COMPUTER SOFTWARE INDUSTRY

IN JUAREZ, MEXICO

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CHAPTER 1
INTRODUCTION

A vibrant and healthy computer software industry is instrumental to any developing country striving to join and compete with the advanced nations of the world. Software serves a critical role of maximizing the productivity gains of the microcomputer revolution for virtually every sector of an economy. With the aid of software, computer technology can accelerate a nation's integrated development by improving decision making in banking, government, manufacturing, transportation, agriculture and every other sector of an economy ("The New International", 1991, p.30). Software enables decision makers to organize, categorize, synthesize and use information in an accurate and timely manner. With Mexico racing toward free trade with the United States, the most powerful economy in the world, it is relevant to examine the indigenous software capability of Mexico's largest frontier city, Ciudad Juarez.

Free trade has Mexican business leaders concerned about international competition, and government officials questioning their ability to provide the increased service levels that explosive growth will demand. Without question, computer technology with the appropriate software can improve Mexico's ability to meet worldwide competition. Imported software is not always the most appropriate technology for a country, due to the language, cultural and legal differences among countries. There are countless examples in industry and government where imported software will not maximize the power of computers for Mexican leaders. Ideally, native software experts should "fine tune" computer technology to solve the unique problems facing the decision makers in Mexico.

Another important reason to examine the indigenous software capabilities of engineers in Juarez is the positive impact that software skills have on cognitive performance in general. The process of becoming a professional software developer requires the individual to learn and follow a systematic approach to solving a problem. These skills are transferable and improve virtually every sector of an economy. Therefore, the improvement in problem-solving skills associated with becoming a competent software engineer makes this study relevant for Mexico and all developing countries.

Purpose

The purpose of this thesis is to analyze the current state of the indigenous software industry in Juarez, Mexico. First, it describes the quantity, quality and type of computer programs in use that are written by Mexican nationals. This study also examines how effective educational institutions and other institutions, within the society, are at building software capabilities for the future. Lastly, the world-wide software industry and software skill requirements are discussed in order to aid the reader in understanding the state of the software industry in Juarez vis-a-vis the rest of the world.

Overview of Each Chapter

The remaining section of this chapter will review the economic conditions in Mexico since the late 1940's. It will describe the economic successes and failures during this period in order to give the reader an idea of how the present is influenced by the past.

The second chapter, Trade Theory and Software Development, begins by explaining trade flows using the orthodox trade theories. These theories shed light on the current state of the software industry in Juarez and aid the reader in visualizing the future potential of this industry. Next, the chapter reviews the common arguments for intervention which have influenced policy-makers in Latin America since the late 1940's. As stated in later chapters, interventionist policies have had a significant impact on the formation of an indigenous software capability.

Chapter Three, Types & Requirements of Software Development, begins with a description of the types of software and programming languages. Throughout the discussion, the degree of difficulty of creating each type of software is highlighted to indicate which ones are more suited to developing countries. This is followed by the phases for developing computer software along with the human skills that are required for each phase.

Chapter Four, Software Development - Opportunities and Constraints for Developing Countries, explores the opportunities and constraints for software development in developing countries. It begins by highlighting the enormous impact that the microcomputer revolution has had on developing countries. The chapter continues by explaining the need for human capital formation and the importance that this formation has on economic growth throughout all sectors of the economy. The popular topic, the new international division of labor in computer software, is evaluated in an attempt to separate fact from fiction. The chapter concludes with the reasons why a new international division of labor for software has not occurred.

Chapter Five, The World Software Industry, provides an overview of the global software industry. The size, nature and major trends of this expanding industry are discussed. The industrialized countries, which control this industry, and the major players from the third world are profiled. Special emphasis is given to the successes and failures of developing countries in order to provide guidance to Mexican policy-makers.

Chapter Six, Software Industry in Mexico, begins by explaining the significant growth that the Mexican computer industry has enjoyed during the last seven years. Next, the past performance of each segment within the software industry is reviewed along with predictions of which segments offer the best outlook for the future. The major software users are identified and the most commonly used software programs are listed. The chapter concludes by explaining the reasons why Mexican companies have been unable to export computer software.

Chapter Seven, Educational Institutions, describe the educational institutions that provide software development training to the Juarez residents. There is a section on each university and an overview of the numerous vocational schools that attempt to teach computer programming. The profile of each university includes the number of students, the qualifications of the teachers, availability of computer technology and other factors that explain the quality of education that the schools provide.

Chapter Eight, Software Industry in Juarez, Mexico, begins with an overview of the economic transformation that Juarez has undergone during the past twenty years. It explains the impact that the maquiladora industry has had on fueling the growth of many sectors throughout the economy. Next, the chapter dissects the successes and failures of every major sector of the software industry in Juarez. This is followed by a computer automation profile of every major government entity in this border city. The purpose of the chapter is to critically evaluate the amount of indigenous software that is being developed in Juarez by local software engineers.

The last chapter, Conclusions and Recommendations, summarizes the main findings of the research and provides suggestions for how the software industry can be improved.

The Mexican Economy

A brief review of the past fifty years is needed to fully appreciate Mexico's economic position of the 1990s. During the 1940's and 1950's Mexico pursued an economic strategy called import-substitution, in which government and private industry worked together to industrialize the country. The government, through highly protectionist policies, shielded the private sector from international competition and the private sector took advantage of this protected environment to establish commercial enterprises. It was called import-substitution because its goal was to substitute domestically produced goods for imports. This strategy reached its peak in the late 1950's and by the late 1960's the private sector became so dependent on its protected status that it hindered further economic growth. Instead of liberalizing the economy in the 1970's, Presidents Luis Echeverria and Jose Lopez Portillo sustained protectionist policies through foreign borrowing and oil export revenues (Purcell, 1988, p.31).

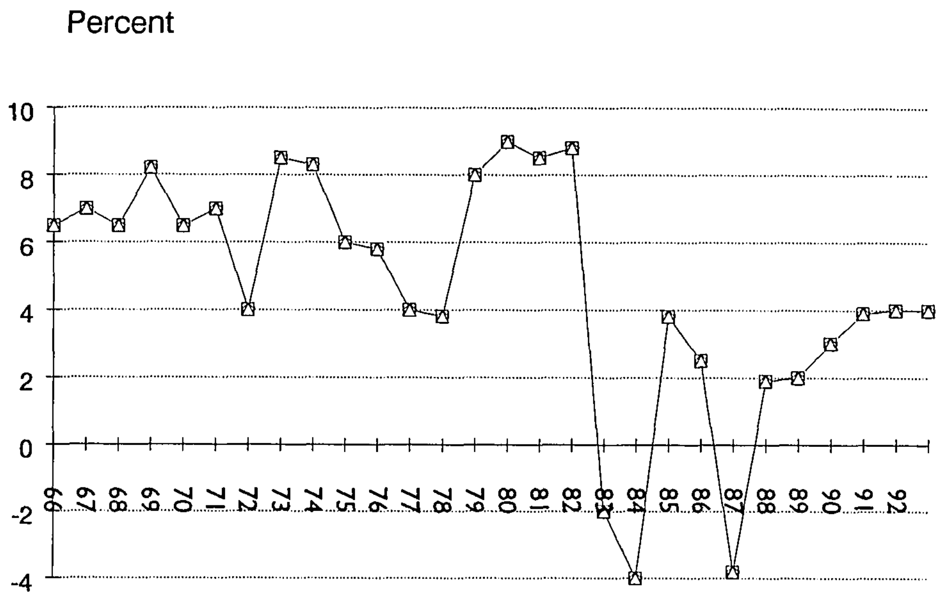
By the early 1980s, Mexico's spend-and-borrow policies resulted in over $85 billion in foreign debt. At the same time, international interest rates were soaring and Mexico's terms of trade were falling at unprecedented rates due to declining oil prices. All these factors combined resulted in a severe balance of payments problem between 1982 and 1988. Mexico's gross outlay for interest payments alone topped $70 billion. This $10 billion per year outflow was about 6 to 7 percent of GDP (Gonzalez de la Rocha, 1991, p. 22). Another problem that was mounting with significant proportions was the number of state-owned enterprises. Although there are no official figures, it is estimated that there were fewer than 300 of these companies prior to 1970 (Vera Ferrer, 1991, pp. 35-57); however, by 1982, state-owned enterprises reached 1,155 (Salinas, 1992, No. 172). With all these factors combined, Mexico, under President de la Madrid, had no choice but to liberalize the economy in the 1980's.

Mexico's gross domestic product (GDP) (Graph 1) grew impressively from 1965 to 1981. During this period GDP grew from a low of 4 percent per year to a high of 9 percent in 1980. However, the bottom fell out in 1982 when the economy tumbled 12 percentage points from an 8 percent growth rate in 1981 to a minus 4 percent in 1983 (Gomez, "The Economy in Graphs: 1992", p.63). Prior to the crash, Mexico clearly made some impressive gains in terms of growth and it is widely believed it could have avoided the tremendous shocks of the 1980's with a gradual liberalization of the economy.

Graph 1

Gross Domestic Product

(Real Terms)



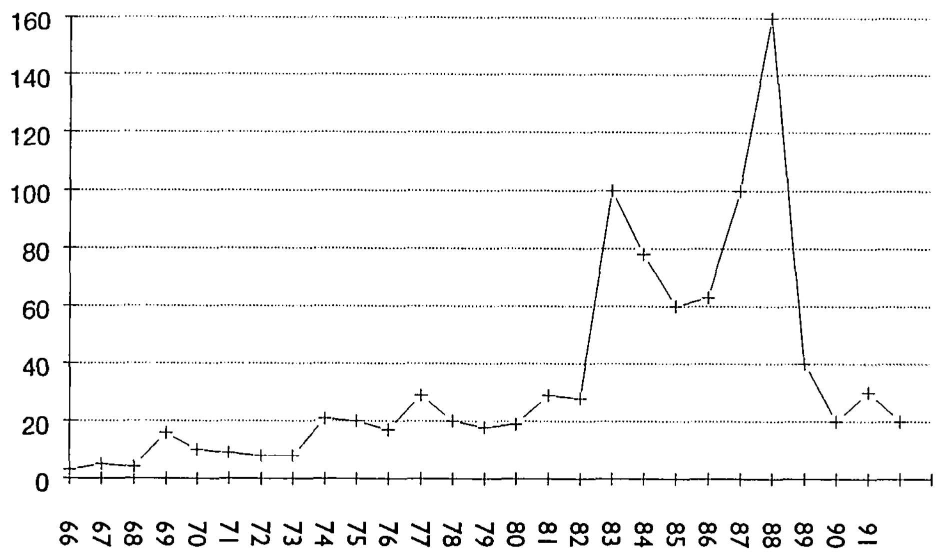
Source: Department of Economic Research, Banamex. Based on data from the Banco de Mexico (Gomez, Feb. 1992, p. 65).

For thirty years, the import-substitution policies achieved their original goal of creating from scratch an industrial economy through the private sector. By the 1960's, Mexico had relatively strong banking, industrial and trading sectors with capable management and well-trained labor. However, protectionism introduced distortions in the economy. The initial purpose of fostering competition was forgotten and protectionism became a way of life (Purcell, 1988, p. 34). When the economy started to show signs of strain, devices to secure protection of domestic firms, as well as power for bureaucrats, proliferated. The government created departments called subsecretarias to regulate competition and promote market-sharing agreements. These policies eliminated incentives to increase productivity, to re-invest profits and to become more efficient. Common practices like import permits, subsidies and even the purchase of failing firms were institutionalized. The net result was that the private sector became fully dependent on bureaucratic goodwill (Purcell, 1988, pp. 34-35). Mexico experienced double-digit inflation (Graph 2) from the mid 1970's to 1991 which indicated significant macroeconomic imbalance during this period. During the 1980's inflation ranged from a low of 25 percent to a high of 160 percent. The government prediction of single digit inflation for 1992 is remarkable, considering it has not happened since the early 1970s.

Graph 2

Inflation in Mexico

(Percentage Growth)



Source: Department of Economic Research, Banamex. Based on data from the Banco de Mexico (Gomez, Feb. 1992, p. 77).

In 1983, the government, under international duress, began making structural changes in the economy and in 1991 these changes were reaffirmed under President Carlos Salinas de Gortari by renewal of the Pact on Economic Stabilization and Growth (Gomez, "The Economy in Graphs: 1992", p.76). During the past 9 years, the government has made structural changes in the economy by privatizing industries, reducing tariffs, streamlining bureaucracy, eliminating "red tape", and exercising fiscal discipline. By 1991, eight hundred and sixty-two state-owned companies (of the 1,155 in 1982) were privatized and the plan is to reduce the number even further to 195 by 1994 (Salinas, 1992, No, 172). During the Salinas administration, Mexico has regained world-wide confidence as a stable and growing country, worthy of investment.

Mexico's economic policy goals for 1992 are single-digit inflation, continuing the gradual recuperation of growth, improving the standard of living and spurring the process of modernization. A central element for achieving these objectives is fiscal discipline. Without this discipline, severe economic imbalances can occur. The financial deficit of 1991 was 1.3 percent of GDP, the lowest in the past twenty-five years. In 1992, the Mexicans expect to reach a milestone that has never been achieved: a financial surplus. They expect inflation to drop to 9.7 percent and GDP to be 4 percent (Gomez, Jan 1992). Considering the disastrous economic performance of the 1980's, this is absolutely remarkable.

CHAPTER 2

TRADE THEORY AND SOFTWARE DEVELOPMENT

Classical economists, like Adam Smith and David Ricardo, explained in the late 18th and early 19th centuries that the welfare of the world is improved through international trade. Entrepreneurs can selfishly pursue profits by buying low in one country and selling high in another country resulting in gains for both countries. Thus, the welfare of the world is improved (Grubel 1977, p.11). As this chapter reveals, not all economists, particularly in Latin America, agree that unrestricted international trade will improve the welfare of all countries.

The first three sections of this chapter will summarize some of the common "free" trade theories which explain trade flows in an unrestricted international market. This is followed by a section on Import-Substitution Industrialization that describes a government-directed theory for economic development that has dominated Latin American economies for the past few decades. The remaining sections will outline two common arguments that justify the need for governments, particularly in developing countries, to intervene in the market to influence trade patterns in order to contribute to overall economic development.

Absolute and Comparative Advantage

Classical economists before Ricardo believed that the existence of trade opportunities between countries depended on the concept of absolute advantage. A country has an absolute advantage when their labor productivity for a commodity is greater than another country's for the same commodity. Thus, a country will export commodities where they have an absolute advantage and import commodities where they do not (Grubel 1977, p.12). This one-factor model states that world output will expand if each country specializes in the goods where they have an absolute advantage.

The theory of absolute advantage was deficient in several areas causing its application in the real world to be very limited. One glaring deficiency was its inability to explain why bilateral trade is profitable even though one country has an absolute advantage in all commodities. In the real world, economists found that bilateral trade exists between countries even though one country has an absolute advantage in all products. Ricardo employing his celebrated England-Portugal, wine-cloth model, solved this glaring deficiency with the concept of comparative advantage.

The comparative advantage model, also known as the Ricardian Model, reveals that international trade is profitable for both countries even though one country has an absolute advantage in all products. The best way to illustrate this principle is through the following example:

Output of One Person per Year

Product	U.S.	U.K
Wheat	12 bushels	6 bushels
Cloth	4 yards	3 yards

In this example, the U.S. has an absolute advantage in the production of both commodities. Under these circumstances, international trade is profitable by taking two bushels of wheat from the U.S. to the U.K. and exchanging them for one yard of cloth. Return to the U.S. with one yard and obtain three bushels of wheat which yields a profit of one bushel. The profitability of trade is due to the fact that the U.S. is relatively more efficient in the production of wheat rather than cloth and vice versa for the U.K. Intuitively, this statement makes sense if one thinks of a business manager who is a better typist than his/her secretary. Even though the business manager is a better typist, he/she will not type his/her own letters because he/she can make more profits if he/she spends his/her time managing (Grubel, 1977, pp. 14-15).

This idea of relative productivity explains why trade is still profitable even though one country has an absolute advantage in all commodities. Often, international trade is opposed by individuals who believe that their country cannot compete with the rest of the world in the production of any good. Free traders argue government intervention alters the true exchange rate of one commodity for another. This intervention disguises the true value of goods and it gives the appearance that a country cannot compete with any product (Grubel, 1977, p. 15). This market distortion can result from tariffs, quotas, license restriction, subsidies and similar interventions.

The absolute and comparative advantage models restrict the value of goods to one factor, labor. The classical economists did not explicitly include other factors of production, such as, the quantity and fertility of soil, climate, capital and level of human skills. The next two sections outline contemporary theories that do consider these additional factors of production.

Heckscher-Ohlin Model

This model, often called the modern theory of international trade, was developed in the 20th Century by the Swedish economists Eli Heckscher and Bertil Ohlin. The Ricardian model states that a country will export goods in which its labor productivity is relatively highest and import goods in which it is relatively lowest. The H-O model, on the other hand, after making a series of simplifying assumptions, states that trade is determined by the relative labor/capital endowments of countries and the relative factor input requirements of the products. Countries with a relative abundance of capital will export capital-intensive goods and countries with a relative abundance of labor will export labor-intensive goods (Grubel 1977, p.61).

In the mid 1950's, there were several studies of U.S. imports and exports that revealed that the simple H-O model did not hold. The simple model predicted that U.S. exports would be capital-intensive and its imports would be labor-intensive. In 1956, Irving Kravis found that the model did not accurately predict trade flows unless human capital was considered along with physical capital. In the same year, a more famous study was done by Leontief using a new mathematical tool of applied economics which he had pioneered. His research found that the U.S., in 1947, exported goods that contained relatively more labor than capital. This study became to be known as Leontief's paradox (Grubel, 1977, p.64).

Leontief explained his results by stating that the U.S. labor force was more effective than foreign labor. This notion gave rise to the idea that the U.S. had higher levels of human capital. Human capital is formed when a person spends time in activities like designing a machine, going to school, or doing research. This type of capital increases the value of output, like other forms of capital. Research and development leads to the improvement of machinery and technological processes used in manufacturing. It also leads to improved managerial techniques used in the organization of business, government and other sectors of society. Formal education, on-the-job training, and health care are the most common factors in the formation of human capital. These factors raise the quality of services and decisions made by labor, management, and bureaucrats (Grubel, p.65).

