted another 30 years. During this period, the Mexican economy grew at an aggregate rate of over 6 per cent a year in real terms, and at more than 3 per cent on a per capita basis. The Mexican economy experienced a profound structural transformation during those decades. The share of agriculture in both employment and gross domestic product (GDP) dropped from 65 per cent and 23 per cent, respectively, in 1940 to less than 50 per cent and 16 per cent in 1970, respectively. These achievements were so impressive that came to be known in international circles as the Mexican Miracle.

The policies behind the Miracle were dubbed as *desarrollistas* (developmentalist), as they had rapid growth as their overriding concern. The political and social stability entailed by such prosperity in turn opened large business opportunities and nurtured the emergence of a dynamic entrepreneurial class.

The impressive industrialization that Mexico experienced during the *desarrollista* period was made possible by an aggressive import substitution strategy that was adopted by virtually all Latin American countries after World War II. During this period both Mexican and foreign companies developed a sizeable manufacturing capacity to serve the protected domestic market. The economy began to slow in the 1970s, as import substitution opportunities became exhausted and Mexico felt the impacts of global economic shocks.

The discovery of large oil reserves in 1976 changed the economic picture dramatically. During the oil boom of the late 1970s, Mexico's GDP grew by over 8% per year as oil exports soared. The government borrowed heavily to expand production and invest in other development projects, based on the expectations that oil prices would continue to rise and interest rates would remain low. However, by 1981 oil prices were falling and world interest rates rose dramatically. Mexico's trade deficit grew, and investors began to move capital out of the country. In 1982 the situation became critical, and the government had to take drastic steps to protect its dwindling foreign reserves, including nationalizing the banking system, adopting foreign exchange controls, and suspending principal payments on foreign debt. This heralded the arrival of the Latin American debt crisis of the 1980s, and Mexico's lost decade of economic growth.

As international bankers, the IMF, and the U.S. government looked for solutions to the debt crisis, Mexico suffered from high inflation, negative growth, and a rapidly depreciating peso. Suffering from a severe shortage of capital, Mexico began to open up its economy in hopes of attracting foreign investment (and to satisfy the demands of the U.S. and IMF). Mexico joined the GATT in 1986, agreeing to a program of liberalization, privatization, and deregulation as part of that process.

¹ This review of Mexico's economic history draws on Roger Hansen (1974) and Nora Lustig (1992), and the work of Lustig and John Adams, Jr., as summarized by Joni Leithe (1997), "Mexico: the economic emergence of the United States' neighbor to the south," *Government Finance Review*, 6(13).

The changes were dramatic. Tax reforms were enacted and public spending was cut to reduce the fiscal deficit. Major state enterprises were privatized, including Telefonos de Mexico (Telmex), the country's two airlines, mining companies, sugar refineries, and a number of manufacturing firms. Banks were again privatized, the banking sector was deregulated, and restrictions on foreign ownership were removed or relaxed in key sectors such as telecommunications, mining, transportation and petrochemicals (although the oil company, Pemex, remained in government hands). Trade barriers were lowered so rapidly that only 20% of the economy was protected by tariffs or import licenses in 1988, compared to 75% in 1985. The opening up of the Mexican economy was not only swift but also unilateral vis a vis major trade partners, especially the United States.

As a result of these changes, investor confidence in the Mexican economy was restored, leading foreign investment to grow from US\$3 billion in 1989 to US\$12.2 billion in 1991 (Leithe, 1997).¹ Also, inflation was brought under control and the economy began to grow again. On this basis, the Salinas administration sought to consolidate its liberalization policies by negotiating and signing the North American Free Trade Agreement (NAFTA), tying Mexico, Canada and the U.S. into one free trade zone in January 1994.

NAFTA, on top of the country's economic restructuring, led to a rapid inflow of foreign investment into Mexico. However, by 1994 the peso, which had been pegged to the U.S. dollar as part of Salinas's anti-inflation Solidarity Pact, was becoming dangerously overvalued. The strong peso, along with the removal of trade barriers, led to an import binge, and Mexico's current account deficit reached 7.7% of GDP. This flow was balanced by the continuing inflow of foreign capital, but in 1994, investor confidence was shattered by two events: the guerilla rebellion and government crackdown in Chiapas; and the assassinations of Colosio and Ruiz Massieu. These events led to a capital outflow that at one point totalled one-third the value of Mexico's outstanding stocks.

The Mexican government tried to defend the peso, until its foreign reserves fell below US\$10 billion. At that point, the newly inaugurated administration of Ernesto Zedillo was forced to allow the peso to float freely, and it lost 40% of its value. The devaluation threatened to push Mexico into default on its foreign debts, so the U.S. government organized a US\$50 billion loan package in conjunction with Canada, the IMF, the World Bank, and private banks. In return, Zedillo agreed to austerity measures that cut the budget deficit, reversed the current account deficit, and enabled Mexico to repay the emergency loans ahead of schedule. The economy fell into a deep recession, with GDP falling by 7% in 1995, but unlike the 1980s crisis, this one was short-lived. Exports grew rapidly, foreign investment returned, and the economy returned to growth in 1996 and 1997. Tables 1 and 2 summarize Mexico's present economic conditions and performance since 1980.

By the late 1990s, Mexico's economy had been irrevocably transformed. During the 1995 crisis, there was no serious consideration of undoing the liberalization process or pulling out of NAFTA. As liberalization and economic integration have expanded and deepened, the impacts on the computer sector have been complex, creating winners and losers among both producers and users.

Table 1. Economic Indicators for Mexico

Population:	96,500,000
GDP per capita:	US\$3467
Industry as % of GDP:	33%

Source: Reed Electronics, *Yearbook of World Electronics Data, 1998*

Table 2. Trends in economic performance (US\$ billions unless noted)

	1980-1992	1993	1994	1995	1996	1997	1998
GDP growth (%)	1.5	2.0	4.4	-6.2	5.2	7.0	4.9
Inflation (%)	62.4	9.8	7.0	35.0	34.4	20.6	16.7
Exports		51.9	60.9	79.5	96.0	110.3	
Imports		65.4	79.3	72.5	89.5	106.9	
Merchandise trade balance		13.5	-18.4	7.0	6.5	3.4	
Current account balance		-23.4	-29.7	-1.6	-1.9	-4.0*	

* First three quarters

Sources: IMF, *International Financial Statistics Yearbook, 1998*. IMF *World Economic Outlook, May 1999*.

C. Infrastructure

The ability to produce and use computers requires a supporting infrastructure, including human resources, telecommunications, and research and development facilities. Without these assets, countries cannot hope to benefit from the opportunities presented by the rapid advances in computer technologies.

1. Human Resources

Perhaps the most critical part of any country's information infrastructure is the quality of its human resources. A well educated population with strong technical skills is a key to both successful production and use of information technology. The computer hardware industry requires electronics engineers, operations managers, logistics experts and other skilled professionals and technicians, as well as a literate work force for factory positions. Software and services companies need software designers and engineers, systems integration specialists, and programmers. Computer use requires programmers, management information systems professionals, and skilled end users.

The quality of Mexico's human resources is mixed (Table 3). There are plenty of low-cost workers with at least basic literacy skills, and a good supply of technicians produced by a large network of technical schools. Universities produce sufficient engineers, computer professionals and managers at the bachelor's degree level, and the output of MBAs and master's degrees in engineering is increasing.

On the other hand, a shortage of Ph.D's in computer science limits Mexico's ability to carry out academic research in the field. It is estimated by Mexico's Consejo Nacional de Ciencias y Tecnologia (CONACyT, the equivalent of the U.S. National Science Foundation) that there are only 100 computer science Ph.D's working in Mexican universities, and about 50 of them are at the Instituto Tecnológico de Estudios Superiores de Monterrey (Monterrey Tech). Only ten are

in Mexico's largest university, the Universidad Nacional Autonoma de Mexico (UNAM), and there are none at the University of Guadalajara, in the heart of Mexico's largest computer industry cluster.

Table 3. Human resource indicators:

Country	Mexico	Brazil	Korea	Taiwan	Singapore	Malaysia	United States
Population (millions) ^a	96.5	159	44.9	21	3.3	20.1	267.1
Adult Literacy (%) ^a	90	83	98	na	91	84	99
Mean years of education ^b	4.7	3.9	8.8	na	3.9	na	12.3
Secondary enrolment ratio (%) ^a	58	45	101	na	n.a.	57	91
Masters and Ph.D.s in science and engineering awarded, 1990 ^c	5916		7070	4011	200	na	66,508
R&D scientists and technicians per 1,000 people ^a	0.3	0.2	2.9	na	2.6	0.2	4
Number of software professionals ^d	321,482	549,840	340,168	140,070	11,336	53,389	2,006,309

a. UNDP, 1998

b. UNDP, 1993

c. Dedrick and Kraemer, 1998. CONACyT, 1995, *Indicators of Scientific and Technological Activities*.

d. Capers Jones, 1993, *Software Productivity and Quality Today – The Worldwide Perspective*. Data updated in 1995 in correspondence to authors.

There is no coordinated federal government effort aimed at increasing the supply of professionals to support computer production or use. There are instead initiatives at the state and local levels, including collaborations between universities--including Monterrey Tech, ITESO, Universidad Autonoma de Guadalajara, and CINVESTAV's Guadalajara Unit--and computer and electronics companies operating in Mexico. In this way, study programs are designed, or adjusted, to the companies' specific requirements.

Wages and salaries for the computer industry in Mexico are very low compared to the U.S., but higher than in many Asian countries. Assembly line workers earn around US\$1.20 per hour, including benefits, compared to as little as 25 cents in some parts of Asia. One multinational reports that it pays about US\$17,000 per year for technicians (including benefits), compared to US\$4500 in its Malaysian plant. On the other hand, a survey of electronics companies in the state of Jalisco found that 72% of professionals earn less than 5500 pesos (about \$550) per month, and that 91% of supervisors earn less than 9000 pesos (\$900) (Dussel Peters, 1998).

2. Telecommunications

Telecommunications supports both production and use of computers. Computer use is most valuable when computers are networked over private networks or the Internet. Computer production increasingly relies on electronic linkages between computer makers, customers and suppliers. A high quality telecommunications network is vital to supporting such data networking.

Telecommunications in Mexico has undergone a major shift in the past decade, from a state-owned telephone monopoly to a competitive, largely deregulated market. This process has

mirrored the general liberalization of the economy, and has been an important element of the liberalization.²

The modern history of telecommunications in Mexico revolves around Telefonos de Mexico (Telmex). Telmex was officially established in 1947, in an effort to overcome the lack of interconnection between two existing providers—Mextelco and Mexeric. Over time, the government became more involved in the management of the company, and in 1958, Ericsson and ITT (who had owned Mextelco) sold their shares of Telmex to Mexican investors. The government also began to buy shares in the company until it gained control of the company in 1972 by acquiring a 51 percent equity holding.

In the 1980s, Telmex struggled to expand and modernize its network. By 1989, Mexico had only six main lines per 100 people, and the number of unfilled connection requests topped one million. In 1989, the Salinas administration undertook a major restructuring of the telecommunications sector, keyed by the privatization of Telmex. This decision was driven in part by the need for better telecommunications to support economic growth, but was also part of Salinas's broader program of liberalization. Privatizing Telmex signalled Mexico's commitment to economic liberalization, both to domestic and foreign investors. The sale also was expected to bring in money to the treasury and spur the growth of Mexico's stock market.

In December 1990, Telmex sold 20% of its stock to a consortium led by Grupo Carso (10%), Southwestern Bell of the U.S. (5%) and France Cable et Radio (5%). In 1991, the Mexican government sold another 4.4% of the company to its employees another 16.5% through international ADR offerings (Petrazzini, 1995). The Mexican government offered the remaining stock between 1992 - 1994 through international stock offerings in the U.S. and global markets (Pisciotta 1997).

In addition to privatizing Telmex, the Mexican government has introduced competition and allowed foreign investors to participate in the telecommunications market. The 1993 Foreign Investment Law permitted up to 100% foreign ownership of many telecommunications operations including cellular telephony and value added services. However, foreign ownership of other telecommunications operations, including basic telephone service, videotext, packet-switched data service and cable television remain is still limited to 49%. Radio and television broadcasting services are reserved for Mexican nationals (Pisciotta, 1997).

When NAFTA took effect in 1994, import duties were eliminated for on-line equipment, PBX switches, cellular phones and modems. In 1998, tariffs were eliminated on central office switches and telephone sets. In 2003, tariffs will be removed on pagers, coaxial cables and antennas.

