Industrial Structure and Innovation: Notes Toward a New Strategy for Industrial Development in Mexico*

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1 Introduction

Despite a recent uptick, Mexico's growth over the past three decades is widely viewed as disappointing. It was not supposed to be this way. Beginning in the mid-1980s, Mexico embarked on an ambitious set of liberalizing reforms, culminating in the North American Free Trade Agreement in 1994. It privatized state-owned enterprises, loosened restrictions on foreign ownership, and generally sought to reduce the role of government in the economy, all along the lines of the "Washington Consensus" views dominant in international economic institutions at the time. Advocates of reform asserted confidently that rising average incomes would follow.

But as papers in a recent symposium in the *Journal of Economic Literature* have pointed out, the reforms have not delivered the expected growth (Hanson, 2010; Kehoe and Ruhl, 2010). Figures 1-3, drawn from Hanson (2010), plot GDP per capita in Mexico against three groups of countries of roughly similar average income and population, from Latin America, Southeast Asia, and Eastern and Central Europe, respectively, with the level of income normalized to zero in 1980. Over the 1980-2008 period, Mexico has been clearly outperformed by Chile, Malaysia, Thailand, Indonesia, Turkey, Hungary and Bulgaria. Mexico is in a league with Brazil, Argentina, the Philippines, and Romania, none of which has adhered as faithfully to orthodoxy. Mexico convincingly beats only Venezuela. Disappointing, indeed.

A number of explanations have been advanced for Mexico's mediocre performance. Some argue that the main culprits are monopoly and inefficient regulation (Arias et al, 2010, Chiquiar and Ramos-Francia (2009)), others that credit markets are poorly developed, especially for commercial lending (Haber, 2004), still others that informality imposes high costs (Levy, 2008), or that corruption and, in recent years, drug violence impose a major drag on the economy. Each of these explanations has merit, and is likely to be part of the story.

Without discounting these possibilities, in this paper I would like to explore a different explanation, namely that the Mexican manufacturing sector has failed to move quickly enough into higher-value-added, higher-quality, more skill- and capital-intensive activities, and that this has left the sector vulnerable to competition from lower-wage countries, notably China. This is not a new hypothesis,[1] but my account will differ in emphasis from existing work, and in particular will focus more on the relationship between the pattern of industrial specialization and the rate of innovation in the manufacturing sector.

Many discussions of Mexico's recent growth experience implicitly or explicitly portray Mexico

[1] See, for instance, Gallagher and Zarsky (2007) and Moreno-Brid and Ros (2009); Hanson (2010) considers the argument briefly.

as a victim of bad luck. In this common view, liberalization was paying dividends and underlay the rapid growth of manufacturing employment in the latter half of the 1990s, thereby helping to pull the economy out of the peso crisis. But then the economy got hit by an unforeseen shock, China's expansion on world markets, and the economy has undergone a period of readjustment. In this view, once China's wages rise a bit more and manufacturing reallocates to activities consistent with Mexico's current comparative advantage, growth is expected to resume.

In the interpretation I would like to advance, in contrast, Mexico's current predicament is not solely an instance of unfortunate timing. I argue instead that the process of international integration in the late 1980s and 1990s, coupled with the particular set of policies in place, tended to lead Mexican manufacturers to specialize in activities with low rates of innovation. While this appears to have been consistent with Mexico's comparative advantage at the time, it also tended to reduce the extent of upgrading, with the consequence that productivity growth in manufacturing has not been sufficient to drive sustained growth in the economy as a whole. In this view, the slowdown in Mexican manufacturing would likely have occurred even without the entry of China. Perhaps it would not have occurred as quickly, and not in the same way. But eventually Mexico would have faced competition from lower-wage countries that were learning how to produce more sophisticated products, and a similar story would likely have unfolded. Mexico has been facing a generic problem of industrial development in middle-income countries: how, in the presence of market failures in the learning process, to continue to move up the ladder of quality and technological sophistication, while staying ahead of poorer countries trying to move up the same ladder. It is not clear that market processes alone would have solved this problem.

Although this assessment may sound pessimistic, it is important to emphasize that integration has had complex effects. There is evidence of upgrading in Mexico, and in part it appears to have been stimulated by increased exports. Moreover, there is no reason to think that the Mexico's disappointing growth has been inevitable. An alternative set of industrial policies may have led — and may still lead — down a very different path. At the end I will offer some general thoughts on what such a set of policies might look like.

Let me be clear from the outset that this interpretation of Mexico's recent industrial evolution is precisely that — an interpretation — and although I believe that it is consistent with the current state of economic knowledge, at certain points it goes beyond what can be stated with confidence on the basis of rigorous empirical studies. I will try to be clear about where more research is needed as we proceed.

The paper is organized in three main parts. The next section asks "What happened?" and sets out some salient facts about Mexico's industrial structure and how it has changed in the since the beginning of Mexico's reform period. Section 3 asks "Why did it happen?" and advances a hypothesis about the links between the pattern of specialization and innovation. Section 4 asks "What to do?" and offers some general thoughts to guide the formulation of industrial policies.

2 What Happened?

This section highlights three dimensions of Mexico's recent industrial evolution: the pattern of specialization across industries (Subsection 2.1); differences between *maquiladora* (assembly-for-export) producers and non-maquiladora producers (Subsection 2.2); and differences in the response to international integration between exporters and non-exporters among non-maquiladora plants (Subsection 2.3).

2.1 Reallocation Across Industries

With the trade reforms of the 1985-1994 period, Mexico shifted quickly from being a relatively closed economy to being a relatively open one. The traditional model economists use to think about the integration of a country like Mexico with a richer country like the U.S., Mexico's overwhelmingly most important trade partner, is the Heckscher-Ohlin model, developed by two Swedish economists in the 1930s. In the simplest version of the model, there are two countries, two goods, and two factors of production. Let's think of the factors of production as skilled and unskilled workers, although one could also think of them as labor and capital. The model predicts that integration will lead the country that has relatively more unskilled workers, Mexico in this case, to specialize in producing goods that require an especially high proportion of unskilled labor in production, and that the more skill-abundant country will specialize in the other direction.

It turns out that this simple model does remarkably well in describing changes in Mexico's industrial structure in the first decade after the beginning of Mexico's reform period. Figure 4 plots the growth of employment for the period 1988-1998 against the share of employees with 12 or more years of schooling, by 4-digit industry. The endpoints are chosen because the employment data come from Economic Censuses conducted by INEGI, the Mexican statistical agency, every five years, with 1988 the first available after the beginning of reform. The schooling data are from the 1999 *Encuesta Nacional de Empleo, Salarios, Tecnología y Capacitacíon* (ENESTyC), a representative survey of manufacturing plants, also conducted by INEGI, which mainly reports information for 1998.[2] Below we will focus especially on three sets of industries in which maquiladoras play a particularly important role — apparel and textile products, electrical and electronic equipment, and transportation equipment – and to highlight them each has been given a separate symbol. The size of the symbols reflect employment in the industry in 1998. The fitted regression line is weighted by employment in 1998.[3]

We see clearly that over the 1988-1998 period there was a declining relationship between employment growth and skill intensity. Less skill-intensive sectors grew faster than more skill-intensive ones, on average, as predicted by the simple version of the Heckscher-Ohlin model. Particularly important in generating this pattern are "cut and sew" apparel (*confección de prendas de vestir*, NAICS industry 3152), the largest red diamond, and auto parts (NAICS industry 3363), the largest blue triangle, which are both relatively less skill-intensive and grew quickly over the period. Figure 5 presents a similar figure, but with capital intensity rather than skill intensity on the x-axis. The negative slope is even more evident.

Figure 6 plots a figure similar to Figure 4 for the period 1998-2008. Here the story is very different. One point to notice is that, on average, industries have shifted down. While employment growth overall in manufacturing was approximately 60% over the 10-year period from 1988-1998, it was just 10% from 1998-2008. The second main message is that there is no longer a negative relationship between employment growth and skill intensity. If a pattern can be discerned, it is that that employment growth was slightly higher in more skill-intensive sectors. Perhaps the most striking difference between this figure and the previous one is in the "cut and sew" apparel industry (the largest red diamond), which saw an increase in employment from approximately 130,000 to 450,000 over 1988-1998 but a decline to approximately 300,000 over 1998-2008.[4] Figure 7, with capital intensity on the x-axis, tells a similar story. On average, the less-skill- and less-capital-intensive industries in which the manufacturing sector tended to specialize over the 1988-1998 period saw sharp slowdowns in employment growth in the 1998-2008 period.

[2] The industrial classification system used in statistics on Mexican manufacturing plants has changed over time. In this figure we use the North American Industrial Classification System (NAICS), the more recent classification, to facilitate comparison with later years. Also, in the ENESTyC survey we focus on large plants, with 100 or more workers. These plants are sampled with certainty, which allows us to avoid a number of technical issues with the sampling weights in the survey.

[3] The change in log employment approximates percentage employment growth; an increase in log employment of .1 corresponds roughly to an 10% increase in employment.

[4] The autoparts industry (the largest blue triangle) also saw a slowdown of growth, but employment growth remained positive over the period.

2.2 Differences Between Maquiladoras and Non-Maquiladoras

In the Mexican context, it is important to make a distinction between assembly-for-export plants participating in a government program to provide relief from import duties, known officially as *maquiladoras de exportación* (exporting maquiladoras), and non-maquiladora plants, often referred to in Mexico as making up the *sector tradicional* (traditional sector).[5] Maquiladoras differ along a number of dimensions from non-maquiladoras, even within the same narrow industries. Although there is heterogeneity among maquiladoras, they have tended to engage in the most labor-intensive phases of production, often on behalf of foreign firms that locate management, design and R&D activities elsewhere.

The maquiladora program relieves firms of duties on imported inputs that are subsequently incorporated into exports. It began in the 1960s, in part to absorb workers pushed out of the U.S. by the end of the *bracero* guest-worker program. Maquiladoras were originally required to locate within 100 kilometers of the border and to export all output; over time those restrictions were loosened, but many continued to locate near the Northern border and to export all or almost all of their output.[6] In Nov. 2006, the existing maquiladora program was merged with another program offering duty relief for temporary imports *(Programas de Importación Temporal para Producir Articulos de Exportación, PITEX)* to form a new program, IMMEX *(Industria Manufacturera, Maquiladora, y de Servicio de Exportación)*. The reductions in tariffs on U.S. imports under NAFTA (to zero on most goods) have reduced the benefit of participating in the program, but the program continues to provide relief from duties on imports from non-NAFTA countries. It also allows participants to avoid paying VAT (normally 16%, or 11% in border regions) on imports that are incorporated into exports.[7]

The ENESTyC survey mentioned above has the advantage that it includes information on maquiladoras and non-maquiladoras in the same survey, in addition to information on schooling by occupational category and other variables.[8] Table 1 presents averages of a number of key variables separately for non-maquiladora non-exporters, non-maquiladora exporters and maquiladoras in 1998. As above, we focus on large plants, with 100 or more workers.[9] First comparing non-maquila

[5]The phrase *maquiladoras de exportación* is used to refer to participants in the government program. The word *maquiladora* is often used to refer generally to a plant producing under subcontract. Here I reserve the term *maquiladora* (or *maquila* for short) to refer to *maquiladoras de exportación*.

