

**ARE BAJA CALIFORNIA'S MAQUILADORA
PLANTS COMPETITIVE?**

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Introduction: The future of manufacturing in Baja California

For at least two decades, the most dynamic part of regional manufacturing has been the maquiladora industry in Baja California. With growth rates of 10-12% per year up until its peak in October, 2000, maquiladora-based manufacturing has been one of the engines of regional employment and income growth since at least the mid-1980s. Consequently, the unprecedented magnitude of the current downturn has quite a few people worried about the future of the maquiladora in particular, and manufacturing in general.

Both the national and local media have begun to question the long-run viability of an industry that sprang from a set of tax benefits that seem to be disappearing and that grew on low wage, unskilled, assembly jobs.² Add China's entrance into the WTO to a mix that already included currency meltdowns in East Asia, a recession in the US industrial sector, and a great deal of tax uncertainty and confusion brought on by Article 303 of the NAFTA, and the maquiladora industry looks wobbly.

This paper attempts to address a fundamental question about the long-run viability of the maquiladora industry. It focuses on the two most dynamic parts of the industry at the national level, electronics and autoparts, but it limits its sample to the two main centers of production in Baja California, Tijuana and Mexicali.³ The goal of the paper is to answer questions about the long-run viability of manufacturing. Since the future is by definition unknowable, rather than trying to make predictions, we concentrate on the fundamental question of whether electronics and autoparts plants are prepared for global

²For example, *Businessweek*, "The decline of the maquiladora," April 29, 2002, and *The Union Tribune*, "Mexico's maquiladoras rebound, but will it last?," May 31, 2002.

³ In Baja California, autoparts are relatively unimportant and make up less than 20 percent of the sample plants analyzed; on a national basis, however, autoparts are one of the two most important sectors.

competition. That is, are the plants as presently constituted capable of competing from their base in this region in a head-to-head competition with the world's best?

Our working hypothesis is that internationally competitive firms are more likely to stay in their current locations and to provide more stability to their employees and communities. There is a growing literature in support of this proposition (summarized by Lewis and Richardson, 2001), and it does not seem to violate common sense to argue that globally competitive firms generate more benefits than uncompetitive firms.

We believe we can say something new on this issue due to the release of an important new survey of electronics and autoparts (COLEF, 2002). Teams of researchers⁴ from El Colegio de la Frontera Norte (Colef) in Tijuana used funding from Conacyt to administer an in-depth survey of technology and industrial upgrading in the two sectors examined. The survey was administered to firms in Ciudad Juarez, Mexicali, and Tijuana, and we limit ourselves in this paper to the most relevant geographical areas, namely Tijuana and Mexicali. This is part of an extensive study "Technological Learning & Industrial Upgrading: Building Innovation Competencies in the Maquiladora Industry" with others teams researchers from Universidad Autónoma Metropolitana (UAM) and Facultad Latinoamericana de Ciencias Sociales (FLACSO).

A survey of such length has many parts to it, and we will present just a few aspects that summarize one important issue: Is there upgrading in Baja California?. Rather, we view this paper as a fairly narrow overview of issues related to competitiveness in electronics and autoparts maquilas of Tijuana and Mexicali. In order to set the stage for a discussion of the survey, we find it useful to begin with an introduction to some recent work on foreign investment and the factors that enable or inhibit its contribution to the international competitiveness of an industry and an economy.

The product cycle

Raymond Vernon's theory of the product cycle (Vernon, 1966) provided one of the first and best explanations for the role of foreign direct investment in the corporate strategies of multinational corporations. Vernon's work aimed at explaining why capital in high income industrial economies did not flow more quickly to less developed economies, but it also highlighted the relationship between parent companies and their foreign subsidiaries and clarified the role of foreign investments in the overall international competitive strategy of multinationals.

This work is particularly relevant to Baja California. Between 1994 and 2000, Baja California received \$4,507 million in foreign direct investment (FDI), an amount surpassed only by the Federal District and the state of Nuevo Leon. Over 94% of the amount invested in Baja California went into manufacturing, with more than \$2 billion (47%) of the total directed towards the electronics and electrical equipment sector (Secretaría de Economía, 2000). Within the auto and electronics sector maquilas in Baja California, 75% of the firms have 100% foreign owned capital (U.S., Japanese, or Korean) (COLEF, 2002).