A new Federal Telecommunications Law was passed in 1995, providing for a competitive regulatory framework and establishing a new regulatory authority, the Federal Commission for Telecommunications (Comision Federal de Telecomunicaciones, or "Cofetel"). Cofetel is charged with implementing the telecommunications law, but must still work closely with the Secretaria de Comunicaciones y Transportes (SCT) in making policy (Pisciotta 1997).

SCT provided rules in 1996 that allowed customers to select their long distance carrier. The government authorized several competitive carriers including Alestra (affiliated with AT&T), Avantel (MCI), and other companies such as Iusatel (Bell Atlantic), Amaritel (US Global Telecommunications), Cableados y Sistemas (known as Bestel), Investcom, MarcaTel, Unicorn, and Miditel. The strongest long-distance competitors to Telmex are Alestra and Avantel.

The impact of deregulation and privatization on Mexico's telecommunications network has been positive. Ninety percent of switches are now digital, compared to 29% in 1990, and many copper lines are being replaced by fiber optic cables. The number of main lines per 1000 inhabitants increased from 65 in 1990 to 96 in 1995, while the waiting list for new telephone lines was reduced from over one million to just 197,000 (ITU, 1997). Prices have declined by 30% within Mexico and 28% from Mexico to the U.S. and Canada. Table 4 presents some basic indicators of telecommunications diffusion and cost for Mexico and other countries.

Table 4. Telecommunications Indicators

	Main Lines Per 1000 inhabitants ^a	Cellular Mobile Subscribers Per 1000 inhabitants ^b	Cost of 3 min local call (US\$) ^a	Cost of 3 min call to the U.S. ^a
Mexico	95	7	.08	3.01
Brazil	96	8	.04	4.68
Malaysia	183	43	.04	5.99
Thailand	70	18	.12	7.39
Korea	430	37	.04	4.88
Taiwan	430	36	.04	na
Singapore	513	98	.01	4.02
Hong Kong	547	129	n.a.	2.64
United States	640	128	.09	--

Sources: a. World Bank, *World Development Report, 1998*

b. ITU, 1997. *World Telecommunication Development Report 1996/1997*

Still, there are problems. Telmex still controls the last mile connection to the home, and its competitors are not investing to develop local networks. Telmex also dominates the long distance market in most communities. MCI has launched a cross border attack against rules that force long-distance companies to give Telmex up to 70% of their billings for routing long-distance calls through Telmex's network. MCI, a partner in Avantel, has threatened to cancel \$900 million in investment in Mexico. AT&T and MCI also appealed a U.S. FCC ruling approving Telmex's entry into the U.S. market. (Smith 1998).

There are specific problems that have hampered Internet use. Most Mexican Internet users can log on at a top speed of 14,400 bps, even if they have 28.8K or 56K modems, because of poor quality local lines. Also, in 1997, Telmex raised its rates for dedicated fiber lines by 300%, hurting Mexican Internet service providers who rely on those lines.

3. Technology and R&D

Long-term success in both production and use of computer technology depends on the development of national technological capabilities. Developing and newly-industrializing

countries depend heavily on imported technologies, but national capabilities are required even to apply imported technology effectively.

Much of the flow of technology into Mexico comes through licensing by domestic companies, or through direct investments by foreign MNCs who bring advanced technologies with them. The presence of many MNCs in Mexico has upgraded the country's technical capabilities, as companies such as IBM, Hewlett-Packard, Lucent, Matsushita, Ford and others have built sophisticated manufacturing facilities, and in some cases carry out R&D in Mexico. However, these companies tend to operate as high-tech enclaves, with limited links to the domestic economy. There is also a lack of entrepreneurial spin-offs from MNCs that would diffuse the technology of those MNCs to the local economy. As a result, there is a large gap between the capabilities of MNCs and those of local companies. The gap between foreign and domestic companies is shown by the fact that from 1990-1996, foreigners applied for 44,668 Mexican patents, while Mexican nationals applied for just 3,659 (CONACyT, 1996, p. 32)

Mexico lags far behind countries such as Korea and Taiwan, spending only 0.3% of its GDP on R&D compared to 2.6% and 1.8% for those countries (Table 5). This is largely due to the absence of locally-owned technology companies that would invest in R&D, and to limited government support for R&D.

Table 5. R&D indicators

	R&D as % of GDP	Industry as % of total R&D
Mexico	0.3	21
Brazil	n.a.	n.a.
Malaysia	n.a.	n.a.
Thailand	n.a.	n.a.
Korea	2.6	74
Taiwan	1.8	54
Singapore	1.2	54
Hong Kong	0.1	n.a.
United States	2.6	72

Sources: NSF, 1993; Dedrick and Kraemer, 1998; CONACyT, 1996, *Science and Technology Indicators at a Glance*.

The Mexican government funded 66.2% of all R&D in the country in 1995, with industry only accounting for 17.6%. Most of the R&D is carried out by universities (46%) and government agencies and institutions (33%). Only 21% is carried out by business enterprises (CONACyT, 1996, p. 13-15). This implies a high emphasis on basic academic research and little applied R&D. This is the reverse of countries such as Korea, Taiwan and Singapore, where 50-70% of all R&D is carried out by industry, and is therefore more closely linked to economic activity.

III. INDUSTRY STRUCTURE

Mexico's industry structure in computers and electronics is heavily influenced by its proximity to the United States, and by government policies in both countries. There is a high concentration of consumer electronics activity in maquiladora plants along the U.S./Mexico border, often with

twin plants operating on both sides of the border. This arrangement is encouraged by both Mexican and U.S. laws which allow parts to be imported into Mexico from the U.S., assembled and shipped back to the U.S. with duties paid only on the amount of value added. Other regions in Mexico have also developed maquiladora industries, including Guadalajara and Hermosillo. In these non-border locations, companies give up proximity in return for lower wages and/or more stable work forces with lower employee turnover.

The heavy involvement of U.S., and now Asian, electronics companies taking advantage of proximity and favorable policies has shaped Mexico's electronics and computer industries in other ways as well. First, the industry is dominated by foreign MNCs, with little participation by Mexican-owned firms. Second, the industry concentrates on assembly activities, and has developed little in the way of a local supply base, since components and equipment can be easily imported from the U.S. Third, the industry consists mostly of large U.S. and Asian companies, with only a limited number of locally-owned small and medium-sized enterprises (SMEs) participating. Thus the industry resembles that of Malaysia or Thailand, rather than the Taiwanese electronics industry, with its thousands of locally-owned SMEs.

A. Complementary Industries: Electronics

An important part of the supporting infrastructure for the computer industry is the presence of complementary industries, particularly contract electronics manufacturers, suppliers of electronic components, plastic moulders and metal shops. The major centers of computer hardware production, such as the Taipei-Hsinchu area in Taiwan, Singapore, Malaysia's Penang, and of course, Silicon Valley, have developed large supply bases in close proximity.

Although electronics production began in Mexico in the late 1940s, it only began to grow rapidly in the 1980s, when production increased from \$108 million in 1983 to \$649 million in 1991. Likewise, exports soared from \$65 to \$573 million during the decade (Mattar and Schatan, 1993: 114). This trend accelerated in the 1990s, as electronics exports exploded from \$6,456 million in 1992 to \$25,128 in 1997 (SECOFI, 1998) According to a more conservative estimate (Reed Electronics, 1998), electronics exports reached US\$16,421 million in 1997.

Table 6. Mexico: Electronics Industry Gross Output Value* (Million dollars)

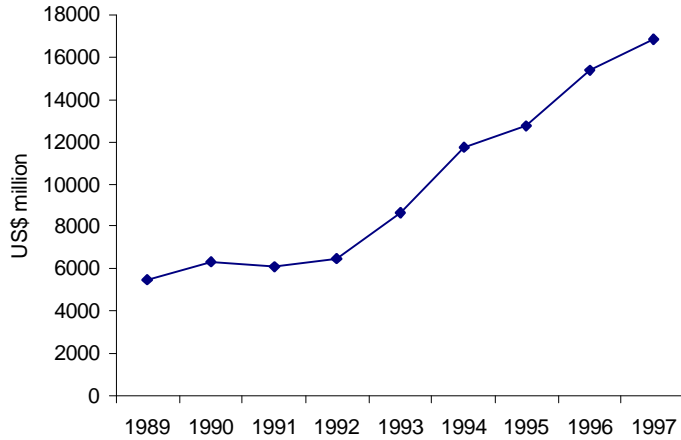
Item	1991	1992	1993	1994	1995	1996	1997
Computers	916	1117	1100	1336	1163	2098	2902
Telecom	1186	1185	1239	1286	1334	1379	1292
Other	355	214	512	194	683	854	483
Total	2457	2576	2851	2816	3180	4331	4677

Source: "The Electronics Industry In Mexico", SECOFI, Internal Report, October 1998.

*Excluding *maquiladoras*. Therefore, values are underestimated.

When maquiladora production is included, the value of electronics production in Mexico is nearly four times greater, as seen in Figure 2. Figure 2 also shows that production began to rise rapidly in 1993, after NAFTA was negotiated and in advance of its implementation.

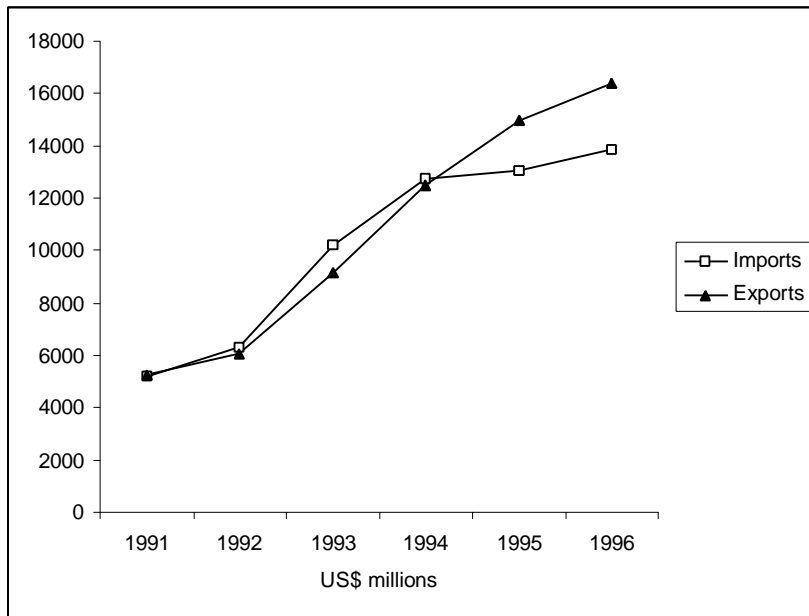
Figure 2. Electronics production in Mexico, 1989-1997 (including maquiladoras)



Source: Reed Electronics, *Yearbook of World Electronics Data*

The electronics industry has become Mexico’s top trading sector, accounting for 23 per cent of total exports and nearly 27 per cent of manufacturing exports. The electronics industry’s trade balance turned from negative to positive in the second part of the 1990s (Figure 3 and Table 7). This reflected growing exports by MNCs and the 1994 devaluation which made Mexican products much cheaper almost overnight, and increased the cost of imports into Mexico.

Figure 3. Mexico’s electronics imports and exports



Source: Reed Electronics, *Yearbook of World Electronics Data*, various years

Table 7. Mexico: Electronics Industry Trade Balance, 1992-1997 (million dollars)

Year	Balance
1992	- 752
1993	- 741
1994	- 753
1995	2855
1996	2361
1997	3879

Source: SECOFI (1998)

The largest segment of the electronics industry is production of TV sets along the U.S. border. TV sets are mainly produced by Asian companies, plus a few European firms. Matsushita, Panasonic, Canon, Sony, Sanyo, Hitachi, JVC, and Samsung are located in Tijuana; Mitsubishi, Goldstar, and Sony have facilities in Mexicali; Toshiba, Thomson, Philips and Zenith in Ciudad Juárez; Daewoo in San Luis Río Colorado; and, another Zenith plant in Reynosa. Major home appliance makers such as Pioneer, Nippon Denso and Vitromatic are located in Monterrey, while other like Clarion, Mabe, Acrotec and Sanyo-Mabe have their installations in Querétaro, Celaya, and San Luis Potosí.

In recent years, Mexico's electronics industry has grown in size and diversity. The passage of NAFTA, with its local content requirements, has encouraged foreign companies to supply their Mexican operations from Mexico, rather than bring in parts from Asia. In addition, the short product cycles of the computer industry have forced computer makers to shorten their supply chains to improve their speed to market. Also, some major U.S. and Asian contract manufacturers have located labor intensive operations in Mexico in order to serve the North American market. The result has been a rapid growth in Mexico's supply base.