[6]To qualify for the current program, firms currently must have annual sales of $500,000 or export 10% of their output. There is no geographic restriction or further export requirement.

[7]There is a separate program, called *Programa de la Promoción Sectorial* (PROSEC), that provides relief from duties on imported inputs in a specific set of categories, independent of whether the goods are subsequently exported.

[8]Maquiladoras are also included in the Economic Censuses but prior to 1999 plants were not identified explicitly and the set of variables is more limited.

[9]The motivation for focusing on large plants is mainly to make the sub-sectors as comparable as possible, given

non-exporters and non-maquila exporters in Columns 1 and 2, we see that exporters on average are larger, more likely to be foreign-owned, and more capital-intensive than non-exporters. Within the blue-collar occupational category, exporters have higher average schooling and average wages than non-exporters. These patterns are broadly consistent with findings for the U.S. and other countries (see e.g. Bernard and Jensen (1995, 1999)) and with the findings for a different sample in Verhoogen (2008). Interestingly, there are only very small differences between non-maquila non-exporters and exporters in the share of the workforce in the blue-collar category, the rate of turnover of the workforce,[10] and the average tenure of the workforce.

Considering maquiladoras in Column 3 of Table 1, we see that maquiladoras are on average larger, more likely to be foreign-owned, and (unsurprisingly) have a higher export share than non-maquiladoras. One would typically expect these characteristics to be identified with high-value-added, capital- and skill-intensive production. But we see that maquiladoras on average have lower capital per worker, a lower share of workers with 12 or more years of schooling, a higher share of blue-collar employment, and lower years of schooling among blue-collar workers than either non-exporters or exporters in the non-maquiladora sector.[11] They also tend to have high turnover and low average tenure rates. In contrast to the general pattern, wages within occupational categories are higher on average in maquiladoras; this in part reflects the fact that nominal wages tend to be high in the border region, which is not being controlled for in this table of raw averages.[12]

INEGI collects separate monthly statistics on plants in the maquiladora program as publishes them as the *Estadísticas Mensuales de la Industria Maquiladora de Exportación* (EMIME). The EMIME tracks maquiladoras in 12 industry categories, which do not correspond to the industries used in the Economic Census or other surveys. Following Bergin, Feenstra, and Hanson (2009), we narrow the focus to the largest maquila categories: apparel and textile products (primarily "cut and sew" apparel rather than knitting mills); transportation equipment (primarily

that maquiladoras tend to be large in employment terms. Also, as discussed above (footnote 2) focusing on large plants allows us to avoid a number of technical issues with the sampling weights in the surveys.

[10]Turnover is defined as .5 * (new hires + separations) for the year. (The survey collects new hires and separations over a 6 month period; these are multiplied by 2 to convert to an annual basis.) The turnover rate is defined as 100*(turnover/employment at time of survey).

[11]Years of schooling for white-collar workers are not reported in the table to save space, but (in contrast to blue-collar years of schooling) are generally similar across the three types of plants.

[12]In a regression of blue-collar wage on indicators for non-maquila exporter and maquilas (with non-maquila non-exporters as the omitted category), controlling for state effects, the coefficient on the maquila indicator is negative, suggesting pay lower wages than non-maquila non-exporters, but it is not statistically significant. In contrast, a similar regression with white-collar wages as the dependent variable, the coefficient on the maquila indicator is positive and significant (although smaller than the non-maquila exporter coefficient). These regressions are not reported in order to save space but are available from the author.

autoparts); electric and electronic materials and accessories, including computer parts; and assembly of electrical machinery and equipment, including televisions and small appliances. To map these consistently into the industrial categories used in the Economic Censuses we combine the latter two categories.[13] I refer to the resulting groups as apparel, transportation equipment, and electrical and electronic equipment. These are the sets of industries highlighted in Figures 4-7 above. Together these three maquila groups made up approximately 75% of maquiladora employment and 18% of total manufacturing employment in 1998.

Appendix Tables A1-A3 present statistics similar to Table 1 separately for each of the three groups. The basic story is the same. Maquiladoras are consistently less capital-intensive than either exporters or non-exporters in the non-maquiladora category. Comparing measures of skill intensity, the average for maquiladoras is either similar to or less than the average for non-maquila non-exporters and consistently below that of non-maquila exporters. In short, despite their high foreign ownership and high export share, the maquiladoras tend to resemble the non-exporting plants in the traditional non-maquila sector more than they do the exporting plants.

Now consider how employment in maquiladoras changed over time. Figure 8 plots maquiladora and total industry (maquiladora and non-maquiladora) employment for our three key groups, with the black solid lines representing maquiladora employment and the colored dashed lines representing total employment in the corresponding industries in the economic censuses, with the colors and plotting symbols corresponding to those used in Figures 4- 7. The EMIME data is available until 2006, when the existing program was folded into the new IMMEX program.[14] (Note that data from the Economic Censuses is available at 5-year intervals, while the data for maquiladoras is available every year; this explains how maquila employment in electrical and electronic equipment can appear to rise above total employment in the industry.) The evolution of maquiladora employment is especially striking for the apparel sector. The sharp run-up in overall industry employment in the later part of the 1990s and the subsequent sharp drop are both largely due to changes in maquila employment. In the electrical and electronic equipment sector, the lion's share of employment is in maquiladoras, and again we see a decline in employment, driven primarily by the decline in maquiladora employment beginning in 2000. Although in this sector maquiladora employment began rising again in 2003, by 2006 it had not regained the peak achieved in 2000. By contrast, maquiladora employment in the transportation equipment sector

[13]We map the first group to NAICS 315 (apparel manufacturing), the second to NAICS 336 (transportation equipment manufacturing), and the combined third and fourth to NAICS 334 and 335 (computer and electronic equipment, and electrical equipment, appliances, and components), respectively.

[14]INEGI did not separately report statistics for the PITEX program, which was also folded into the IMMEX program in 2006.

has been considerably more stable and, like non-maquiladora employment, has been growing relatively steadily over time.

2.3 Differential Upgrading Within Industries

In a previous paper, I advanced the hypothesis that international integration has led to a process of *differential quality upgrading* within industries in Mexico (Verhoogen, 2008). The paper presented a theoretical model in which more-productive firms are better able to produce high-quality goods, and in which a given Mexican firm produces a higher-quality good for the export market in the U.S., in order to appeal to richer consumers there. The model predicts that when Mexican firms increase exports, they shift toward producing higher-quality goods, as compared to less-productive firms in the same industry. This in turn requires purchasing higher-quality inputs, including higher-quality labor inputs.

Establishing the direction of causality in this sort of situation is difficult. If we observe exporters producing high-quality goods, do we conclude that exporting caused firms to raise quality or that firms already able to produce high quality were the ones that decided to export? To address this issue, the paper used the peso devaluation of late 1994 as a "natural experiment." The idea is that the devaluation of the peso increased the incentive of Mexican plants to export, but that only those plants that were able to access the export market — which tended to be larger, more productive plants — were able to take advantage of it. This arguably generated experimental variation in the incentive to export within industries, with greater incentive for initially larger, more-productive plants.

As an illustration of the quality-upgrading process, consider the example of the Volkswagen (VW) plant in Puebla, Mexico. Until 2003, the plant produced the traditional Old Beetle (known as the *Sedan* or, more affectionately, the *Vochito* in Mexico), using technology imported from Germany in the 1960s. Almost all of the Old Beetles were sold in Mexico. During the same period, the plant also produced a number of state-of-the-art new cars, including the Jetta, the Golf, and, beginning in 1997, the New Beetle. The newer, high-quality cars tended to make heavier use of skilled technicians *(especialistas)*, typically graduates of a 3-year school on the plant grounds. Figure 9 illustrates the changes in product composition at the plant from 1998-2002. The devaluation led to a sharp increase in the share of cars exported, and also to a shift toward production of the higher-quality varieties, the Jetta, Golf, and later the New Beetle, and a shift away from production of the Old Beetle. Generalizing from this example, one would expect a similar process of quality upgrading at other plants where exports increased. One would not expect a similar upgrading process in plants oriented solely toward the domestic market, which tended to be smaller, less-productive plants.

Using a survey that follows individual plants over time in the traditional, non-maquiladora sector, the *Encuesta Industrial Anual* (EIA), the paper showed that initially larger, more-productive plants increased exports more than smaller, less-productive plants in the same industry in response to the devaluation. They also tended to invest more and to raise wages, especially of white-collar workers. Using the ENESTyC dataset mentioned above, the paper also showed that they were more likely to acquire ISO 9000 certification, an international production standard.[15] It appears, in other words, that the shock to exporting indeed led to differential quality upgrading within industries, and that this led to a divergence in capital intensity, skill levels, and wages across plants within industries.

An important note of caution for these findings is that we do not directly see product quality in the data, and so the evidence for quality upgrading is somewhat circumstantial. But the basic story has held up well in further research. Recently customs data on trade transactions by firms have become available in a number of countries, and it turns out that firms consistently charge higher prices to richer destination markets, even within very narrow product categories, consistent with the idea that they are selling higher-quality varieties in them.[16] Using the Colombian manufacturing censuses, which include information on prices of all products sold and all inputs purchased by plants, Maurice Kugler and I found that larger plants pay more for their inputs and charge more for their outputs within industries, also consistent with the quality interpretation (Kugler and Verhoogen, 2012). Many others have contributed to this literature.[17] Although it remains rare to observe product quality directly, it seems difficult to explain the growing set of consistent results from different countries and datasets without reference to quality.

[15] The paper also compared the differential changes during the peso-crisis period (1993-1997) to the differential changes in other periods without devaluations (1989-1993 and 1997-2001), to check that the results were not simply generated by stable differential trends between larger and smaller plants.

[16] See Bastos and Silva (2010) on Portugal, Manova and Zhang (2012) on China, Martin (forthcoming) on France, and Görg, Halpern, and Muraközy (2010) on Hungary.