Further studies by Peter Kenen (1965), Donald Keesing (1966) and Raymond Vernon (1967) showed that U.S. export performance could be traced to those industries in which a high level of skills was required. They found that U.S. export performance, as measured by industries' ratios of exports to total U.S. production, was an increasing function of the proportion of the industries' labor force in highly skilled categories and the research and development expenditures expressed as a percentage of the industries' sales. In general, when human capital is considered, these findings support the H-O theory that countries export goods produced intensively with the factors of production they possess in relative abundance (Grubel 1977, p.66).

As presented in Chapter Three, software development is a very labor intensive activity requiring relatively high levels of human capital. Given this assumption, the H-O model predicts that countries with relatively high levels of human capital will dominate the software industry. Chapter Five certainly supports this position by revealing that the industrialized nations of the world dominate software development. Nevertheless, as other chapters demonstrate, there are tremendous opportunities and benefits for emerging software industries in less developed countries.

Product-Cycle Hypothesis

Raymond Vernon of the Harvard Graduate School of Business felt that mainstream theories of trade did not explain the impact that a product's life cycle had on international trade. In particular, they failed to explain the impact of technical change involving time on international trade. Vernon developed a dynamic theory to explain why a country without a comparative advantage in a fairly mature industry could all of a sudden achieve an advantage in that industry with a new innovation. For example, if the rest of the world has a comparative advantage in the manufacture of roller bearings, how can the U.S. gain an advantage in the production of a special heat and corrosion-resistant bearing? Since the input requirements for all roller bearings are very similar, why can't the rest of the world produce them as cheaply as the U.S.? Vernon answered this by saying that the U.S. producers possess a certain input in the production process that is not available to the rest of the world (Grubel, 1977, pp. 83-84).

Oftentimes, the foreign producer lacks the knowledge about how to produce, market, or service a particular good. The knowledge may be protected by government decree (i.e. patent or copyright) or the protection may be more natural, like possessing superior experience. This knowledge is not accessible to others except through an expensive period of experimentation and learning on their own. This natural protection is prevalent in industries whose technology is evolving and changing rapidly. In such industries, it has been widely observed that costs per unit of output fall with the passage of time and the quantity of output (Grubel, 1977, 84).

Over time this knowledge tends to depreciate so that imitation becomes possible without the need to incur high costs of learn-by-doing. As the product or technology matures and the knowledge becomes obsolete, production is shifted abroad; therefore, a country that exports in the early phases of a product's life can become an importer of that product in the latter phases. In the meantime, further innovations result in new exports and the cycle begins again. A good example of product cycles involves the manufacture of radio receivers since the end of World War II. The U.S. dominated the world market for radios with vacuum tubes until the Japanese were able to gain a large market share by exploiting their advantage in low labor costs. The advantage shifted back to the U.S. when it developed the transistor radio. Once again, after a few years, the Japanese with their low-cost labor advantage were able to capture the market. The next cycle of temporary U.S. advantage was based on printed circuits which replaced transistor radios (Grubel 1977, 85). As we see today, the Japanese have gained the ability to incur the risk of innovation; therefore, they are no longer switching every few years with the U.S. Instead, as products mature, they periodically lose their advantage in consumer electronics to Taiwan and Korea, until a new innovation comes along and shifts the advantage back to Japan.

Vernon's theory has two essential ingredients. First, it involves time and therefore, it is dynamic. Secondly, it introduces the idea that comparative advantage may to a large extent be based on a country's stock of knowledge (Grubel, 1933, p. 86). This supports the findings of the previous section on the H-O model with extensions that human capital does determine international trade flows. Certainly the computer software industry being very human-capital intensive, has developed consistent with these models. However, we have not seen the comparative advantage shift to developing countries as products mature. The product life cycle for computer software is so short that developing countries cannot gain the knowledge required to gain an advantage before a new innovation comes along. There is some shifting of software maintenance to developing countries for mature products that are no longer being updated. This is happening in India and it is starting to happen in Mexico.

Arguments for Intervention

Protectionism first appeared in the 1700's during The Industrial Revolution in England when large numbers of people migrated to the cities to work in factories. The natural reaction to these massive changes was a demand from society for government to bring order to the chaos by regulating industry (Grubel 1977, p.11). Beginning in the 1950's, Latin American policy makers believed that intervention was necessary in order to improve the economic condition of Latin America. They believed that without intervention, they would not be able to break the cycle of poverty that was created by, and being maintained through, international trade with developed countries. The section on import substitution industrialization (ISI) explains this cycle further and the policies for intervention.

Today, with the decline of ISI, a more relevant topic for this thesis is whether government intervention is necessary and effective at fostering internal technological capability (ITC) for software development. We will describe what is meant by internal technological capability and then discuss the benefits for fostering ITC through government intervention. The justification for intervention will be the infant industry argument expanded to include the social benefits of ITC.

Import-Substitution Industrialization

One of the most important influences during the last thirty years on Latin American economic thought is the structuralist school of development. Raul Presbisch in 1947 led a group of Latin American social scientists in formulating ideas for improving the well-being of Latin Americans. They believed the prevailing orthodox and neoclassical theories were absolute failures for developing countries (Kay 1990, p.25). One of their fundamental premises is that development and underdevelopment is a single process because the center and periphery are closely interrelated, forming part of one world economy (Kay 1990, p.26). The center is the industrialized nations and the periphery is underdeveloped countries, like Latin America. They believed that the disparities between the developed center and the underdeveloped periphery are maintained through international trade.

Neoclassical theory stated that through international trade the terms of trade between countries would equalize and thus distribute the wealth to the periphery; however, Prebisch and his followers found that the terms of trade actually deteriorate and thus the economic well-being also deteriorates. Therefore, the problems of the periphery are located within the context of the world economy (Kay 1990, pp.27-31). At about the same time, Hans Singer elaborated a similar idea about the unequal sharing of the benefits of trade (Singer, 1950, pp. 473-485). Early on, a lively debate developed around whether or not there had been a decline in the terms of trade of developing countries. This discussion of terms of trade dealt primarily with the trade of raw commodities.

The debate continues today, but the issue is not particularly relevant to this thesis because software is anything but a raw commodity.

The structuralists believed that the current economic conditions based on the production and export of primary products (i.e. agricultural) was created by the dominant capitalists during the colonial times. They termed the pattern of development for the periphery as the "primary-export model" or the "outward development" model. The export of agricultural products made the periphery intertwined and dependent on the center countries. In order to break this cycle of outward dependence, a model of import-substitution was advocated with the state taking a key role in transforming the economy from its heavy dependence on the export of primary products to a more diversified and balanced economy. Import-substitution was an inward-directed model that substituted internally developed products for imports from industrialized countries. The import-substitution policies were implemented through easy credit, infrastructural support, favorable foreign exchange rates and tariffs on all imported products that were to be replaced. The structuralists advocated protectionism when the productivity of the periphery's industry falls below that of the center countries, and so long as this productivity differential is not compensated for by wage differentials (Kay, 1990 pp.36-37).

Another related body of literature is on the dependency theory which is intentionally not reviewed here because (1) dependency, as a theory of political economy, has lost its momentum, (2) the dependistas' recommendations on trade and investment rest on the policy of full or partial delinkage of the periphery from the center, the consequences of which are not fully explained, and (3) the dependency theory has very little current influence over the political or economic policies of Mexico. Those interested in the corpus of dependency literature should read the relevant chapters in Latin American Theories of Development and Underdevelopment by Cristobal Kay published in 1990 by Routledge in New York.

As described in Chapter One, the Mexican government significantly relaxed its import-substitution policies in favor of more market-oriented theories when the economy hit bottom in 1982. During the past year, the government has privatized banks, the national telephone company (Telefonos de Mexico) and a large number of other entities. There are even discussions about privatizing the grossly inefficient social security administration that pays its staff a three-month Christmas bonus, a two-month vacation and only requires a seven hour shift. The average company in Juarez gives a two-week Christmas bonus, one week of vacation and requires an eight to nine hour shift. Today, under President Carlos Salinas de Gortari, Mexico has emerged from an import-substitution dominated economy to join the market-oriented nations of the world.

Internal Technological Capability

Technology is a broad term used to describe everything that relates to the transformation of inputs into outputs. Knowledge is a fundamental requirement for technological capabilities and it is embodied in people, in institutional procedures, in physical capital, books, films, and in other forms. Internal technological capability (ITC) is the competence to locate, select and negotiate for technology (James 1988, p. 6). Dilmus James writes that ITC includes "the capacity for operating, adapting and modifying the technology, as well as the capabilities for using the technical information as a foundation for developing new designs, novel products and original contributions to the stock of knowledge" (James 1988, p.6). Without ITC, a country is doomed when it comes to information technology because it is not productive to merely transfer information technology from developed to developing nations.

ITC is critical to the successful selection and implementation of information technology because of the myriad of options for employing it and the necessity of adapting it to local conditions. Very sophisticated users in developed nations have a difficult time selecting the right technology for their needs due to the complexity and wide variety of options, while users in developing nations have an even greater problem due to their geographical, cultural and educational distances from the technology suppliers.

After the technology is selected, it must be adapted to local conditions to accommodate language differences, educational differences, and legal and procedural differences. One example is Mexican payroll programs. Mexican software engineers dominate this market niche because the average American payroll program is totally inadequate. Even when American engineers develop payroll programs for the Mexican market, they are not able to respond to government changes as fast as a Mexican supplier because of their inability to access information in a timely manner. Programming Services International (PSI) is the largest U.S. supplier of Mexican payroll programs and they have a difficult time dealing with the complexity and rapidity of changes in Mexican law. Even though they are based in El Paso, they are not close enough to Mexico to accommodate these changes quickly without the assistance of Mexican nationals. Oftentimes, a law must be implemented within days of final interpretation.

Infant Industry Argument

One of the most common justifications for government intervention in the market is the infant industry argument (IIA). According to the argument, countries should intervene to assist an industry that has the potential for gaining a comparative advantage. The modern concept of comparative advantage for the IIA is to protect an industry so that it can mature technologically (Bell 1985, pp. 101-128). The modern concept of the IIA rests on the accumulation of technological prowess at the enterprise or industry level. It is an intra-industry concept of comparative advantage when a country can be an importer and exporter of products within the same industry. By maturing technologically, the industry is able to compete, and as importantly, the industry has the opportunity to create beneficial externalities, such as ITC.

The IIA theorists believe that their position is supported by historical evidence because the world's three largest market economies, the United States, Germany and Japan, all developed with the assistance of their governments (Krugman 1988 p. 230). Government intervention can come in the form of protectionist policies or in terms of special assistance to a targeted industry. The current mood within Mexico is to pursue the latter. It is important to distinguish IIA policies from ISI. IIA intervention is aimed at a narrowly defined segment of an industry, whereas ISI is a broad-umbrella policy that encompasses entire industries.

Regarding the formation of ITC, government intervention can yield benefits in the form of social returns, which market-oriented polices do not always provide in developing countries. One example is indigenous research and development to adapt foreign technology to developing country conditions. This project can yield beneficial externalities in the following areas:

Reduce "Brain Drain": Through higher salaries and access to technology, local scientists do not have to seek opportunities in developed countries.

Teach Skills: Local workers are taught valuable skills that would otherwise not be available.

Solve Local Problems: The technology is tailored to local needs and it gives scientists the confidence to solve their own problems.

Improves Selection of Technology: It provides the questions and answers to scientists when selecting technology. This also reduces the monopoly power of the sellers of technology because local experts can shop around in the international market.

Improves Technology Transfer: Local workers actively participate in the transfer process which instills an understanding and ownership commitment.

Builds National Independence: They are no longer so heavily dependent on foreign experts for solving their local problems. (Villarreal 1990, pp.41-44)

Proponents of the infant industry argument further justify their position by pointing to some market failure within the developing country that needs to be fixed. Two of the most common market failures deal with imperfect capital markets and the problem of appropriability. The imperfect capital market means that there is no efficient mechanism to allow savings from profitable sectors to finance new emerging sectors. Most agree that it is better to create a better capital market than it is to protect or intervene significantly in the emerging industry, but this is easier said than done in most developing countries (Krugman 1988, p.232). As later chapters will reveal, large scale software development can require significant investment that may not be readily available in Mexico. Banks do have funds, particularly for industries with an export potential; however, based on quotations from Banca Servin in Juarez, the interest rate is significantly above international rates. Private investor groups also have funds for more traditional industries; however, due to the infancy of the software industry in Mexico, it is unlikely that funds are readily available for software companies.

The appropriability argument for infant industry protection deals with the idea that firms in a new industry generate social benefits for which they are not compensated. Firms that pioneer the market may incur start-up costs that other firms can use without the same initial costs (Krugman 1988, p. 232). Under these conditions, entrepreneurs are not willing to enter the market. This issue is relevant to the software industry because of the need for software entrepreneurs to have intellectual property rights protection. In August 1990, the Mexican Congress passed a new bill completely revamping copyright and other intellectual property rights. In particular, computer programs are protected against unauthorized reproduction for a term of fifty years. The Salinas administration believes that this law is essential to the modernization of industry and commerce in Mexico (Maquila 1991, p.32). As discussed later, Juarez programmers are not convinced that the government will aggressively enforce this new law.

The main points covered in this chapter are that human capital plays an important role in determining trade flows and that government intervention may be beneficial in fostering ITC. This intervention does not have to be protectionist; rather it could be in the form of R&D subsidies, educational benefits and other measures that do not restrict trade. As the next chapter will demonstrate, high levels of human skills are essential to building a significant software industry. In later chapters, recommendations for fostering the formation of ITC in computer software will be provided.

CHAPTER 3

TYPES AND REQUIREMENTS OF SOFTWARE DEVELOPMENT

This chapter will acquaint the reader with the concepts associated with software development and describe the level of human-capital skills required. Throughout the chapter, the difficulty of activities are highlighted to give the reader an understanding of which are more suitable to a developing country like Mexico. In general, the more difficult activities are not common in Juarez.

Types of Software

Computer software is the procedural logic that controls all processes within the computer to define how the computer calculates, manipulates, sorts, displays and stores information. Software can be categorized as applications software or systems software. Application software is normally what the user sees on the computer screen while the systems software operates in the background to serve as an intermediary between application software and computer hardware. Common applications are spreadsheets, word processors, data base managers, accounting programs and other type of programs that solve user problems. Systems software, in simple terms, solves the programmer's problems while he writes application software.

Systems software operates underneath applications software to carry out the application software's instruction. It helps the computer manage its memory, interact with peripheral devices (i.e. printers, screens etc...) and execute application programs. For example, when a word processor's print command is selected, a message is sent to systems software to carry out the instruction. The most common types of systems software are called operating systems and they include brand names like MS-DOS, UNIX, MVS, MS-Windows, Macintosh, VM, VMS and others. MS-DOS and UNIX are considered to be open operating systems that have developed into the most commonly used (i.e. de facto standard) products today. In terms of users, they outdistance the proprietary systems like MVS, VMS, VM and others (Flamm 1989, p.20). The benefits of using UNIX and MS-DOS are significant cost savings, productivity gains and long-term flexibility; therefore, developing countries should seriously consider these products when deciding how their scarce resources will be spent.

Standard operating systems reduce cost because they support a large number of computer components from a wide variety of vendors. The results are economies-of-scale pricing and more competitive pressure among the vendors. For example, when a buyer adds a new disk drive, he/she can choose from a large number of sources, whereas with proprietary systems, the options are significantly limited. The flexibility and productivity gains stem from being able to move application programs easily to the latest innovation in hardware. Most major computer manufacturers support these two standard products. On the other hand, proprietary operating systems restrict the developer's options and generally force him to rely on one vendor, like IBM or DEC.

Developing systems software is more tedious and difficult to write than applications software. It is often written in lower level languages to increase the speed of processing. It is extremely comprehensive and includes all of the possible features that a wide variety of computer languages and applications may need. According to Ed Ganter, Senior Director for Candle Corporation, systems programmers tend to be a little arrogant, are hard to find, and are able to command a higher wage than application developers. Candle Corporation is a major supplier of systems software for IBM mainframe computers. As the later Chapters will reveal, even though there is very little systems software development occurring in developing countries, it does take place in Juarez.

Another way to classify software is pre-packaged or custom. Pre-packaged software requires the designers to assess the needs of an entire market, whereas custom software is designed for a specific customer. It is more difficult to develop a product suitable for an entire market than it is to develop a custom program for one customer. Most of the software development in Juarez is considered to be custom software.

Computer Languages and Programming

The basic concepts of modern programming were created by Konrad Zuse, a German soldier who escaped the Soviet Army at the end of World War II, in order to refine his ideas in the West. His concepts are used by contemporary programmers who convey ideas called algorithms to computers in a notation called a programming language. An algorithm is a detailed list of steps for solving problems and the steps are expressed in a programming language (Anderson 1988, p.407). Programming languages are usually categorized by their level within a hierarchy. Because low-level languages are more cryptic and difficult to use, they require more training than higher-level languages. Lower-level languages often establish rules for programs written in higher-level languages; therefore, the more that developers in Juarez understand the lower-level languages, the more likely they will be able to maximize the power of the computer.

Machine language programs are the lowest form of encoded algorithms, and the only programs that the computer can understand without modification. A machine language program is a series of binary numbers (zeros and ones) that defines an instruction in extremely intricate detail. Programs written in other languages must be translated into machine language before they can be used by the computer. This is one of the reasons that lower-level languages establish the rules for higher-level languages. A lower-level language, like an assembly language, translates instructions one for one into machine instructions, whereas one instruction in a higher level language could translate into hundreds or thousands of machine instructions. The following is a sample of how detailed low-level instructions need to be for sending someone to the store to buy milk:

1. Lean forward in your chair.
2. Push up with your hands and legs.
3. Raise up into a standing position.
4. Move your left foot forward.
5. Move your right foot forward.

......

100. Grasp the doorknob with your right hand.

Conversely, instructions in a higher level language would be much more compact as follows:

1. Stand up and walk to the door.
2. Get into your car and drive to the store.
3. Go into the store and get a quart of milk.
4. Pay for the milk and leave the store.

......

12. Get out of your car and come into the house.
13. Give me the milk.

As the above example illustrates, higher-level languages express the same meaning with fewer instructions (Anderson 1988, p.408). This example clearly shows that lower-level languages require more concentration and effort to use. Most of the languages used today are higher level languages, and they vary by the degree of their compactness. Fourth generation language is a term used to identify the highest type of languages, whereas assembly languages are the lowest type of languages. As the following chapters reveal, programming students in Juarez are exposed to lower-level languages in school; however, there is no serious assembly language development occurring in Juarez. Most of the programs in Juarez are written in a fourth generation language, like dBase and Clipper.