B. Computer Industry Structure

The Mexican computer industry is dominated by MNC subsidiaries, mainly from the United States. Most computer production involves assembly of circuit boards and complete PCs, and is highly dependent on imports of parts, components and advanced equipment.

1. Companies

The top tier players in the Mexican market are IBM and Hewlett-Packard. Both have long histories in Mexico, and since the mid-1980s, each has expanded the size and scope of its operations in Mexico considerably.

IBM

IBM de Mexico began manufacturing operations in 1957, making typewriters in Mexico City. Manufacturing was moved to Guadalajara in 1975, and production of minicomputers (S/34, S/36 and AS/400) began in 1982. After a dispute with the government over retaining 100% ownership of its Mexican facilities, IBM began producing PCs in Guadalajara in 1985.

Production of disk drive components began in 1986. Output grew rapidly, and by 1988 IBM's total exports from Mexico were over US\$300 million.

Since the liberalization of Mexico's PC market in 1990, IBM has diversified its production in Guadalajara. Production decisions are no longer based on meeting government requirements, but rather on filling a role in IBM's global production network. Even former government officials who were involved in the dispute over the Guadalajara plant admit that IBM has played an important role in developing the Mexican computer industry. IBM now produces desktop and notebook PCs, PC servers, and disk drive components.

Employment at the Guadalajara plant was estimated at around 8,000 workers in 1998.³ Not only is IBM the biggest producer and seller of IT products and services, it has also been a leader in developing local suppliers. IBM Guadalajara uses 25 local suppliers (including foreign-owned contract manufacturers) among its total of 200 suppliers. IBM's goal is to develop local suppliers who can produce for IBM's global operations, not just for its Mexican facilities. An interesting example is in disk drive components, where IBM outsources head assembly to a locally-owned company called CompuWorld. This company used to make packaging materials for IBM, and asked IBM for an opportunity to work with them in new areas. The company made a \$2 million investment to get started, and IBM taught them how to set up do clean-room operations that mirror IBM's own facilities. Now CompuWorld provides extra capacity to balance IBM's production with demand fluctuations.

IBM's disk drive operations in Guadalajara assemble sliders and head stacks, which are sent to plants in Thailand, China and Hungary for final disk drive assembly. Final drive assembly is not done in Mexico because the other locations offer a range of financial incentives not available in Mexico. Production processes involve a mix of manual and automated processes that offer flexibility in production and reduce the cost of capital investment. IBM has 28 automated lines that make head gimbel assemblies (HGAs), which are not touched by human hands. These lines run 24 hours a day, 7 days a week, supported by 160-170 engineers. IBM's executives in Guadalajara and in the U.S. say that the plant is highly competitive with other IBM plants, owing to the high quality of local workers, engineers and technicians.

In June, 1999, IBM had announced a \$200-million expansion of its Manufacturing and Technology Plant near Guadalajara , "The plant's expansion is dedicated exclusively to the manufacturing of high-technology parts," plant manager Alfonso Alva said in a press release. The company said 2,750 jobs were created as a result of the expansion.² Later that month, IBM announced it was eliminating 1100 jobs at its San Jose facilities and moving production of tape drives and server drives to Guadalajara, Hungary and Fujisawa, Japan. It explained that the move was part of a restructuring intended to cut costs and reduce the time it takes IBM to move storage products to market.³

In addition to its hardware activities, IBM also develops software in Mexico. A team of 150 software engineers develops software for the AS/400 product line in Guadalajara. In 1998, IBM bought a software developer in Mexico City called TecnoSys, which is developing custom

² *Dow Jones International News*, "Mexico's IBM Unit Finishes \$200 Mln Plant Expansion," 6/8/99

³ K. Oanh Ha, "IBM Begins Layoffs at Disk Drive Operation in San Jose , Calif.," *San Jose Mercury News*, 6/25/99

software for IBM customers in Mexico. IBM also operates a software foundation that works with local universities to help train developers. Periodically, they recruit about 200 of the best graduating students from selected local universities for a one-year apprenticeship. Most either get full-time positions with IBM or are hired by other local companies before the apprenticeship is over. In this way, IBM has access to the cream of the local engineering talent.

Hewlett-Packard⁴

Hewlett-Packard's activities in Mexico have gone through several phases since the early 1980s. HP established its Guadalajara Manufacturing Solutions (GMS) operation in 1982. From 1982-1985, it manufactured products for restricted market segments needed to meet government requirements for market access. Products included the HP 3000 minicomputer, PCs, disks, and line impact printers, which were sold in the Mexican market. HP also had a joint venture for PCs with a domestic Mexican company called DESK Fomento Industrial, which owned 51% of the venture. After IBM started producing PCs in Guadalajara with 100% ownership, HP dissolved its joint venture and started producing in its own 100%-owned facilities.

In 1987, HP started exporting from Mexico to North America and Latin America. In 1988, HP's GMS operations were given engineering responsibilities for minicomputers, and in 1989 it gained worldwide responsibility for line impact printers. In 1992, HP moved integration and distribution for the Latin American market to Mexico, with the establishment of its Latin American Distribution Operation (LADO) in Guadalajara. LADO has about 1000 employees, doing final assembly and distribution of PCs for Latin American markets. In the same year, HP also began R&D for paper handling accessories on its Laser Jet printer line in Guadalajara. In 1994, coincident with the implementation of NAFTA, HP expanded its high-volume manufacturing in Mexico for the North American market, and by the late 1990s had expanded Mexico's role as a regional manufacturing center.

As of 1998, HP GMS consisted of four operations, with a total of about 500 employees:

- Paper handling solutions: supports laser jet printer operations world wide. Responsible to HP's Boise, Idaho plant.
- MIPO (Mexico International Procurement Office): develops suppliers in Mexico to serve HP divisions in U.S. and Europe. MIPO procures cables and harnesses, PCBs and monitors in Mexico for HP's worldwide operations. Contract manufacturers in Guadalajara such as Solectron and SCI are important suppliers to HP's printer divisions in the U.S.
- American hard copy manufacturing operation. Makes Deskjet and All-in-one printers. Responsible to HP Palo Alto, Vancouver, WA, and San Diego.
- Optical Electronic Division: Makes LEDs. Responsible to HP San Jose.

HP began doing R&D in Mexico in the 1980s just to meet government requirements, but now continues to do R&D because it makes business sense. The company has developed an engineering team of 35 people in Guadalajara, focused on paper handling technology for printers. As of 1998, they had generated 15 patents and seven multi-speed products for five different printer platforms.

To summarize, HP's activities in Mexico have evolved from producing for the protected local market to high volume manufacturing to support regional operations to worldwide responsibility for R&D, engineering, procurement and manufacturing for specific product lines. Like IBM, HP uses Mexico's capabilities to complement its U.S. engineering and production activities, with Mexico playing an important role in its global production strategies.

Acer

The biggest winner in the first five years after liberalization was Taiwan's Acer. Its local subsidiary, Acer Computec Latino America (ACLA), was started as a joint venture between Acer and its major local distributor, Computec. ACLA is now listed on the Mexican stock exchange. Acer entered the Mexican market in 1990 with a line of low priced PCs that undercut both foreign and local brand name PCs, and came close to the prices of local clones, while providing a strong brand name and technological capabilities. As a result, it was the leading PC vendor in Mexico from 1991-1996.

ACLA operates from a headquarters in Mexico City, and also runs an assembly plant nearby that serves Mexico and other Latin American markets. In addition, two other members of the Acer Group have manufacturing operations in Mexico. Acer Computer Inc. has opened a plant in the border city of Ciudad Juarez to produce PCs on an OEM basis for IBM. Acer Peripherals Inc. makes computer monitors in another border town, Mexicali (LePedus, 1998). Each of these operations is linked to headquarters in Taiwan, and are independent of ACLA in the decentralized Acer Group organization. Both were set up for mass production for the North American market, to shorten delivery times and take advantage of NAFTA.

Local branded PC companies

Several locally-owned Mexican PC companies have managed to survive in the post-liberalization environment. The leader is Lanix, a company established in 1990, which sold 32,000 PCs and held 5% of the local PC market in 1997. 88% of Lanix's PCs are sold in Mexico, with the rest exported to Latin America. Lanix was spun off from Micro Computación Aplicada del Pacífico (MAP) by MAP's director general, Benjamin Aguilar. Mr. Aguilar and his partner Francisco Noriega are the owners of a corporate conglomerate whose business concerns include Lanix, a software company (Microtecnica), a construction company, a hog breeding farm, a meat processing plant (for export), and a cattle ranch. Headquartered in Hermosillo, the company's annual revenues are around \$35 million a year.

Another local company that has survived liberalization but in a diminished capacity is Printaform. During the years of market protection in the 1980s, Printaform was the leading PC vendor in Mexico, and its quality was considered good enough from 1986-1988 that the National Autonomous University (UNAM) purchased Printaform PC's over IBM or HP models based on their price and quality. At this time, Printaform was purchasing boards and components from Taiwan's Acer. However, they then switched to a Korean supplier (Lucky-Goldstar), and quality reportedly dropped dramatically. Printaform also lost its top distributor Computec, which merged with Acer into ACLA. Printaform has survived by producing office equipment, but it has only a minor role in the PC market.⁵

The third significant local brand name is Gama, which has about 1-2% of the Mexican PC market. Like Lanix, Gama's parent company, MCA Computers, is a spin-off from MAP. MCA bought the Gama brand name from MAP and went into business in 1997. Gama produces about 10,000 PCs per year for the local market.

Each of the three branded Mexican PC makers finds itself squeezed between aggressive foreign brands on the high end and low cost "white box" clone makers on the low end. Foreign brands benefit from global economies of scale, strong technology, and the resources to support nationwide marketing efforts. White box makers sell in small quantities to local customers and do not have to support the marketing costs of a brand name vendor.

These vendors all were hit hard by liberalization and NAFTA, which put many of their counterparts out of business. Liberalization brought in a flood of imported PCs, while NAFTA lowered tariffs on finished PCs while retaining tariffs on components used by local vendors. Now components tariffs have fallen as well, allowing local brands to compete on a more even footing, but the position of those companies is precarious at best. Each of them faces stiff competition in the domestic market, and none has the resources to take advantage of potential opportunities created by NAFTA to sell in the U.S. or Canada.

The third tier are "non-branded" white-box assemblers. The wide proliferation of these faceless competitors that has occurred in Mexico in the last decade has become a serious challenge for both multinationals and branded assemblers. According to CANIETI, there are about 3,000 of those white-box companies spread throughout the country. "Non-branded" assemblers include hundreds of distributors and retailers that offer the customer either parts and components or a completely assembled PC. Executives from Lanix and Gama both agreed that non-branded clones represent the most serious threat to their companies which struggle to stay in the market by assuming all the costs involved in keeping a national brand against the fierce competition of foreign PC makers. On the positive side (at least from the users' point of view), white-box assemblers have helped bring PC prices down over the last decade. It is estimated that in 1998 74 per cent of PCs will be sold from less than \$1,000 to \$1,500 (*INFOchannel*, 1998, p. 42).

Software and IT services companies

Mexico's software industry is still small, and most companies have only one or two products, and a few employees. In the packaged software market, three Guadalajara companies typify the range of Mexican developers. The largest is Computación en Acción (COMPAC), which produces accounting software for small businesses. COMPAC had 102 employees in seven offices around Mexico as of 1998, with revenues of US\$3.5 million in 1997. Its four PC-based packages are bilingual and multicurrency, and sell for around US\$350 apiece. COMPAC also offers software development tools that allow other developers to write add-ons to the standard package. COMPAC is working with Microsoft on integrating its accounting package into Microsoft's Small Business Server and on developing links for its programs with Microsoft Excel. Still, Excel is also a major competitor to COMPAC, and the relationship with Microsoft is cautious: the company is willing to remain a competitor to, or possibly to be bought out by Microsoft. COMPAC is an example of a Mexican company producing a software package

aimed at a particular function (accounting) for a specific market (small business), but for a wide range of industries.

A second packaged software vendor is CompuCampo, which develops agricultural packages for swine management, crop management, irrigation, fertilization, and pest control. CompuCampo's target market is much more specialized than that of COMPAC, consisting mainly of government agricultural agencies and more technologically sophisticated farmers and suppliers. CompuCampo has only 10 employees, and expected revenues of US\$50,000 for 1998. However, it sees large market potential throughout Latin America as it develops marketing channels to expand outside Mexico.

Another small vendor is Software Educativo Profesional, which produces a brand of educational programs called KidsPC. The software is intended for elementary school classroom use with a teacher's supervision, and guides students through various modules in math, language, biology, natural sciences, geography, and history. Unfortunately, its market is overwhelmingly in the private schools, as computer use is just being introduced in public schools. Software Educativo Profesional has 10 employees, and its products are used in 45 schools in Mexico.