[17] In one of the few papers with direct evidence on product quality, Crozet, Head, and Mayer (2012) use expert assessments of the quality of French Champagne producers and show that firms producing higher-quality firms are more likely to export, charge higher export prices, and sell more on the export market than lower-quality producers. Using newly available price data from the monthly version of Mexican EIA plant survey, Iacovone and Javorcik (2012) show that plants charge higher prices for exported products (which in the Mexican case almost always means sold to the U.S.) than for domestic products in the same narrow product category, and also that the prices plants charge start to rise *before* they enter the export market, suggesting that plants upgrade quality in preparation for exporting. Using a combination of a plant survey and trade-transactions records in Argentina, Brambilla, Lederman, and Porto (forthcoming) show that increases in exports to higher-income countries lead firms increase average skill and wages, but find no such effects for exports to countries at the same income level (e.g. Brazil). Other important contributions to this literature, using more aggregate data, are Schott (2004), Hummels and Klenow (2005), and Hallak (2006).

My previous paper focused on the peso-crisis period in order to get at the issue of causality, but one would expect a similar differential quality upgrading process to occur in response a bilateral reduction of tariffs, or even a simple reduction of transport costs.[18] It seems likely that the quality upgrading has continued among exporters in the traditional non-maquiladora sector, as trade costs have continued to fall.[19]

The extent to which upgrading has occurred among maquiladoras remains an open question. I have focused on the non-maquiladora sector largely because of data availability (the EIA does not cover maquiladoras). There is some case-study evidence to suggest that there has been upgrading within the maquiladora sector (see e.g. Sargent and Matthews (2008)). At the same time, there is little rigorous statistical evidence that a broad segment of the maquila sector has made the jump to higher-value-added production. This is an area where more research is needed.

3 Why Did It Happen?

To this point, we have seen evidence for three broad patterns in Mexico's industrial evolution: (1) From 1988-1998, the manufacturing sector tended to specialize in less-skill-intensive and less-capital-intensive industries, and these industries saw sharp slowdown in growth in the subsequent decade. (2) From 1988-2000, much of the employment growth in two key manufacturing sectors, apparel and electrical and electronic equipment, was driven by maquiladoras, which tend to be less skill-intensive and capital-intensive than other plants in the same industries; the subsequent declines in employment were driven by declines in maquiladora employment. (3) Within the non-maquiladora sector, there has been a process of differential quality upgrading, with larger, more-productive, exporting plants upgrading relative to smaller, less-productive, non-exporting ones. In this section, we return to the issue raised in the introduction, of Mexico's disappointing growth performance. What are the links between these patterns of industrial evolution and Mexico's disappointing growth?

I do not want to argue that the rise of China has been unimportant. The expansion of Chinese exports must certainly be part of the story. Economists who have attempted to evaluate the qualitative impact on competition from China on Mexico have found sizable negative effects (Hanson and Robertson, 2010; Hsieh and Ossa, 2011; Freund and Özden, 2009). The effects have

[18] In these cases, as in the case of a devaluation, the potential profits from exporting will increase, but only firms that are able to enter the export market will be able to reap them. At the same time, firms are likely to face tougher conditions in the domestic market, in the case of the peso because of the general contraction of domestic demand and in the case of reductions in trade costs because of increased competition from abroad.

[19] There is also evidence that increased competitive pressure from abroad itself led Mexican firms to increase R&D expenditures. See Teshima (2010).

been more severe for Mexico than for other countries in Latin America in part because Mexico tends to produce few of the primary commodities that China consumes and many of the products that it sells (Devlin, Estevadeordal, and Rodriguez-Clare, 2006; Mesquita Moreira, 2007). The long, slow re-appreciation of the peso following the 1994-1995 devaluation must also have played an important role. Appendix Figure A1 plots the real exchange rate from 1988-2012.[20] The long re-appreciation from 1995-2002 rendered Mexican exports steadily more expensive in the U.S. market.

But we should also consider the possibility that there is something deeper and more long-term going on, that Mexico's pattern of specialization in the 1990s itself played a role in Mexico's slow growth. There is a tension between the pattern of specialization consistent with a country's current comparative advantage and the one consistent with maximizing its growth. The standard theoretical case for liberalization — that free markets lead countries to do what they have a comparative advantage in, and that this maximizes welfare — is based on static models (i.e. without a time dimension), in which, by assumption, innovation plays no role. Once one allows for the possibility that the activities a country engages in can affect the rate of innovation and hence productivity growth, the case for *laisser-faire* — what are sometimes referred to as "market fundamentalist" policies — is significantly weaker. This is an old idea. Here let me review it briefly and show how I think it is relevant to the recent experience of Mexico.

Back in the 1950s, Raúl Prebisch (1950) worried that trade liberalization would lead many developing countries to specialize in the production of primary commodities, and that this in turn would lead to long-run stagnation, because primary sectors would experience less technological change than manufacturing.[21] While Prebisch focused on primary sectors, the basic point applies more broadly: if some activities are inherently more likely to generate learning and innovation, then all else equal countries are likely to grow faster if resources are allocated toward the more dynamic sectors.

In recent years, this idea has been advocated most prominently by Dani Rodrik, Ricardo Hausmann, and co-authors. They have clarified the theoretical argument, noting that when choosing whether to impose a tax or subsidy to shift production toward more dynamic sectors, countries face a trade-off between static efficiency and improvements in the long-run rate of

[20]The real exchange rate is defined as the nominal exchange rate times the ratio of the U.S. consumer price index (CPI) to the Mexican CPI.

[21]Hans Singer (1950) emphasized the related worry that as developed countries became richer they would tend to consume a smaller and smaller share of primary products, which would work to the disadvantage of developing countries.

growth.[22] Conceptually, it is clear that, despite the efficiency cost, under some circumstances reallocating production away from sectors with current comparative advantage is in countries' long-run interest. Whether or not those circumstances exist in the world remains an open question, of course.

Empirically, perhaps the strongest evidence for a link between industrial structure and long-run growth comes from a 2007 paper by Hausmann, Rodrik and Jason Hwang with the apt title "What You Export Matters" (Hausmann, Hwang, and Rodrik, 2007). The authors calculate a weighted average GDP per capita of countries that export a particular product, which they label PRODY, and then a weighted average of the PRODYs of the products exported by a given country, which they label EXPY. EXPY can be interpreted as a measure of the overall level of sophistication, or "quality", of a nation's exports. Figure 10 plots the log of EXPY against log GDP per capita for many countries in 2003. It is not surprising that there is a positive slope: rich countries on average produce goods that are on average produced by rich countries. What is interesting is the dispersion around the (implicit) regression line; in particular notice that China (CHN) has a high EXPY — high product sophistication — for its level of income. This becomes important when EXPY is related to subsequent growth as in Figure 11, which plots growth of GDP per capita over 1992-2003, controlling for initial log GDP per capita and a measure of human capital, against the initial level of log EXPY.[23] The positive correlation suggests that initial product sophistication is a strong predictor of subsequent growth.

There are many reasons to be cautious about the interpretation of this pattern. The first, and perhaps biggest, is that the direction of causality is not clear. It could be that some countries have unobserved characteristics that lead them both to produce sophisticated products and grow fast, which would generate a correlation like the one in Figure 10 even in the absence of a causal effect of EXPY on growth.[24] A second reason is that for countries with large assembly-for-export sectors such as Mexico and China, the EXPY measure may be overstated: China may be exporting high-tech electronics, but many firms only do low-tech assembly of high-tech components imported from other countries (Xu, 2010). Nevertheless, in my view the correlation displayed in Figure 11 is an important and provocative one, and it has already played a very useful role in focusing

[22] See, for instance, Rodriguez and Rodrik (2001), which develops a model based on Matsuyama (1992). See also Redding (1996, 1999).

[23] To be precise, the y-axis variable is $X_i\widehat{\beta} + \hat{\varepsilon}$ estimated from an instrumental variables regression $\triangle y_i = X_i\beta + Z_i\gamma + \varepsilon_i$ where $\triangle y$ is change in log GDP/capita from 1992-2003, X_i is EXPY in 1994, Z_i includes log initial GDP/capita and a measure of human capital in logs, and log population and log land area are used as instruments for EXPY.

[24] The authors instrument for log EXPY with log population and log land area, but it is not clear that the exclusion restriction (an assumption necessary for the estimate to be interpreted as a causal effect) is satisfied.

researchers' and policy-makers' attention on the links between product specialization and growth.

Is there evidence of a link between product specialization and growth in Mexico? The availability of rich data on manufacturing plants in Mexico allows us to examine this question at a lower level of aggregation. The ENESTyC survey in 1999 asked respondents whether in the previous two years the plant had carried out research and development (R&D). If they answered yes, the survey asked them to specify whether the activities were directed at "design of new products," "process improvement," "improvement of product quality," "design, improvement, or construction of new equipment," or "other." Note that the implicit definition of R&D is quite broad, and applies to all systematic efforts to gain knowledge, not only to the activities of scientists or inventors. This measure is by no means an ideal measure of innovation. One would also like to have information on R&D expenditures, as well as information on the outcome of the innovative activity, for instance from patent data. But as a first step it seems to be a reasonable proxy for whether plants are trying to innovate.

Using this measure, Figure 12 plots the share of large plants performing R&D against the share of workers with 12 or more years of schooling from the same survey, by 4-digit NAICS category. There is a clear, statistically significant, positive relationship.[25] Figure 13 plots the same R&D share against capital intensity. Again, there is a clear, significant, positive relationship.[26] Take a look back at Figures 4-7, which have the same x-axis variables as Figure 12 and Figure 13. The message is clear: over the 1988-1998 period, the Mexican industrial sector tended to specialize in less-skill-intensive and less-capital-intensive industries, and *these were industries with relatively low rates of innovation.* The shift toward less-skill-intensive and less-capital-intensive industries may well have been consistent with Mexico's comparative advantage at the time, and may have reaped a static gain from reallocation, but it appears to have been bad for the overall level of innovation, a primary driver of growth in the economy.[27]

What can we say about the relationship between product specialization and innovation *within* sectors? In Table 1 above we observed that among non-maquiladora plants, exporters are more skill- and capital-intensive than non-exporters. This observation also holds for innovation. On average for non-maquiladoras in all of manufacturing, 50% of exporters but only 36% of non-exporters report R&D activity. This pattern generally holds within individual 4-digit sectors as well.[28] In

[25]The estimated slope from the least-squares regression weighted by employment (the fitted line) is 0.53 with standard error 0.13; the R^2 for the regression is 0.16.

