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Trade Liberalization and Industrial Pollution in Mexico: Lessons for the FTAA

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ABSTRACT

As the barriers to hemispheric trade and integration are lowered, it will be asked whether we will we hear the "giant sucking sound" of poorer nations luring U.S. and Canadian firms south to take advantage of low wages and lax environmental regulations? Or, will Latin American nations passively accept this problematical specialization in doing the world's cheap and dirty work?

Mexico is the ideal laboratory for such research. Though NAFTA took effect in 1994, trade liberalization in Mexico began long before that. From 1982 to 1996 Mexico transformed itself from one of the most closed to one of the most open economies in the world. As a first step in such efforts, this paper looks at the relationship between industrial pollution and economic activity in Mexico, compares those results to the United States, and draws out implications for the FTAA.

The study finds that many of the industries deemed the dirtiest in the world economy are actually cleaner in Mexico than in the US, and the industries labeled the cleanest are dirtier in Mexico. To generalize, this exhibits that trade liberalization can have both positive and negative environmental effects in developing economies. Sectors where plant vintage determines pollution levels can benefit from their ability to take advantage of newer technologies after liberalizing trade, as is the case with the Mexican steel industry. However, if pollution is a function of end of pipe technology, as in the paper industry, pollution levels are determined by levels of regulation, enforcement and compliance, which are lower in Mexico.

I. Introduction.

Controversy over the implications of economic integration was continual throughout the NAFTA negotiations and will resume in discussion of the FTAA. As the barriers to hemispheric trade and integration are lowered, it will be asked whether we will we hear the "giant sucking sound" of poorer nations luring U.S. and Canadian firms south to take advantage of low wages and lax environmental regulations? Or, will Mexico and other Latin American nations passively accept this problematical specialization in doing the world's cheap and dirty work?

[1] This chapter will be published in Esty, Daniel (ed). The Environment and the FTAA: What Can We Learn from the NAFTA Process? (New Haven: Yale University Press, 2001).

Mexico is the ideal laboratory for such research. Though NAFTA took effect in 1994, trade liberalization in Mexico began long before that. Mexico's transition from a high-tariff, import-substitution strategy to its current export-oriented free-trade policies began in 1984, triggered in part by a debt crisis in 1982. Mexico's transformation to an open economy has been thorough, and their effects can now be studied. As a first step in such efforts, this paper will look at the relationship between industrial pollution and economic activity in Mexico, and compare those results to the United States.

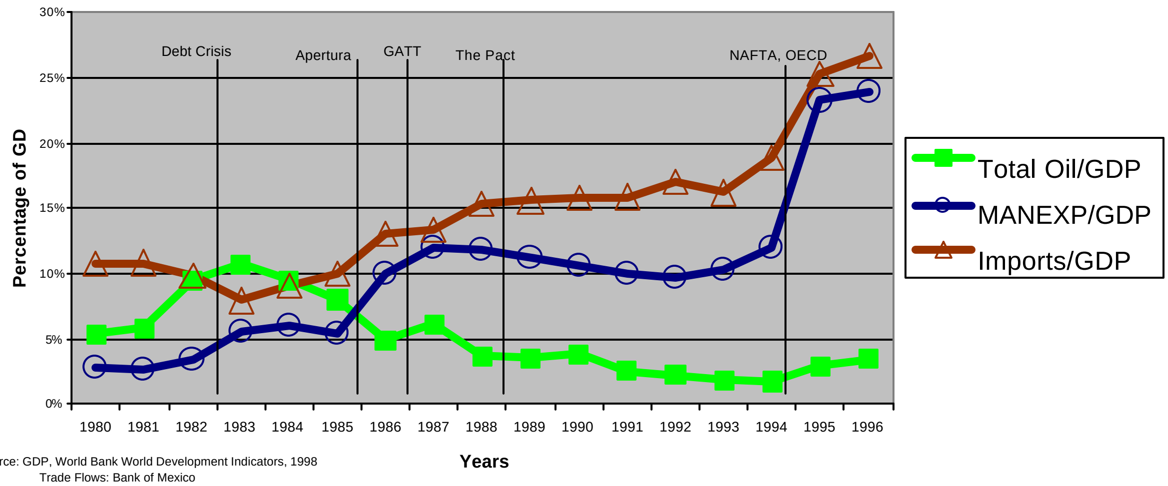
The rest of this chapter is organized as follows: first is a brief review of trade liberalization policies and overall levels of industrial pollution in Mexico; second, the theoretical perspective that is used to conduct the analysis is presented; this is followed by a discussion of previous research on industrial pollution and economic development in Mexico; fourth is an analysis of industrial pollution and economic activity in Mexico at present and during their recent period of trade liberalization; finally the results will be summarized and implications for the FTAA process will be offered.