These three companies illustrate the entrepreneurial nature of the Mexican software industry. Their small size also illustrates the problems in raising capital, hiring personnel with the required skills and developing distribution channels for packaged applications. Nonetheless, it is worth noting that new, more complex firms are emerging in Mexico that combine software and hardware expertise, and which can even be regarded as sophisticated R&D companies. As a result, these companies are becoming significant service suppliers to major U. S. vendors.

A typical example is Arquitectura en Sistemas Computacionales Integrales (ASCI), a Guadalajara-based company established in 1993 by a group of local engineers whose main business is the development of software, firmware, and hardware (both electronic and mechanic) products. It also provides quality assurance services for software and hardware systems; its main customer since 1994 has been Hewlett-Packard. It has developed programming and firmware packages as well as designing of hardware and system architecture and tools for HP Guadalajara's R&D and quality assurance departments. It has also worked with HP's color laser printers division in Boise, Idaho.

Although ASCI is a small company, it has experienced a spectacular growth: it has doubled annually both its personnel and its revenues in the last three years, going from only three employees in 1993 to 35 in 1998. ASCI competes with other companies for contracts in the US and Europe. ASCI says it gets contracts because of the quality of its work, not because its services are cheaper. Its software engineers are in the process of getting the Microsoft Certified Solution Developer certification.

On the other hand, there are a number of larger companies in the custom programming market, doing product localization and other custom development for large clients such as banks, manufacturers and even multinationals. The Mexican market for custom software was US\$186 million in 1998, with 97% produced locally.⁶

The largest custom programming firm is Softek based in Monterrey, which has over 2000 employees and over 50 million dollars in sales in 1997. 70% of the company's sales were in the domestic market, 18% exported to Latin America and 12% to the United States. Softek jumped on the opportunity to develop a large business in Year 2000 fixes for U.S. clients. Another firm, EDM, based in Ciudad Juarez, has 2,000 employees providing a range of services including data entry, Spanish-language telemarketing, software development and systems consulting. In 1998, GE Capital bought an 80% interest in EDM. Joining forces with GE Capital will enable EDM to expand to new global markets, says chief executive Danny Vickers (Jastrow, 1998). As mentioned above, TecnoSys in Mexico City was bought out by IBM, and its 200 employees are developing software for IBM customers. Companies such as these avoid the problems of developing distribution channels and raising capital to support product development by writing custom programs on a contract basis.

2. Regional Production Clusters

Electronics production in general shows a fairly well defined pattern of regional specialization in Mexico. Most operations take place in three main regions. Production of audio and video equipment, which includes TV sets and PC monitors as well, is concentrated along the Mexico-U. S. border. Home appliances are produced in the country's center and northeast, and computers and telecommunication equipment in Guadalajara and its metropolitan region.

Computer production, including parts and components, takes place in various states in Mexico's interior, and in some towns on the Mexico-U. S. border. Major centers of production are the Federal District, Mexico State, and Sonora; lesser ones include Guanajuato, Chihuahua, and Aguascalientes. Nonetheless, the Guadalajara area is by far the largest production center, accounting for over 60 per cent of total computer output.

Mexico City and its environs, largely Mexico State municipalities that surround the Federal District, boast the largest concentration of electronics companies in general. About three fourths of CANIETI's member companies are located in this giant urban agglomeration. These are typically small companies making a wide variety of parts and components for the electronics industry, except for a handful of clone assemblers.

Significant activity also takes place in Chihuahua state. Digital Equipment Corporation (now part of Compaq) has a state-of-the-art plant in Chihuahua City which makes PCBs using cutting-edge surface mount technology. In addition, Acer is about to open a new \$20 million assembly plant in Ciudad Juárez that will produce 800,000 PCs in its first year (mostly for IBM) and will have 4,000 employees by the year 2000.

In Guanajuato, two PC makers operate in the city of Irapuato: Computadoras Micron and Electroquímica Vimar. A Motorola (communications division) plant is located on the León-Silao highway, along with a local video chip manufacturing firm, Video Chips del Bajío. Hermosillo is home to one of Ford Motor Company's most sophisticated manufacturing plants worldwide. The establishment of this plant in the mid-1980s gave Hermosillo and the state of Sonora a decided industrial vocation that is now reflected in the existence of about 265 *maquiladora* plants and over 60 major industrial companies in the state.

Hermosillo is also home to Mexico's major domestic PC makers, namely Lanix Technology, MCA Computers and Printaform. The Printaform plant has been operating in Hermosillo for 20 years, and now makes PCs, data banks, electric typewriters, fax-telephone-copying machines, calculators, watches, and workstations for PCs, among other things. The combined presence of these PC makers, in conjunction with the boost provided by the state government's industrial promotion policies, has created a favorable environment for the development of computer and electronics production in this part of Mexico. The recent establishment of other major electronics companies in Hermosillo like CMC and Maxi Switch attest to this trend. CMC, a US-based contract manufacturing company, recently set up a leading-edge plant that makes motherboards and IC cards for video games and cellular phones. Maxi Switch is a joint venture between Asian and local capital; its Hermosillo plant assembles keyboards, monitors and power supplies for computers and video games.

Finally, other areas with several companies that make electronics parts and components used in PC assembly are Aguascalientes and a number of towns along the Mexico-U. S. border. Aguascalientes is home to Nissan's assembly plant in Mexico and a myriad of its supplying companies. In addition, there are two large electronics manufacturing plants located in this city: Xerox and Texas Instruments. A third significant electronics company in Aguascalientes was Interelec, which operated up to April 1998 and used to assemble integrated circuits and manufacture cables and harnesses for PCs.

Jalisco: Mexico's leading computer industry cluster

The state of Jalisco, whose capital and largest city is Guadalajara, ranks third in contribution to gross domestic product, just after the Federal District and Mexico State. Jalisco is the largest producer of women's footwear, jewelry, beef, milk, tequila, and, above all, computers and telecommunications equipment. Jalisco boasts the third largest concentration of leading export companies operating in Mexico, after the Federal District and Nuevo León (Palacios, 1995). The state's most dynamic export activity since the late 1980s has been electronics and computer production. According to the Foreign Trade National Council (CONACEX) Guadalajara office, electrical and electronics products have accounted, in average, for about 52 per cent of the state's total exports for the last five years.

The electronics industry in Jalisco has shown a remarkable dynamism since the mid-1980s. The enactment of NAFTA and, above all, the December 1994 devaluation of the Mexican peso gave the industry an important boost in the last three years, opening new investment outlets and creating new business opportunities. According to the state government's Department of Economic Promotion (SEPROE), 25 new companies were established in Jalisco between 1995 and 1997, and 40 more opened during 1998. Presently there are about 120 companies employing over 50,000 people. In absolute terms, electronics exports topped \$7 billion in 1998, according to SEPROE.

Electronics production is highly concentrated among a few foreign companies, with IBM, SCI Systems, Motorola, and Lucent Technologies accounting for about 95 per cent of the state's total electronics exports in 1997 (*El Informador*, 1998). In 1993, IBM's overseas sales alone accounted for 25 per cent of Jalisco's total export value (Palacios, 1995).

In 1996 electronics companies generated \$900 million of value added, but imported \$2.4 billion in parts and components. Some \$850 million were invested in expansions and new plants between 1995 and 1997. Between March 1995 and September 1998 foreign direct investment in electronics amounted to \$1,295 million, which accounted for 43 per cent of all FDI inflows to Jalisco in that period.

The product mix in Guadalajara's electronics industry is diverse. Major products include: computers, printers, telephone sets, power supplies, keyboards, motherboards, PCBs, subassemblies, semiconductors, software, relays, connectors, harnesses, cables, and photo CDs.

As a result, Jalisco has become Mexico's main computer and telecommunications maker. The state produces nearly two thirds of the nation's computer output and as much as 95 per cent of telecommunications equipment (*El Informador*, 1998). As a reflection of Jalisco's drive toward the adoption of information technologies, the state government is linked with the state's 124 municipal governments through a network platform operated via Internet.

Guadalajara's computer hardware industry includes companies in all the categories identified at the national level (Table 8) The main players are IBM and Hewlett-Packard whose overwhelming presence dominates the area's IT industry scene. These U. S. subsidiaries are the two pillars around which the rest of the local industry gravitates.

Table 8. Computer and Electronics Firms in Guadalajara

Company (home country)	Activities
IBM (US)	PC assembly, hard disk head assembly, software development
Hewlett-Packard (US)	R&D, marketing and logistics for global laser, inkjet and all-in-one printers; LED production; international procurement office, final assembly, configuration and distribution of PCs for Latin America.
Lucent (US)	Telecommunications equipment
NEC (Japan)	Telecommunications equipment
Kodak (US)	Compact disks, floppy disks
SCI (US)	Contract manufacturer--Printed circuit board (PCB) assembly, including PC motherboards
Soletron (US)	Contract manufacturer--PCB/motherboard assembly and "build-boxes" for PCs; assembly of printers, cell phones.
Dovatron (US)	Contract manufacturer--PCB/motherboard assembly, build-boxes
Electronica Pantera (US, subsidiary of JPM)	Cables and harnesses
Molex (US)	Cables and connectors
NatSteel (Singapore)	Contract manufacturer –PCB assembly
Jabil Circuit (US)	Contract manufacturer—PCB assembly
Flextronics (US)	Contract manufacturer
Cumex (Mexico)	PCB manufacturing and assembly
Best Technology Computer (Mexico)	PCs
Delinte (Mexico)	PCB manufacturing and assembly

The next category of computer companies is represented by Best Technology Computer (BTC), a branded white-box assembler that started operations in 1997. BTC is a rather small company established by Malaysian investors, which assembles PCs under its own BTC brand. It is part

of a group of three companies: Computer World, Best Technology Computer, and JB Computers. The first two are located in Guadalajara and the last one in Mexico City.

Best Technology Computer is a corporate name derived from Behavior Tech Computer Corporation headquartered in Chung Li, Taiwan. BTC Corp. is a major global manufacturer of computer components and peripherals, which started producing keyboards in 1987. Now it strives to excel in optical storage, multimedia, memory, and image products, including motherboards and scanners. Most of the key components used by Best Technology Computer in Guadalajara to manufacture its computers are from BTC Corp.

The third layer corresponds to non-branded white-box assemblers. These include a myriad of small retailers and distributors whose services include the assembly of the entire PC. Some of the more representative are AMB Computadoras, Net Connection, Fast Computer, PC Digital, IS Hardware-Software-Internet, PAC Computadoras, Office Compu World, PC Shopping, Digicom de Occidente. Three established companies in this category are Sistemas Innovativos de Computación, Compu Magna, and Premium Internacional. The first two are local start ups that have survived after the liberalization of the Mexican PC market in the early 1990s.

A CM-led boom

Although the electronics industry in Guadalajara has shown a steady development from its inception in the late 1960s, the process has gained a significant momentum in the last few years. There are signs suggesting that the implementation of NAFTA may be in part responsible of such unprecedented dynamism. However, a new and significant trend has emerged in the last two years that may provide a more sound explanation of Guadalajara's electronics boom.

This is the sudden arrival of a number of the world's largest contract manufacturers (CMs). SCI Systems was the pioneer in the late 1980s, when this giant US-based CM set up its first plant in the El Salto Industrial Corridor in 1987. However, in just two years, between 1996 and 1998, other six CM plants were established in different locations on the fringes of Guadalajara's metropolitan area, including SCI's second plant, which is still under construction on the Guadalajara-Chapala highway. The newcomers include subsidiaries of other large CMs, namely Solectron, Flextronics, Jabil Circuit, NatSteel, Dovatron and Avex Electronics. What makes it intriguing is that all these set up shop in the area in a matter of months.

What has lured seven of the world's largest CMs to Guadalajara? Certainly the presence of leading customers such as IBM, Hewlett-Packard, NEC and Lucent Technologies has been a strong attraction by itself. In fact, an HP manufacturing manager in the U.S. said that he encouraged Solectron to locate in Guadalajara in order to support HP's ink jet printer operations. However, the presence of major MNCs in Guadalajara does not fully explain the simultaneous arrival of so many CMs in the past two years. The explanation may rather be, as some analysts have argued, that CMs are coming in response to demand from computer and electronics OEMs which need to have some products assembled in a NAFTA-member country.

Alternatively, as some CM executives pointed out, CMs have come to this part of Mexico not to simply follow OEMs but rather in response to the lowest CIF [landed] cost logic that governs the location decisions of multinational corporations in general. In this case, Guadalajara's

proximity to the U.S. market gives it a cost advantage in transportation that may exceed the labor cost advantages of some Asian locations.