[26]The estimated slope from the least-squares regression weighted by employment (the fitted line) is 0.05 with standard error 0.01; the R^2 for the regression is 0.14.

[27]I am not aware of previous work documenting the negative correlation between skill- or capital-intensity and the rate of innovation at the industry level in Mexico.

[28]The shares for exporters and non-exporters in apparel are 33% and 19%, respectively; for electric and electronic

Table 1 above we also observed that on the dimensions of skill- and capital-intensity, maquilas resembled non-maquila non-exporters more than non-maquila exporters. Maquilas compare a bit more favorably when comparing innovative activity than when comparing skill- or capital-intensity. For all of manufacturing, 41% report engaging in innovation, a share that falls squarely between the shares for non-maquila non-exporters and exporters. This pattern holds sector-by-sector in most cases.[29] Still, it seems fair to say that the maquiladoras are not generally on the leading edge of innovation in their industries.

Would the slowdown in manufacturing have occurred even if China had not entered (and the peso had not re-appreciated)? We of course cannot observe the counterfactual universe in which China remained a closed economy. But ultimately it is extremely difficult to sustain a robust rate of growth without a robust rate of innovation. There is evidence of some export-driven quality upgrading by traditional non-maquila exporting plants (and suppliers to them), but given the magnitude of the shifts toward lower-skill, lower-capital industries, and toward maquilas within industries, it seems unlikely that it would have offset the tendency toward slowdown. It appears that the tendency to specialize in activities with low rates of innovation would inevitably have tended to dampen growth.

4 What To Do?

In the case of Mexico's industrial development, it is easier to offer a diagnosis than a cure. Although many economists might take issue with details above, the basic idea that there may be a tension between static comparative advantage and long-run growth is widely acknowledged to be sound. Where the controversy really arises is in what to do about it. I am not going to be able to resolve the controversy here, nor even cover all the major issues. Readers are referred to discussions in the literature for more exhaustive treatments (Amsden, 1989; Wade, 1990; Evans, 1995; Rodrik, 1995, 2004, 2007; Kohli, 2004; Pack and Saggi, 2006; Harrison and Rodríguez-Clare, 2010; Lederman and Maloney, 2006, 2012). Here I would like to offer just a few highly idiosyncratic, subjective ideas suggested by my own previous work and the patterns we have seen above.

At the outset, let me reinforce the view that industrial policy is an appropriate topic for

equipment 54% and 35%; and for transportation equipment 62% and 40%. The differences between means are all statistically significant.

[29] Perhaps surprisingly, the apparel sector is an exception to this pattern. The share for apparel maquiladoras is 34%, not significantly different from the share for non-maquila exporters. The shares for maquilas in the electric and electronic equipment and transportation equipment sectors are 45% and 54%, respectively.

discussion. Until recently, it was hazardous for economists to utter the words "industrial" and "policy" together in polite company. That situation is now changing quickly, thanks to the stubborn efforts of Dani Rodrik, Ricardo Hausmann, Andres Rodriguez-Clare, Ann Harrison, Joe Stiglitz, José Antonio Ocampo and others to open space for debate. Two points that Rodrik and Hausmann have made in defense of industrial policy are especially compelling. The first is that the fact that mistakes have been made in industrial policy in the past is not a strong argument against considering industrial policies in the present. Mistakes have been made in monetary and education policy as well, but no one believes we should do away with them completely. Second, governments undertake policies that affect the prices (for instance, taxes and tariffs) facing industrial firms all the time. The maquiladora program is a case in point: it has long provided assistance in the form of reduced tariffs and taxes to a particular sort of industrial activity. This is industrial policy, and we should not shy away from calling it by this name.

After that rousing endorsement of industrial policy as a subject of debate, let me add some words of caution. Critics of industrial policy also have compelling arguments on their side. First, there is no reason to believe that governments have better information than firms about how a particular technology can be improved, or what sorts of new products are likely to appeal to consumers. That is, governments have no special ability to "pick winners." Second, industrial policies often create scope for rent-seeking by firms trying to win favors from well-placed officials. In some cases this gives rise to outright corruption, in others simply to an unwillingness or inability of officials to cut off support for underperforming industries. Both of these points seem clearly right.

And yet neither is decisive. Both caveats must be weighed against an important argument in favor: there is a coordination failure among firms in learning. Learning generates positive externalities for other firms. Because firms cannot reap the full benefit of their own learning, they do less of it than would be optimal for the society as a whole. There is a strong rationale for government policy to counteract this coordination failure and encourage investments in innovation. Are the externalities, and concomitant coordination failures, large enough to justify the potential costs of intervention? The honest answer is that we don't really know. We need more careful research trying to estimate both the benefits and the costs. But to me it seems quite plausible that well-designed interventions, targeted at addressing the coordination failure in learning, yield greater benefits than costs. The policy challenge is to find ways to promote innovative activities while minimizing both wasteful spending and the capture of officials by the industries they oversee.

Let me now turn to some lessons for industrial policy that I see emerging from recent work on the subject. At the risk of disappointing policy-makers who are interested in concrete programs, I will try to draw out some general principles that are broadly applicable.

A first lesson is that *industrial policy interventions should be targeted narrowly at addressing coordination failures among firms, especially coordination failures in learning.* This point has been emphasized by Harrison and Rodríguez-Clare (2010) and others. It has two corollaries. One is that interventions should not seek to prop up declining industries. Doing so may be popular politically, but it is not likely to serve the larger goal of sustained growth. A second corollary is that interventions should not offer blanket support to entire industries. From the perspective of innovation, not all activities within industries are created equal. Some activities require — and stimulate — learning more than others. The more microdata have become available on individual firms, the more researchers have observed that there is tremendous heterogeneity among firms even in the same narrowly defined industries, and even among production lines in the same firm. Industrial policy needs to be creative in finding ways to promote the activities within industries that involve innovation, and not the ones that don't.

A second lesson is that *industrial policies should seek to promote learning about how to improve the quality of products, not just about what products to produce.* The existing literature has tended to emphasize the role of learning about what products a country is good at producing (Hausmann and Rodrik, 2003; Hausmann, Hwang, and Rodrik, 2007). But the argument also applies to learning how to improve the quality of an existing product, how to tailor it to the tastes of foreign customers, or how to produce a given product more cheaply. Case studies of firms in developing countries typically place as much emphasis on the latter aspects of learning as on discovering what new sectors are viable.[30] In addition, although we would like to have better data on this issue, anecdotally it appears that quality upgrading often requires moving to newer vintages of technology, as in the Volkswagen example, and for that reason may stimulate learning in a way that starting production in sectors that have not been active in a country (but have been active elsewhere in the world) may not.

The focus on product quality has another feature to recommend it. Quality upgrading is typically accompanied by rising wages. While more research is needed here, this pattern suggests that an important advantage of high-quality production, from the perspective of long-run industrial development, is that a country can remain competitive in an industry even as wages rise. Low-quality production, on the other hand, typically requires the lowest possible costs, and hence employment in low-quality production may be quite sensitive to fluctuations in relative wages or

[30] See for instance Artopoulos, Friel, and Hallak (2011) and Easterly and Reshef (2010).

real exchange rates.

A third lesson is that *industrial policies should seek to promote the supply of high-quality inputs.* Above I summarized evidence that increases in the incentive to export led some Mexican firms to increase the average quality of their products, and that this in turn led them to purchase higher-quality inputs. But one could also imagine the causal arrow going the other direction: one would expect an increase in the supply (equivalently, a decrease in the prices) of high-quality inputs to lead firms to upgrade the quality of their final products.

On can, and should, still worry about whether governments have the information to choose wisely which input sectors should be promoted. But to the extent that inputs are general-use, promoting them may benefit — and give incentives to upgrade to — many producers in many different sectors. Promoting the supply of high-quality general-use inputs can thus be seen as a *broad-based* subsidy for upgrading across a range of sectors. It becomes less important whether any particular final-good producer is ready or willing to upgrade.

A prime example of a general-use input is technically skilled labor. Investments in technical vocational schools and engineering programs at local universities can be seen as a form of subsidy for upgrading. It is important to note that technical skill is typically not entirely general. Training programs and technical schools are often most useful when their curricula are developed in conjunction with local industry and directed especially toward training in skills required by local firms. But training in many subjects is nonetheless likely to be portable to some extent across firms and industries, and in this sense is broad-based.

In promoting the supply of high-quality material inputs, it appears better to do so through direct subsidies than through tariff schedules. It may be tempting for governments to maintain tariffs on inputs, in order to provide a larger market for domestic input suppliers. But if the goal is to promote quality upgrading, this can be counter-productive. In joint work with Maurice Kugler, we have used detailed input price data from Colombia to argue that imported inputs tend to be of higher quality than domestic ones (Kugler and Verhoogen, 2009).[31] Tariffs on imported inputs are thus likely to raise disproportionately the price of higher-quality varieties of a given input. This in turn may dampen the incentives for final-good producers to upgrade.[32]

A final lesson is that *the value-added content of exports is a better performance metric than*

[31] The key fact is that Colombian firms consistently pay higher prices for imported inputs than domestic inputs, even within the same narrow product category in the same year. The paper presents a number of other facts also consistent with the quality interpretation.

[32] This argument is consistent with the observation of Harrison and Rodríguez-Clare (2010, p. 4111) that although in general there is little empirical correlation between tariff levels and country outcomes, the exception is tariffs on intermediate inputs and capital goods, which are associated with lower growth.

gross exports. A key component of the successful industrial policies in many Asian countries has been to use export targets as a condition for continued support for industries or firms. But exports *per se* are not a convincing measure of performance if firms are primarily assembling inputs imported from elsewhere, as maquiladoras do in Mexico. Assessing performance using the domestic value-added component of exports is likely to place more weight on activities that generate innovation and spillovers for the rest of the economy.

After those general lessons, let me suggest one practical policy idea that seems worthy of further consideration: public-private venture capital funds. As Josh Lerner (2010) and others have pointed out, it is important that public funding be matched by funding from the private sector, to ensure that the funds are not squandered on unprofitable projects. As in the wholly private venture-capital industry, we should not expect all funded projects to succeed. But a few successes may have high enough payoffs to offset the costs of the failures. As Rodrik (2005) and others have emphasized, the key to an effective policy is to be disciplined in pulling away support from under-performing firms or sectors.

My concluding thought is that the broad area of industrial policy is one where more research is sorely needed. One of the reasons that discussions of industrial policy become so heated is that we have so little rigorous empirical evidence on its effects. Ideally one would like to be able to run controlled experiments, and indeed a few experiments with firms have been or are being conducted.[33] But given the practical difficulties in running experiments with firms, it is clear that we will also have to continue developing new sources of microdata and using "natural experiments" to broaden our base of knowledge about what works and what doesn't in industrial policy. Cooperation from statistical agencies, government officials, and private firms will be crucial in this process.