Phases for Software Development

A competent computer scientist will follow a rigorous methodology in developing computer software. The methodology requires a series of steps in a predetermined order to ensure that the final product meets the needs of the user. One of the easiest ways to separate a novice from a professional is to examine their methodology. A professional will not write computer code until a comprehensive investigation, analysis, and design is completed.

The steps in a typical methodology to create computer programs are as follows:

1. Investigation: Identify needs and determine feasibility.
2. Analysis: Study current and new systems.
3. Design: Propose alternatives and design of new systems.
4. Development: Program and test new systems.
5. Installation: Replace old system with new.
6. Maintenance: Evaluate, repair and enhance the systems (Anderson 1988, p.380)

The investigation phase, which is the starting point of a successful project, entails a clear definition of the needs of the computer user which generally is very difficult to determine. The user often does not think in the level of detail that is required for the creation of a computer program, and the developer is not familiar enough with the user's needs. The analysis and design phases also require years to learn because a good computer program should not only duplicate, but also improve the manual methods of operation. The remaining three phases are often accomplished by less experienced computer personnel. The computer software industry uses a wide range of titles to denote experience and skill levels, the most common being analyst, engineer and programmer. The analyst and engineer are capable of performing all six phases while the programmer, who is less experienced, normally handles the last three.

Human Skills and Software Development

The most important determinant of software productivity is the skill of the software developer. Research has shown that a person's ability can vary software productivity by a factor of 20 to 1. In tests to find errors in computer programs, it was found that a person's education, experience and skill affected their ability to find the bug by a factor of 8 to 1 for one program to 22 to 1 for another program (Curtis 1985, pp.1-2).

Beth Adelson, in her work entitled When Novices Surpass Experts, found that experts perform better than novices in both qualitative and quantitative ways. In explaining programming material, experts were capable of using abstract representations, defined as what a program does, whereas novices tended toward more surface and concrete representations, defined as how a program functions, (Curtis 1985, p. 55). This is consistent with the previous discussion that analysts and engineers define what a program needs to do (Phases One, Two & Three) and the less experienced programmers are more involved in how it is done (Phases Four, Five and Six). An in-depth discussion of the cognitive abilities of computer personnel is beyond the scope of this work; however, it is important to note that a person's ability to perceive, organize, process and remember information is as important in software development as it is in solving any problem.

Formal education and training are the foundation for improvements in developing and using information technology; therefore, a degree from a university is in most cases a prerequisite. On-the-job training normally is a supplement, but not a replacement, for a formal course of study that universities offer. Robert Schware listed nine areas that a formal educational process should address. These include:

Communication Skills
Software Development and evaluation processes
Problem analysis and specification
System design
Data engineering
Software generation
System quality
Project management
Software engineering experience in industry
(Schware 1989 p.63)

Experience has shown that countries seeking to start up software development for domestic consumption should use professional generalists rather than software specialists. A generalist is someone who combines software engineering expertise with experience in communications, education, mathematics, construction, manufacturing, utilities, finance and other areas. A person should have good communication skills and project management experience to enable him/her to manage a group of programmers. Most successful software companies have personnel with diversified experiences and very few specialized engineers (Schware 1989 p.60). However, as discussed later, software specialists are needed in order for a country to develop an aggressive export strategy.

There is some speculation that automated tools and methodologies will enable developing countries to compete in the international software industry with less skilled personnel. In Edward Yourdon's book, Decline & Fall of the American Programmer, he outlined areas that world class software organizations must have in order to compete in the 21st Century. He described tools and methodologies for reducing the development cycle time while increasing software quality. Clearly, these ideas offer promise for improving the productivity of software personnel through the use of object-oriented methods (re-usable code), CASE (computer-aided software engineering) tools and structured methods. As these tools and methodologies emerge, it will be interesting to see if they can overcome the educational gap in developing countries. Presently, there is healthy debate as to whether these tools improve productivity. According to a recent survey, fewer than 35 percent of the CASE users believed that it improved their productivity (Brandt, 1991, p.104). These tools do augment the development process by forcing discipline and structure on a novice programmer; however, they still require a high level of technical competence to use.

In summary, this chapter has touched on several important points for developing countries to consider. First, it is advisable to focus on application software for users instead of systems software. Secondly, higher level languages like fourth generation languages and standard operating systems like MS-DOS and UNIX offer the maximum potential for countries with limited resources.

Thirdly, programming tools and methodologies can enhance software development, but they cannot replace the need for significant investments in human capital. With this in mind, the next chapter will outline some of the benefits of fostering a software industry for third world countries.

CHAPTER 4

SOFTWARE DEVELOPMENT - OPPORTUNITIES AND CONSTRAINTS FOR DEVELOPING COUNTRIES

Microcomputers and Economic Development

"Microcomputers in development already have faded away as a topic which excites donor interest; now they are treated much as any other piece of office equipment. In some sense, this is probably as it should have been all along. On the other hand, the microcomputer is not just another generation of office equipment. It is fundamentally different and will reshape societies at least as much as the automobile shaped America" (Mann 1987 p.161). The microcomputer has had a profound impact on the developing countries that was not felt to the same degree in the industrialized nations. When the microcomputer was introduced, the industrialized nations were already enjoying the benefits of computing with large mainframe computers, whereas microcomputers were the developing nations' first introduction to the power of computers. The low cost and ease of programming this technology has made it appropriate to the developing country's conditions (Mann 1987, p.159).

The average rates of decline in real, quality-adjusted computer prices have exceeded 20 percent per year over the last three decades. This technological and economic progress seems to have caused continuous decline in cost for economically significant goods almost of a magnitude greater than anything seen during the first great industrial revolution. This tremendous rate of progress has had an enormous economic impact. Industrial users in the U.S., in just one year, received a benefit equivalent to 0.3 to 0.8 percent of GNP which is a significant percentage, considering that GNP has only grown at the rate of 2 to 3 percent per year (Flamm 1989, p.2). The economic impacts of this technology cannot be ignored by any country without running the risk of falling further behind in the world-wide economy.

There are countless examples of how computers have improved institutional performance, national planning, individual career enhancement and other worthwhile activities in technical assistance projects in developing countries. In Tunisia, agricultural planners were able to project statistically their supply and demand for cereal products to the year 2000 (Mann 1987, p.11). In Kenya, microcomputers were instrumental in improving budgeting and financial management of various government ministries and researchers believe that this case proves that microcomputers can assist any country with management problems (Pinckney 1987 p.88).

For further information involving computer use in developing countries, one can read the following sources, all of which are included in the bibliography :

Education: (1) See various contributions from the Board on Science and Technology for International Development (BOSTID) 1982. (i.e. Microcomputer Applications in Education and Training for Developing Countries.) (2) Anandakrishnan, et al. on education in India and Kenya.

Health services: (1) On health in Egypt see Galal (1988), (2) in Chad, Colombia, Malaysia and Saudi Arabia, see Bertrand, et al. (1988) and (3) general treatment on developing countries, see R. G. Wilson. (1988) and Chapter 3 in BOSTID (1986).

Agriculture: (1) See Tottle and Bakar (1988) on Malaysia and (2) Chapter 9 in BOSTID (1986) for developing countries in general.

These are all microcomputer applications for what are considered to be traditional sectors for developing countries.

There are also a profusion of uses in modern economic activities. Using a few examples from Mexico to illustrate the point, Anne Lower (1988) describes the computer-driven iron ore pipeline, the largest of its kind in the world, that controls the volume and mix of iron ore brought from the La Perla and Hercules mines in Chihuahua to a large steel plant in Monclova, Coahuila. There are also numerous examples of automation in assembly plants, known locally as maquiladoras, (Palomares and Mertens; Dominguez-Villalobos, 1988; and Shaiken, 1990) and within the banking, insurance and financial services sectors (Mertens, 1992).

In banking, microcomputer applications allowed Banamex to expand the number of transactions per employee from 3,453 in 1984 to 14,189 in 1988, a 32.7 percent annual rate of increase. The rate of growth in transactions per employee over the same period was 11.3 percent for Bancomer and 23.0 percent for Comermex. In the insurance industry, the number of policies issued each year and total insurance premiums (in real terms) per year is rising faster than real

GNP; this is at least in part, one would conjecture, because of microcomputer applications (Mertens, 1992, p.28).

On the other hand, some believe the distributional effects of income from this technology are not always positive. For developing countries, it could lead to social hardship in the short-term, unless the technology is intentionally applied to job-creating uses. Without this specific goal in mind, its introduction would not alleviate the massive problem of unemployment and poverty facing many of these nations. The majority of studies of information technology have concentrated on productivity and comparative advantage at the sectorial level without studying the interrelations with other sectors in the society (Cole 1986, p.1291). The main point is that the society at large should be considered when planning the introduction of technology of this nature to a developing country.

Many researchers believe that the true potential of the microcomputer for developing countries has not been reached (Mann 1987, 161). In order to maximize this potential, developing countries must have the software development skills to exert control over the use of microcomputers and be able to induce change. Without such skills, developing countries are not able to extend the benefits of the microcomputer revolution to every sector of its economy. In the case of Kenya, it originated change by actively designing and creating its own data base. Researchers are convinced that this was integral to its overall success

(Mann, 1987, p.14). As the next chapter reveals, Taiwan, Korea and India have acquired the skills to adapt the technology for their particular needs. As Chapter Eight indicates, Juarez developers, on a limited basis, have demonstrated the ability to invoke change.

Software Skills and Cognitive Performance

The importance of software development to virtually any area of industrial productivity makes a strong argument for the psychological study of programming as an end in itself. The side benefits of studying the process of becoming a competent computer scientist include a wealth of information on human problem solving, cognitive performance and organizational behavior. The difference between experts and novices in virtually any field is their ability to process large amounts of meaningful information. For example, this difference can be seen in chess, bridge, go, music and physics. Experts have not only more information but they also have it organized into more meaningful chunks. Instead of dealing with pieces of information, they are able to process meaningful groups of information, which is significantly more efficient and effective (Curtis 1985, p.40).

Based on a century of research, psychologist Jerome Bruner states that the most basic lesson about the human memory is that unless details are placed into a structured framework, they are forgotten. The computer facilitates the structuring of information into a logical framework along with providing a mechanism for integrating new information with old. This supports the idea that computers have the potential to re-shape an entire society, much like the automobile re-shaped America (Mann 1987, P15).

As Charles Mann concluded in the book, Microcomputers in Public Policy - Applications for Developing Countries, the most exciting aspect of microcomputers is the quantum leap this technology promises in providing decision makers more timely and more complete information upon which to base decisions. Effective decision making is absolutely critical to economic development. Decision makers are able to organize large amounts of information into a meaningful framework that was previously not possible with pencil and paper. This frees the decision maker to think at a higher level of complexity. The end result of better decision-making methods is the formation of human capital - a prerequisite for significant development (Mann 1987, pp.7 & 11).

New International Division of Labor - Fact or Fiction

Some believe that software development offers considerable income opportunities for developing nations. They argue that software development requires what the industrialized nations lack and what the developing countries have in abundant supply - labor. Others argue that software development demands a tremendous technological capacity to keep pace with rapid changes, a capacity that developing countries do not have (Watanabe 1989, p.1). There is agreement, however, that the proportion of labor in the total cost of software is high and that tools are emerging for simplifying the craft of creating software. In 1985, labor cost averaged $12 billion of the total software sales of $30 billion world-wide, and if this same percentage holds in 1990, over $42 billion of the total $110 billion in software industry sales is labor (Watanabe 1989, p.3).

The U.S. Labor Department expects the demand for software professionals to double by the year 2000; however, interest in software development careers appears to be falling. The demand for programmers and software engineers in the U.S. grew from 300,000 in 1977 to over 1.2 million in 1990. The rate of growth during this period was constant and positive. However, the number of U.S. students receiving bachelor degrees in computer science peaked at 40,000 in 1986 and has fallen steadily to about 28,000 in 1990 (Brandt 1991 p.105). Similarly, by 1995, MITI estimates that Japan will have 1 million fewer programmers than needed to satisfy demand (Brandt 1991 p.101). Even with these shortages, there is not a significant amount of software being exported from third-world countries to developed nations. As the next chapter indicates most software activities in developing countries are being absorbed by the home country.

A new international division of labor in the software industry has not happened yet. As outlined in the next chapter, the main reasons are significant domestic demand in developing countries, lack of knowledge of foreign markets, and high marketing cost to reach international markets. By teaming with foreign experts, developing countries are able to contribute to the development and maintenance phases (Phases 4 and 6, as described earlier) of software projects that have a world-wide distribution. In fact, as discussed in Chapter 8, one of the largest groups of software engineers in Juarez is teamed with foreign experts to produce world class software.

CHAPTER 5

WORLD-WIDE SOFTWARE INDUSTRY

General Overview

In 1990, the worldwide software industry reached $110 billion and it is predicted to grow to $340 billion by 1996. The main areas encompassing this industry are custom software development, packaged software, systems integration, and related consulting services. U.S. companies control nearly 60 percent of the world's market employing 1.2 million programmers and software engineers plus an additional 200,000 people in related jobs (Brandt, 1991, p.98). This industry was once the exclusive domain of the U.S. and its distant competitors, France and Japan; however, in terms of revenue and the number of new software firms, this industry is spreading worldwide. America's industrialized competitors are investing billions to improve their software capabilities to take advantage of a software industry growing at 20 to 30 percent a year. Another major reason they are investing billions of dollars is because high quality software is the key to automated factories, airlines, banks and virtually every other sector of society.

The worldwide industry can be described with phrases like continuous innovation, improvement and rapid change. There are five major trends occurring in this industry:

(a) severe personnel constraint

(b) global battle for operating system standards

(c) multi-vendor solutions replacing single vendor solutions

(d) hardware vendors emphasizing software development

(e) an expansion and fragmentation of the industry resulting in a growing number of independent software vendors (Schware 1989, p.1).

In Europe, five countries have joined forces through fourteen companies and institutes to create a project called Eureka Software Factory. They employ 250 programmers and plan to spend $400 million over ten years to overcome the same challenges faced by U.S. and Japanese companies: huge backlogs of unwritten software, long development times for new programs and a shortage of programming talent. Similar to the Japanese, the Europeans are trying to apply a factory concept to software automation. The Japanese are using a more rigid set of procedures to produce bug-free software while the Europeans are trying to create an environment that promotes more creativity. The primary goal of the

Eureka project is to produce a computer environment where different software-writing tools can be used without worrying whether such tools are incompatible with each other. This will enable a large number of programmers to work on the same project. Another major goal is to maximize the reuse of code to enable different programs to use a common set of code. The bottom line goal is to reduce the average time of 33 months to design, write and install a major new business program (Brandt, 1991, p.104).

The are other estimates of application development backlogs of sixteen months for mainframe users, twelve months for mid-range users and six months for personal computer users (Schware 1989, p.11). Software suppliers are attempting to solve this backlog with a movement toward packaged software instead of customized software. In 1991, packaged software sales from U.S. based vendors was $47 billion or 57 percent of the total software services provided by U.S. vendors (Watanabe 1989, p.5). Packaged software development is a risky business because it requires substantial investments in research and development and marketing for uncertain returns. Packaged software has been criticized for lacking flexibility and thus limiting a customer's growth (Schware 1989, p.13). As Chapter 8 indicates there is very little packaged software development occurring in Juarez.

Systems integration is another segment of the software industry that has experienced tremendous growth, and promises significant future opportunities. This market segment was $1 billion in 1986 and it is expected to top $16 billion in 1992 (Schware 1989, p.14). Systems integration is one of the most technologically difficult areas of the software industry. It requires a significant amount of skills in the following areas:

(a) system design of hardware, system software, application software, communications networking and the ability to tie it all together
(b) product evaluation and selection
(c) vendor coordination when there is a mixing and matching of products
(d) custom tailoring hardware and software to the customers' unique requirements
(e) system installation, training and maintenance

Only the very large companies have proven to have the skills to be integrators, although there are opportunities for smaller companies by specializing in a particular industry (Schware 1989, p.15). EDS, the world's second largest integrator, has an office in Juarez to primarily support their parent, General Motors. Chapter 8 includes a description of the services that EDS provides to Juarez users.

The computer industry invests more in research and development than any other industry, except for aerospace and missiles. The computer industry spends 12 percent of sales on research and development and it employs 69 researchers per 1,000 employees (Flamm 1989, p.4). Governments play an important role in funding the basic research for the computer industry. Since basic research is the most difficult to convert to a commercially viable product, the computer companies' contribution to basic research is less than 2 percent. In the U.S. in the early 1980s, the government paid for 66 to 75 percent of the basic research, 40 percent of all research and about 20 percent of research and development (Flamm 1989, p.10).

Perhaps the main lesson of this section for developing countries is that the software industry is extremely dynamic and it requires significant investment in research and development. Since developing countries lack the resources to compete in many areas, they should search for niches that they can exploit better than industrialized countries. The most obvious area is application development for their own market, which will be discussed in greater detail later.

The next sections will highlight the key strategies and accomplishments for some of the more successful non-industrialized countries. These experiences will give the reader a frame of reference for evaluating developing countries. Special emphasis will be given to India because of the significant effort that the Indian government has committed to that industry.

India

Rajendra Pawar, managing director of India's National Institute of Information Technology stated: "India is like a snake. The head is moving into the twenty-first century, but the tail is still in the seventeenth century. Our problem is keeping the head moving forward while not forgetting about the body and the tail". In 1984, Rajiv Gandhi was committed to leading the head, body and tail of India into the twenty-first century and one of his core industries was information technology (Yourdon 1992, pp.282 & 279).

As stated in their policy document of November 1986, India's strategy was to capture a sizeable proportion of the global software market. Its push for exports appears to be far greater than any other non-industrialized country. In 1990, it exported $70 million in software services from a total of $22 million in 1984. Even though this surpasses other non-industrialized nations, it was well below the government goal for 1990 of $250 million ("The New International", 1991, p.13). Most of the exports were "manpower contracts" in which Indian programmers worked in the foreign country at the customer site (Schware 1989, p.35).

In 1988, there were 40,000 software professionals and 350 institutions of higher learning offering degrees in computer science. This year, 10,000 degrees were awarded as compared to 1,000 degrees from 30 institutions in 1983. During this period, there were about 500 organizations involved in the software industry of which most were software houses (Watanabe 1989, p.7). In 1987, India's total software industry revenues were $160 million and were growing at a 50 percent annual growth rate. The industry consisted of a large number of small thinly capitalized organizations. The top three vendors had sales over $10 million while the remaining companies had sales under $1 million. In 1987, about 75 percent of the companies had sales under $100,000.