It is estimated that presently the contract manufacturing industry is worth \$73 billion worldwide and is expected to continue to grow at 25 per cent over the next three years. This occurs as a result of the growing tendency of major electronics companies to use contract manufacturers to outsource their manufacturing operations. HP for instance aims to have 90% of its printer production outsourced worldwide. Ultimately, the explosion of contract manufacturing on a global scale is the upshot of the spread of outsourcing practices among large, multinational electronics and computer makers which are trying to take advantage of the expertise and dedicated installations of major electronics contract manufacturers.

Therefore, while NAFTA has played a role, the present electronics boom in Guadalajara seems to be primarily a CM-led phenomenon that may be driven by the cost and time-to-market demands of companies serving the U.S. market.

As to the economic interconnections of CMs with the local economy, it should be pointed out that although they import almost all of their inputs, the plants have developed linkages among themselves and with other companies operating locally. For example, Flextronics has assembled printers for HP Guadalajara, and NatSteel's local plant has supplied PCBs for those printers. Likewise, DTM, a plastic injection firm located at Flextronics' industrial campus, makes plastic molds that are sent to Solectron Guadalajara for use in the assembly of electronics components. Philips has produced answering machines with PCBs made by NatSteel, Flextronics, and by Philips itself. In this way, CMs are contributing to the formation of a more integrated industrial cluster in the Guadalajara area.

Guadalajara: Silicon Valley South?

Since the 1980s, Guadalajara and its surrounding region have been dubbed as the "Mexican Silicon Valley." More recently, the city has been given the adjective "Silicon Valley South" as part of a new advertising campaign in corporate circles. However, in spite of the sizeable concentration of companies in the electronics and computer industries it boasts, and even of the recent boom it has experienced in the last few years, Guadalajara is still far from warranting the Silicon Valley label. For one thing, except for Motorola which makes diodes, transistors and other low-scale semiconductors, none of the other electronics companies in the area works with silicon materials.

The scale of Guadalajara's electronics industry also is nowhere near that of Silicon Valley. While only about 120 companies make up the electronics industry in Guadalajara, over 7,000 are in operation in Silicon Valley. A total of 65 companies were established in Guadalajara between 1995 and 1997 involving an investment of about \$850 million. In comparison, 3,575 new businesses were started in Silicon Valley in 1997 alone investing \$3.7 billion! Moreover, in the first quarter of 1998 an additional \$1.9 billion were poured into new ventures in Silicon Valley. (*Business Week*, 31 August 1998: 46-49). Another crucial difference is that in addition to its remarkable economic infrastructure, its entrepreneurial climate and its large pool of highly qualified engineering and managerial talent, Silicon Valley offers a vast pool of venture capital and funding sources that can hardly be found in Guadalajara.

The fact is that the development of Guadalajara's electronics industry is a qualitatively different phenomenon vis a vis Silicon Valley's (Palacios, 1992). Nonetheless, some analysts have noted recently that thanks to the NAFTA- and CM-fed boom Guadalajara has been enjoying for the last three years, "the city is fast achieving a critical mass of cutting-edge production facilities" and so it is in the process of developing "an integrated high-tech industry that transcends assembly... and in general an electronics hub for the long haul" (*Los Angeles Times*, 8 March 1998).

An encouraging development in that sense is the existence of R&D activity in foreign companies operating in the area, mainly IBM, Lucent and Hewlett-Packard, as well as in local, wholly-owned Mexican firms like Mixbaal, Advanced Technology Research, Arquitectura en Sistemas Computacionales, and GPI. This is in addition to the pioneering work of the federally funded Semiconductor Technology Center (CTS) which has designed and developed ICs, PCBs, dedicated chips, and motherboards for the computer and telecommunications industries since 1988 [Mixbaal is a spin-off of CTS]. Moreover, the arrival of subsidiaries of the world's top CMs is reinforcing that trend as they can include design responsibilities in their operations, as they do in the US and elsewhere.

In sum, it can be said that although Guadalajara still does not warrant the Silicon Valley adjective, significant developments are taking place in the area that point towards the formation of an interrelated industrial complex that already shows some of the basic features that characterize the original Silicon Valley phenomenon. Those features include the generation of spin-offs, the creation of production networks and the growth of R&D activities.

III. INDUSTRIAL AND TECHNOLOGY POLICY

The Mexican government intervened heavily in the economy in the past, but in line with its general shift toward liberalization, it has generally eschewed industrial or technology policy in the 1990s. This is particularly true in the area of computers. After imposing protectionist policies in the 1980s, the government opened up the computer sector to foreign competition in 1990 and has largely ignored it since. The impact of this shift from statist to laissez faire policy has been to reshape both the computer industry and the IT market.

A. History of technology policy in Mexico

Mexico's first major technology policies were a series of laws passed in the early 1970s aimed at increasing national self-sufficiency and reducing the outflow of capital for technology imports. These laws enhanced the state's role as an industry regulator and promoter, matching the country's nationalistic economic ideology at the time.

The first important step in the development of a national technology strategy was the creation of the National Council on Science and Technology (CONACyT) in 1970. CONACyT was made responsible for coordinating science and technology policies and is the leading source of research funding even today.

The next steps were the passage of the Law on Technology Transfer and the Foreign Investment Law in 1973. The Law on Technology Transfer required all technology transfer contracts to be registered with the newly created Registry of Technology Transfer. The Registry was given authority to reject all contracts deemed not to be in the national interest, such as when the foreign party placed restrictions on the Mexican company's activities, or when an equivalent technology was available in Mexico. The Foreign Investment Law put restrictions on foreign ownership in strategic industries such as computers and electronics.

During the Lopez Portillo administration (1976-1982), bureaucratic control over technology and foreign investment policies shifted among several agencies. Then in 1983, early in the de la Madrid administration, the functions were centralized under the Secretariat of Commerce and Industrial Development (SECOFI). SECOFI's orientation was toward industrial promotion, as opposed to the more autarkic approach of the 1970s. The legal environment changed along with the bureaucratic orientation in the 1980s. The 1982 Law on Technology Transfer moved away from regulating technology transfer and towards emphasizing local technology development.

Policies in the 1980s: industry protection and promotion

During the 1980s the Mexican government adopted a quite nationalist approach in regards to computer policy. The domestic computer market remained highly protected, as the importation of most new computer equipment was strictly prohibited. Federal action was guided by a controversial policy that was never made official and which led to disputes within the Mexican government and between Mexico and IBM and even the U.S. government.

In 1981, SECOFI's forerunner, the Ministry of National Patrimony and Industrial Promotion (SEPAFIN) formulated and started to implement the so-called "Program to Promote the Manufacture of Electronic Computing Systems, their Central Processing Units and their Peripheral Equipment", more commonly referred to as the Computing Program in English and the PC (Programa de Computadoras) in Spanish. This program was never published in the official government gazette as some in the government were concerned about reaction from the U.S., and others were uncomfortable with SEPAFIN's expanding power. Instead, the government implemented the plan for about nine years, without formally promulgating it. The key goals of the plan were (Borja, 1995):

- To generate local production of mini- and micro-computers
- To create a national industry of parts and components for computer production
- To create a national export capacity
- To achieve technological autonomy

The following policy packages were adopted to achieve these objectives (Borja, 1995):

- A trade policy that virtually created a national market reserve, as access to the domestic market was granted exclusively to companies that would produce according to the Program's provisions. The policy dictated that domestic production would displace imports in five years time.

- A policy to regulate foreign investment, which (a) permitted full foreign ownership in the production of minicomputers and core processors, provided 75 per cent of the output was exported; and (b) limited foreign ownership to 49 per cent in the production of PCs and peripherals.
- An R&D policy that required foreign investors to use advanced technologies, invest a fixed percentage –between 3 and 6— of gross sales in R&D, and fund the creation of research centers and human resource development programs.
- A government procurement policy that gave preferential treatment to companies registered in the program.
- A domestic content policy that required a minimum proportion of domestic parts and components in final products (45 per cent for PCs and 35 per cent for minicomputers in the third year of the program).
- A fiscal and credit incentives policy for new companies in the computer industry, which consisted of fiscal credits and soft loans from government development funds, as well as preferential prices on electric power.

According to José Warman, considered the key architect of the plan, the Computing Program aimed to move Mexico away from import substitution to a more balanced strategy that included export promotion and the creation of domestic technological capabilities. The PC was seen at the time as offering a new opportunity for Mexico to develop a domestic computer and electronics industry. The government granted exemptions to the foreign investment law for mainframes and for minicomputer companies already in Mexico. But it banned imports of PCs and required foreign makers to enter a joint venture with a Mexican company (who would have majority control) in order to produce PCs in Mexico.

Almost as soon as the computer program was put in place, the environment began to change dramatically. In Mexico, the debt crisis of 1982 shifted the government's emphasis from industrial policy to financial policy, with the balance of payments becoming the critical concern. This weakened the government's emphasis on investing in national capabilities for the computer industry and made it more willing to make trade-offs to attract foreign investment and promote exports. In the computer industry, the introduction of the IBM-PC led to the standardization of the PC industry on the IBM architecture and the creation of a global production network for high-volume PC production (Dedrick and Kraemer, 1998).

The convergence of these two developments led to a change in Mexico's computer strategy when IBM balked at the joint venture requirement, which went against its policy of operating 100%-owned subsidiaries in all countries. IBM had already abandoned India rather than give in to demands that it enter a joint venture there, and it had been fighting with the Brazilian government over Brazil's market reserve plan. So when IBM asked permission to produce PCs in Guadalajara, it demanded full ownership of the operation.

The Mexican government was opposed to granting an exemption to IBM, especially since other foreign firms such as Unisys, Apple, Hewlett-Packard and Wang had already formed joint ventures with Mexican partners. But IBM was not only the biggest computer maker in Mexico and the world, it was now the dominant PC maker and a global industry was growing around its

standard. Keeping IBM out of Mexico's PC market would isolate the country at a time that it hoped to become more integrated into the emerging industry.

IBM offered a number of concessions to get permission for 100% ownership of its plant. It invested \$11 million in a new semiconductor research center called CTS, run by the Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV-IPN) in Guadalajara. It also agreed to develop local suppliers. Probably most important, it agreed to export a large share of the plant's output, helping Mexico reduce its trade deficit in computers at a time when it desperately needed to improve the national trade balance.

IBM had allies in both the U.S. and Mexican governments. The U.S. government was concerned about threats to national competitiveness in computers and was naturally responsive to the interests of its leading computer maker. It is believed by many in Mexico that pressure was applied on behalf of IBM during this time. Within the Mexican government, the Ministry of Foreign Affairs and others were concerned not to create friction with the U.S. and the international community at a time when Mexico was struggling to cope with its debt crisis. In such a climate, IBM and the Mexican government came to an agreement that gave IBM the right to retain full ownership of its new plant, which opened in 1986. Soon thereafter, Hewlett-Packard also received permission to take 100% control of its Mexican operations, while Apple decided to pull out of the Mexican market.

The IBM decision marked the beginning of the end of the Computing Program. People who were in SECOFI at the time argue that the program not only lacked support in other parts of the government, but lacked even the wholehearted support of the top officials at SECOFI. More importantly, the technocrats in the de la Madrid administration (including Carlos Salinas) were trained in the laissez faire culture of U.S. economics departments, which saw industrial policy as anathema to the process of economic liberalization.

SECOFI's policy goals in the late 1980s shifted away from national integration to emphasize cutting PC prices to encourage diffusion. In 1987, computer makers were allowed to import components for assembly with a 13% tariff and operate outside the Computing Program, an option taken by some Mexican PC makers who became simple assemblers of Asian PCs. PC prices dropped but Mexico failed to develop a domestic supply base for parts and components. On the other hand, IBM's PC exports helped lower the trade deficit in PCs from \$200 million in 1985 to \$78 million in 1987 (Borja, 1989).

When the Salinas administration came into office in 1988, it accelerated the pace of liberalization. In 1990, it opened up the Mexican computer market to imports, eliminating import permits and retaining only a 20% tariff. R&D requirements were dropped and all companies were given access to government procurement contracts. The Computer Program was now a thing of the past, leaving in its place a nearly free market in the computer sector.