In the product cycle model, firms use a combination of innovation, market power gained from being the first to enter a particular product market, and transitory barriers to entry, to earn higher than normal profits. The model is particularly useful and descriptive in consumer goods markets, such as consumer electronics, where branding and marketing play important roles in exploiting innovations and enforcing market power. Exports to high income countries follow production in the home-country, but the technological

⁴ Jorge Carrillo Coordinator, COLEF Researchers: Araceli Almaráz, Rocio Barajas, Redi Gomis, Alfredo Hualde and Marta Miker.

capacity of those countries makes it relatively easy for their firms to copy products and production processes. Hence, FDI in high income countries follows quickly.

Eventually, competition in the high income markets forces firms to look for ways to strengthen their competitive positions internationally. The desire to gain an advantage over producers based in high income countries leads to the outsourcing of component production in developing countries, followed eventually by larger and larger shares of overall production in developing country markets.

In 1966, Vernon argued that firms would need to tightly integrate their global production as part of their overall international competitive strategy, a point that was amply demonstrated by the work of Stopford and Wells in 1972. Integration of the host country's subsidiary into the competitive strategy of the home country's parent firm naturally led to tensions between host country governments and foreign controlled firms. In particular, host country governments feared that so-called screwdriver plants⁵ would undermine or completely eliminate the benefits of FDI for economic development. This would happen, it was feared, as a result of doing all the skilled and high value added work outside the host country. Consequently, many host country governments put conditions and restrictions on FDI as a means, in their view, to ensure that some of the benefits of FDI spilled over into the local economy. These conditions often limited the ways in which parent company investors could integrate their foreign subsidiaries into an international strategy, and often led to foreign investments becoming "cash cows" which produced for the (often highly protected) local market, and helped to raise profits for the parent company, but that were not integrated into a global economic strategy.

⁵ The term stems from the notion that all a host country would have to do is to turn a couple of screws and the plant would be up and running.

The dichotomy in foreign owned firms

Foreign owned firms tend to have relatively distinct characteristics that depend significantly on whether they are part of their parent company's international strategy or are simply a means for the parent company to profit from the specific national market where they are located. Moran (2001) identifies several differences between these two types of foreign owned firms. Plants that are integrated into the parent company tend to:

- be wholly owned by the parent company;
- export a large fraction of their total output;
- fully utilize economies of scale in production;
- follow best practices in management, quality control and production technology;
- upgrade their management techniques, quality control, and production methods more often;
- provide more human resources training.

All of the above—and their opposites—are visible in the survey of electronics and autoparts maquila in Tijuana and Mexicali. That is, these two industrial sectors contain both elements of the dichotomy emphasized by Moran. Some firms are at the technology frontier, providing high levels of training and following best practices in all the relevant areas of business operations. These firms are an important part of the international strategy of the parent company, and are likely to weather short-run and medium-run cyclical fluctuations caused by such factors as a slowdown in US industrial production or an overvalued peso. Other firms in the region lag behind the all the frontiers, whether in technology, skills and training, or any other indicator of competitiveness.

In order to see this dichotomy more clearly, we turn to the literature on the maquiladora industry and to the recent survey of electronics and autoparts maquilas in Tijuana and Mexicali. The next section examines a variety of areas that directly relate to the characteristics of highly integrated firms enumerated by Moran.

Industrial upgrading in the maquiladora industry

Both the autoparts and electronics industries began with plants that assembled simple parts using processes that are intensive in the use of unskilled labor. Over time, plants that are intensive in the use of technology and skilled labor began to appear (Carrillo and Hualde, 1996; Lara Rivero, 1998; Dutrenit, Garrido, and Valenti, 2001). This “industrial upgrading” in the maquiladora industry, or moving up “the ladder of comparative advantage,” has been described as an evolution from first to second to third generation maquiladoras (Carrillo and Hualde, 1996).⁶ While these designations are essentially metaphorical, they are a useful taxonomy for representing both change over time and the differences between firms at a given point in time. That is, first generation maquilas coexist with second generation, and they both coexist with third. In the survey results described below, there is substantial evidence for all three types.

First generation plants are simple assembly operations that use relatively unskilled, low wage, labor. Although this type of production requires an industrial labor force (or must generate one), issues of quality control and technological complexity of the products and processes are minimally important.