There are several U.S. companies, like Texas Instruments, Citicorp and Unisys, that have established Indian subsidiaries to develop software (Schware 1989, p.37). Even though the charter of these subsidiaries allows for services to be provided to companies other than the parent, they have not been successful. They have found it much easier to work in a more formal relationship where they have a "captured" customer. The Unisys subsidiary has achieved marginal success in providing services to companies other than Unisys. Robert Markell, a former executive with Unisys, indicated that Unisys absorbed the majority of the qualified Indian programmers. He indicated the primary interest of an Indian programmer was to receive an assignment in the U.S., in order to qualify for permanent work status. Once this was achieved, the programmer moved to a better paying job within the American software industry. This confirms other researchers' findings that the top five percent of India's experts are lost to the West (The New International 1991, p.21). A more startling statistic estimates that 35 percent of India's programmers emigrated from 1983 to 1987 (Yourdon 1992, p.297). The primary reason for this "brain drain" is that Indian developers earn about $3,000 per year as compared to $12,000 per year in Hong Kong, Taiwan, Singapore and South Korea and $24,000 per year in the United States (The New International 1991, p.17).

So far, the Indian case reveals that there is very little indigenous software development for export. The export success has come from manpower contracts and by partnering with companies from industrialized nations. Indians rely on their foreign partner for product design and to be a conduit to the international market. Mr. Markell of Unysis believed that the Indian programmers did not know enough about the market needs in other countries, and therefore were unable to develop software products on their own. Other researchers also attribute India's lack of indigenous exports to India's lack of market trends in the West and the high cost of marketing, which can exceed 70 percent of the final software price (The New International 1991, p.23). In particular, Indian companies lack the specialization to create and market packaged software, which is half the world market. As mentioned earlier, developing countries are advised to train software generalists, not specialists, which may make it difficult to pursue the export and domestic market simultaneously.

Not only are the Indians having a difficult time in the export market, but also their internal computer utilization is generally poor, due to the scarcity of indigenous software designed for the national market (Watanabe, 1989, p.9). A widely acknowledged reason for India's software industry problems is rampant piracy. Independent surveys by Tata Unisys and Wipro Information Technology estimate that 80 percent of the computer installations use pirated software. This damages the domestic software industry by creating a mind-set that software is free (Yourdon, 1992, pp.287-288). Another problem with the domestic software industry is a wide spread antipathy toward computers by many clerical and administrative workers. They fear that management is introducing automation to reduce staff. The feeling is so strong that one state government recently announced it will not automate its administrative functions (Yourdon 1992, p.284). The last major problem that the domestic software industry faces is the government stranglehold on imports of foreign technology. Even though they have been reduced during Rajiv Gandhi's administration, protectionist policies still cause Indian computer prices to be 107 percent above international prices (Yourdon 1992, p.283).

Perhaps the most revealing statistic of the use of computers within India is the percentage of computer purchases (hardware and software) of gross national product between 1985 and the projected year 2000.

Year	% of GNP
1985	0.07
1987	0.13
1990	0.25
1995	0.65
2000	1.00

By contrast most developed countries spend between 3 to 5 percent of their GNP on computers (Yourdon 1992, p.288).

In summary, India has made some impressive export gains relative to other developing countries; however, the people of India have paid a tremendous price and they face major obstacles in the future. Their push for exports has contributed to the lack of software development for domestic uses, and to extremely high levels of "brain drain". Their restrictions on the importation of foreign technology, and their lack of software copyright laws, have stifled the domestic software industry. Their experience can help Mexican policy makers avoid the same mistakes.

Taiwan

Since 1980, the Taiwan government has considered the information services to be one of their strategic industries. It believes that it is strategic because it has ties to other industries, it offers tremendous market opportunities, and it is technology intensive. In 1987, there were 300 software firms employing 4,000 people with sales of $170 million. Its exports that year were $11 million of which the majority were to Southeast Asia. The industry is experiencing 48 percent annual growth which exceeds the U.S. in its heyday. In 1987, the majority of the firms were less than 5 years old and more than 50 percent of the employees had less than 3 years experience (Schware, 1989, pp.33-34).

The Taiwan government offered incentives for the creation of many local software companies and for the inflow of foreign firms. With tax incentives, Hewlett Packard, IBM and Wang established software development groups in the early 1980s. In 1986, Japanese and American firms accounted for 20 percent (or $76 million) of the total capital invested in this industry (Watanabe, 1989, pp.11-12). The China Management Systems Corporation is the largest software company in Taiwan with $12 million in sales and 300 professionals.

In 1986, Custom software development accounted for one third of total revenues, followed by consulting services (30 percent), turnkey system development (20 percent) and software packages (17 percent). There is a high demand for general purpose management and industry specific applications. Over 50 percent of the software companies are engaged in packaged software development and the more difficult area of system integration appears to be promising in the future. Government organizations and service industries are the largest buyers and they require integrated hardware and software solutions to meet their processing needs (Schware 1989, p.33).

In contrast to the Indian model, Taiwan is more focused on building a software industry that satisfies domestic automation needs. This can be seen from its level of software exports and its high percent of custom software development. It appears to have a good mix of development among custom software, packaged software and integration services. The government policy of providing incentives to foreign companies that invest, and the dynamic domestic market, appears to have reduced the number of technical experts seeking emigration. Overall, it appears that Taiwan has a well balanced software industry that supplies other sectors of the economy with effective information technology.

South Korea

Like Taiwan and India, the government of the Republic of Korea established national goals for software development. In 1988, there were 463 companies employing 6,100 programmers, 3,100 analysts, 2,000 operators and 900 technicians. In 1987, the annual sales of software were $107 million and $40 million of related services. Exports were estimated at $7.1 million (Watanabe 1989, pp.8-10). The exports were repackaged or modified versions of imported software (Schware 1989, p. 35). Eighty five percent of the companies had capital of less than $600 thousand and 70 percent had less than 30 employees. Ssangyong Computer Systems Corp. is probably the largest with sales of $26 million and 430 employees (Schware, 1989, pp.34-35).

Due to language barriers and difficulties of providing software maintenance to foreign markets, the Korean developers have concentrated on the domestic market. With the government's encouragement, they have focused most of their attention on the UNIX operating system (Schware, 1989, p.35). They have translated this American product to the Korean language in order to aid Korean application developers. The benefits of UNIX is that is runs on a wide variety of computers and supports a large number of peripherals from different manufacturers. It is considered by many to be an "open system" that provides a lot of flexibility to developers and users. The net result is to increase the productivity of developers because they do not have to contend with hardware and software incompatibilities that can be very time consuming and distract from focusing on customer needs. Many computer experts would agree that their selection of UNIX shows that they are fairly sophisticated at buying technology.

Domestic demand for software is expected to grow at 38 to 44 percent annually between 1984 and 1990. It is expected that computerization in almost all sectors of the economy will increase along with demands for exports. In order to meet this demand the Korean Software Usability and Productivity Enhancement Research (SUPER) Project was established. SUPER includes the establishment of software factories. A project for the Ministry of Communications has been awarded to develop software in the areas of resident registration, land registration, export-import customs administration, automobile management, business site management and cargo management (Schware 1989, pp.34-35). Overall, Korea appears to have a good start for building an effective software industry.

In conclusion, this chapter outlined several important points for developing countries that deserve summarizing. Due to the dynamic and complex nature of the industry, developing countries should exploit niches where they have a comparative advantage. Market demand for software in virtually every country is outdistancing supply; therefore, there is no significant need to try and become a leader at exporting software. Instead, a developing country's strategy should be to use their scarce resources wisely by pursuing domestic niches as a first priority. It is not realistic in the short run for a developing country to match the heavy expenditures in R&D in order to take a technological lead internationally.

As discussed in Chapter 4, there are significant opportunities at home to enhance domestic information technology which has a positive ripple effect throughout the economy.

However, as the next chapter will discuss, there are domestic obstacles to overcome to support an internally focused software strategy. In the case of Juarez, one major obstacle was eliminated this year by the passage of a new copyright law protecting the rights of software developers.

CHAPTER 6

SOFTWARE INDUSTRY IN MEXICO

Introduction

The first computer in Mexico was installed in 1957 at the National University of Mexico. Many people, including researchers and academic administrators, opposed its installation, arguing that it would soon disappear. They believed a poor country like Mexico should not squander its scarce resources on this esoteric technology (Murray-Lasso 1987, p.3). In 1992, this "esoteric technology" represents $1.5 billion in sales of hardware, software and services throughout Mexico and it is growing at a rate of 20 percent per annum (Flores 1990, p.3).

R. Clay Woods from the U.S. Department of Commerce characterized the Mexican computer market with the following comments:

Good Potential	Price Sensitive
High Market Growth	Decreasing Prices
Highly Competitive	Increased User Sophistication
Maturing Market	
Microcomputer Oriented	

The Mexican Computer Industry

The Mexican Computer Industry grew faster than 20 percent per year from 1985 to 1989 (Table 1) and it is expected to maintain this impressive rate through 1992. By far, the largest number of users are microcomputer based (Table 2) and the growth rate of this segment is increasing faster than the mainframe and minicomputer segments. In terms of software sales, microcomputers are also the largest segment at forty-two percent of sales while minicomputers and mainframes are 35 percent and 23 percent respectively (Flores 1990, p.11). The trends in the computer market are toward computer networks (i.e. Local Area Network) and smaller more powerful computers, such as laptops and multiuser systems (Flores, 1990, p.2).

Table 1

Mexican Computer Industry

(millions of dollars)

	85	86	87	88	89	92P
Hardware	248	268	349	398	579	914
Software	71	89	98	127	159	265
Maint & Serv	103	120	125	177	212	368
Total	423	478	573	703	951	1,547

Source: Dr. Ricardo Zermejo, former Director of the Electronics Industry at SECOFI (hardware), Wallace & Asociados (software) and U.S. Embassy estimates based on CANIECE data.

Table 2

Mexican Computer Hardware Industry

(millions of dollars)

	85	86	87	88	89	92P
Microcomputers	76	101	135	198	312	540
Minicomputers	78	84	95	89	129	207
Mainframes	93	82	118	111	137	163
Total	248	268	349	398	579	911

The domestic computer industry (Table 3) has grown at an average annual rate of 51 percent since 1983. In 1989, local production satisfied 38 percent of total hardware consumption and generated export sales of $470 million. This year, domestic production is expected to decrease to 30 percent of total consumption as a result of the opening of the border to imports (Flores 1990, p.4). The United States is by far the largest supplier of computer technology to Mexico with an 81 percent share of computers, 73 percent on peripheral equipment and 94 percent on software (Flores 1990, p.6). Most of the computer manufacturers in Mexico import the bulk of the parts and components and then assemble the equipment in Mexico. The local content typically represents about 25 percent of the final product. According to the Secretariat of Commerce and Industrial Development (SECOFI), the Mexican computer industry is increasingly moving toward export markets (Flores 1990 p.4)

Table 3

Apparent Consumption of Computer Hardware in Mexico

(Millions of Dollars)

	85	86	87	88	89	92P
Production	171	251	392	543	687	1,045
Imports	157	116	143	182	362	626
Exports	79	99	186	328	470	665
Total	248	268	349	398	579	1,006

Source: U.S. Embassy estimates using SECOFI data.

The Mexican Packaged Software Industry

As Table 1 indicates, the industry for packaged software has grown by about 20 percent per year since 1984; however, virtually all of the software sales were generated with imported products. As previously mentioned, the U.S. accounts for 94 percent of the software imports followed by France, Japan, West Germany and the United Kingdom (Flores 1990, p.9). Local software houses are slowly increasing their market penetration which consists of off-the-shelf packages for microcomputers and customized software for mainframe and minicomputers. Local development efforts are included in the category entitled Maintenance and Services from Table 1 or are not accounted for at all. The Data and Software Services section below explains the major contributions from local software developers.

There are 100 software companies registered with the National Association for the development of the Industry of Computer Programs (ANIPCO). Most are located in Mexico City. In addition to those registered, ANIPCO estimates that there are 300 more producers of software throughout Mexico. Arturo Borja in his paper, Estudio Nacional Sobre La Economia de Los Servicios en Mexico - Casos de Los Servicios de Software Y de Computacion, expresses doubt that there are 400 producers of software in Mexico (Borja 1990, p.34).

Software is distributed through independent software companies, representatives of foreign software companies, multifunction companies that develop and cross license software from foreign sources and hardware manufacturers (Flores 1990, p.10). Approximately two thirds of all software sales are made by the computer manufacturers themselves or through their distributors. The largest are IBM, Unisys, Hewlett Packard, Digital Equipment and NCR; these account for approximately 40 percent of total software sales (Borja 1990, 34). Since these hardware vendors mostly distribute mini and mainframe software, microcomputer software is mostly sold through the smaller software companies and dealers. The most important computer manufacturers, listed by software market share, are as follows:

	Percent of Market
IBM	24.5
Unisys	7.5
NCR	3.5
Digital Equipment	2.5
Hewlett Packard	2.0
Honeywell Bull	2.0
Sigma Commodore	2.0
Tandem	2.0
Micrologica Aplicada	2.0
Mai de Mexico	1.5
Infosistemas	1.0
Cromex	1.0
Control Data	0.5

(Borja 1990, p.35)

The most important software houses in Mexico are as follows:

	Percent of Market
Grupo Infodinamica (A.G. Software)	7.5
Kronos (Management Software America)	3.0
Siga Desarrollos (Ashton Tate)	2.5
Grupo Tea	2.5
Execuplan (Lotus)	2.0
Datanet Sistemas (Cullinet)	2.0
Microsoft	2.0
Apemex (Borland)	2.0
Softron (McCormack & Dodge)	1.0

(Borja 1990, p.35)

Others as follows:	8.5

Oracle

Unycorp (Santa Cruz Operation)

Applied Data Research

Misermi (Docubase System)

Computer Associates

Megaplan (Software Publishing Corp)

Uniplex de Mexico (Uniplex)

Kuazar

Opi de Mexico

Equipos y Procesos Interactivos

Cincom

Power House

Televideo

(Flores 1990, p.7)

Virtually all the major developers of horizontal software packages from the United States are represented on these two lists. The U.S. affiliates are in parentheses except for Grupo Infodinamica which is affiliated with a German supplier of database technology. Vertical market software suppliers from the U.S. are conspicuously absent. Generally, the vertical market products require very specialized skills (i.e. CAD/CAM); therefore, Mexican customers are often supported by the software manufacturer in the U.S. Accugraph, a major worldwide supplier of CAD/CAM software, supports their Mexican customers from their headquarters in El Paso.

Arturo Borja pointed out that Mexican universities are not getting software development projects for industry (Borja 1990, p.36). According to Hector Melendez, a Project Manager for EDM International, a database program similar to dBase III, called SYSINFO, was created in Monterrey in cooperation with Instituto Tecnologico de Estudios Superiores de Monterrey (ITESM). This program is used by industry to a limited extent in Monterrey and Torreon. Mr. Melendez likes its ease of use and debugging capabilities; however, it is very slow

- a major drawback. This product sells for around $500 per copy which is similar to the cost of popular database programs in the U.S. According to Mayel Espino, a Project Manager with EDM International, the Universidad Autonoma de Ciudad Juarez also developed a database program using the C language. For unknown reasons, this development effort has not been accepted by industry.

Dr. Zermeno, former Director of the Electronics Industry at SECOFI, estimates that approximately 50 percent of the total software used in Mexico is clandestinely imported and illegally reproduced, particularly for microcomputers (Flores 1990, p.11). There is hope that the new copyright law and stricter enforcement will reduce the practice of illegally copying software. Based on interviews of developers in Juarez, they do not believe that the government will rigorously enforce the new law and they believe this lack of enforcement will discourage developers from producing packaged software. The SYSINFO program mentioned above used a security algorithm embedded in special hardware to prevent it from being copied. This special hardware device increased the price/cost of the program which reduced its market demand and thus discouraged more indigenous development of software packages. Hector Melendez believes that it would have been better to allow the program to be copied illegally in order to gain wider market acceptance. After the unauthorized users become dependent on SYSINFO, the developers of SYSINFO would then be able to collect revenue for upgrades, manuals and on-going support. This is a strategy that some U.S. software companies employ.

Type of Software Demanded

The trend in software throughout Mexico is toward enhanced communications, more integration, relational data bases and fourth generation languages. Based on a percentage of sales, accounting applications, spreadsheets, operating systems and data bases (Table 4) represent the majority of software demand. The accounting and specialty application categories offer the most opportunity for Mexican developers because these applications require knowledge of the legal and cultural environment of Mexico.

Table 4

Software Demand by the Type of Software

Expressed as percent of Demand

	87	88	89	93
Application:				
Accounting	39.6	38.6	38.0	35.6
Spreadsheets	10.1	10.4	11.3	14.4
Operating Systems	12.2	12.0	11.6	10.4
Data Bases	6.5	6.5	6.4	6.1
Utilities	4.0	3.9	3.9	3.7
Word Processor	3.1	3.1	3.4	4.4
Graphics	1.0	2.0	2.0	2.0
Subtotal	76.5	76.5	76.6	76.6
In Millions	$75.3	$97.2	$121.	$303
Specific Applic	18.0	17.7	17.4	16.4
In Millions	$17.7	$22.5	$27.5	$64.9
Educational	2.0	2.1	2.1	2.3
Recreation	1.5	1.6	1.8	2.4
Other	2.0	2.1	2.1	2.3
Total	100.0	100.0	100.0	100.0
In Millions	$98.4	$127	$158	$396

(Borja 1990, p.39)

The majority of demand for software will be for microcomputers. In 1987, it outdistanced the demand for mini and mainframe computers and the gap has grown ever since. In 1993. expressed as a percent of sales, microcomputer software will be about 69 percent of total software sales, while mini and mainframe software will be 22 and 9 percent respectively (Borja 1990, p. 46).

According to a poll published in Computerworld Mexico, the most common applications of software for microcomputers, measured by the percentage of companies using them, are as follows:

	Percent of Users
Spreadsheets	97
Word Processing	93
Data Base Management	87
Micro-Macro Communication	77
Business Graph	72
Financial Analysis	67
Accounting	65
Project Design	54
Local Networks	42
Window Management	37
Statistical and Scientific	36
Inventory Control	30
CAD/CAM	29
Desktop Publishing	27
Electronic Mail	27

Users of Software

The most important end users of software (Table 5) are the government, financial services, manufacturing and wholesale/retail companies. In Table 5, the public service companies are PEMEX and the Federal Electricity Commission and the communications company is Telefonos de Mexico. Other entities include health care, education, research, transportation, communications, accountants, management consultants, engineers, attorneys, doctors and consumers. Although not listed, another source states that utilities demand 4 percent and computer manufacturing firms absorb 5 percent of total software sales (Flores 1990, p.12).