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[33]Particularly notable in this recent trend are studies by de Mel, McKenzie, and Woodruff (2008), which randomized cash grants to small firms in Sri Lanka, and Bloom, Eifert, Mahajan, McKenzie, and Roberts (2011), which randomized consulting services to textile firms in India. In ongoing work with co-authors I am involved in a randomized evaluation of provision of a new technology to soccer-ball producers in Pakistan.

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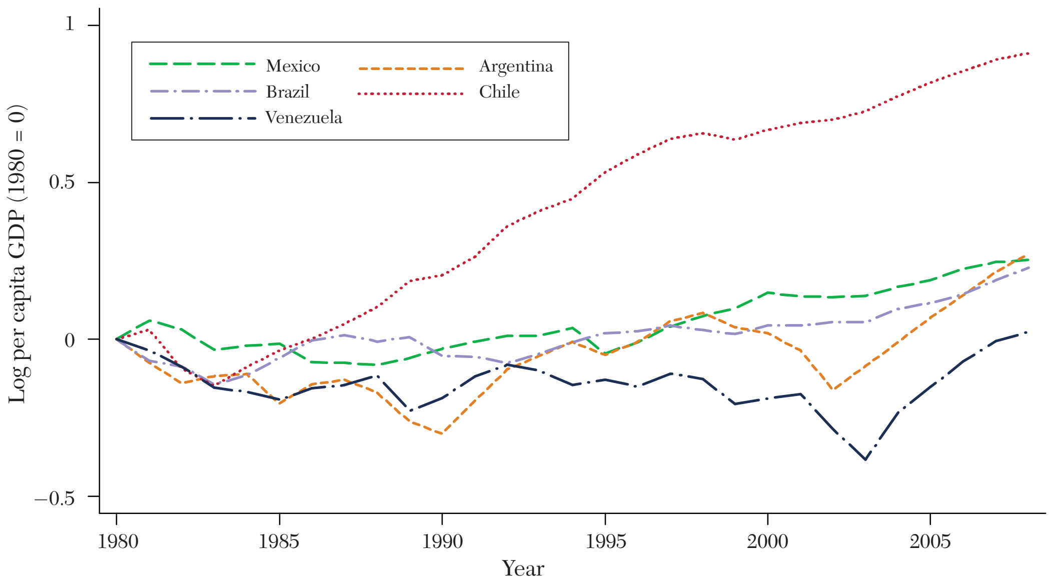
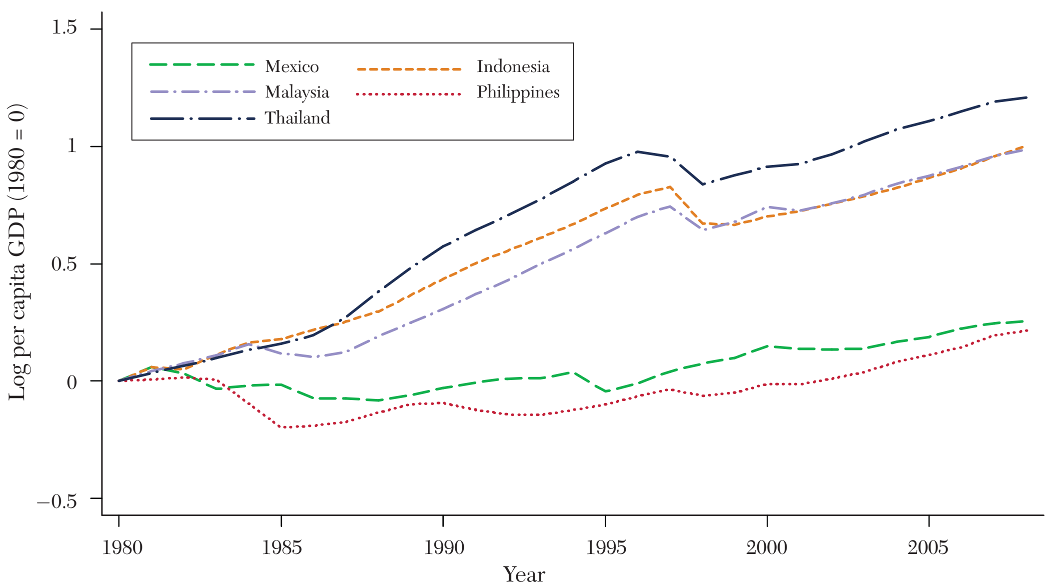
Figure 1. Growth in Mexico and Comparison Countries: Latin America



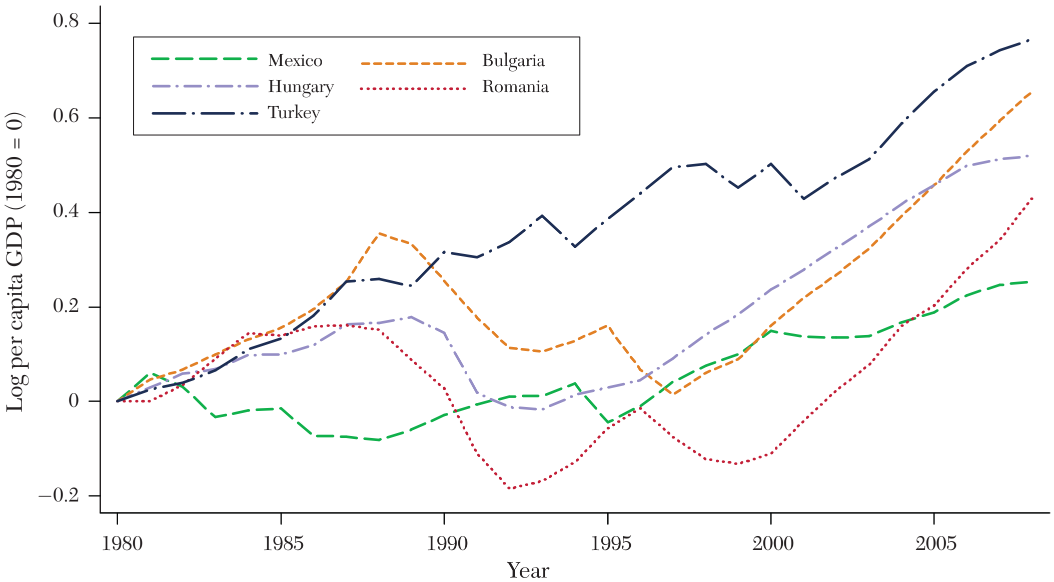
Source: Hanson (2010).

Figure 2. Growth in Mexico and Comparison Countries: Southeast Asia



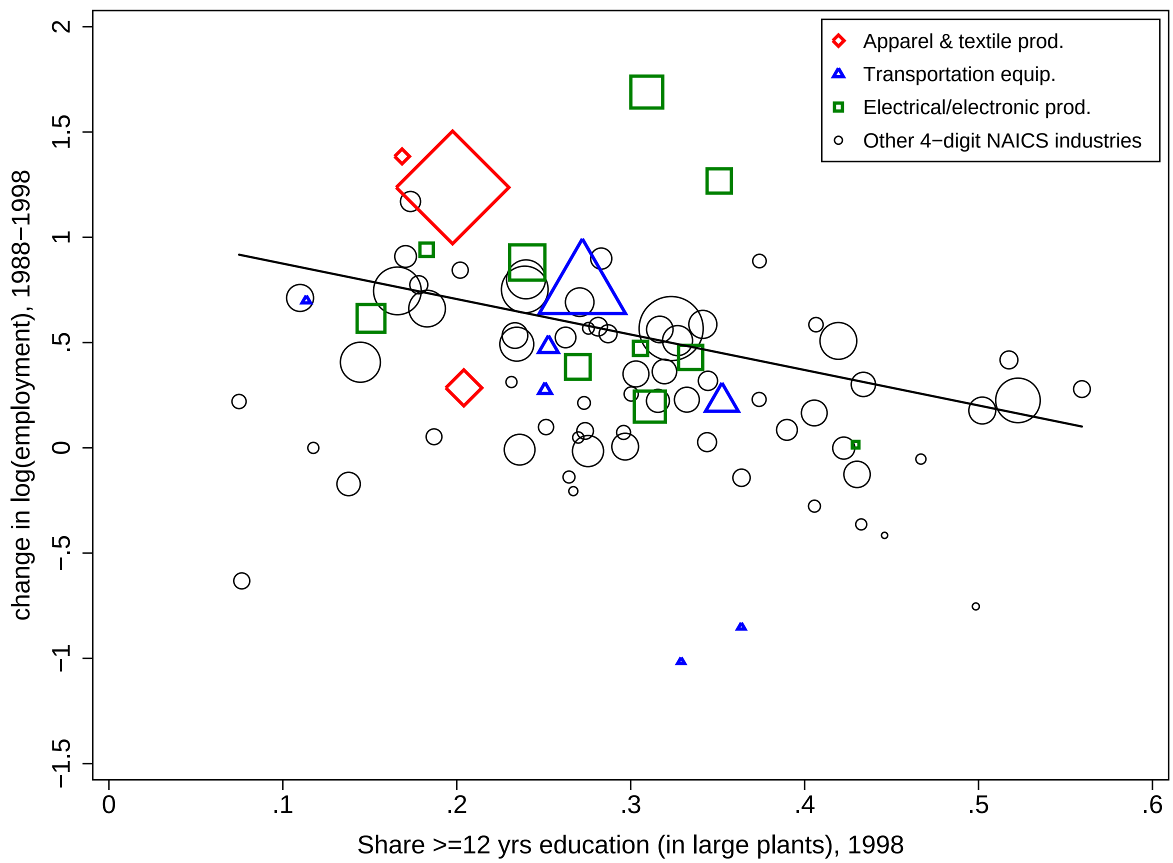
Source: Hanson (2010).