Policies in the 1990s: Liberalization and economic integration

Mexico's IT policy for the 1990s could be described as one of benign neglect, based on the belief that liberalization of the sector would ensure the best results and that there was little role for the

government in promoting production or use of IT. That policy stance changed somewhat with the arrival in December 1994 of Ernesto Zedillo as president. Zedillo explicitly called for the development and exploitation of information technology as a national goal. This goal was given form in the Plan for the Development of Informatics (PDI), which targets: (1) promotion of IT use; (2) human resource development; (3) research and development; (4) development of a local IT industry to exploit niche opportunities; (5) improvement of the telecommunications infrastructure; and (6) creation of the necessary legal framework to support IT (e.g. intellectual property rights).

Within government itself, departments and agencies have been encouraged to develop their own IT initiatives. Some of the projects developed so far include a plan to put at least 5 PCs and a local area network in every public school, a national crime fighting database, development of a web site for government procurement, a national health information system, and a regional information project to help municipal governments offer better public service. In addition, the CONACyT provides grants for computer science research and training at twelve key universities and institutions around the country.

The PDI is a promising plan that focuses on IT use and developing national capabilities. There are two key problems at this point, however. First, there are no funds set aside to pay for these projects. Instead, funding must come from the relevant government agencies' budgets. Experience in other countries such as Korea suggests that such plans tend to founder when forced to compete in the regular budget process, as it is often difficult to measure the benefits directly, and there is no strong constituency for IT in most agencies (Dedrick, Kraemer and Choi, 1996). Second, there is little coordination among the institutions involved in the PDI, and no pilot agency to ensure that projects are designed so as to complement each other.

In addition to promoting use, the government is also encouraging development of local production, mostly through creating a supplier base to support the multinationals producing in Mexico. The greatest emphasis is on the consumer electronics industry, but there are similar efforts to attract computer components suppliers. The organizations involved are the Mexican Investment Board, which sends representatives to the U.S., Asia and elsewhere to attract investment; the foreign investment office of SECOFI; and two development banks—Banco Nacional de Comercio Exterior (Bancomext) and Nacional Financiera (NAFIN). Their efforts, along with those of various state governments, have helped attract foreign investment in the computer, consumer electronics, and electronic components industries. Also the national computer, electronics, and telecommunications industry chamber (CANIETI) and its affiliated organizations have developed a strategy to develop a local supply base for the computer and electronics industries. However, there is little coordination of efforts, and no overarching strategy aimed at developing long-term capabilities.

In sum, no formal policy on the computer industry has been undertaken by the Mexican government since 1993 when the April 1990 decree was derogated. A number of *ad hoc* measures were adopted, however, during 1994 in a series of meetings between SECOFI and representatives of various industries. The most significant included:

- Elimination of the 8th Rule tariff regarding the importation of computer parts and components. The rule stipulated that each item had to be imported according to a specific tariff, and that import taxes had to be paid separately for each tariff. Its elimination permitted the importation of parts and/or components, and the payment of the corresponding taxes, on a single tariff.
- Elimination of import duties on about 80 types of machinery and equipment which were necessary for the operation of the national electronics industry. The only condition was that such machinery and equipment were not produced in Mexico.
- Prohibition of importation of used computer equipment for ten years. The purpose was to give the domestic industry a grace period to prepare for competition from older machines imported from the U.S.

Other policy measures implemented during the 1990s include the establishment, by decree published on May 3rd, 1990, of the Temporary Importation Programs to Produce Articles for Export (PITEX), and new rules for the operation and promotion of the maquiladora industry. Virtually all computer and electronics companies in Mexico operate under one of those schemes, which allow duty-free importation of components when they are used in export products.

c. State government initiatives: Jalisco

While the federal government has maintained a hands-off approach to the computer industry, some state governments have developed policies to promote the industry locally. The leading example is the state of Jalisco, whose policies have helped support the growth of the state's computer industry cluster.

Aware of the growing importance of the electronics industry in Jalisco, the present PAN (National Action Party) administration has implemented an innovative, though poorly funded incentive program to attract new companies to the state. A federal budget item, of about \$20-30 million, originally destined for social development and poverty alleviation programs, was used to establish a revolving fund to provide incentives for new industrial and agricultural projects, including small productive ventures.

A State Commission for Economic Promotion (CEPE) was created as a consultative board, which decides over the use of the funds. CEPE assesses each project and then determines the incentives to be awarded in each case; the respective company then signs a contract with CEPE to assure it will live up to its commitments. The extent of incentives is determined in general by the number of jobs created, the amount invested, the level of wages paid, the location of the premises outside the greater Guadalajara metro area (to reduce congestion and promote development in other municipalities), and other criteria.

The incentives include government support and assistance for both the installation of the plants and the constitution of the companies, and even for finding and purchasing the required land. Other support items for new companies include scholarships for training prospective employees, and certain money allowances that depend directly on the number of jobs created, the size of the investment made, and the type of activity to be performed.

Another more indirect but also valuable promotional support provided by the state government is the construction of industrial parks with all the required infrastructure and facilities. Presently there are six new parks under construction in the state, in addition to the nine already in operation.

Although useful and opportune, the above scheme is nonetheless insufficient as it has limited resources and lacks the backing of a corresponding federal incentive framework. This has caused Jalisco, and Mexico, to lose new investments to other places in Asia and elsewhere. That was the case with an assembly plant Intel considered establishing in 1997 in Guadalajara. The plant was finally located in Costa Rica where tax incentives were offered to Intel that Mexico did not try to match.

A common request among foreign companies operating in Jalisco is at least 5- to 10-year tax holidays to attract new ventures and facilitate their implementation. They point the case of Malaysia where the federal government grants a 70 per cent reduction in revenue taxes during the first 10 years, and of Ireland where the revenue tax rate is zero during the first 5 years.

In Mexico, the most important policies affecting the IT sector in the 1990s have not been IT policies, but the creation of NAFTA, privatization and deregulation of telecommunications, and general liberalization of the economy. Mexico's case is best seen as a study of the impacts of liberalization and economic integration on a high-technology industry.

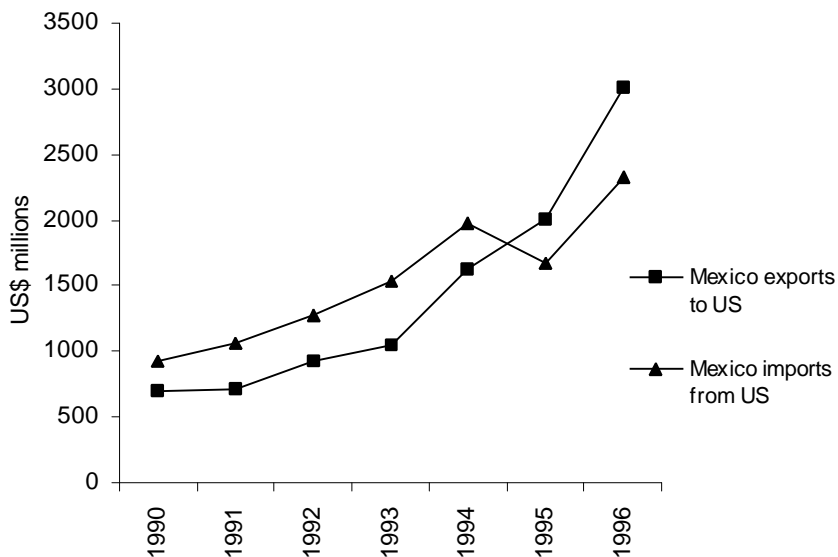
Impacts of NAFTA and economic integration

In order to understand the impacts of NAFTA on a specific industry such as computers, we first consider evidence of the impacts on trade and investment more broadly. While NAFTA is still only five years old, and data tends to be complicated by the impacts of the peso crisis of 1995, there is already some evidence of the effects of NAFTA on trade in North America. David Gould (1998), concludes from an econometric study of North American trade that NAFTA has had a significant positive effect on trade flows between the United States and Mexico. He also argues that an important impact of NAFTA was that it prevented Mexico from erecting new trade barriers in the wake of the 1995 crisis, as it had done in previous crises, and helped mitigate the effects of the crisis by encouraging a return of foreign investment. More generally, Gould finds that NAFTA resulted in neither a dramatic increase or loss of U.S. jobs, but does not estimate the impact on employment in Mexico.

Robinson (1997), says that NAFTA has helped lock in Mexican liberalization, and has been more "trade creating" than "trade diverting." This is a major issue for economists, as free trade areas are considered to be beneficial only if they increase overall trade, rather than just divert trade, for instance if U.S. trade with Mexico just replaces U.S. trade with Asia. From a more political point of view, even trade diversion might be considered desirable. For Mexico it means more economic activity and jobs, and for the U.S. it provides benefits for a neighbor whose economic conditions have implications for a variety of binational issues, including immigration.

If the impacts of NAFTA so far are indeed mildly beneficial at the macro level, what can we say about the impacts on the computer industry? First, we look at trade in computer hardware between the U.S. and Mexico. Figure 4 shows that trade in both directions was growing steadily before NAFTA was implemented in 1994, with the U.S. running a stable trade surplus. In 1995, however, Mexico's imports declined, while its exports continued to grow, due to the peso crisis that year. Since then, trade has again continued to grow in both directions, but now with Mexico running a surplus. The peso crisis makes it difficult to identify any direct impact of NAFTA, and of course other factors would have to be controlled for in order to quantify any possible effects. But what the data suggest is that NAFTA probably has not had a big impact, given that the computer sector had already been liberalized in 1990.

Figure 4. Mexico-US trade in computers and office equipment



Source: AEA and NASDAQ, 1997, *Cybernation: The Importance of the High Technology Industry to the American Economy*

In addition to quantitative analysis, it is valuable to actually talk to people in the industry and find out how their businesses have been affected by NAFTA. Based on interviews with over 20 companies in Mexico and the U.S., including Mexican-owned firms and multinational subsidiaries, we found the following:

Impacts on Mexico

- NAFTA and economic integration have not made a dramatic difference on Mexico's role as an export platform, as they operate under either the maquiladora or PITEEX regimes, and thus do not have to pay taxes on parts and materials that are re-exported as part of finished products. In general, the impacts have been varied. One company that operates under PITEEX did say that NAFTA had accelerated the reduction of tariffs on all goods, which could include inputs such as capital equipment that are not re-exported. This company felt that NAFTA helped make Mexico more competitive against Asian suppliers. For another

company, a large contract manufacturer, NAFTA had no influence either on its decision to set up shop in Guadalajara, nor on its subsequent operations.

- One reason for NAFTA's rather low effect on the computer sector was that the PITEX and maquiladora regimes, under which the major players in the Mexican PC industry operate, were enacted well before 1994 and have provisions that prefigured NAFTA's. At best, the accord has played a role as facilitator of transactions between subsidiaries and their parent companies in the U. S. or Canada, and as a safeguard for foreign companies to invest in Mexico.
- For Mexican computer companies, the impacts of NAFTA have been minor, as most of them had been driven out of the market by the liberalization of 1990. But for the few remaining domestic "branded" PC assemblers like Gama and Lanix, NAFTA has had negative effects as it has further opened up the Mexican market by lowering tariff rates even lower than the 20% rate established in 1990.
- NAFTA was expected to provide benefits for Mexican companies in terms of access to the U.S. market. However, most of these companies are small and do not have the resources to establish distribution channels in the U.S., so they have not seen any major growth in sales to the U.S. However, companies providing services such as custom programming have found opportunities to do contract work for U.S. companies.
- Interestingly, one Asian company mentioned that Mexico's free trade agreements with other Latin American countries give it an advantage over the U.S. as a location for serving the Latin American market. Because the U.S. does not have similar agreements, there is roughly a 5% cost advantage to supply Latin America with production in Mexico rather than the U.S.
- For computer users, NAFTA lowered tariffs on computer imports, but the most important changes had already taken place in 1990. A NAFTA provision that may have a more direct effect will be the liberalization of used computers imports in 2004, for this will enable Mexican consumers to buy useful equipment that is already obsolete in the U. S. A more indirect impact was the opening of the Mexican market to U.S. companies in banking, retail and other services industries. These companies brought with them advanced information systems, helping to diffuse new technologies and practices into the Mexican economy.

Impacts on the United States

- For U.S. computer companies, NAFTA and the associated economic integration of the U.S. and Mexico has helped open up the Mexican market for the full range of hardware, software and services. Prices have dropped, demand has grown, and U.S. companies have been able to capture the largest share of the new market opportunities. Taiwan's Acer is the only non-U.S. company to gain a major share of the Mexican computer market since liberalization, and even it has struggled the past couple years.
- NAFTA is most important to companies such as IBM and Hewlett-Packard, for whom Mexico is an important market and also a link in a global production strategy. NAFTA lowers the cost of imports from the U.S., which is important for these diversified companies who might be producing PCs or printers in Mexico, but also import larger computers and other products to sell there.
- NAFTA helps maintain production in North America as a viable alternative to Asia. U.S. companies can locate labor-intensive operations in Mexico, close to the U.S. market, while retaining higher value jobs in design, engineering, marketing and other functions in the U.S.