Since the 1980s many researchers have noted that some maquiladoras were implementing, or had implemented, organizational changes associated with Japanese manufacturing techniques, including work-teams, quality circles, worker “multi-qualification,” and others (Mertens and Palomares, 1988; Brown and Dominguez, 1989; Carrillo and Ramirez, 1990; Wilson, 1992; Carrillo, 1993; and Contreras, 2000). Carrillo and Hualde (1996) designated this the second generation of maquiladoras, with the

intention of singling out plants with higher degrees of decision making autonomy, more advanced manufacturing technology, including automation or semi-automation, higher levels of participation by engineers and technicians, and a clear emphasis on product quality.

The third generation of plants have characteristics that include an intensive focus on the use of information technology, along with the development of R&D capacity, and advanced manufacturing capabilities (Carrillo and Hualde, 1996). Data on the number and relative importance of third generation maquiladora plants are unsystematic,⁷ and none of the researchers that have studied the emergence of third generation plants tries to claim that this is an inevitable evolution for all plants. Rather, the case is made that some plants are evolving much more advanced production processes, and are able to produce complex products which are at the industry frontier.

Television production illustrates this evolution. It has evolved from making wooden cabinets (labor intensive, simple commodities) to flat panels, and digital and high definition television sets (Lara Rivero, 1998; Barajas Escamilla, 2000; and Carrillo, 2001a.) A number of plants, for example Sony, Samsung, RCA, and Philips, have their own R&D, particularly in product design, and they manufacture under their own labels and those of other companies. As is obvious when comparing wooden cabinets to flat panels, the level of technology embodied in the products has risen substantially. Even within some standardized products, however, such as wiring harnesses for autos,

⁶ Gereffi and Tam (1998) discuss “industrial upgrading” from the disciplinary perspective of the sociology of labor. Bhagwati (2002) describes the “ladder of comparative advantage” from the perspective of trade economics. Bhagwati attributes the term to the late economist Bela Belassa.

⁷ This is one of the research gaps that the COLEF survey “Aprendizaje Tecnológico y Escalamiento Industrial” attempts to fill.

embodied technology and the rate of technological change is very high (Carrillo and Hinojosa, 2000).

Additional evidence of technological evolution and industrial upgrading in the maquiladora industry is provided by the development of greater decision making autonomy at the local level. Purchases of equipment, selection of suppliers, changes (improvements) in manufacturing processes, selection of manufacturing technology, product design, and other decisions have become more common (Carrillo, Mortimore and Alonso, 1999; Buitelar, Padilla, and Urrutia, 1999; Katz and Stumpo, 2001). The development of greater local autonomy has gone hand-in-glove with increases in quality standards and the use of more skilled labor. Engineers, in particular, have come to play a greater role in maquiladoras (Colef, 2001; Hualde, 2001).

While the primary emphasis of the discussion so far has been on technological changes, organizational changes are also important and a number of studies demonstrate the transfer of new management models. In particular, Taddei (1992) and Kenney and Florida (1994) describe the application of “Japanese production systems” in Japanese maquilas since the mid-1980s. Lara Rivero (1998) and Contreras (2000) show that many Japanese firms have successfully implemented “flexible organizations” and “learning organizations.” In Lara Rivero, the case is made that many Japanese firms have introduced the concept of “continuous learning” through individual worker responsibility for quality control, quality circles, and learning through mistakes. Contreras compares electronics firms in Japan with Japanese owned maquilas and concludes that the latter are effectively organized around the concept of continuous improvement (*kaizen*).

Characteristics of the electronics and autoparts sectors in Tijuana and Mexicali

The electronics and autoparts sectors comprise the two largest and most dynamic manufacturing sectors in the northern border region. The COLEF survey (COLEF, 2002) was administered to 180 maquiladora plants in Baja California. We are using a sample of a 105 maquiladora plants, 83 in the electronics sector, 19 in autoparts, and 3 that produce for both sectors. The definition of the electronics sector is fairly general, but the vast majority of the plants are classified in branches (ramas) 3823, 3831, 3832 of the Mexican economic classification system, Clasificación Mexicana de Actividades y Productos (CMAP). Respectively, these are (1) manufacture and assembly of office, calculating, and information processing machinery, (2) manufacture and assembly of electronic machinery, equipment, and accessories, including for the generation of electrical energy, and (3) manufacture and assembly of electronic audio-visual, communications, and medical equipment (INEGI, 1999). In 1998, the last economic census in Mexico counted 275 firms in these three sectors, with more than half (143) in the audio-visual, communications and medical equipment manufacturing sector (branch 3832). Taken together, these three sectors employed 87,232 workers in 1998, or about 17% of total state employment. Additional descriptive statistics for the sample of plants are contained in the appendix.