Figure 3. Growth in Mexico and Comparison Countries: Eastern and Central Europe



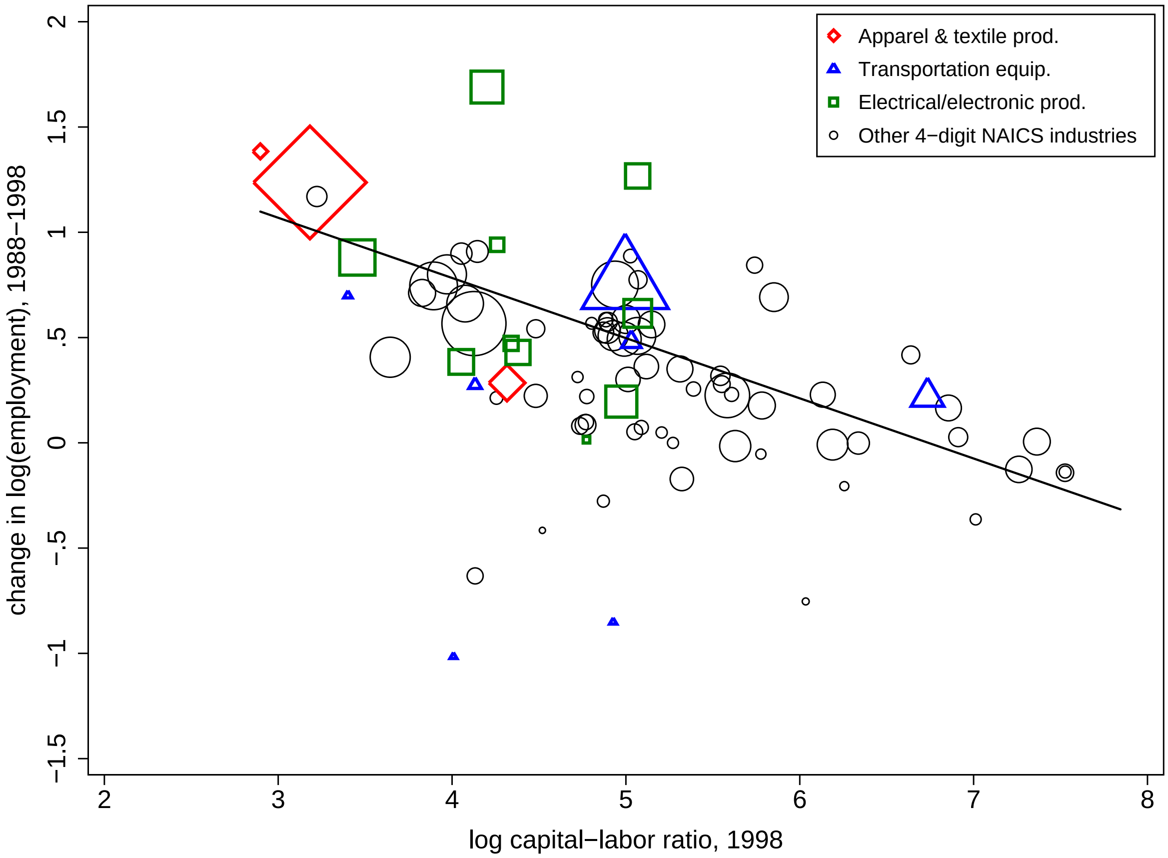
Source: Hanson (2010).

Figure 4. Employment Growth vs. Skill Intensity, 1988-1998



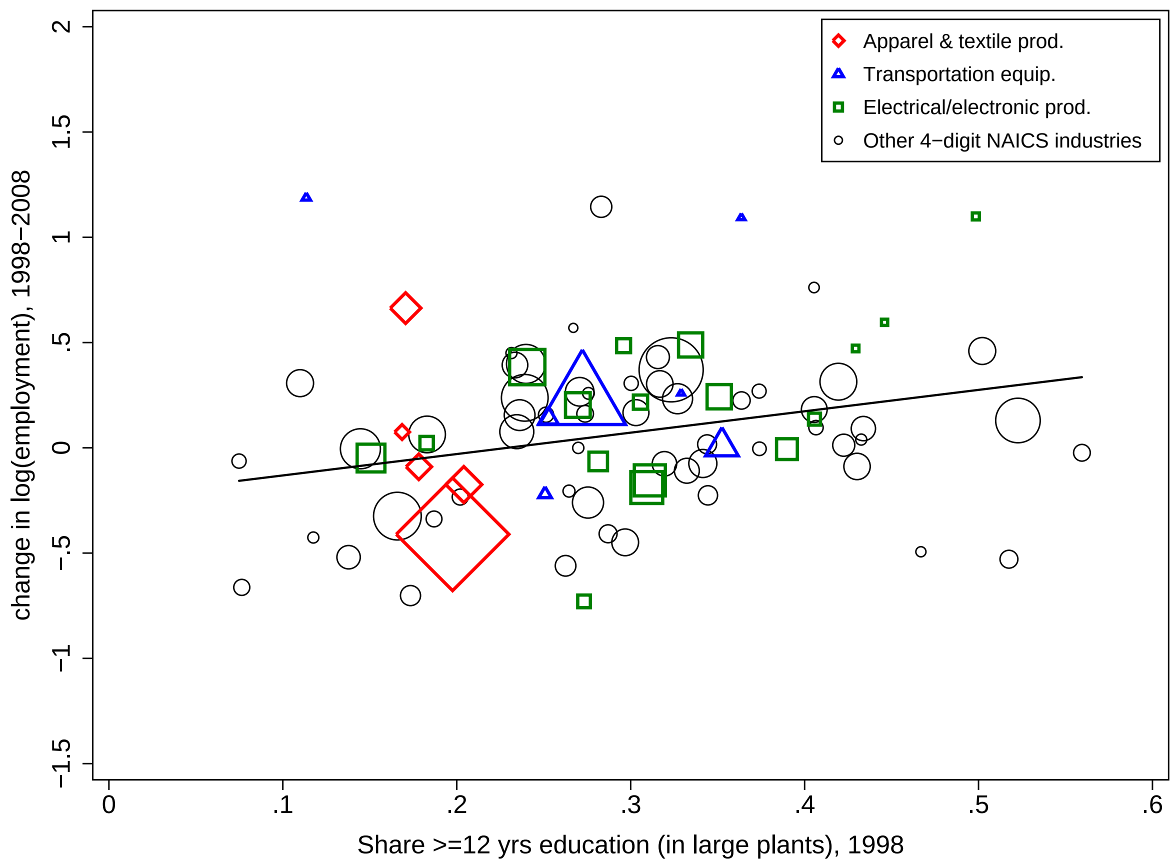
Notes: Data on employment growth are from the INEGI Economic Censuses from 1989 and 1999 (containing information from previous year). Data on schooling are from 1999 ENESTyC. Each symbol represents a 4-digit industry in the North American Industrial Classification System (NAICS). The size of the symbols reflect employment in the industry in 1998. The fitted regression line is weighted by employment in 1998. A similar graph (using a different industry classification) appeared as Figure A1 of Verhoogen (2008).

Figure 5. Employment Growth vs. Capital Intensity, 1988-1998



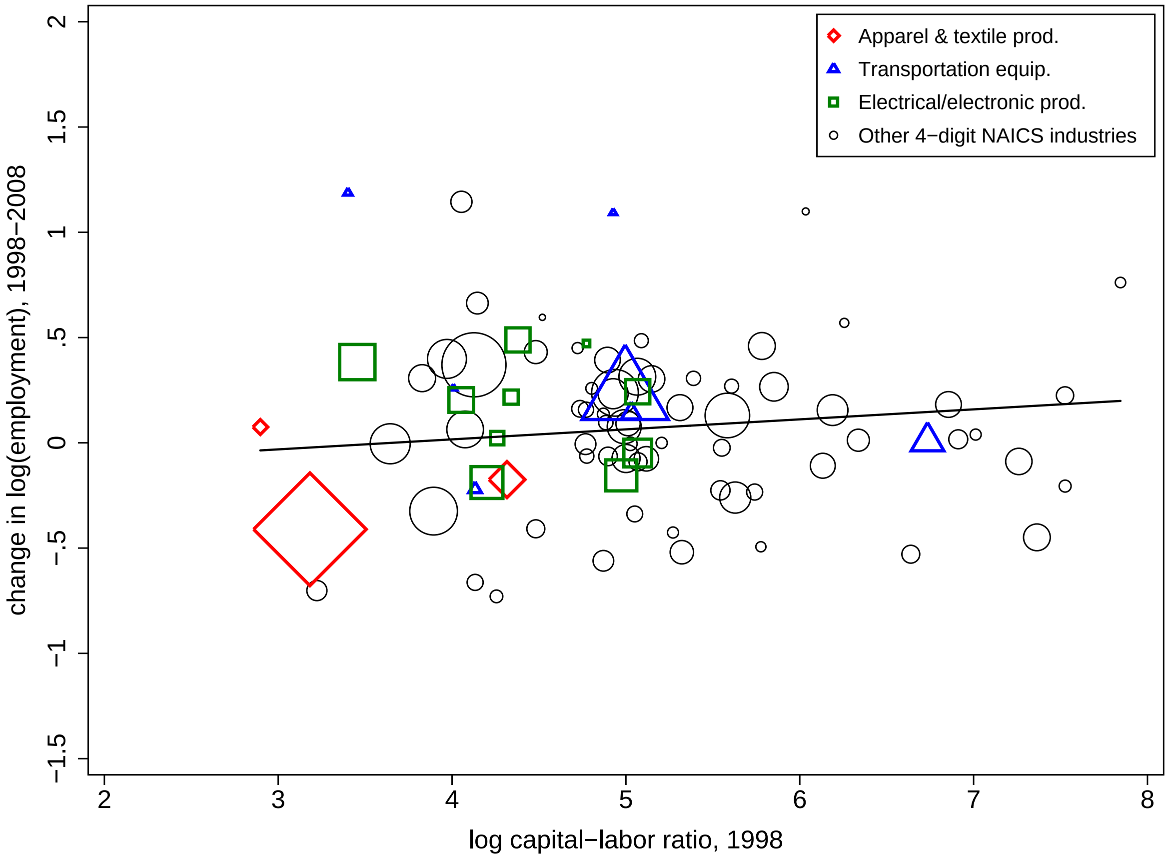
Notes: Data on employment growth and capital-labor ratio are from the INEGI Economic Censuses from 1989 and 1999 (containing information from previous year). Each symbol represents a 4-digit industry in the North American Industrial Classification System (NAICS). The size of the symbols reflect employment in the industry in 1998. The fitted regression line is weighted by employment in 1998. A similar graph (using a different industry classification) appeared as Figure A2 of Verhoogen (2008).