- NAFTA has had little effect on the U.S. computer market, as there are no Mexican computer makers capable of competing in the U.S. market. Also, no European or Asian companies have used Mexico as a platform for exporting to the U.S., except Acer, which produces PCs and monitors mainly for IBM.
- The inflow of U.S. contract manufacturers into Mexico has created jobs in Mexico, but probably not at the cost of many U.S. jobs. Those labor-intensive operations would likely have been located in Asia or elsewhere, but not in the U.S., where wages are too high to support low-end assembly. In short, there has not been evidence of the “giant sucking sound” of jobs moving from the U.S. to Mexico that Ross Perot predicted.

The impacts of NAFTA on production are likely to become more significant as the maquiladora and PITEEX regimes are phased out and all production in Mexico is guided by NAFTA rules. As this takes place, companies will have less incentive to use Mexico as a pure export platform. Instead, there may be more benefit to treating North America as one market, with production optimized throughout the continent according to local advantages in labor costs, infrastructure, technical capabilities, or local government incentives.

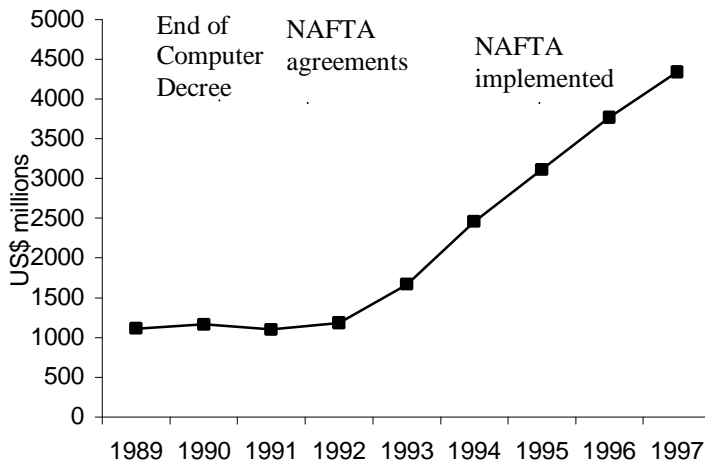
IV. THE COMPUTER SECTOR

A. Hardware production

In the 1990s computer production in Mexico expanded rapidly as foreign manufacturers increased production. Computer production appears to have been influenced by signing of NAFTA, which was agreed to by the three countries in the 1991 and implemented in January, 1994.

Computer equipment output increased from \$916 million in 1991 to \$2.9 billion in 1997, not including production by maquiladoras (SECOFI, 1998). When maquiladora production is included, computer hardware production topped US\$4.5 billion in 1997 (Figure 4).

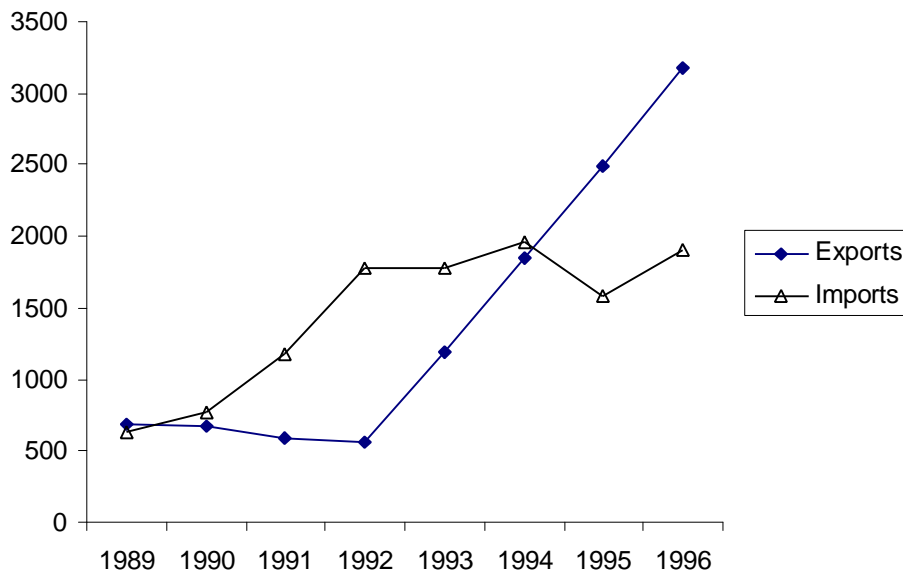
Figure 5. Computer Hardware Production in Mexico, 1989-1997



Source: Reed Electronics, Yearbook of World Electronics Data

Computer exports have shown high growth rates as well, paralleling the growth of production. The value of the PCs exported increased nearly sevenfold from only \$553 million in 1990 up to \$3,815 million in 1997 (SECOFI, 1998). Figure 6 shows Mexico's overall trade in computer hardware from 1989 to 1996.

Figure 6. Mexico's Trade in Computer Hardware, 1989-1996



Source: Reed Electronics, Yearbook of World Electronics Data

B. Software

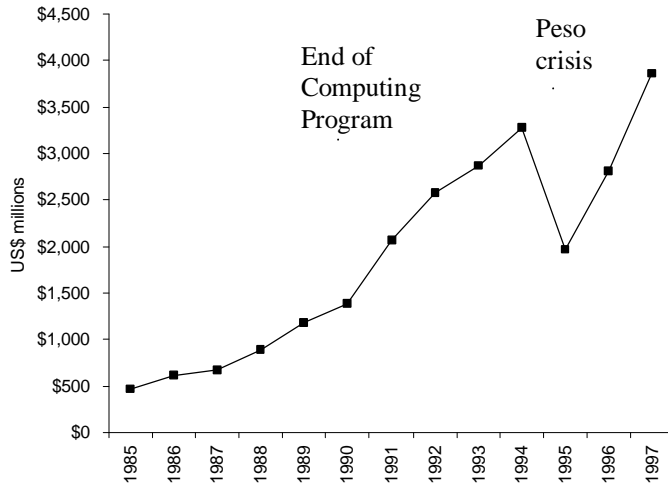
Mexico's software market is served largely by imports of U.S. operating systems and applications. The total number of software firms in Mexico is unclear, as it is in many countries, due to the difficulty of counting and tracking the many small firms and distinguishing which are actually developers versus distributors. Actual levels of software production and exports are very difficult to determine, as software has not even been a separate category in most national and international accounts until recently. However, the U.S. Department of Commerce (1998) puts local production of packaged software at \$28 million in 1998, with exports of just \$1 million.

C. Computer use

Liberalization and economic integration has affected computer use in Mexico at least as much as production. In particular, the reduction in tariffs and restrictions on PC imports has attracted new vendors to the Mexican market and led to more competition and lower prices. As a result, PC diffusion has spread and overall IT investment has grown rapidly. Investments in information technology have quadrupled from US\$1.1 billion in 1989, the last year of the

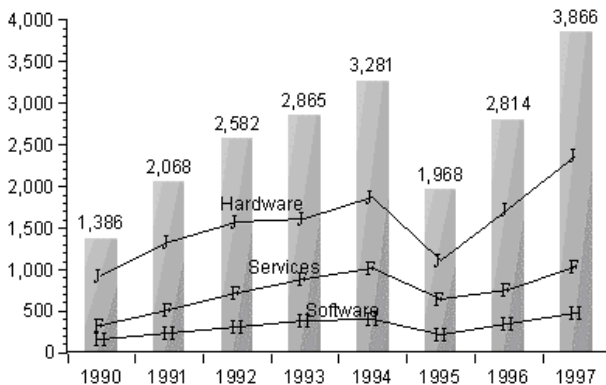
Computing Program to over US\$3.8 billion in 1997, in spite of a deep decline during the 1995 peso crisis (Figure 7).

Figure 7. Total IT spending in Mexico, 1985-1997



Source: IDC

Figure 8. IT spending by category, 1990-1997



Source: Select-IDC

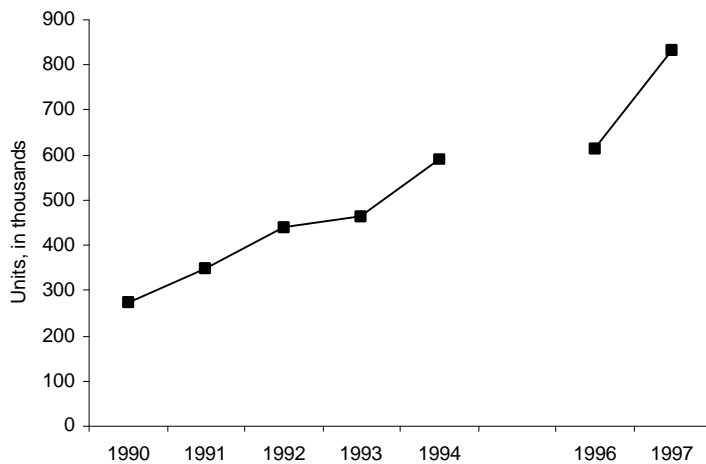
Software is packaged software; customized software is included in services

During the run-up to NAFTA, companies invested more heavily in hardware, but during the peso crisis, many firms shifted their emphasis to systems integration services in order to get more value from their existing hardware stock. By 1997-1998, the trends were toward enterprise resource planning software (such as SAP and Baan), and outsourcing of IT functions, as companies restructured and focused on core business activities. As one industry executive put it, “the crisis forced companies to rethink who they are, and where they want to be.”

PC Market

Mexico's PC market began to grow rapidly after the market opening in 1990, with unit sales growing around 20% per year from 1990-1994 (Figure 9). After dropping during the economic crisis of 1995, sales rebounded strongly in 1996 and 1997.

Figure 9. PC sales in Mexico, in units



Sources: CRITO database (1990-1994), Select-IDC (1996-1997). 1995 unavailable.

Mexico's IT market has been dominated by foreign vendors since the first computers were introduced in the country. IBM controlled most of the mainframe market, although Burroughs and others were active as well. The computer policies of the 1980s did not affect large systems, created openings in the PC market. Printaform took the lead in PCs until liberalization in 1990, followed by local companies such as Lanix, Gama, and Electronica Zonda, with its Logix brand. IBM and HP were the only major foreign brands, as they were willing to produce in Mexico under the Computer Program rules.

After liberalization, foreign companies such as Acer, Compaq and AST entered the Mexican market, and quickly took the lead. Acer was the top PC vendor from 1991 to 1996, before being surpassed by Compaq in 1997, when the top five PC brands were Compaq, Acer, IBM, HP and Lanix (Table 9).

Table 9. PC market share in Mexico, 1997

Vendor	Share
1. Compaq	20%
2. Acer	13%
3. IBM	13%
4. HP	13%
5. Lanix	5%
6. Dell	3%
7. Apple	2%
8. White boxes	30%

Source: PC company data provided to authors

An interesting phenomenon in Mexico, similar to many developing countries, is the major role played by PC clones, known as “white boxes” in the low end of the market. At the end of the 1980s, white boxes accounted for 70% of the market, due to large price gap between them and branded PCs. The gap was reduced after the market opening in 1990 and further closed in 1992 when Compaq cut prices aggressively (as it did around the world). The share commanded by foreign brands hit a historic high in 1994 when they captured 84 per cent of PC shipments in Mexico (*INFOchannel*, 1998, p. 42). White boxes dropped to 5% of the market in 1994, then began to grow again.

In 1995, the major brands’ cost structure increased because of the need to hedge against currency movements. There was also an oversupply of components, so white box prices fell as clone makers bought cheap components on the spot market while brand name vendors were locked into longer term contracts. The price gap opened again, and by 1998 clones had an estimated 35-50% of the market (estimate from Select-IDC). The biggest victims of the white box phenomenon are “premium clone” brands such as Acer and AST, as well as local brand-name PC makers who can’t easily match the prices of white boxes in the present environment. In the corporate market, the major vendors such as Compaq, IBM and HP have the advantage in offering a full line of hardware and services.

Nature of IT use

Computer use is heaviest in the financial sector, totalling 1.45% of the sector’s economic output (Table 10). The financial sector has invested in IT as a competitive tool as the sector has been privatized and opened to foreign participation. Under NAFTA, U.S. banks have entered the Mexican market through joint ventures, bringing with them their advanced information systems, and Mexican banks have responded by increasing their own IT investments to keep up.