Table 5

Software Demand by End User

	87	88	89	93
Govt. Sectors:				
Govt. Agencies	22.7	22.4	22.5	22.6
Banks & Insurance	21.4	21.0	20.9	20.6
Public Service Co.	4.3	4.4	4.4	4.0
Communications	1.6	1.6	1.6	1.6
Subtotal	50.0	49.4	49.4	48.8
In Millions	42.8	54.6	67.9	172.
Private Sectors:				
Manufacturing	21.4	21.5	21.4	21.3
In Millions	18.3	23.8	29.4	75.1
Commercial	19.1	19.1	19.1	19.4
Other	9.5	10.0	10.1	10.5
Total	100.	100.	100.	100.
In Millions:	85.6	110.5	137.5	352.4

(Borja 1990, p.51).

As indicated, fifty percent of software sales are to government agencies and government owned entities, which is consistent with other sources that state the Mexican government accounts for 70 percent of the total computer industry sales (hardware and software). There are 1,173 computer centers throughout the country and the state-owned entities that have the greatest demand are PEMEX, the Federal Electricity Commission, and TelMex. All three use mainframes, minis and microcomputers. The major government agencies using computers are:

Secretariat of Finance and Public Credit

Secretariat of Budget and Planning

Secretariat of Commerce and Industrial Development

Secretariat of Communications and Transport

Secretariat of Agriculture and Hydraulic Resources

Secretariat of Education

Secretariat of Tourism

Secretariat of Mines and Parastatal

All of these agencies use mainframes for storage of large amounts of information and mini and microcomputers for individual processing. The Secretariat of Commerce and Industrial Development has eighty local area networks with 500 workstations. These networks are connected to seven buildings in Mexico City and eight state offices (Flores 1990, p.14).

The second largest sector is financial services firms like banks, brokerage houses, currency exchange houses and insurance companies. Mexico has about twenty banks of which the most important are Banco Nacional de Mexico (Banamex), Banco de Comercio (Bancomer) and Banca Serfin. Banamex's main computer network is ten Burrough and Tandem mainframes along with mini and microcomputers. Bancomer has one IBM 3090 mainframe, two IBM 4381s (old mainframes) and 40 IBM 36s (old mini). Banca Serfin uses one IBM 3090 mainframe. The most sophisticated banks have on-line communications among their branches in Mexico City and their regional centers throughout the country. They are able to make immediate funds transfers and conduct transactions (Flores 1990, p.14).

During 1989, large commercial establishments, like Aurrera, Gigante, Comercial Mexicana, Palacio de Hierro, purchased about $143 million in computer technology. They used point-of-sale equipment connected to their mainframe for inventory control, sales credit and other accounting purposes. This sector is using bar code readers to update inventory and sales information, which is state-of-the-art technology for that industry. The large commercial establishments are the fastest growing segment of the Mexican economy for computer purchases.

Manufacturing companies in 1989 purchased $128 million to do product design, manufacturing, payroll, accounting, inventory control and administrative tasks. They primarily use mini and microcomputers. The purchases by maquilas in Juarez are not included in these sales figures because they import the technology from the U.S. in-bond.

Unlike advanced countries, Mexico does not have very many companies that offer "one-stop shopping". A full service company in advanced countries offers hardware, software, installation, consulting and on-going maintenance. Rodrigo Flores, Senior Manager for EDM International, states that there is no company in Juarez that provides full services in a professional manner. There are some companies that claim to provide these services; however they have a reputation for poor service, particularly in the area of custom software development. Mr. Flores believes that there is significant market demand for a professional company that can provide full services.

Computer Services

There are six main types of Mexican companies (Table 6) offering data and software services: software house, data bank and time sharing, data processing, consulting, sales of hardware and software, and other. Software houses create custom programs for users. Data banks or time sharing companies rent time on their computers to users who are often connected via a telephone line. Data processing allows a user to outsource an entire application such as payroll or, accounting, to a data processing company. The demand for services (Table 7) comes from the same sectors that demand computer software. The government sector absorbs about 49 percent, with manufacturing, commercial, and other entities demanding 22, 19, and 10 percent respectively.

Table 6

Computer Services by Mexican Companies

Expressed as a Percentage

	87	88	89	93
Time Sharing	30.0	30.3	29.9	30.0
Data Processing	28.9	28.8	29.7	29.7
Software Houses	20.0	20.5	20.0	20.0
Sale of Computers	10.0	10.0	10.2	10.1
Consulting	6.1	5.4	5.3	5.3
Other	5.0	5.0	4.9	4.9
Total	100	100	100	100
In Millions	12.0	15.5	19.2	48.0

(Borja 1990, p.57).

Table 7

Demand for Computer Services by User

Expressed as a Percentage

	87	88	89	93
Govt. Sectors:				
Govt. Agencies	22.3	22.3	22.3	22.4
Banks & Insurance	20.9	20.7	20.8	20.3
Public Service Co.	4.1	4.3	4.5	4.0
Communications	1.6	1.6	1.6	1.6
Subtotal	48.9	48.9	49.2	48.3
In Millions	4.9	6.4	7.9	19.2
Private Sectors:				
Manufacturing	22.1	21.9	21.8	22.7
Commercial	19.3	19.1	19.0	19.2
Other	9.7	10.1	10.0	9.8
Total	100.	100.	100.	100.
In Millions:	10.0	12.9	16.0	39.86

The discrepancy of $8.16 million in total services between Table 6 and Table 7 was not explained in the source (Borja 1990, p. 61).

Government Policy

Even though it was never formally passed, the Mexican Computer Decree of 1981 was put into practice in 1983 by President de la Madrid (Villareal 1990, p.75). The decree had several objectives: to regulate the computer industry; to offset high imports of computers, peripherals and software; to promote exports; to generate employment; to foster research and development; to develop local components manufacturers; and to reduce prices for equipment in the national market (Villareal 1990, p.79). Import licenses, which virtually closed the market to foreign competition, were the main policy instruments for protecting the Mexican market. Other policy instruments were import tariffs and domestic incentives.

The import licenses controlled the amount of imports and linked imports to levels of production. The licenses were allocated among distributors and manufacturers with preference given to manufacturers. Over a five year period, manufacturers had to produce as much in Mexico as they imported and distributors had to sell as many Mexican products as they imported. (Villareal 1990, p.86). The domestic incentives for manufacturers included the following:

1. Twenty percent tax credits on investment and payroll

2. Thirty percent discount on energy costs

3. Preferential treatment for sales to government

4. Lower interest rates and longer credit terms on debt

5. Preferential treatment for imports through access to import licenses, lower tariffs and preferential financing terms

6. Fiscal incentives for technological development (Villareal 1990, p.87)

As expected, companies operating under the decree were subject to a wide variety of restrictions (Table 8). The provisions restricted the location of production, ownership percentages, local content of physical inputs, research and development levels and other similar items. Microcomputers were more heavily restricted than minicomputers because it was thought that Mexico had a real opportunity to develop their own microcomputer technology. In addition, large minicomputer manufacturers like IBM and HP were able to negotiate better terms than were the microcomputer manufacturers (Villarreal 1990, p.89).

Table 8

Technical Requirements for Firms in the Mexican Computer Electronics Industry

1. Foreign investors may maintain 100 percent equity in their Mexican minicomputer operations and 49 percent equity in microcomputer, peripheral or component operations.

2. A weighted average, the degree of national integration (DNI), will be used to determine the level of integration of locally produced components into the machines. Such integration should proceed according to the following schedule: (M=mini, m=micro)

	1st Yr		2nd Yr		3rd Yr	
	M	m	M	m	M	m
Recommended DNI (%)	30	45	35	50	50	60
Minimum DNI (%)	25	35	25	40	35	45

3. Each company will have a foreign currency budget and will have to compensate a percentage of their imports with exports as follows:

	1st Yr	2nd Yr	3rd Yr	4th Yr
Minis (%)	30	60	75	100
Micros (%)	0	25	35	45
Peripherals (%)	25	35	45	70

4. Research and development expenditures required for government approved projects (% of total sales): Minis = 5%, Micros = 6%, Peripherals & components = 3% (Villarreal, 1990,84)

From the perspective of software development, the decree hampered the formation of an indigenous software industry in two significant ways. First of all, the decree made it difficult to freely access technology; therefore, Mexican developers did not have the same hardware and software technology options that developers in other countries had. Secondly, the price of technology was higher than international prices. As Table 9 indicates, the average price of microcomputers in 1990 was between 35 and 43 percent higher in Mexico than the United States (Villarreal 1990, p.94). Accugraph Corporation reported that the average price for Hewlett Packard minicomputers during the mid 1980s was around 40 percent higher in Mexico than in the United States.

Table 9

Microcomputer Price Comparison in Mexican and U.S. Markets - 1990

XT Computers

	Mexico	U.S.	Difference
Minimum	1,970	1,149	$821 (71%)
Maximum	2,210	1,779	$431 (24%)
Average	2,090	1,464	$626 (43%)

The XT microcomputer has an 8088 microprocessor, 10 MHZ speed, 640 kb memory, 30 MB hard drive, a 5.25" 360 KB diskette drive, DOS operating system, 1 serial port, 1 parallel port, keyboard and a monochrome monitor.

AT Computers

	Mexico	U.S.	Difference
Minimum	3,834	2,537	1,297 (51%)
Maximum	4,800	3,942	858 (22%)
Average	4,362	3,240	1,123 (35%)

The AT microcomputer has an 80286 microprocessor, 10/12 MHZ speed, 1 mb memory, 40 MB hard drive, a 5.25" 1.2 MB diskette drive, DOS operating system, 1 serial port, 1 parallel port, VGA or EGA adapter, keyboard and monochrome monitor (Villarreal 1990, p.95).

Beginning in 1986, Mexico began liberalizing the computer industry when they became a member of the General Agreement on Tariffs and Trade (GATT). GATT promotes free trade by encouraging countries to reduce tariff and non-tariff barriers. The import value subject to licenses fell from 80 percent in 1982 to 35 percent in 1986 and the maximum tariff fell from 100 percent to 45 percent in those same years (Villarreal 1990, p.78). As discussed later, today, there is essentially unrestricted trade between Juarez and the United States for computer hardware and software.

Another major change occurred in April 1990, when the government removed import license restrictions under the plan called the Program for the Modernization of the Computer Industry. This new policy will be in effect until 1993 and it gradually opens the market over a three year period to computer products not manufactured in Mexico. These imported products were supposed to be manufactured by companies that already manufacture in Mexico, in order to receive the benefits from the program (Flores 1990, p.4). However, in reality this is not always the case because importers in Juarez are able to freely import products without being connected to manufacturers in Mexico. The purpose of the modernization program is to support the Mexican computer industry by reducing import duties by 100 percent on components and finished computer equipment. The manufacturers are allowed to import up to 80 percent of the domestic integration value plus the net value of the investment in fixed assets plus two times the value of research and development expenditures. The program expects to generate export income of $1 billion and increase domestic production to $1.5 billion.

The immediate benefit of the program to the consumers is the availability of technology at near international prices. Under the program, distributors were supposed to pay a higher import duty than manufacturers and have easy access to import licenses. The reality in Juarez is that import licenses are easy to get and they are only required to pay 5 percent duty on most computer hardware items. Therefore, it does not appear that Mexican manufacturers have much of an advantage today over licensed importers in Juarez. As usual in Mexico, another area of the country may provide manufacturers more of an advantage. Importers in Juarez are also reporting that for all practical purposes there is no duty on computer software. They declare the software as manuals and they are imported without duty.

As the recent computer quotations in Table 10 reveal, the prices of microcomputers in El Paso and Juarez are similar. The quotations from Juarez suppliers are for microcomputers manufactured in Mexico and for imports. If the purchaser (without import license) does not pay the 20 percent duty for buying in El Paso, it would be cheaper to buy in El Paso which is what the majority of non-business consumers do. They save the 20 percent by illegally importing the computers. They also save the El Paso sales tax by receiving an export manifesto from a U.S. customs broker. Hewlett Packard Mexico confirmed that today there is very little difference in price for buying an HP 9000 or HP 3000 minicomputer in El Paso or in Juarez.

Table 10

Microcomputer Price Comparison

in Mexican and U.S.

July 1992

		Difference
Lowest in Juarez	Lowest in El Paso	
1,926	1,860	66 (3.5%)
Middle in Juarez	Middle in El Paso	
1,987	1,914	73 (3.8%)
Highest in Juarez	Highest in El Paso	
2,149	1,977	172 (9%)
Average in Juarez	Average in El Paso	
2,020	1,917	103 (5%)

The 386 25 MHZ microcomputer includes 4 MB of memory, 1.44 MB diskette drive, color monitor, 1 serial port, 1 parallel port and a 120 MB hard drive. The El Paso price includes 20 percent for the Mexican duty and excludes the El Paso sales tax. The Juarez price includes 10 percent for the Mexican sales tax.

Juarez businesses normally buy microcomputers from local suppliers in order to receive a legal Mexican invoice which enables them to deduct depreciation. Several years ago Mexican consumers bought microcomputers in El Paso for price and support. Today, some still buy in El Paso for support; however, it appears that the Mexican suppliers are doing a better job of providing their customers with support for hardware and horizontal packaged software (i.e. Spreadsheets, Word processing). As discussed in later sections, most Mexican suppliers do not have a good reputation for providing custom software services.

The import rules for the in-bond (maquila) industry are very different than those discussed above because they can import any type of computer technology with minimal restrictions and without paying import duty. They are required to get an annual license to import technology which is not difficult to get. Most maquilas include far more on the list than they expect to import in order to avoid multiple filings per year. They are also required to get quotations from local suppliers to prove that the technology in the local market is more expensive than what is available on the international market. Again, this rule is easy to comply with because the government merely wants the maquila to shop the local market. As later sections will describe, there are over 300 in-bond companies in Juarez that contribute to the development of software capabilities.

The 1982 Technology Transfer Law is responsible for the registration and approval of all technology transfer licensing agreements. It prohibited payments for the transfer of technologies existing in Mexico, patents for over 10 years, and the amount a Mexican licensee paid for technology. Its aim was to ensure that Mexican companies have fair access to advanced technology at minimum cost, and to promote the development of technology within Mexico (Villareal, p.81).

Imports and Exports of Software

Prior to 1987, imports and exports of computer software were classified with video and audio tapes. In that year, software was reclassified to enable it to be tracked more effectively. The duty rate on imported software has dropped from 1984 to 1989 as follows:

1984	40 percent
1987	33 percent
1988	15 percent
1989	10 percent (Borja 1990, p.66)
1992	10 percent

From 1984 to present, an import permit has not been required. Mexican software imports mainly come from the United States, France, Japan, Germany and the United Kingdom (Borja 1990, pp.66 & 71).

Mexican software exports have not been significant because they have not had companies capable of creating the team effort that is required to successfully export (Borja 1990, p. 72). A company must be able to develop a product that meets the needs of a foreign market, provide an efficient means of supporting the product, and then establish the marketing channel to sell it. In 1989, Mexico exported $481 thousand to Peru (28.1 percent), Costa Rica (19.6 percent), Columbia (11.8 percent), United States (19.6 percent), and the remaining 21 percent to other countries. Beginning in 1990, Mexico has averaged at least $1.8

million in sales to the United States. Arturo Borja reports about $1 million in exports, and EDM International in Juarez exports another $800 thousand per year, which is not recorded in any official statistics (Borja 1990, p.73). Mr. Borja believes that the government must help software companies with marketing and financial assistance if they are going to be able to successfully export software.

CHAPTER 7
EDUCATIONAL INSTITUTIONS

Introduction

There are five major educational institutions that offer bachelor and, in some cases, masters degrees in computer science for Juarez residents. There are three institutions in Juarez: Universidad Autonoma de Ciudad Juarez (UACJ), Instituto Tecnologico de Ciudad Juarez (ITCJ) and Instituto Tecnologico de Estudios Superiores de Monterrey Campus Juarez (ITESMJ). The fourth school that many Juarez residents attend is located in Monterrey, Mexico and it is the prestigious Instituto Tecnologico de Estudios Superiores de Monterrey (ITESM). Lastly, since Mexicans in financial need are charged Texas in-state tuition, many Juarez residents attend the University of Texas of El Paso (UTEP). There are also a large number of vocational schools that attempt, but do not succeed at teaching computer programming. This chapter will review each of the universities and it will summarize the role and value of the vocational schools.

UACJ and ITCJ receive funding from the government, while ITESM and ITESMJ are privately funded. It is widely believed in Juarez that ITESM offers the best education in computer science, followed by ITCJ and UACJ. The first graduating class of ITESMJ was December of 1990; therefore, it is too new to be rated. However, since it is part of the well-respected ITESM system, many expect it to offer a superior education to the two state funded universities in Juarez.

The National Association of Educational Institutions in Informatics (ANIEI) worked for several years to develop the degree plans for information systems and computer science. Twenty six educators from educational institutions throughout Mexico developed curriculums that included the study of computer hardware, systems software, application software and mathematics. It also taught the social context in which computers operate (Bajar 1991, p.18). The curricula ANIEI created are:

1. Licenciatura en Informatica (Bachelor degree in information systems)

2. Licenciatura en Sistemas Computacionales (Bachelor degree in computer sciences)

3. Ingenieria en Computacion (Bachelor degree in computer engineering)

4. Ingenieria en Comunicaciones y Sistemas Digitales (Bachelor degree in communications and digital systems) (Bajar 1991, p.17)

These curricula are constantly consulted when national colleges and universities formulate their degree programs.

This survey is based on all science and engineering degrees that have a heavy computer science emphasis. The information was gathered by interviewing university administrators, teachers, students and data processing personnel of the universities. The college degrees that were investigated are the following:

Ingeniero en Sistemas Computacionales (B.S. in Computer Science)

Ingeniero en Sistemas Electronicos (B.S. in Electrical or Computer Engineering)

Licenciado en Sistemas de Computacion (B.A. in Computer Science or Computer Information Systems)

Maestria en Ciencias Computacionales (M.S. in Computer Science)

Maestria en Sistemas de Informacion (M.S. in Computer Information Systems)

Maestria en Ingenieria de Sistemas Computacionales (M.S. in Electrical or Computer Engineering)

The Bachelor of Science and Master of Science in Electrical or Computer Engineering is hardware oriented. The students do study software areas; however, individuals with these degrees normally seek a hardware engineering position. These graduates are included in this study because in many cases they end up programming when they are unable to find a hardware-oriented job.