Ownership, exports and scale economies

As discussed above, plants that are integrated into the parent company's international economic strategy tend to have a variety of characteristics such as 100% parent company ownership, a large share output that is exported, and full use of economies of scale in production. Of the 105 firms surveyed, 85 are 100% owned by

their parent company (77 of 105 if the Mexican owned firms are excluded; see Appendix). The advantage of 100% ownership is that it gives the parent company greater protection of its innovations and other elements of its business strategy.

A second characteristic of dynamic foreign-owned firms is that they tend to export more, while foreign-owned firms that are not part of a global strategy tend to produce for the (often highly protected) local market. Of the firms in the sample, 83 firms (79%) export 100% of their product while only 4 firms (4%) export 0%. This is perhaps mainly due to the history of the maquiladora industry and its requirement that output be exported. However, the requirement is no longer in place, and regardless of the ultimate reasons for such a high proportion of exports, it is consistent with the profile of internationally competitive firms.

A third characteristic of firms is that they take full advantage of economies of scale. On the other hand, firms that produce for a local market tend to be smaller than average. This often raises production costs since the minimum efficient size for many lines of production is greater than the demand in the local market can sustain. In the Tijuana-Mexicali sample, the median average sized firm is 200 workers. The largest 21 plants (20% of the sample) have 650 or more workers, and the largest 10 plants (10% of the sample) have 1400 or more.

In order to provide some perspective on economies of scale, Table 1 compares US and Baja California plant sizes in electronics and transportation equipment sectors.

These are mean averages (workers divided by plants) rather than median averages, and they cover all plants in the two sectors, not just maquilas. Although Baja California's maquilas tend to be smaller than in other states (e.g., Chihuahua), comparison of similar

sectors in the US and Baja California indicate that, if anything, they are larger than in the US.

Table 1: Evidence on scale economies

	<i>Workers per plant</i>	
	<i>Electronics*</i>	<i>Transportation equipment</i>
Baja California (1998)**	313	185
US (1997)	94	143

*CMAP branches 3823, 3831, 3832 in Mexico; NAICS codes 334, 335 in the US. **Baja California data are for all firms, both maquila and non-maquila. Sources: INEGI, 1999; US Census Bureau, 2001.

Product differences between the US and Mexico make a direct comparison relatively weak, but it does indicate that there is no simple evidence pointing to a lack of economies of scale. Indeed, given its export orientation toward a world market, the scale of operations in profitable plants requires a minimum efficient size.

Best practices and industrial upgrading

Management practices, quality control, and production technology all stand out in the survey. What is remarkable is the heterogeneity of the industry. Survey questions directed towards uncovering information about the level and rate of change of industrial technology and management practices, portray a maquiladora sector with a wide range of practices.

Table 2 illustrates this point. Firms were asked to rank their technology compared to the world level. As shown, more than one-third thought they were comparable to the best, but one-fourth were 5 to 10 years behind.

Table 2: Technology compared to the world level

<i>Level</i>	<i>Percent of firms</i>
Comparable to the best	35
1-2 years behind	21
5-10 years behind	25

Fuente: Encuesta Aprendizaje Tecnológico y Escalamiento

Industrial en Plantas Maquiladoras, COLEF, 2002.
 Proyecto Conacyt no. 36947-s “Aprendizaje Tecnológico y Escalamiento Industrial. Perspectivas para la Formación de Capacidades de Innovación en las Maquiladoras en México”, COLEF/FLACSO/UAM.

Plants at the technology frontier have capabilities that go beyond assembly and manufacturing. Table 3 contains survey results showing that over one-fourth of plants surveyed engage in research and development (R&D), one-fifth do product design, and over one-tenth of the plants have developed a patent. For the minority of firms with these characteristics, and perhaps for many others as well, international competitiveness is a matter of the application of technology and skill.