Table 10. IT market by economic sector, 1997

Sector	Share of IT market	Spending as % of GDP
Public Sector	35.4%	1.04
Finance	23.5	1.45
Distribution	8.5	0.52
Services	4.5	0.64
Manufacturing	20.1	0.90
Other	8.0	1.06
Total	100.0	0.91

Source: Select-IDC

Two early examples of this trend were Abaco Grupo Financiero and Banco Serfin. Abaco invested \$30 million from 1991 to 1995 developing a client/server technology infrastructure that allowed the bank to offer new services to customers. Abaco's first major project was the development of a point-of-sale (POS) system that supports more than 140 types of financial transactions. By 1995, the system was running at 200 branches on more than 1,000 teller PCs. (Hoffman, 1995a)

Serfin invested in client/server technology, including an executive information system (EIS) and data warehouse to enable its top officers to review outstanding customer loans daily on a branch-by-branch basis. The bank estimated that the new EIS/data warehousing system decreased Serfin's response time to perform a forecast from two hours to 30 seconds (Hoffman, 1995b)

Both of these banks made their IT investments in response to the impacts of NAFTA and the arrival of foreign competition, but they both realized unexpected benefits when the 1995 peso crisis resulted in a surge of inflation and soaring interest rates. Being able to track outstanding loans on a daily basis helped them to respond to customer applications for loan extensions and to manage more effectively during the crisis. However, more recently the two banks have run into financial trouble for other reasons, and ABACO was bought by Citibank.

A similar trend can be seen in other sectors. In retailing, companies such as WalMart and Price Club have entered and expanded rapidly in Mexico, bringing their powerful information systems with them. Another example is in manufacturing, where Volkswagen revamped its information systems in the Puebla plant now responsible for producing the popular new Beetle for the North American market. VW Mexico outsourced its IT operations to Gedas, who completely revamped VW's information systems. Thanks to a new factory information system, Beetles, Golfs and Jettas produced in Puebla can be custom-configured to customer requests at a rate of 850 vehicles per day. As part of a US\$100 million outsourcing contract, Gedas migrated 42 systems with 3,500 programs from mainframes to Unix systems. Included were the factory information system and a new dealer communications system. The software projects were completed in less than two years by a combined VW/Gedas team of 200 developers, all without shutting down the factory (King, 1998).

Still, IT spending in Mexico is less than one percent of GDP, much lower than countries such as Singapore, Hong Kong, Korea and Malaysia (Table 10). The big gap is in small business and home use. While multinationals and some large Mexican firms are heavy IT users, small companies lack the financial and human resources to support IT investment. This situation is changing gradually as younger people with computer skills enter family businesses, and as lower cost PCs makes IT affordable even for small businesses. As for home use, Mexico's highly skewed income distribution limits the number of households that can afford to buy a PC, and poor quality Internet service limits the benefits from owning a computer. Select-IDC estimates that about 600,000 Mexican households had a PC in 1998 (out of about 18 million).

Table 10. IT use indicators

	IT/GDP (%) (1996) ^a	PCs per 100 people (1995) ^b
Mexico	0.8	2.61
Brazil	1.0	1.30
Malaysia	2.0	3.97
Thailand	1.1	1.52
Korea	2.6	12.08
Taiwan	0.8	8.32
Singapore	3.3	17.24
Hong Kong	2.3	11.63
United States	5.1	32.80

Sources:

a. CRITO database

b. ITU, 1997. *World Telecommunication Development Report 1996/1997*

Software

Packaged software represents 12.1 percent of the total IT market, reaching \$428 million dollars in 1997. The customized software market was estimated at \$132 million dollars in 1997. Over 90% of the packaged software sold in Mexico is imported, mostly from the U.S., but most customized software is developed in Mexico (U.S. Department of Commerce, 1998). This is common in most countries, as custom software usually is developed on-site in close collaboration with the customer.

Table 11. Mexico's Packaged Software Market (US\$ millions)

	1997	1998
Imports	406	515
Local Production	22	28
Exports	1	1
Total Market	428	542
Imports from U.S.	391	494

Source: U.S. Department of Commerce, 1998

Table 12. Mexico's Customized Software Market

	1997	1998
Imports	4	6
Local Market	130	184
Exports	3	4
Total Market	132	186
Imports from U.S.	4	5

Source: U.S. Department of Commerce, 1998

There are no barriers to imports of software, but piracy remains a problem. According to the Business Software Alliance, illegally copied software accounted for 67% of software in use in 1997, down from 78% in 1994. The U.S. government is pressuring Mexico to prosecute software pirates and Microsoft has a hotline that informs the Mexican government of reported software abuses. However, some critics blame the software industry itself for piracy, as prices for applications in Mexico are higher than U.S. prices. The Mexican attorney general claims the software industry can hamper efforts to prosecute software pirates because they frequently drop charges in exchange for a percentage of the profits from illegal software (Machuca and Cole, 1998). Local software companies may be more vulnerable to piracy as they depend on selling shrink-wrapped software and cannot get their products bundled with PCs as Microsoft does.

Internet use

In 1990, there were no Internet hosts in Mexico or for that matter in all of Latin America. As in many countries, Internet service in Mexico began with the educational institutions such as the National Autonomous University (UNAM), and Monterrey Tech (ITESM). They had links to the U.S. and sold access to both the public and private sectors in Mexico. Now there are many information service providers (ISPs), ranging from Compuserve to small local providers, who either connect directly to the U.S., or to the university nodes. Telmex bought out a local network called Red Uno (Network One) to offer its own Internet service, but it has been slow to take off. In 1997, MCI joined with Financiero Banamex-Accival to create a Aventel, which is a joint venture to provide expand Internet services in Mexico.

After a slow start, the Internet has been catching on rapidly, with Mexico being the second largest and fastest growing Internet user in Latin America (Table 11). Select-IDC estimated that there were about 400,000 Internet users in Mexico in 1997, and predicts that the number will reach 2 million by 2000. Internet use is hampered by poor quality telephone lines in much of the country, which limit users to connection rates of 14.4 Kbs at best. And while long-distance phone rates have gone down, local service rates have gone up since the telecommunications market has been liberalized. Telmex, which controls virtually all local access recently tripled the cost of a fiber-optic line for use by ISPs, creating another burden on Internet use. The average cost of an Internet connection in Mexico is about \$35 per month, compared to \$20 in the U.S. Given the low penetration of PCs, high cost of service, and uneven income distribution in Mexico, it is likely that the Internet market will remain limited to large companies, universities, and a small segment of the household population.

Table 11. Internet Growth Statistics for Latin America

Country	Number of Web sites 1995	Estimated Internet Users 1995	Number of Hosts, 1997	Hosts per 100 people, 1997	Host Growth from 7/95-7/96	Domain Growth from 1/96-1/97
Brazil	20,113	200,000	77,148	5	291%	284%
Mexico	13,787	140,000	29,840	3	150%	116%
Chile	9,027	100,000	15,885	11	71%	n.a.
Argentina	5,312	50,000	12,688	1	125%	139%
Colombia	2,262	28,000	9,054	2	125%	139%
Venezuela	1,165	10,000	2,417	1	50%	107%

Sources: ITU World Telecommunications Development Report, 96/97; Network Wizards Report, PR Newswire, June 4, 1997.

A survey of 1300 Internet users by Select-IDC found that users are predominantly young (72% between 21 and 40 years old), male (80%), professional (55%), and well-educated (67% have a bachelor's degree or equivalent). Not surprisingly, income is a big factor in a country with a very uneven income distribution, but surprisingly, 10% of the users surveyed earn less than 3000 pesos (about US\$350) per month, and another 14% are between 3000 and 5000 pesos (US\$350-580). The main uses are e-mail (93% of users), research (83%), file transfer (76%), and education and entertainment (67%). Only 14% have used the Internet for shopping and 8% for banking.

Despite the relatively high telecommunications costs and low bandwidth currently available for the Internet, growth in Internet use is expected to increase considerably, extending further into the commercial, educational and government domains. As Internet use extends from larger to smaller corporations and to the SOHO market, from higher education to secondary and even primary schools, and from the central government to local governments, it will fuel further growth in computer use in Mexico.

CONCLUSIONS

Liberalization and economic integration have removed barriers to IT use and helped attract multinationals to produce in Mexico. But the lack of a coordinated national IT policy has limited the degree to which Mexico benefits from its unique geographical location and its membership in NAFTA. For the Mexican computer industry, liberalization and NAFTA together have had mixed impacts at best. Local brand-name computer firms have all but disappeared, but white box makers continue to do well. Liberalization also has brought thousands of new assembly jobs to Mexico and has created demand for higher skilled technicians, managers and computer production. Packaged software companies have had some success targetting specialized markets, but lack the capabilities and capital needed to commercialize their products effectively in Mexico and abroad. On the other hand, companies providing IT services such as custom programming control most of the domestic market and in some cases have become contractors serving the U.S. market.

The lack of a national IT policy is hurting Mexico's workers and companies who might benefit even more from the opportunities created by economic integration. The lack of investment incentives has cost Mexico opportunities to attract more foreign investment, and the lack of venture capital has limited the growth of domestic companies. Based on the lessons of successful IT producers and users such as Singapore, Taiwan, Ireland and Malaysia (Dedrick and Kraemer, 1998; Kraemer and Tallon, 1999; Palacios, 1995), we would argue that Mexico should develop a highly targeted program aimed at developing national capabilities and making Mexico a more attractive investment environment. Some elements would involve:

- support for individuals, through education, training, and on-the-job training that upgrades skills in areas needed by industry,
- support for local software and service companies, through low-cost loans, export assistance, management advice, and small business incubators,
- new roles for universities through more support for computer science, technical training, joint industry-university cooperative research, and co-location of business incubators,
- incentives and funding for government agencies to use IT and information networks innovatively,
- further telecommunications reform to increase the availability and quality and to reduce the cost of Internet service,
- targeted incentives to attract suppliers of components and materials and to encourage MNCs to expand their activities in Mexico. These would be based on close interaction with MNCs to understand their needs and help their Mexican operations better compete with other regional units for internal business and investment.

In order to carry out such policy initiatives in a coherent fashion, there needs to be support from the highest levels of government, and there needs to be a pilot agency with the authority and resources to coordinate IT policy. Such an agency would work with other government bodies, universities, the computer industry and users to make sure that the various initiatives complemented each other. It would have an independent budget that it could use to seed new projects, or to leverage the funds of other institutions. The success of countries such as Singapore, Taiwan and Ireland in developing effective IT policies clearly shows the critical role played by such a coordinating agency. Absent such an agency, with high level support, policies are likely to get bogged down in bureaucratic turf wars or die from lack of resources.

From the U.S. point of view, liberalization and economic integration with Mexico have had generally positive impacts. There has been some loss of some assembly jobs to Mexico, such as the IBM San Jose jobs that were moved to Guadalajara, but those would most likely have been lost to Asia or elsewhere anyway. Most assembly jobs in the disk drive industry had already left the U.S. back in the 1980s (Dedrick and Kraemer, 1998). This is not to minimize the impact of such job losses on U.S. workers, but to point out that economic integration with Mexico only affected where the jobs ended up, not whether they would have been lost.

For U.S. computer companies, liberalization has opened and expanded the Mexican IT market, and it has helped sustain North America as a viable production platform in competition with Asia. In the IBM case, for instance, San Jose retained 90% of its jobs, mostly in R&D, and

announced it would add jobs in customer and technical support. Expansion of free trade to other countries in Latin America would likely have similar favorable effects on the U.S. industry.

Perhaps the biggest surprise of all is the lack of big surprises in the Mexico story. Liberalization has had roughly the types of impacts that economic theory would predict, and there haven't been any major unintended consequences, either positive or negative. Even the peso crisis was short-lived, and failed to shake confidence in the process of liberalization or in the benefits of NAFTA. As for the computer industry, Mexico's failure to capitalize fully on the opportunities of free trade are more due to weaknesses in its industry structure and the lack of well-conceived policies to create the necessary capabilities to reach its potential.

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¹ It is worth noting that capital flows into and out of Mexico are driven to a great extent by the investment decisions of Mexican nationals, who can easily move large amounts of money back and forth from Mexico to the U.S. Thus, the notion of foreign investment flows must take into account the confidence that Mexicans have in their own economy.

² Much of the history of Mexico's telecommunications sector is from Petrazzini (1995)

³ Information on IBM's present activities in Mexico draws on interviews with IBM managers in Guadalajara, Mexico City, and San Jose, California.

⁴ Information on Hewlett-Packard from interviews with HP managers in Guadalajara and San Diego, CA.

⁵ Information on Printaform's history from interviews with Mexican officials involved with IT policy, including procurement of PCs for government-related institutions.

⁶ "Mexico - Computer Software: Packaged/Customized" - ISA980901
U.S. Department of Commerce, International Trade Administration