The long years of economic crisis from 1981 to 1987 resulted in reduced government spending on education. This meant fewer jobs and lower wages which lead to the deterioration in both availability and quality of public education. From 1981 to 1987, spending in real terms (Table 11) declined and, as a percentage of GDP, was lower in 1987 than the previous eleven years. The declining investment in education resulted in fewer free textbooks, increased student-teacher ratios and the halting of spending for infrastructure. A corollary effect of the economic crisis was to force students to work while attending college. The effect of the crisis in education is reflected in the graduation rates of only one out of ten at the university level (Gonzalez, de la Rocha 1991, pp. 31-32).

Table 11

Education Expenditures

	1981	1983	1985	1987
Total Expenditures (billions of pesos)	27	22	22.2	21.7
Educ Spending as Percent of GDP	3.7	2.8	3.0	2.6
Per Capita Spending	426.7	295.6	282.5	270.1
Educ. Expenditures as % of total Expend.	8.0	5.9	6.8	5.0

Source: (Gonzalez de la Rocha, 1991, p.32)

Out of economic necessity, most Juarez students work during the day and attend college at night. The exception is ITESM, where most of the students are from affluent families or are on scholarship. The Mexican curriculum requires that a student work in industry for about six months in order to qualify for graduation. The basic classes for the first two years are taught by full-time professors in the morning, which is a very difficult time for students to attend classes. In the last two years, classes are normally taught by part-time professors from 6:00 PM to 10:00 PM. Students must finish their degrees in six years in order to graduate. After graduation a student can then seek a higher level of certification by earning a title. A title can be earned in a wide variety of ways like taking a test, presenting a thesis, or passing several graduate courses with a certain grade point average. Only about 20 percent of engineers actually earn a title after graduation.

Vocational Schools

There are a large number of vocational schools that teach data base programming, word processing and spreadsheets. The duration of the courses varies from a week to a full year of instruction. Although many vocational schools claim to teach computer programming, graduates from these schools are unable to create a useable computer program. The teachers are not qualified to teach computer programming and the students do not have the proper background. Many students attend these schools without a high school education with the idea that they can bypass the long process of formal education. They are hoping that computer literacy will enable them to make a decent wage without having to spend years in school.

The average graduate is capable of executing basic commands in popular programs like word processing, spreadsheets, and data bases. He/she is not capable of writing a useable computer program. In fact, he/she normally does not know how to apply his/her knowledge of how to even operate a program. For example, a student may know how to operate Lotus 123, but he/she cannot apply the knowledge by designing a useable worksheet. The student's proficiency is consistent with the previous section in Chapter 3 on Human Skills and Software Development. An expert is capable of explaining "what" a program does, while a novice explains "how" it works. A vocational graduate can tell you how to save a file in Lotus, but he/she generally cannot apply the technology to real world applications. The vocational schools do not provide students with applications knowledge, like most universities attempt to do.

This inability to apply software technology to real world applications is a real key to understanding the main deficiency of Juarez software developers. Even students from the universities do not learn how to apply computer technology to real world problems. They learn the rules of a programming language, but they do not know enough about the real world problem in order to develop a useable system. One could argue that American computer science graduates have this same problem and they do, but not to the extent of graduates in Juarez. This is an important point that the reader should remember while reviewing Chapter 8, Software Industry in Juarez, Mexico.

Another point worth emphasizing about vocational schools is the large number of students that attend these schools. As discussed in the next sections, the interest in computer science courses at the university level is also increasing. There is a tremendous desire among the general population to improve its computer literacy. It is also relevant to mention that there does not appear to be any resistance to the introduction of computer technology in any sector of the Juarez economy. Even though people may not understand the proper application of the technology, they do understand its long-range potential.

Universidad Autonoma de Ciudad Juarez

UACJ is funded by the State of Chihuahua and from private sources. Companies are assessed 2 percent of payroll to help fund the University. The school is virtually open to any student with a high school degree because the tuition cost is a symbolic 200 pesos ($.07) per semester. It offers only one degree plan in computer science at the bachelor's level and none at the master's level. The computer science program was first offered in 1986. The UACJ programs have undergone the most growth from all the ones surveyed. From 1989 to 1990, the total number of students in computer science grew by 40 percent from 671 to 942. Although the exact number of students for 1992 are not known, the university expects the student population in computer science to remain at about 1,000 for the next several years.

The school has two computer labs with about 80 microcomputers available for the School of Engineering and Architecture. They have one Novell network of microcomputers and the rest run in the stand-alone mode. They use a DEC VAX minicomputer for school administration and they recently purchased a popular IBM AS400 minicomputer for programming students. The computers run the programming languages C, C++ and Basic. The newest language, C++, is an object-oriented language that currently has the attention of international software experts. They also run end-user applications for drafting (Autocad), spreadsheets (Lotus) and word processing.

The University has about 25 instructors teaching computer science of which about 50 percent are part-time. About half of the teachers are recent graduates at the bachelor level with little or no experience. The other half do have several years of industry experience. Instructors complain about only receiving between $3 and $4 per hour and they attribute low pay and poor administration to high turnover among teachers. One instructor complained about absenteeism among teachers and he blamed the administration for not disciplining them. Another very experienced instructor, who is well-respected among his peers, stated that only about five out of thirty students in their last semester are prepared for graduation. He believes most experienced instructors teach in spite of the low wages and poor administration because the students are eager and sometimes desperate to learn.

In 1990, forty-five degrees were awarded from a total of fifty-six students in their last year of college. Applying the same failure rate for 1991 and 1992, the number of degrees awarded should have been eighty-five and one hundred respectively. University officials expect this number to stay between 100 and 120 for the next five years.

Instituto Tecnologico de Ciudad Juarez

ITJC is funded by the Federal Government and private sources. In recent years, its funds have been cut which has significantly hampered its ability to retain good teachers. The tuition at $50 per semester is higher than UACJ; however, it is affordable for most students.

ITCJ offers a Bachelor of Science in Computer Engineering and a Bachelor of Science in Computer Science. Prior to offering the first computer science degree in 1984, the school traditionally prepared students for the electrical and mechanical engineering fields. There are 550 students in the computer science program, and about the same number in the computer engineering program. School officials expect the size of both programs to remain the same for the next few years.

The degree plans are modified periodically to reflect the changes in technology. Recently, the C programming language was switched from an elective to a requirement. The emphasis in the fields of study between the two programs are as follows:

Degree	Hardware	System Software	Application Software
Computer Engineering	45%	25%	0%
Computer Science	15%	30%	25%

The remaining percentages are composed of mathematics and elective courses. The school has about 100 stand-alone microcomputers that are available to students in all degree programs. They are running the same software as UACJ.

In 1990, each program granted about eighty degrees and this number is expected to remain around the same number for the next few years. ITCJ has about twenty-five instructors for both programs and they have similar profiles and wage rates as UACJ. In fact, even though grossly inadequate, some feel the UACJ does a better job of compensating and directing teachers than does ITCJ. One instructor stated that the bureaucracy sometimes takes five to six months to pay new teachers for the first time. Prior to the economic disaster of 1982 and 1983, ITCJ was considered to be a very good school with highly competent instructors. During the economic crisis, the Federal government slashed funding to the school which drove the more experienced teachers into industry. As discussed later, some of the more successful software companies were started by these instructors shortly after this period.

On the positive side, ITCJ requires all instructors to have their titles to prove they are more qualified than the average graduate. They also require at least one year of industry experience. Another policy that deserves further research is the issuance of scholarships to instructors to pursue a master or PHD program at UTEP or New Mexico State University. In return, the instructor must teach two years after finishing graduate studies.

University of Texas at El Paso

UTEP offers a Bachelor of Science in Computer Science, a Bachelor of Business Administration in Information Systems and a Master of Science in Computer Science. UTEP also offers a Bachelor of Science in Computer Engineering and a Master of Science in Computer Engineering, both of which are hardware oriented curricula.

The University has a wide variety of computers available to students. It has several microcomputer labs, an IBM 3081 mainframe, a VAX 11/780 minicomputer, an HP 3000 minicomputer and engineering workstations. In reviewing the curriculum, there does not seem to be enough emphasis on UNIX and C language programming, two technologies that are becoming very common with industry.

In the fall of 1990 there were a total of 373 undergraduate and 66 graduate students in the college of engineering whose majors were computer science and computer engineering. School officials indicated that it is very difficult to identify the students from Mexico with certainty. Even though some students are Mexican nationals, they give permanent addresses of relatives in El Paso. To add to the confusion, there are also American citizens living in Juarez. This is consistent with the diversity of citizenships and resident statuses of Hispanics working in Juarez. Juarez companies employ American citizens who have never lived or worked in the U.S. They also employ Mexican citizens who have U.S. residency status.

The number of students in the undergraduate program from 1986 to 1990 was as follows:

Year	Total	Internat'l	Hispanic
1986	572	11%	56%
1987	475	10%	58%
1988	489	11%	88%
1989	467	15%	69%
1990	373	15%	45%

For the same years, the number of students in the graduate programs were:

Year	Total	Internat'l	Hispanic
1986	115	60%	9%
1987	76	53%	21%
1988	78	53%	14%
1989	73	51%	22%
1990	66	54%	18%

We can estimate the number of students from Mexico by assuming that 60 percent of the international students and 30 percent of the Hispanic students are from Mexico. For 1990, this yields eighty-four undergraduate and twenty-five graduate students from Mexico. From the information provided by UTEP, the number of graduate and undergraduate degrees granted to students from Juarez is ten to twenty per year. Experienced software managers in Juarez feel that in general UTEP graduates are more prepared than students from UACJ and ITCJ.

Instituto Tecnologico de Estudios Superiores de Monterrey

ITESM was founded in the mid 1940's by a well-respected businessman in Monterrey. The school has been able to adjust to the left leaning political and economic systems of Mexico without sacrificing its founding principles or changing its pro-business curriculum. A founding principle was self-sufficiency. It does not rely on the government for any financial support, and, with the aid of prominent business people, it has been able to build campuses throughout Mexico. The school adopted the curricula from Massachusetts Institute of Technology (M.I.T.) many years ago and ITESM is often called the M.I.T. of Mexico. A student is required to pay approximately $1,800 per semester in tuition.

ITESM offers two undergraduate and two graduate degrees in computer science and information systems. The undergraduate options are a Bachelor of Science in Computer Science and a Bachelor of Arts in Business Computer Systems. The graduate programs are a Master of Science in Computer Science and a Master of Science in Information Systems. ITESM also has a Master of Science in Computer Engineering that is almost totally focused on hardware. In January 1991, there were 1,122 undergraduate students and 113 graduate students in all five programs. This number is down from an average of 1,400 students during the previous four years.

ITESM has over 1,000 microcomputers, an IBM 4381 mainframe, "futuristic" Next Computers and a wide variety of UNIX workstations. The Next

Computers run UNIX, have object-oriented programming and are able to handle voice technology. It is rather unusual that ITESM has invested in computer technology of this type considering that it is not widely accepted by industry. Most of the UNIX workstations are used for computer-aided design and manufacturing applications, instead of for computer science students. In general, ITESM has as much computer technology as many U.S. schools.

By 1995, ITESM plans to require that all undergraduate instructors at all campuses have at least a master's degree. Currently, fifty percent of the undergraduate instructors have advanced degrees. It is also trying to increase the number of graduate instructors with doctorate degrees. ITESM provides satellite instruction from the main campus in Monterrey to all the campuses in the ITESM system. It has a production studio on campus that transmits "live" interactive instruction throughout Mexico. The students are able to ask the instructor questions by typing into a computer screen.

On average, the graduates from ITESM are more prepared than graduates of the Mexican universities in Juarez. There are several reason why these graduates are more prepared. The first reason is that the students are more prepared when they enter college because they go to the best grade, middle and high schools. Since they are from wealthy families or on scholarship, they are able to concentrate full-time on their studies and many have the opportunity to study in foreign countries before, during or after college. Effective administration of the school is another reason that the students are better prepared. The number of degrees awarded for 1989, 1990 and the first half of 1991 are as follows:

	1989	1990	January 1991 (1st Half)
Undergraduate	152	239	94
Graduate	30	36	8

It is not known how many of the graduates go to Juarez to seek employment. It is safe to assume that 10 to 15 percent do come to Juarez because in the past twenty-four months one Juarez company alone hired twenty ITESM graduates, and it is known that other Juarez companies recruit these students too.

Statistics by University and Degree Type

Number of Students by Department in 1990

Degree	UACJ	ITCJ	UTEP	ITESM	ITESM Juarez
B.S. in C.S.	902	550	81	729	0
B.S. in C.E.		550	20		
B.A. in C.I.S.				578	12
M.S. in C.S.	40		24	62	
M.S. in C.I.S.				28	
M.S. in C.E.			5	33	
Total	942	1,100	130	1,430	12

Number of Degrees by School in 1990

Degree	UACJ	ITCJ	UTEP	ITESM		Total
B.S. in C.S.	45	80	8	63		196
B.S. in C.E.		80	5			85
B.A. in C.I.S.				91		91
M.S. in C.S.			2	16		18
M.S. in C.I.S.				10		10
M.S. in C.E.						
Total	45	160	15	180	=	400

The number of degrees by department were estimated for UTEP. During 1990, there were an additional ninety-five degrees awarded at ITESM that could not be categorized by department. More than likely, the majority of these ninety-five students received hardware-oriented degrees in computer engineering. ITESM in Juarez did not graduate any students in 1990.

Summary

During 1990, there were approximately 153 graduates in computer science seeking jobs in Juarez. This excludes the hardware oriented curricula (B.S.C.E. & M.S.C.E.) and this assumes that 10 percent of the ITESM graduates came to Juarez looking for work. This also assumes that ten of the fifteen degrees awarded at UTEP were software oriented. The majority are students from UACJ (45) and ITCJ (80), the two state funded schools in Juarez.

Several software managers, who have interviewed hundreds of programmers, indicated that only 10 to 15 percent of the graduates from UACJ and ITCJ are qualified to create computer software. The remaining graduates require an extensive amount of on-the-job training. Therefore, there were only 19 out of the 125 graduates from UACJ and ITCJ that were considered qualified to create software without extensive training. This reduces the total number of programmers in 1990 from 153 to 47 (UTEP 10, ITESM 18, 7 UACJ, 12 ITCJ). Clearly, Mexican leaders need to implement strategies that will improve the qualifications of students graduating from UACJ and ITCJ.

CHAPTER EIGHT

SOFTWARE INDUSTRY IN JUAREZ, MEXICO

Introduction

Often called the "maquila capital", Juarez has evolved from a sleepy border town to a vibrant city with a diversified economy during the last twenty years. Maquilas, the catalyst behind the growth, are foreign owned factories that are allowed to import machinery and raw materials, duty free, in order to take advantage of Mexico's low labor rates. These factories assemble a product or provide a service for export. In 1988, the maquila industry became the second largest sector of the Mexican economy behind oil (Frames 1988 p.10). Today, there are 2,010 maquilas throughout Mexico employing 493,000 workers which add over $5 billion dollars to the economy each year (Vargas 1992, p.56). With 321 factories and over 135,000 workers, Juarez is by far the largest maquila employer in Mexico (Maquila Scoreboard 1992, p.126). Of the net value of $5.12 billion added to the Mexican economy this year, the State of Chihuahua's contribution alone is expected to be $1.8 billion (Vargas 1992, p.57) Since 1981, the value added to the Chihuahuan economy from maquilas has grown by over 31 percent a year. Using employment ratios between Juarez and the rest of the state, about 80 percent of the $1.8 billion in value added in 1992 will come from Ciudad Juarez. In terms of employment, Chihuahua's maquila employment has grown from 49 thousand workers in 1981 to 173 thousand workers in 1992 for a growth rate of about 23 percent per year (Vargas 1992, p.57).

Even though the maquilas are often criticized for having poor manufacturing linkages to the local economy, they have stimulated the service sectors of the Juarez economy in a very significant way. The service sectors that have grown include: food service, construction, education, accounting, legal, transportation, auto service, distribution, retail and others. The majority of the factories hire independent contractors to prepare food for the workers and the ones that do not provide cafeteria benefits stimulate local restaurants near the plants. In addition, there are several thousand American professionals working in Juarez that eat at the local restaurants, shop at the stores, pay Mexican auto insurance and consume similar services.

The construction industry has boomed over the last ten years by building factories, administrative offices, government buildings, restaurants, roads, homes, schools, stores and apartments. Not only has UACJ and ITCJ grown, the seed capital for the Juarez campus of ITESM was provided by businessmen who became wealthy from the maquila industry. Since annual audits and tax returns are mandatory for over 300 companies, the accounting firms are able to offer opportunities to a large number of professionals to handle this need. The legal profession is booming in the areas of corporate, international, environmental and immigration law. The fifteen hundred trucks that cross the border each day are reserved for transportation companies from Juarez. This is only a small number of examples of how the maquilas stimulate the local economy. The biggest impact comes from the wages and taxes that are paid to the more than 135,000 workers each day. They further stimulate the economy by spending their wages at the local establishments.

With all this economic activity, one would think that a vibrant software industry would be stimulated to meet the information needs of the decision makers in each of these sectors. Another reason for positive expectations is the proximity of Juarez to the U.S., the world's software industry leader. This proximity should provide easy access to technology, magazines, market information, software experts and other factors that could aid the formation of a software capability. However, the findings of this research are quite disappointing. To date, all this economic activity has not caused the formation of a significant indigenous software capability. There is very little serious software development occurring throughout the economy. Most of the software is imported from the U.S. or from Mexico City. Most sectors of the economy control their most important software decisions outside of Juarez. The selection, analysis, design, and development activities occur somewhere else. This leaves the local developers to handle minor modifications and maintenance activities. On the other hand, there are a few bright spots that provide hope that an active industry may emerge in the future.

This chapter will first deal with the suppliers of software packages and software services to the local users. It will describe the type, quantity and quality of services that they provide to computer users in Juarez. The chapter will then profile the major users of software technology. These profiles will discuss the type and source of software technology along with the degree of automation that is taking place.

The information in this chapter was gathered through conducting interviews with software developers, suppliers of technology, users, academicians, business leaders and other knowledgeable individuals.

Packaged Software Suppliers for Local Consumption

Packaged software is a computer program that is written to satisfy the needs of a market niche instead of being created for the needs of one customer. As mentioned earlier, package software is generally considered to be more difficult to create than custom software because the developer has to design the program to handle a broad set of needs. In a third world country like Mexico, the needs can be difficult to identify, particularly when the programmer must comply with some vague and dynamic set of laws.