Table 3: Indicators of industrial upgrading

<i>Activity</i>	<i>Plants actively engaged</i>
Research and development	27%
Product design	20%
Product testing	82%
Developed a patent	11%

Fuente: Encuesta Aprendizaje Tecnológico y Escalamiento Industrial en Plantas Maquiladoras, COLEF, 2002.
 Proyecto Conacyt no. 36947-s “Aprendizaje Tecnológico y Escalamiento Industrial. Perspectivas para la Formación de Capacidades de Innovación en las Maquiladoras en México”, COLEF/FLACSO/UAM.

ISO certifications are another indicator of the use of best practices. The International Organization of Standards (ISO) is a network of national standards institutes that claims participation by over 140 countries (<http://www.iso.ch/>). Initially, it limited its standards-setting activities to highly specific technical standards, mostly of use to engineers, but in 1987 it began a program to certify generic management system practices (ISO 9000), aimed at ensuring that businesses are capable of delivering the product or service that its customers require. The ISO 9000 series was followed in 1997 by the ISO 14000 series of environmental standards, aimed at ensuring that a plant’s production processes minimize the harmful effects they have on the environment. Table 4 shows the share of plants attaining different kinds of ISO certification.

Table 4: ISO Certifications

<i>ISO Certification</i>	<i>Number certified (%)</i>	<i>Number in process</i>	<i>Number certified in last 3 years</i>
Management systems			
9000	11 (10)	5	7
9001	24 (23)	4	11
9002	37 (35)	4	17
Env. control systems			
14001	16 (15)	2	13
14002	3 (3)	0	3

Fuente: Encuesta Aprendizaje Tecnológico y Escalamiento Industrial en Plantas Maquiladoras, COLEF, 2002. Proyecto Conacyt no. 36947-s “Aprendizaje Tecnológico y Escalamiento Industrial. Perspectivas para la Formación de Capacidades de Innovación en las Maquiladoras en México”, COLEF/FLACSO/UAM.

Given that the ISO 14000 certifications are newer (created in 1997), fewer plants have obtained them. Note that ISO 9001 are relevant to plants that do R&D, and the percentage of plants claiming to have ISO 9001 is nearly the same as plants that claim to do R&D.

Tables 2, 3, and 4 indicate that perhaps one-fourth of the maquiladora in the electronics and autoparts industry could be considered third generation. This group is joined by another 10-15% of plants that do not do R&D or product design, but that are at the technology and management frontiers of their industry. In sum, between 30 and 40% of the plants sampled are “comparable to the best” (Table 2).

An additional 10-25% share of the plants is not far behind. Table 2 shows that 25% of the plants are 1-2 years behind world levels, and Table 5 shows that a relatively large share of plants is actively upgrading their technology and especially their management skills and product quality. Sixty percent of plants have increased their level of engineering input over the last three years, 78% have increased their management skill levels, and fully 80% of the respondents said that the quality of their product had improved.

Table 5: Indicators of competitiveness

<i>Activity/area</i>	<i>Changes over the last 3 years</i>	
	<i>Increased (%)</i>	<i>Decreased (%)</i>
Market share	52	22
Number of customers	42	23
Complexity of production	52	12
Automation	38	5
Quality of product	81	1
Level of engineering input	60	2
Management skill level	78	1
Rejects for quality reasons	na*	94

*Unknown whether quality rejects increased or stayed the same.

Fuente: Encuesta Aprendizaje Tecnológico y Escalamiento Industrial en Plantas Maquiladoras, COLEF, 2002. Proyecto Conacyt no. 36947-s “Aprendizaje Tecnológico y Escalamiento Industrial. Perspectivas para la Formación de Capacidades de Innovación en las Maquiladoras en México”, COLEF/FLACSO/UAM.

Tables 6 and 7 are similar to Table 5, but focus on technology. Whereas in Table 5, 52% of the respondents said the complexity of production had increased in the last three years, in Table 6, 50% said technological innovation in production processes were relatively frequent. One might infer from Tables 6 and 7 that the upgrading of production processes is connected to the upgrading of information systems, an area where many firms have been active investors (Table 7).

Table 6: How common is technological innovation?