Figure 6. Employment Growth vs. Skill Intensity, 1998-2008



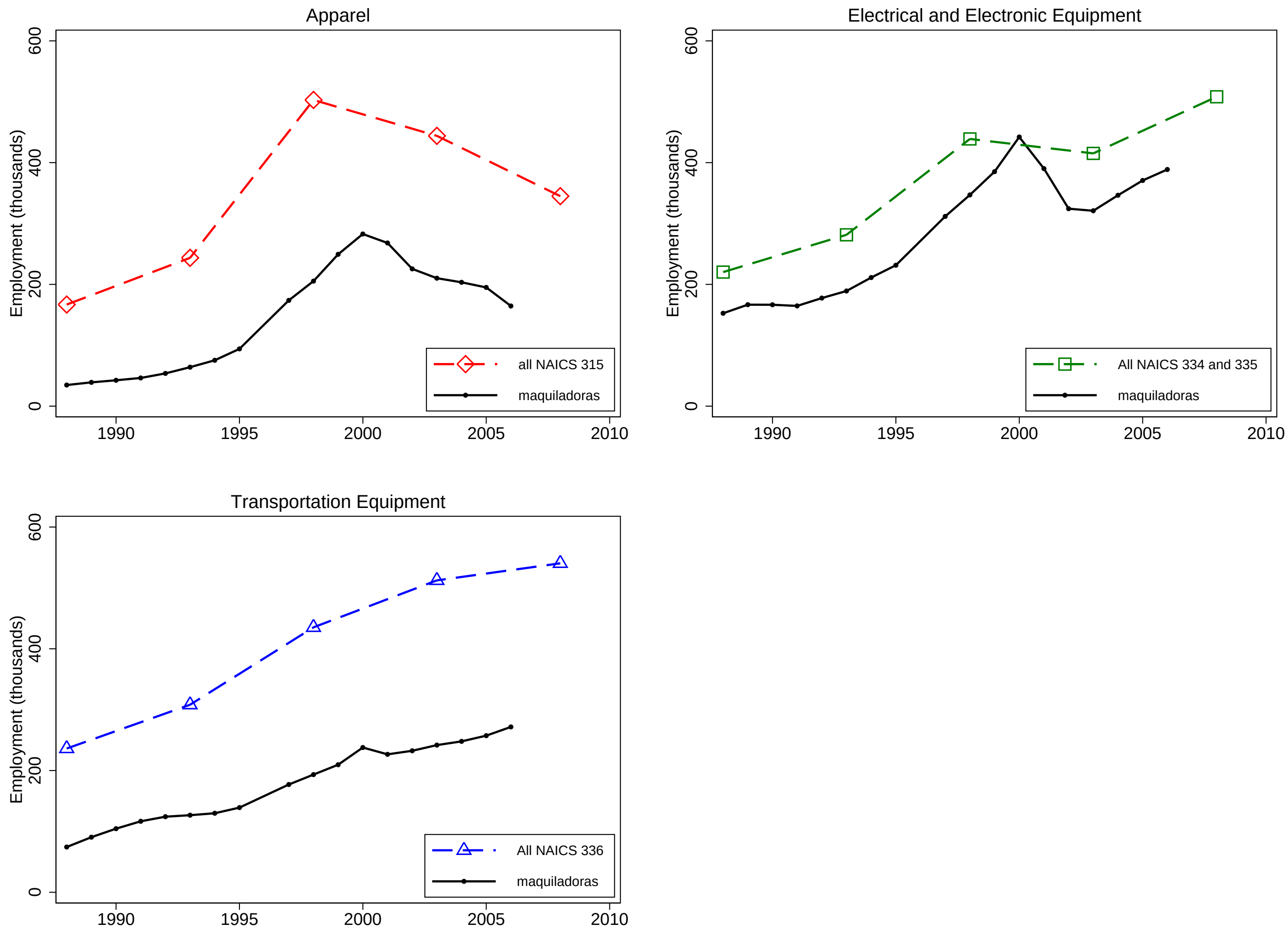
Notes: Data on employment growth are from the INEGI Economic Censuses from 1989 and 1999 (containing information from previous year). Data on schooling are from 1999 ENESTyC. Each symbol represents a 4-digit industry in the North American Industrial Classification System (NAICS). The size of the symbols reflect employment in the industry in 1998. The fitted regression line is weighted by employment in 1998.

Figure 7. Employment Growth vs. Capital Intensity, 1998-2008



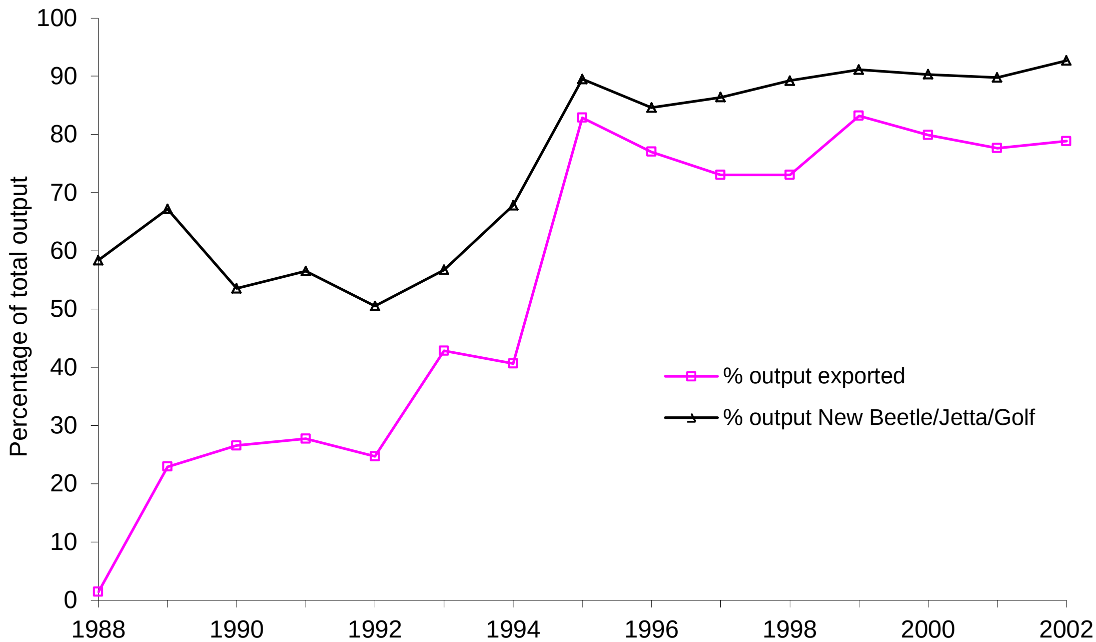
Notes: Data on employment growth and capital-labor ratio are from the INEGI Economic Censuses from 1989 and 1999 (containing information from previous year). Each symbol represents a 4-digit industry in the North American Industrial Classification System (NAICS). The size of the symbols reflect employment in the industry in 1998. The fitted regression line is weighted by employment in 1998.

Figure 8. Maquiladora and Total Industry Employment, Key Industry Groups, 1988-2008



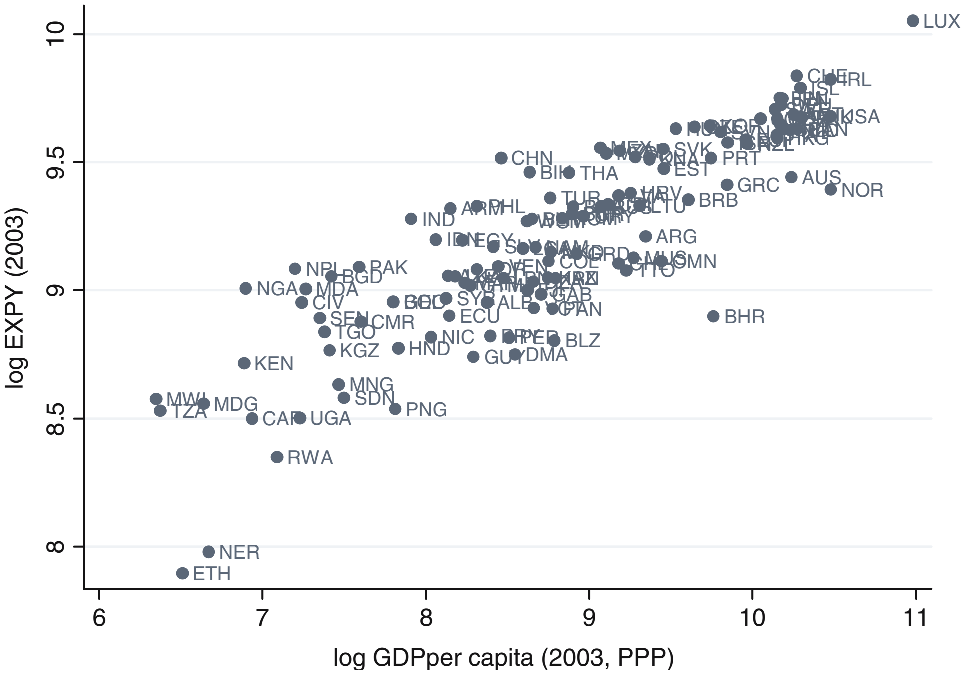
Notes: Maquiladora employment is from the *Estadísticas Mensuales de la Industria Maquiladora de Exportación* (EMIME) for 1988-2006; total industry employment is from the Economic Censuses of 1989, 1994, 1999, 2004, and 2009. We map apparel and textile products (maquila group 2) into NAICS 315 (apparel manufacturing); transportation equipment (maquila group 6) into NAICS 336 (transportation equipment manufacturing); and electrical and electronic equipment (maquila groups 8 and 9) into NAICS 334 and 335 (computer and electronic equipment; and electrical equipment, appliances, and components).

Figure 9. Quality Upgrading at VW Puebla



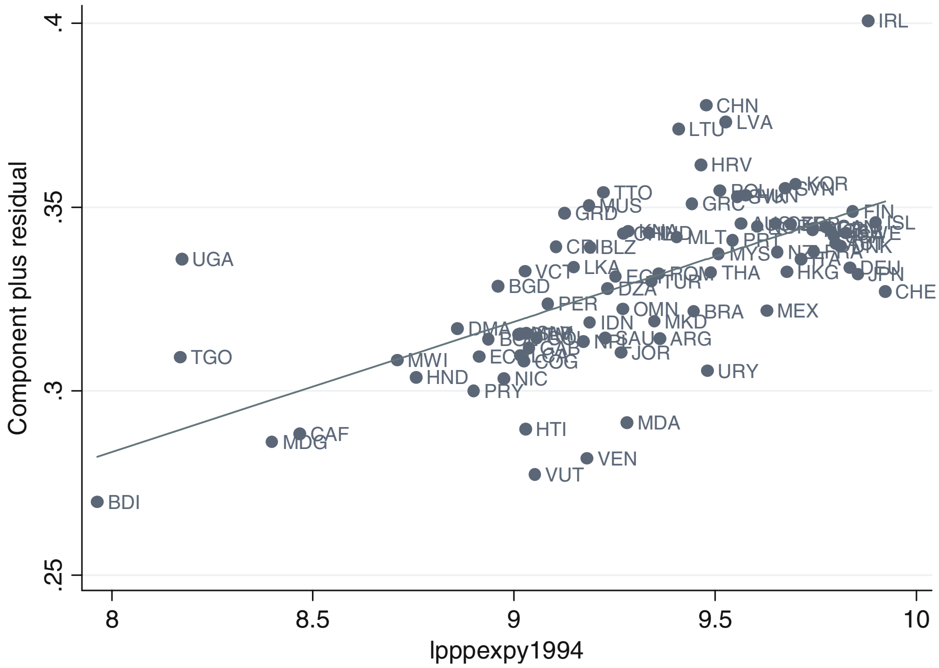
Notes: Output measured in number of vehicles. Data are from the Bulletins of the *Asociación Mexicana de la Industria Automotriz* (AMIA). Source: Verhoogen (2008).