Packaged software is also more difficult to sell because the developer has to convince the buyer it will meet his/her needs even though the software is not specifically designed for him/her. This is not an easy task in Mexico and other third world countries because the user cannot always apply a general tool to his/her specific problems. In fact, the lack of computer literacy among users in Juarez is one of the most difficult obstacles for package software developers to overcome. Among software engineers the term "idiot-proof" software is a commonly used phrase. It means that the engineer must design a system that anticipates every possible mistake that an inexperienced user may make. Generally, the engineer opts for less functionality by limiting the features of the software. Since packaged software by design has a large number of features, in order to apply to the general case, there is a built-in conflict between packaged software and an inexperienced user. Many of the powerful and general software programs written in the U.S. for microcomputers overwhelm users in Juarez. For example, many users of Lotus 123 (spreadsheet) know a small fraction of the commands and they frequently get into trouble by invoking a powerful command by mistake.

Another obstacle to packaged software development is the lack of uniformity of interpretation of the rules for a particular application. For example, there is a wide range of interpretations or enforcement of the Mexican payroll tax laws. This causes chaos for packaged software developers, because no two companies calculate payroll the same way. Another obstacle is the lack of respect for software copyright laws. A company cannot afford to develop a package that is going to be illegally copied. More will be said about the obstacles for creating software packages in Mexico, by describing the experiences of Juarez Computacion, the only successful developer of packaged software in the city.

There are only two software development companies from Juarez that have developed software packages that are being used by a large number of users. All the other companies offering software packages import the software from the U.S. or other parts of Mexico (mostly Mexico City). Both of these Juarez companies develop application software for accounting and general management purposes. The software packages include payroll, accounts receivable, accounts payable, general ledger, inventories, invoicing and time accounting. The software is developed with a higher level data base language called Clipper. One company has achieved a good reputation in the Juarez business community whereas the other company has not. The company that has not been successful has not followed a focused strategy. It has gotten into too many areas and has been unable to manage them properly. It was criticized for allowing students without supervision to write software. The students often left the company before they completed their projects. Only profits from the company's hardware sales and hardware maintenance have kept them from going out of business.

The other company with a good reputation is Juarez Computacion. This company has over a hundred users, which is quite impressive. Juarez Computacion is owned by two senior engineers who graduated from ITCJ, and they have three junior programmers from the same school. This company is "purely" Mexican in the sense that the founders did not rely on any assistance from foreign sources. Prior to Mexico's economic problems in the mid 1980s, the founders were considered to be among the top teachers at ITCJ. Since the University was unable to maintain proper incentives, the owners began developing software on a part-time basis for industry while continuing to teach at ITCJ. Eventually, they left teaching and worked full-time for Juarez Computacion. They adopted a forward thinking philosophy of only having one version of each application program. Even though many customers request "fine tuning", they install the same version of the software at each customer site. This requires a high degree of skill to incorporate enough flexibility to satisfy a large user base while maintaining the same version of the software.

The company's packages include the same productivity tools that one would expect from a good application program in the United States. For example, their payroll program is able to electronically supply the social security administration with information about new employees, terminated employees and changes of salary. With employee turnover averaging over 100 percent per year, there is a tremendous amount of personnel information to manage and to send to the social security administration. They are also able to generate extremely tedious bi-monthly reports that track absenteeism, new hirings, terminations and changes of salary. Very few of the payroll programs written around the needs of one company are able to electronically communicate with social security and print bi-monthly reports that meet the legal requirements of social security. Without this level of automation, it is virtually impossible to do these calculations accurately for a company with over 50 employees. The average accounting clerk in Juarez does not have the skills to create a system to track these calculations manually.

Mexican payroll is one of the best examples where imported technology is not appropriate for the local conditions. The requirements are unique to Mexico and to states within the country. Even though the payroll laws are driven by the Federal government, the administrative procedures will sometimes vary by state. Frequently, when payroll laws change, they do not give companies a lot of notice before the effective date of the change. Since this requires rapid changes to payroll programs, foreign suppliers of Mexican payroll programs are unable to respond quickly enough.

Juarez Computacion's original focus was exclusively software development and the majority of their efforts were devoted to creating software packages. Since most software companies begin with custom software and evolve to package development, Juarez Computacion's beginnings are quite remarkable.

After several years of struggling financially, the company started selling microcomputer hardware. They were unable to charge enough for software and software maintenance to fund any significant growth. They charged about $500 per package and $40 per month for maintenance. In some cases, they gave the software away just to sell the hardware and the software maintenance. Over time, the hardware portion of their business became the dominant source of revenues and profits by a large margin. Today, their primary focus is to sell hardware and hardware maintenance which means that software development gets less attention.

There are several important lessons in Juarez Computacion's experience that provide insight into the nature of the Juarez market for computer software. The first lesson is that the average Juarez business (non-maquila) does not value the effort it takes to develop professional software. The average business is more willing to pay for hardware and hardware maintenance, because it is tangible and easier to justify. The users do not fully appreciate the need for software because in many cases they do not have the skills to use it fully. The second lesson is that there is a significant amount of software maintenance and ongoing training required in order for the user to be successful. The extensive training is due to low skills, high employee turnover and frequent changes in the laws. The main problem with the maintenance and training is that the businesses do not want to pay what it is worth. As discussed later, they will pay for training on U.S. developed software (i.e. Lotus spreadsheets) but not on the software created in Mexico. The third lesson is that the larger companies (i.e. maquilas) hire their own programmers because they do not trust outside software companies. In the end, in most cases, these large companies do not appear satisfied with the results of hiring their own programmers to do projects.

In many ways all of these lessons are similar to what U.S. companies went through in the late 1970's and early 1980's. They were not willing to pay for software because they did not appreciate its value and use. They hired in-house programmers to develop software for their own use and the users lacked the skills to fully exploit the power of the system. They were willing to invest in computer hardware but not software. If software exceeded 10 percent of the total system price, customers resisted buying it. In the late 1970's, industry experts predicted that software would exceed the price of hardware within ten years. Perhaps, in time Juarez business leaders will change their attitude toward software like the U.S. industry did in the 1980's.

There are two types of companies based in Juarez that offer imported software. The first group consists of the small retail dealers that sell hardware and packaged software. There are about three or four of this type company, and they sell the popular microcomputer software like spreadsheets, word processors and data bases. In most cases, they do not know enough about the applications to train the users. They refer their customers to other companies that provide the training. The other group of software suppliers with offices in Juarez is made up of large transnational hardware manufacturers like IBM and Hewlett Packard. The group's software is written in the U.S. or Mexico City. Perhaps the most disappointing statistic about IBM and HP is that they do not have any software engineers in Juarez who can provide training to the local engineers. All of their software support is done elsewhere.

IBM opened an office in Juarez about four years ago to sell hardware and software to the local market. For a city the size of Juarez, it is a small office for IBM. It has one sales person, one part-time software engineer and one hardware technician. The software engineer mainly supports the sales efforts. It has 12 to 15 midrange computer installations (AS400, IBM36 & IBM38), running software from the U.S. The computers are used for administrative, accounting and manufacturing management purposes. The only programming that is being done locally on these computers is to generate specialized reports. These reports are created with a report writer embedded in the U.S. software. Since it is not a difficult task, it does not require a programmer.

Hewlett Packard has penetrated the Juarez market to a greater extent than any other major computer manufacturer. HP has about 40 midrange computer installations (HP 3000 and HP 9000) in the city. HP has five employees dedicated to sales and hardware maintenance; however, HP does not have any software engineers locally. Whenever a local user has a software problem, the user must call Monterrey or Mexico City. Like IBM, the HP users run administrative, accounting and manufacturing applications. The users do hire local programmers to customize the HP software for their unique information needs. These programmers use high level report generators and data-base languages to customize screens and reports.

Another major software supplier that does not fit any of the above categories is Programming Services International (PSI). The company started in El Paso about ten years ago for the sole purpose of writing software for the maquila market in Mexico. PSI is the largest supplier of software to the maquilas with several hundred installations throughout Mexico. PSI customers are the large Fortune 500 type companies like 3M, A.O. Smith and Johnson and Johnson. These companies make their software decisions from the U.S.; therefore, companies like Juarez Computacion are not even considered.

PSI provides payroll, accounts payable, accounts receivable, general ledger and other accounting programs. In order to stay current with changes in Mexican laws, the company employs Mexican nationals to work in its El Paso office. Its software is fully bilingual and perhaps even bi-cultural. Even though the technology is designed for the Juarez environment (i.e. Spanish, legal compliance and ease-of-use), PSI personnel complain that the local user is in constant need of assistance. Assistance is needed because of rapid employee turnover and poor educational training of the user's personnel.

Unlike Juarez Computacion, PSI charges much higher prices. Instead of $500 per program, its prices range from $4,000 to $17,000 for each program. It is also able to charge significantly more than Juarez Computacion for software maintenance and training. The main reason PSI is able to charge more than their Mexican competitor is that American buyers are willing to pay more for software and related services. With better marketing to U.S. controlled maquilas, Juarez Computacion could significantly raise the average price of its software. The sales staff would need to travel to cities in the U.S. to make sales presentations, which is virtually impossible for its non-English speaking sales staff to do.

In the final analysis, there is only a handful of software developers at two companies in Juarez creating software packages for local consumption. This is not a very impressive base on which to build an indigenous software capability. There are several structural reasons within the society for their lack of success. The first reason is the lack of adequate technical training to handle the more difficult phases (investigation, analysis and design) of software development. Without proper training the development process takes a very long time and often misses the mark with the users. The next reason is the lack of adequate capital to fund product development. Engineers do not have access to the financial resources to spend a year without revenue to create a product. The owners of Juarez Computacion started their company with personal savings, with hours of "burning the midnight oil", and with student involvement. Another major obstacle is marketing. As mentioned, the users do not appreciate the value of software and the suppliers do not know how to effectively sell their programs. There are computer companies, like Milasa in Juarez, that specialize in marketing other companies' software; however, this speciality has not yet fully matured.

The next section offers a more positive outlook by describing a software company that develops packaged software for world-wide distribution. That section is followed by a section describing the companies that provide system integration, custom software and service bureau services. These types of services are contributing more to building an indigenous software capability than is packaged development for local consumption. However, as the computer market in Juarez matures, packaged software development for local consumption will mature.

Packaged Software for World-wide Distribution

In 1988, EDM International incorporated under the maquila program in Juarez to offer data services and contract programming to U.S. software companies. The founders of the company are from El Paso and Juarez. The El Paso partners have competed in the worldwide computer software industry for many years and the Juarez partners bring many years of experience in the maquila industry. After a year and a half of marketing efforts, EDM was able to convince U.S. software companies to outsource a portion of their software development in Juarez.

The U.S. clients made several visits to the city to survey the availability and quality of software programmers. After lengthy negotiations, several U.S. companies decided to test, on a trial basis, the technical abilities of Juarez developers. The tests were extremely successful, and the company has grown to over 700 employees, of which about fifty are developing computer software packages.

The alliances that EDM has formed with its clients are extremely important to improving the indigenous software capabilities of Juarez engineers. Several EDM clients are professional software companies that compete worldwide. These strategic alliances bring the software technology along with the software specifications. Software technology includes source code, internal documentation, original design documentation (i.e. Flowcharts) and development methodologies. This information is far more beneficial for ITC than merely importing a software product or software specifications.

Initially, the contract programming was directed by two American managers of EDM with many years of experience in the computer industry; however, in a very short period of time the responsibility was turned over to a Mexican national. The senior manager is from Juarez and is educated at UTEP and the University of Texas at Austin. He graduated in the top of his class from U.T. Austin with a bachelors and a masters degree. The initial team he directed was composed of four developers from ITESM and one from UTEP. Shortly, thereafter the team expanded to twelve programmers with graduates from all the schools in Juarez. Today, EDM has about fifty developers working in a wide variety of computer and programming environments.

The company develops application and system software for microcomputers, minicomputers and mainframes. The majority of the development is system level software for the IBM mainframe computers. This work is done in the following languages: SSPL (high level proprietary language), C, C++ and some IBM assembly language. Since it is system software, it must be carefully designed for maximum efficiency in order to minimize the use of the computer's resources to run. This software runs in virtually every Fortune 500 company in America and in every advanced country in the world. The quality of the software is paramount because many large companies use their computers for mission critical activities.

Initially, virtually all aspects of the projects were controlled from the U.S. The training, personnel selection, specifications and development standards were imposed by experts from the U.S. The initial role for the Juarez programmers was phase four and six of the development process, which is to develop programs and provide maintenance. The other more difficult phases of investigation, analysis, design and installation were done by U.S. developers. During the first twelve months the Juarez team proved that they were capable and eager to learn; therefore, their responsibilities were expanded to the design and analysis phases. Today, they are involved in all phases of development and they are regularly consulted by their colleagues in the U.S. on technology matters. The philosophy of the Juarez team is to improve the best technological ideas of the U.S.

EDM invests in all the latest productivity tools (i.e. computer-aided software engineering), training courses and computers. In addition to mainframe software, the company develops software for midrange computers running UNIX and microcomputers running OS/2 and DOS in a local area network. The UNIX software is in the highly specialized area of CAD/CAM which like the mainframe software is distributed throughout the advanced countries. The microbased software is used for internal purposes and for companies in El Paso. From a software industry perspective, EDM has a broad base of technological capability because the company has experience with the more common operating environments: mainframe MVS, DOS, UNIX and OS2. At this time, EDM is only considered to be expert in DOS; however, within the next year, the company will approach a high degree of competence in all these areas.

In addition to the latest environment for programmers, the company has the latest in office automation tools. The administrative and management staff of about 125 people use spreadsheets, word processors, electronic mail, general accounting, PC FAX and graphics packages. In addition, they have specialized programs customized for their unique management purposes. The company has one of the largest local area networks around, with about 400 microcomputers all connected with high speed communications, including state-of-the-art fiber optics.

Aside from the non-technological linkages to the Juarez community, EDM provides many technological benefits to the society at large in the areas of software development, administrative and general management. In software development, many of the software engineers teach at the local universities and work part-time, developing software for local Juarez businesses. EDM loans money to all developers desiring to purchase a computer for their after hours work. As the next section describes, there is a significant amount of programming work being done on a part-time basis throughout Juarez. In administrative and general management areas, the main linkage to the local community comes from employee turnover. Although turnover is low at the management and administrative positions, there are times when managers must leave to work in a family business or relocate to other parts of Mexico.

It is safe to say that EDM would not have been as successful without the initial efforts of the American management team. However, after the initial set-up phase, the company's growth was fueled by the competence and dedication of the Mexican management team. Today and in the future, this company offers a good base to build a serious software capability in Juarez, particularly when the company turns its expertise to providing services to the local market.

The next section covers the remaining suppliers of software services to the market before we examine companies with in-house programming staffs.

System Integration, Custom Software and Service Bureaus

The other types of companies that provide some type of software services are: system integrators, custom software developers, and service bureaus. As previously discussed, a systems integrator provides a turnkey automated solution to its customer. Based on the needs of the client, integrators supply the hardware, software, training, consulting, and even the personnel to operate the system. This requires tremendous technological expertise to accomplish, and Electronic Data Systems (EDS) is the only company in Juarez offering these services.

EDS is a multi-billion dollar company owned by General Motors and it established an office in Juarez in the mid 1980s. EDS came to Juarez to support its main client, General Motors and other large maquilas, like General Electric. Its market is the large companies, because EDS is known for charging prices that small companies cannot afford. Out of a total staff of 250, EDS employs about 30 software developers from the local universities, of which 90 percent are dedicated to the support of General Motors. Its original plans were to penetrate the Juarez market (outside of GM) to a greater degree; however, the company has been unable to do so. EDS does not share the reasons for their lack of marketing success; however, it could be because the large companies and government entities control their technology decisions from the U.S. or Mexico City. More will be said about this in the following sections that profile the automation of the major entities in Juarez.

EDS mostly uses HP 3000 midrange computers with software packages that are written in the U.S. Most of their personnel operate and maintain the systems which is not a technologically challenging task. However, they do develop programs locally for inventory control, customs accounting, Mexican payroll, and Mexican accounting. This development does expand the skills of the developer, because the developer learns the EDS software development methodology, called System Life Cycle Model, which, based on its market presence, must be one of the most comprehensive in the world. The linkages EDS has had to the local community are through the universities, custom software, and employee turnover. Like EDM, they provide instructors, general consulting and feedback to the universities. Its custom software has improved decision-making of local maquila managers and through management turnover EDS has contributed to providing many Juarez businesses with well trained staff from the maquilas. Due to its high pricing, non-maquilas cannot afford to use EDS; therefore, its custom software is mostly confined to the maquilas.

The other types of companies in this section are custom software developers, and service bureaus. As previously discussed, custom software is a program that is written solely for the needs of one user. Aside from EDS, there are no substantial companies doing custom software. There are a large number of part-time programmers that write programs for local businesses on their off-hours. They write programs for inventory, payroll, customs accounting, invoicing, general accounting, and other areas that are unique to the Mexican environment. In most cases, imported software is not a good fit in these areas because it is not bilingual, and it does not meet the Mexican legal requirements. These applications are the obvious niches that local developers can exploit to satisfy the local market, and improve decision-making at non-maquila businesses.

For a variety of reasons, the part-time custom software developers have not added a lot of value to the local users. In the first place, they are unable to finish projects because of their part-time status. In addition, projects in the beginning are not clearly defined due to the developers' lack of analysis and design skills. Without clear initial specifications, the project often meanders without ever reaching a final conclusion. It is like the "ink never dries" because the user and the developer are not in agreement on the project's specifications. In many cases the programmer leaves the project incomplete and the second programmer is unable to follow the work of the first one. A successful custom software industry hinges on the competence of the software engineers and the competence of the user. A user must be able to articulate his needs, select a suitable developer and then implement the technology once it is written. At present, most non-maquila companies generally do not have these skills.

The last category of software-related service providers is service bureaus. A service bureau processes information for companies at the service bureau office. In Juarez, there are two or three service bureaus offering payroll and general accounting services. The service bureau will calculate the payroll and prepare the payroll tax reports for its customers. For general accounting, the bureau creates all the accounting ledgers and prepares the financial reports for the fiscal authorities. In general, the scope of its services is fairly limited to traditional accounting areas. The service bureaus are unable to provide customized management information, and thus do not aid decision-makers in their mission-critical decisions. In fact, the bureaus resist custom software requests because they do not want to be distracted from providing their main services.

In the future, the type of services outlined in this section should improve in terms of volume and quality. The main improvement needs to occur in the custom software area, because this will enable applications to be created for the unique needs of Juarez decision-makers. Many of the smaller businesses need software in Spanish, in order to effectively manage their business. As the Juarez users become more computer literate, they will be able to critically evaluate and assist custom software developers, in order to form a team effort, to fully utilize the power of the microcomputer.