<i>Activity/area</i>	<i>Innovation in the last 3 years</i>	
	<i>Frequently (%)</i>	<i>Never (%)</i>
Equipment	29	38
Processes	50	20
Products	30	38
Information systems	45	17

Fuente: Encuesta Aprendizaje Tecnológico y Escalamiento Industrial en Plantas Maquiladoras, COLEF, 2002. Proyecto Conacyt no. 36947-s “Aprendizaje Tecnológico y Escalamiento Industrial. Perspectivas para la Formación de Capacidades de Innovación en las Maquiladoras en México”, COLEF/FLACSO/UAM.

Table 7: Information technology investments in last 3 years

<i>Important investments in last 3 years</i>	<i>Percent of firms</i>
Computational resources	83
Computers	81

Median number per plant: 24	
Plants with Internet: 98%	
Software	70
Cables, telecommunications, etc.	70

Fuente: Encuesta Aprendizaje Tecnológico y Escalamiento Industrial en Plantas Maquiladoras, COLEF, 2002. Proyecto Conacyt no. 36947-s “Aprendizaje Tecnológico y Escalamiento Industrial. Perspectivas para la Formación de Capacidades de Innovación en las Maquiladoras en México”, COLEF/FLACSO/UAM..

Human resources

According to Moran (2001) and others, subsidiaries that are integrated into the international competitive strategy of their parent company provide more training and upgrading of human resources than plants that are not similarly integrated. This follows from their need to stay abreast of current trends and developments. Tables 8 and 9 shed some light on the relative importance of skills and training in the local electronics and autoparts maquila.

Table 8: Skills, training, and education

	<i>Changes during the last 3 years</i>	
	Percent of firms with increases	Percent of firms with no change
Number of engineers	33	43
Number of professionals	36	44
Education level of workers	46	54
Skills	63	35
Hours of training	51	42

Fuente: Encuesta Aprendizaje Tecnológico y Escalamiento Industrial en Plantas Maquiladoras, COLEF, 2002. Proyecto Conacyt no. 36947-s “Aprendizaje Tecnológico y Escalamiento Industrial. Perspectivas para la Formación de Capacidades de Innovación en las Maquiladoras en México”, COLEF/FLACSO/UAM..

Table 8 shows that one-third of the firms sampled experienced increases in the number of engineers, and a slightly higher 36% saw an increase in the number of professionals. Again, this is roughly the same percentage as firms that consider their technology comparable to the best (35% Table 2), or that have obtained ISO 9002

certification (37%, Table 4), and slightly more than the percent doing R&D (27%, Table 3).

Table 8 also sheds light on the lagging firms. Between 40-45% of the firms have not increased their hours of training, or the numbers of professionals and engineers employed in the plant. This is consistent with Table 6, which shows that just under 40% of the plants have not innovated equipment or products over the last 3 years (Table 6) and 46% are more than 2 years behind the technology frontier (Table 2).

Table 9: On-the-job learning for engineers and technicians

<i>Primary method</i>	<i>Percent of plants</i>
Formal work groups	22
At the parent company	21
Individual practice	18
On-site training offered by the parent company	16
Courses at local institutions	16
Informal work groups	7

Fuente: Encuesta Aprendizaje Tecnológico y Escalamiento Industrial en Plantas Maquiladoras, COLEF, 2002. Proyecto Conacyt no. 36947-s “Aprendizaje Tecnológico y Escalamiento Industrial. Perspectivas para la Formación de Capacidades de Innovación en las Maquiladoras en México”, COLEF/FLACSO/UAM.

When foreign subsidiaries of multinationals are integrated into the global strategy of the company, more human resource training occurs. One of the indicators of this fact is that a share of the training takes place via rotations through the parent company’s home branches or offices. Table 9 shows a variety of mechanisms through which training of engineers and technicians occurs, including about 21% of the plants that use training at the parent company as their primary means, and another 16% that use on-site training provided by the parent company. It is interesting to note that 16% of the firms depend on courses at local institutions.

First, second, and third generation maquilas

Technological sophistication does not guarantee a competitive firm. Indeed, the promise of competitive success cannot be guaranteed under any circumstances. Still,

firms that are at the frontier of their industry and that compete successfully in an international arena where national policies offer little in the way of protection, are more likely to succeed in the long run. In part, the discussion of 1st, 2nd, and 3rd generation maquiladora plants is related to the widespread desire to understand the competitive future of the industry. Third generation plants are at a competitive advantage relative to 2nd and especially 1st generation plants, because they can innovate products and processes, apply best-practices management techniques, and compete on the basis of product quality.