Figure 10. EXPY vs. Level of GDP/capita



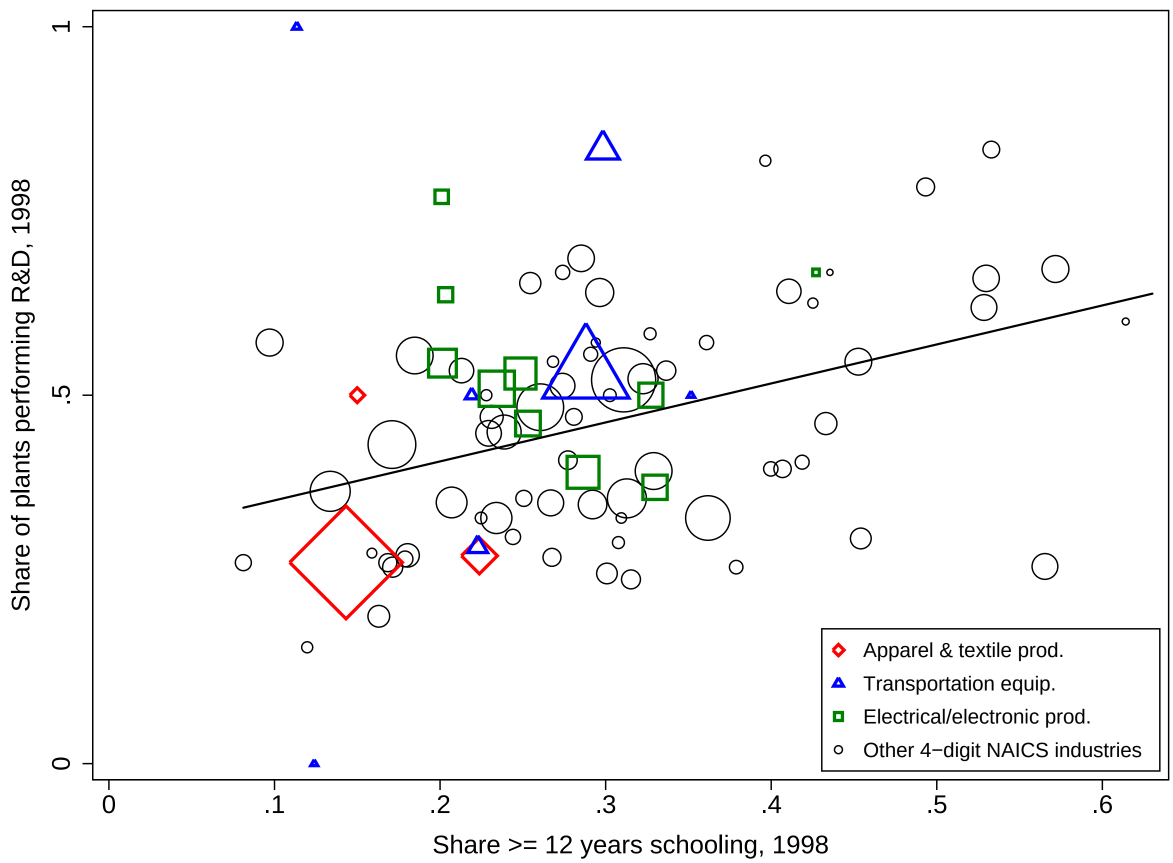
Notes: Figure appears as Figure 4 in Hausmann, Hwang, and Rodrik (2007).

Figure 11. Growth of GDP/capita vs. EXPY



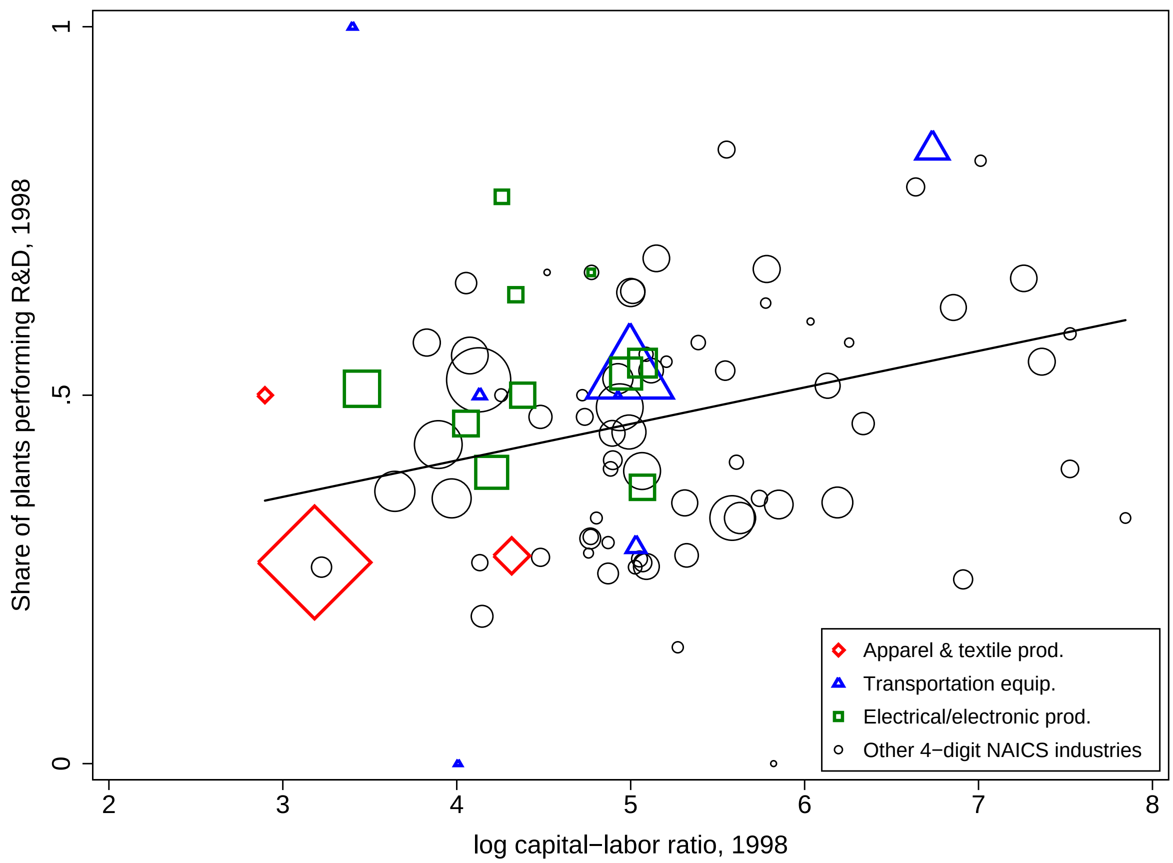
Notes: On y-axis is $X_i\widehat{\beta} + \hat{\varepsilon}$ estimated from an instrumental variables regression $\triangle y_i = X_i\beta + Z_i\gamma + \varepsilon_i$ where $\triangle y$ is change in log GDP/capita from 1992-2003, X_i is EXPY in 1994, Z_i includes log initial GDP/capita and a measure of human capital in logs, and log population and log land area are used as instruments for EXPY. Figure appears as Figure 8 in Hausmann, Hwang, and Rodrik (2007).

Figure 12. R&D Intensity vs. Skill Intensity, 1998



Notes: Size of plotting symbols reflects employment in industry. The fitted regression line is weighted by employment. The estimated slope is 0.53 with standard error 0.13; the R^2 is 0.16. Industry-level averages are for large plants (≥ 100 employees).

Figure 13. R&D Intensity vs. Capital Intensity, 1998



Notes: Size of plotting symbols reflects employment in industry. The fitted regression line is weighted by employment. The estimated slope is 0.05 with standard error 0.01; the R^2 is 0.14. Industry-level averages are for large plants ($\geq$ 100 employees).

Table 1. Comparisons of averages, all sectors, ENESTyC, 1998

	non-maquiladoras		
	non-exporters (1)	exporters (2)	maquiladoras (3)
Employment	315.43	438.97	969.67
	(8.23)	(11.07)	(30.02)
Export percentage of sales		30.81	96.52
		(0.72)	(0.63)
Foreign ownership indicator	0.08	0.29	0.84
	(0.01)	(0.01)	(0.02)
Capital-labor ratio	254.26	309.07	54.87
	(19.11)	(14.45)	(7.18)
Share with >= 12 years schooling	0.28	0.32	0.19
	(0.01)	(0.01)	(0.01)
Percentage blue-collar	70.18	70.75	83.04
	(0.56)	(0.46)	(0.63)
Years of schooling, blue-collar	7.86	8.15	7.37
	(0.04)	(0.04)	(0.06)
Blue-collar hourly wage	3.59	3.92	3.83
	(0.06)	(0.05)	(0.10)
White-collar hourly wage	7.45	9.32	9.33
	(0.14)	(0.15)	(0.27)
Turnover rate	41.47	40.54	72.37
	(1.22)	(1.06)	(2.66)
Tenure (years)	6.25	6.59	3.53
	(0.09)	(0.08)	(0.08)
N	1423	1774	557

Notes: Standard errors of means in parentheses. Sample is plants with $\geq$ 100 employees in 1999 ENESTyC. Capital-labor ratio measured in thousands of 1998 pesos; blue-collar and white-collar hourly wage in 1998 pesos. Foreign ownership indicator is 1 if foreign share of capital $>$ 0, 0 otherwise. Turnover is annual percentage turnover, defined as 100*[.5 * (new hires + separations)/employment]. Average 1998 nominal exchange rate: 9.1 pesos/dollar. See text for further details.