The next several sections turn to the type of in-house development that is occurring in Juarez.

Software Development and the Maquilas

Many of the over 300 maquilas in Juarez have programmers on staff to maintain software, train operators, operate programs and in some cases write custom software. Since most maquilas are cost centers of large U.S. companies, most automation decisions are made in the U.S. The U.S. parent controls the selection and implementation process from its MIS department at corporate headquarters. The information that is needed by corporate planners (i.e. production and inventory data) is tightly controlled from the U.S.; therefore, the local software engineers have very little involvement in the design of the software to handle this information. The local engineers are sometimes involved when the information is only needed within Mexico. For their main information needs, maquilas can either have terminals connected to a computer in the U.S. or have its own in-house computer. The maquila with an in-house computer offers more development opportunities for local programmers.

Since a maquila is a factory that needs to compete world-wide, it must manage large amounts of diverse information to be competitive. The areas that need automation are production management, materials management, quality control, human resources, payroll, customs accounting, general accounting and administration. The software to manage production and materials is the most comprehensive software in the plant and it is developed in the U.S. The involvement from the local programmers is to maintain and extract data for local managers, which is not technically challenging. The operational managers receive tremendous experience from using these sophisticated management programs but the programmers' development skills are not enhanced significantly. The most common software packages for production and materials management run on the popular midrange computers, HP 3000 and the IBM AS400.

For quality control, many plants have local developers writing fairly small programs for test and process control equipment. These are simply programs that do not improve a programmer's ability to write a large comprehensive software system. In the administrative area, most maquilas are not very automated. The administrative personnel do not have access to word processing, electronic mail and spreadsheets. When they do use this technology, it is imported from the U.S. The role of local programmers is to install, maintain and train on the use of the packages. Once again, this area does not contribute significantly to the software development skills of the programmers.

In the human resource and payroll area, there are different approaches used by the maquilas. Many maquilas purchase their software from PSI, the El Paso company mentioned earlier. Many others use service bureaus and a lot write their own. The ones that write their own payroll software provide local programmers their best opportunity; however, the results are mixed. Many are successful in completing a package while many others are not satisfied with the results. It is safe to say that very few payroll programs written by maquilas are automated to the extent of electronically updating the social security administration and the banks for the new pension information. In addition, very few in-house programs print the complicated bi-monthly report required by social security; therefore, the accounting staff is required to perform a large amount of manual calculations that result in many errors.

Like the payroll programs, the source of the general and customs accounting programs for the maquilas varies. Some write them in-house, some use a service bureau and some purchase their software from PSI. The customs package, which tracks the customs declaration forms, improves the accuracy and productivity of the administrative staff of the maquila. Virtually every maquila of any size uses a computer for this function. Recently, Mexican customs requires that all export declarations be transmitted electronically, in order to improve the accuracy of the information and to speed the flow of trucks across the border. Another related program that some of the larger more sophisticated maquilas use is a computer program to track the movement of their tractor trailers between Juarez and El Paso. This enables the maquila to optimize the flow of the trucks and to pin-point problems before they get out of hand. Just like payroll programs, the maquilas that develop their own accounting programs provide the best opportunity for computer programmers to gain experience.

Since the maquila's primary mission is not software development, maquilas are not usually structured to provide local programmers with advanced software development training. Many do provide continuing education courses in programming and many by virtue of their size do provide a more supportive environment for development than the average Mexican business. The developers have access to more technology and oftentimes they liaison with software engineers from the U.S. Since they are capable of employing several full-time developers, a programmer has the opportunity to learn and exchange ideas with a team of programmers. In addition, the manager of a maquila is often more computer literate than the average non-maquila manager and as stated earlier a knowledgeable user is a requirement for a successful computer installation.

Government and Public Service Companies

This section will highlight the level of automation and the source of software in the government and public service companies. As demonstrated earlier, the government sector represents the largest user group in Mexico; therefore, it can have a profound impact on the software industry.

Comision Federal De Electricidad

The electric company is controlled by the Federal government and it is not known for its state-of-the-art technology. It uses a technically obsolete midrange computer for billing and cash receipts. It bills once every two months and some believe poor management and lack of technology are the reasons it is not able to bill once a month. A former electric company employee thinks the software was written in Torreon where the Juarez electric company is controlled. It bills the user based on history of usage because it is unable to read the meters often enough for billing purposes. The more alert users read their own meter to insure that they are not getting over billed. When electric company personnel get around to reading a meter, some customers get billed retroactively for 18 months of incorrect billings.

In most cases it does not use automated tools for its administrative functions. It instead uses typewriters and adding machines. The newest computer technology is being installed in the substations which manage the flow of power throughout the city. It took about seven years to get authorization to purchase technology to manage the large volumes of information for the ten substations in Juarez. Each substation manager needs a maintenance history on each transformer, and a history of the usage by user and circuit, in order to balance the power in the city. Without this information, some parts of the city will get too much power, and others will not get enough. The new system will enable the sub-station manager to pro-actively balance power, and start gas generators, when more power is needed to avoid outages. It recently purchased microcomputers with data base tools and a spreadsheet to enable them to model its data. Even with the new technology, it lacks an accurate history of the usage by customer, because the billing system is not connected and is generally not accurate. These new microcomputers will be programmed locally to handle the substation manager's needs.

Telefonos de Mexico

The electric company with all its weakness is in better shape technologically than TelMex. Every night, every city in Mexico sends a magnetic tape to Mexico City with a list of every long distance call that was made that day. These tapes are processed so that at the end of the month a consolidated bill is printed for every telephone user in Mexico. From a computer operations standpoint, this is a nightmare of information to handle in an extremely inefficient manner. The cost of creating, mailing and loading all these tapes is astronomical compared to what it could cost if done locally. This information should be stored to magnetic disk without any manual intervention. Secondly, mailing the telephone bills from Mexico City is an extra delay, and it has proven to be unreliable. TelMex is the only public service entity that delivers its bills by mail. The other utilities hire delivery personnel. It is not unusual for a bill to get lost, and if the user is not alert his telephone line will be cancelled for lack of payment. Once cancelled, it is not very easy to re-connect. An alert user will realize his bill did not arrive and he will go to TelMex to pay it. Since the bill is lost and the computer data base is in Mexico City, the telephone user does not know how much to pay. With some delay the TelMex employee can access billing information from a backup system that is kept on microfilm. From a computer and administrative perspective, TelMex is grossly inefficient and it is not utilizing the software development skills of the locals in any way. There are many areas in which custom software can improve productivity and there is hope that the recent privatization of the utility will improve service through the application of technology.

Instituto Mexicano Del Seguro Social (IMSS)

IMSS, the social security administration, is a huge and powerful government agency that manages the national health and disability programs in Mexico. Every week the Juarez office of IMSS receives thousands of forms to record new employees, terminated employees and changes of salaries. With employee turnover exceeding 100 percent per year, this is a mountain of paperwork that must be tracked each week. Whenever minimum wage changes, in addition to the normal work load, IMSS receives a few hundred thousand change-of-salary forms. IMSS uses a midrange Honeywell computer with 11 terminals and about 15 microcomputers to key these forms. All the programming is controlled in Mexico City. Its system has 1 billion bytes of storage to keep track of this data.

IMSS uses this information to calculate the amount of taxes that each company should pay every two months. IMSS generates a bi-monthly report that is used as an invoice for companies. In nearly all cases, the report is not accurate because of keying errors and timing differences. Companies of any size spend significant amounts of time reconciling the report before paying their taxes. Companies have been pressuring IMSS to accept information for new employees, terminated employees and salary changes on diskette to avoid keying errors, timing differences and to save labor costs at IMSS. In Mexico City, programmers have recently written software to accept change-of-salary information via diskette, and IMSS is also allowing companies to generate its own bi-monthly report, but the reports have to meet very strict rules. These two procedures have enhanced productivity significantly for IMSS and the companies.

Calculating social security benefits for each worker is one area that needs automation. Presently this is a manual process, and it slows the process of rendering health care and disability benefits to the workers. A worker cannot go to every IMSS clinic for assistance; but instead, he must go to the clinic to which he/she is assigned. The assigned clinic has his/her file that determines his/her qualifications for benefits. Whenever a file is lost, it is very difficult to find, delaying the rendering of services. This area, along with many others, could be significantly improved with customized software development; however, the local officials do not know of any plans to add any new software applications.

Junta Municipal De Aguas y Saneamiento and Gas Natural De Juarez, S.A.

The water utility uses a midrange computer to generate bills and track receipts. The source of the software is not known; however, it may have been developed locally, because the water utility is run by the city government. It reads the meters every month and sends a bill based on the amount of usage. The smaller homes do not have meters; therefore they are not billed. Customers can pay at remote locations like banks or shopping malls. The payment is not keyed into a computer at the time of payment. It is sent to the main office for keying. In general, its customers seem to be pleased with the efficiency of the billing process. When a customer detects an error, the utility generally reduces the bill without delay.

The gas company is privately owned and licensed by the government. Of all the utilities, it has the best automation and in fact it may be one of the most automated companies in Juarez. It employs a team of eight programmers who write custom software to improve their in-house productivity. Its software encompasses billing, receipts, general accounting, inventory of parts for trucks and even the management of the trucks. It uses a Novell local area network running thirty microcomputers. Its software programming is done in Clipper (high level language). A customer's receipt is entered on-line at the time of payment, providing the customer pays at the gas company's office. Its customers report that its billing and receipts process is very efficient compared to the other utilities. It is obvious from its customer service levels that the gas company is employing an indigenous software capability to tap the full power of microcomputer technology.

Secretaria De Hacienda y Credito Publico

Throughout Mexico, Hacienda purchased fifty HP 9000 midrange computers to automate the collection of federal taxes. One of these computers will be installed in Juarez and it will be connected to Mexico City via satellite. In Juarez, there will be a terminal at each point of entry to record items that are imported to Mexico. After the system is completely installed, there will be thirty terminals in Juarez connected to the computer. The software is being written by Hewlett Packard in Mexico City. They will probably hire programmers to handle maintenance and report writing duties in Juarez; however, this project will not provide software development opportunities to Juarez programmers. On the other hand, from a user perspective, this system will significantly improve Hacienda's productivity and the productivity of the companies having to deal with them.

Aside from the gas company, the common thread running through all these government entities is centralized control from outside of Juarez. In most cases, Mexico City insists on controlling automation which is an obstacle for the efficient and effective use of technology in Juarez. It is also an obstacle for improving the software development capabilities of the locals. The Juarez software engineers and users do not select or develop the technology, but instead, they inherit it. This autocratic approach fosters apathy and dependency, two deadly "diseases" for any successful endeavor.

CHAPTER NINE

CONCLUSION AND RECOMMENDATIONS

Summary of Findings

The amount and quality of indigenous software development in Juarez is not very impressive. None of the traditional development areas of packaged software, custom software or software integration is approaching maturity. The two state funded universities, which have the largest student populations, do not provide a quality education in computer science. The large government sector is suppressing the development of local software skills by dictating automation decisions from Mexico City. Although better than the government sector, the large maquila population is not encouraging serious software development by controlling its technology decisions from the U.S. The remaining user group, Mexican commercial enterprises, is also importing its technology, or unable to effectively work with local software suppliers.

Another corollary problem to the lack of indigenous software development is the productivity loss that exists throughout the economy. It is obvious that few users are maximizing the productivity potential of the microcomputer. There is not enough indigenous development to localize the technology and there is not adequate utilization of imported software technology. The lack of experienced software engineers is part of the problem, but there is also a lack of computer literacy among users. A successful software industry depends on competent software engineers and competent users.

On the positive side, the resilience of the Juarez leaders and workers will overcome these obstacles, as they did when they transformed Juarez from a sleepy village to a vibrant city. The most positive indication that software development and automation in general will improve, is the tremendous awareness, appreciation, and hunger for computer technology. Software developers at Juarez Computacion, EDM International and other companies proved that they are capable and eager to learn. All they need is an opportunity. Another positive indication is the volume and growth rate of computer industry sales within Mexico, which shows that users value its potential. There is no apparent resistance to computer technology; but instead, student populations at universities and vocational schools are increasing. The question in the minds of Juarenses is not whether computer technology offers great promise, but instead, the question is how to tap its full potential. The final section will attempt to answer this question.

Recommendations

This section will outline recommendations for fostering the development of an indigenous software industry in Juarez, Mexico. Many of these suggestions apply to other developing countries as well. The recommendations are based on research by Kenneth Flamm, Senior Fellow at The Brookings Institute, Robert Schware, official at the World Bank, and the author's own experience in the international software industry for the past 16 years.

Invest in People

The most important goal is to invest in the skills of the people. Without highly trained people, a successful software industry is not possible. The most obvious starting place is to increase funding to the local universities. The universities need to pay a competitive wage in order to attract and retain qualified teachers. This can be accomplished by raising tuitions, increasing government funding, and by encouraging local taxpayers to invest. Juarenses can afford to pay higher tuition and local taxpayers will invest, providing the funds are used properly. A plan similar to the new pension (SAR) and housing fund needs to be evaluated. The new plan completely revamped the old "dark-hole" housing fund by allowing businesses to deposit money directly to the employee's bank account, instead of paying a government agency that never seems to provide a service. Since businesses are already paying a university tax, the first step is to evaluate the success of this method of taxation and administration.

Select a Non-Proprietary Automation Strategy

A developing country should base its automation strategy on non-proprietary technology. As stated earlier, this provides more long-run flexibility and tremendous cost savings because computer programs are portable across a wide variety of computer hardware. This enables software engineers to easily move computer programs to the latest in hardware technology without having to re-write the programs. A country should select two non-proprietary operating environments like UNIX and MS-DOS, in order to avoid the problems of being too dependent on one operating system. There are two good ways to implement this strategy. The first is to provide incentives to universities to teach students non-proprietary technology. IBM proved a long time ago that whatever a student studies, he/she buys. The other method is to require all sales to the Mexican government to be non-proprietary. Many governments (i.e. U.S. and So. Korea) influence technology very effectively in this manner.

Encourage Automation Standards

Automation standards are a further refinement of a non-proprietary strategy mentioned above. Standards should be defined in the following areas: user interfaces, communication protocols, network, image, file formats and other areas. The same benefits of non-proprietary technology of flexibility, and cost savings are achieved by defining standards. There are additional benefits, like ease-of-use, and integration/exchange of information among users. If all programs use the same type of user interface, it is easier and faster to train computer users. For example, with a common user interface, the print command in spreadsheets is identical to the print command in word processors; therefore, the user only has to learn one command, which works for both programs. With communication standards, users are also able to easily exchange information electronically. These standards will lower costs, improve productivity, and ensure long-run flexibility. The Mexican government can encourage standards the same ways it encourages the purchase of non-proprietary technology.

Identify Niches in National Market for Applications

There are a large number of untapped niches in the Juarez market where local developers have a comparative advantage over suppliers from the U.S. or Mexico City. The locals should focus on applications (as opposed to systems software) in the areas of general accounting, payroll, customs accounting, inventory control, invoicing, and other similar applications. Even though the local developers have already tried and failed to exploit these niches, they should continue until they get it right. They should not run the risk of trying to export or of re-inventing the "wheel" with applications that already exist.

Use Software Development Methodologies

Mexican universities should train engineers to follow proven software methodologies. This will teach developers the importance of following the proper steps when creating computer software. It will avoid poor designs, reduce development time, force discipline and improve overall quality. Most importantly, it will insure that the application meets the precise needs of the user who often cannot explain his/her needs in sufficient detail. Once again the government can encourage the adherence to development methodologies by supporting universities and requiring all government contractors to follow one.

Build Alliances and Import Software Technology

The Mexican government should encourage the formation of alliances between national firms and foreign technology providers. In most cases, the national educational institutions cannot provide all the knowledge that is critical to successful software development. Successful software development requires more than good technical skills which is often taught in universities; it requires an understanding of the application area. Ideally, nationals should work inside organizations and institutions with demonstrated expertise. EDM International is a case in point where the company has formed alliances with world-class software developers. The best way for the government to pursue this recommendation is to improve the quality of education, minimize protectionist policies, encourage automation standards, and other actions which make doing business in Mexico attractive. There is no need to provide special incentives other than the ones already in place through the maquila program.

Enforce Copyright Laws

In order to encourage indigenous development of packaged software, it is imperative that the government enforce its new copyright laws. The enforcement must be swift, consistent and fair. Most of the software development will come from small thinly capitalized companies that cannot afford a costly and complicated court procedure. Effective and efficient dispute settlement is the key to the success of this new law.

Decentralize Technology Decisions for Government

The Federal government needs to include local engineers and users in the selection, development and implementation of information technology. Since the government is the single largest purchaser of technology, it can have an immediate and profound impact on fostering local software skills by allowing locals to participate in all phases of automation.

Maximize Applications of Computers.

As stated earlier, there are enormous economic benefits of computer use due to steep declines in computer price-performance being passed on to the user. Given the actual behavior of computer prices, it appears that the innovators in the computer industry have not earned a significant technological rent that innovators in other industries typically enjoy. Through intensive competition, the prices of new innovations decline rapidly so that the benefit of the technology is passed directly to the computer user. Successful users are a prerequisite to a successful software industry.

Minimize Government Intervention

As previously stated, the government's current policies do not restrict or charge high duties on the importation of computer technology. These policies need to be continued because protectionism can have a significantly adverse affect on the development of an indigenous software industry. Since computers have about a -1.5 price elasticity, an increase in computer prices due to a tariff will significantly reduce demand (Flamm 1989, p.30). Many software developers indicated that past policies requiring licenses and high duties significantly impaired their ability to access computer technology. One software engineer stated that non-intervention is the best policy that the government can have for the software industry. He would be satisfied with no government assistance with the other recommendations, providing the current non-interventionist policies are maintained. Given enough time, the other obstacles will be overcome.

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Danny Lee Vickers graduated from the University of Texas at El Paso with a Bachelor of Business Administration degree in 1977. While in college, he joined Holguin Corporation, a worldwide software supplier, as chief financial officer. During his nine years with Holguin Corporation, in addition to chief financial officer, he held the titles of vice-president of finance, vice-president of international, executive vice-president and president. During his tenure, he traveled to over 30 countries in order to establish distributors for the company's computer-aided design software products. Upon leaving Holguin Corporation, he started an international trading company that represented foreign manufacturers in the Far East region. In 1988, he established Electronic Data Management International, a data services company in Juarez, Mexico. Today, EDM is the largest diversified data services company in Mexico.