The relative importance of 1st, 2nd, and 3rd generation plants is uncertain, in part because the categories themselves are not precisely definable. Based on the data presented, however, a rough accounting for the size of each group can be estimated, at least for the combined electronics and autoparts sectors in Tijuana and Mexicali. Depending on the indicator, somewhere between 25% and 35% of plants seem to be at the technology frontier. This 25-35% accords with the number claiming to be at the frontier of their product category, have ISO certifications, upgrade their equipment and products frequently, and have increases in the number of engineers and technicians.

At the other end, it appears that around 40% of the sample consistently lags. This is roughly the size of the group that is three or more years behind in technology, that has neither ISO 9001 or 9002 certification, that never innovates in equipment and products, and that has not changed the number of engineers, technicians, or hours of training in its plants. These plants are more likely to compete primarily on the basis of prices, rather than product quality or some other feature, and to look for locations with abundant supplies of low-wage, unskilled, labor. The information in Table 10 is consistent with

this view. Forty-one percent of the sample stated that they competed primarily on the basis of price.

Table 10: Primary source of competitiveness

<i>Source</i>	<i>Percent of firms</i>
Quality	43
Price	41
Delivery time	8
Economies of scale	4

Fuente: Encuesta Aprendizaje Tecnológico y Escalamiento Industrial en Plantas Maquiladoras, COLEF, 2002. Proyecto Conacyt no. 36947-s “Aprendizaje Tecnológico y Escalamiento Industrial. Perspectivas para la Formación de Capacidades de Innovación en las Maquiladoras en México”, COLEF/FLACSO/UAM.

What explains the recent downturn?

The primary purpose of this paper is to characterize technological learning and industrial upgrading in the electronics and autoparts sectors of Tijuana and Mexicali’s maquiladora industry. We would be remiss, however, if we did not briefly address the recent decline in the numbers of firms, workers, and production.

In order to account for the layoffs and plant closures over the last 1.5 years, the slowdown in US industrial production has to be taken into consideration. Activity levels in the maquiladora industry are, in part, determined by level of industrial activity in the US (Gerber and Balsdon, 2001; Gruben, 2001; Fenandez and Navarette, 1986). Gerber (2002) provides a relatively succinct analysis based on parameter estimates taken from econometric models developed by Gerber and Balsdon (2001) and Gruben (2001). These two papers employ different models and different statistical techniques to arrive at very similar conclusions. Namely, a 1% decline in US industrial production leads to a decline of just over 1.25% in maquiladora employment nation-wide. The effect, then, of the slowdown in US industrial production is a 8-9% loss of jobs in the maquiladora industry,

or about 40% of the actual job loss (20% of total employment was lost from October, 2000 to April, 2002.)

A second key factor in the current situation is the relative strength of the peso. While the peso has begun to fall very recently, over the last several years, it has increased about 20% in value against the US dollar, and about 30% against East Asian currencies. Given the parameters found in Gruben (2001), the rising dollar cost of Mexican labor may explain another 25-30% of the employment loss.

Taken together with the slowdown in US industrial production, between 65 and 70% of the job loss is easily explainable. Support for this notion comes from the recent turn around in US activity and the very recent decline in the peso. While both factors tend to effect the maquiladora industry with a lag,⁸ employment figures for 2002 show a flattening out in the rate of job loss, and an actual increase in April, 2002.

This still leaves around one-third of the job losses unexplained, for which there are a host of possibilities: China's entry into the WTO, confusion over the new tax rules, both in the area of Article 303 and its replacement (Programa Sectoral) and in the now resolved area of Permanent Establishment, safe harbor, and advance pricing agreements (Gerber, 2001), problems of security, and lack of infrastructure such as the water shortages in Tijuana and the growing energy shortage throughout northern Mexico.

The link between layoffs in the industry and the discussion of 1st, 2nd, and 3rd generation maquiladora should be obvious. Few firms, regardless of their technological or managerial sophistication can be considered free from the effects of business cycles and currency values. Second and third generation firms, however, represent long-term

commitments to the region with greater investments in technology, industrial upgrading, and managerial skills. There can never be a guarantee that these plants will not leave the region,⁹ but they at least have tools that will allow them to cope with the adverse impacts of external economic events.

Conclusion: Manufacturing in the long run

Based on the analysis offered in this paper, electronics and autoparts manufacturing have a solid foundation for a long run presence in the region. Growth will not be constant, however, and a long run decline is not totally inconceivable. From a probabilistic perspective, however, in the long run, expansion seems more likely than decline. The solid foundation of technological upgrading, internationally competitive firms, best practice management skills, constant innovation, and competition on the basis of product quality, make a strong case for production staying in the region in the long run.

This is not to say that plants will not shut down. Approximately 40% of the electronics and autoparts sectors appears very vulnerable to world trends in prices and labor costs. These 1st generation plants may have an advantage to location in Tijuana or Mexicali given that they are part of a larger industrial cluster which has created an industrial labor force and service suppliers, but they are also much more likely to be influenced by rising labor costs since they compete primarily on the basis of the price of their product and to a lesser degree on product quality or timely delivery.

⁸ The lag for the impact of the US slowdown is around seven months; for changes in the value of the peso it is somewhat longer, perhaps 1-2 years. Note, however that US industrial production began to rise last October, and that maquiladora employment followed in April—seven months later.

⁹In a panel of US firms, Davis, Haltiwanger, and Schuh (1996) found that approximately 10% of all manufacturing jobs were destroyed each year in the US, with an approximately equal number created. The rule is that manufacturing is highly innovative and in a constant state of change.

Two issues have not been addressed in this paper. One is the extent to which the electronics and autoparts clusters are representative of overall manufacturing, and another is the problem of linkages to the rest of the economy. These issues are not unrelated if we look at them from the perspective of a cross-border economy. One of the criticisms of the electronics industry is that it is not well-linked to either the local Mexican economy or to San Diego. In the case of San Diego, this lack of cross-border integration in electronics is probably mostly the result of the relative unimportance of manufacturing on the north side of the border, and the lack of a consumer electronics sector in particular. In addition, San Diego's R&D strengths do not match production in Tijuana, located as they are in wireless communication, digital media, and biotechnology.

Still, the future may hold some hope of cross-border industrial integration in ways that serve both sides. In particular, the growing maquiladora sector of medical devices and equipment is geographically well-positioned to take advantage of an area of strength in San Diego. The San Diego Association of Governments (1998) identified this sector as a regional (San Diego) cluster, employing more than 6,000 workers north of the border in 1996, and feeding off the R&D and high technology capacity of local firms, universities, and hospitals.

And finally, the issue of linkages to the local Mexican economy has not been addressed. The Colef survey sheds light on this issue, but it is a separate topic with too many elements to be addressed in this paper. A couple of points are worth mentioning, however. One is that a number of linkages have been created to local service suppliers, such as transport (cargo and people), maintenance firms, finance (on the San Diego side of the border), food service, and others. In addition, it is possible that there is an

undercount of parts and components suppliers due to the mis-counting of trade between maquilas. Even if the linkages are weak, however, the other benefits of foreign direct investment, namely technology transfer and skill creation, seem strong.

Appendix
Characteristics of the Tijuana/Mexicali sample

105 firms:

- 76 in Tijuana;
- 29 in Mexicali.

2 sectors:

- 83 electronics;
- 19 autoparts;
- 3 both.

Ownership:

- 50 firms 100% US owned;
- 14 firms 100% Japanese owned;
- 13 firms 100% Korean owned;
- 8 firms 100% Mexican owned;
- 20 firms of mixed ownership.

Exports:

- 83 firms (79%) export 100% of their product;
- 4 firms (4%) export 0%.

Size:

- 60 or fewer workers: smallest 20% of plants;
- 120 or fewer workers: smallest 40% of plants;
- 200 workers: median;
- 650 or more workers: largest 20% of plants;
- 1400 or more workers: largest 10% of plants.

Distribution of workforce by occupation:

- Production workers, median share: 80%;
- Technicians, median share: 7%;
- Administrators, median share: 8%;
- Directors and managers, median share: 2%.

Average number of engineers per plant: 4.

Share of workers with maquiladora experience prior to current job: 80%.

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