II. Background.

Over the past 17 years, Mexico has transformed itself from a quintessential example of Import Substitution Industrialization to one of the most open economies in the world. Occurring in the midst of a number of macroeconomic crises, trade liberalization increased during four policies: the "Apertura" policy of 1985, joining the General Agreement on Tariffs and Trade in 1986, Mexico's "Economic Solidarity Pact" in 1988, and finally NAFTA in 1994 (OECD, 1996).

A significant result of Mexico's trade liberalization policies has been the emergence of manufacturing as Mexico's chief export –the sector of the Mexican economy that is the focus of this study. As Figure 1 illustrates, from 1980 to 2000, petroleum, once the major source of foreign exchange in Mexico, became an export of secondary importance. Since 1985 Mexico's chief export has been manufactures. Independent of a host of macroeconomic stabilization programs that occurred during this period, it has been shown that trade policy significantly affected this rise in manufactures exports by its effect on the peso/dollar exchange rate, and by the tariff reductions within the policy in and of themselves (Gallagher, 2000).

Figure 1. Trade Patterns and Policies in Mexico, 1980-1996



source: GDP, World Bank World Development Indicators, 1998
Trade Flows: Bank of Mexico

This transformation came at an environmental cost. A number of studies indicate that cost of environmental degradation and depletion during the period has been quite significant (Ros et al, 1996). In an early attempt to integrate environmental and economic accounting, it was estimated that the economic costs of environmental problems were 7.6 percent of annual Mexican GDP. Over half of these costs are accounted for by air pollution (3.9 percent (Tongeren et al, 1993). Interestingly, total pollution abatement and control expenditure by the public and private sectors is estimated at 0.8 percent of GDP (OECD, 1998).

The high costs associated with air pollution are due to the number of people exposed to air pollutants above WHO air quality standards (Margulis, 1992). Of all the types of environmental degradation in Mexico, air pollution also has had some of the most adverse health effects. (WHO, 1999) While Mexico City, where national nitrogen oxide (NOX) standards are exceeded nine days out of ten, is internationally famous for its levels of air pollution, this is largely due to transportation. Industrial air pollution, is significant in a number of Mexico's industrial centers (OECD, 1998).

III. Trade Liberalization and Environmental Degradation: The Theoretical Framework

While many studies provide a useful overview of the economic effects of industrial pollution in Mexico, they lack a clear picture of the differential patterns of current industrial pollution within the manufacturing sector and the change in patterns over time.

A useful framework for thinking about trade and the environment has been proposed by Grossman and Krueger (1993). They identify three mechanisms by which trade and investment liberalization affect the environment: scale, composition, and technique effects.

Scale effects occur when liberalization causes an expansion of economic activity (output). If the nature of that activity is unchanged but the scale is growing, then pollution and resource depletion will increase along with output.

Composition effects occur when increased trade leads nations to specialize in the sectors where they enjoy a comparative advantage. When comparative advantage is derived from differences in environmental stringency (i.e., the pollution haven effect), then the composition effect of trade will exacerbate existing environmental problems in the countries with relatively lax regulations. The opposite can be true when comparative advantage is a function of strong environmental controls.

Technique effects, or changes in resource extraction and production technologies, can potentially lead to a decline in pollution per unit of output for two reasons. First, the liberalization of trade and investment may encourage multinational corporations, who adhere to stricter environmental regulations in industrialized countries, can transfer cleaner technologies to developing countries. Second, if economic liberalization increases income levels, the newly affluent citizens may demand a cleaner environment.

Of the three effects, the scale effect is a straightforward consequence of economic growth; the technique effect leads to interesting questions of technology transfer. Most of the literature on trade and the environment concentrates on the composition effect. This chapter focuses on the scale and composition effects, but only small attention is paid to the technique effect because of data limitations (discussed later in this chapter).

IV. Trade Liberalization and Environmental Degradation: Selected Literature Review

There is a growing empirical literature that examines the extent to which trade liberalization affects the environment. The methodologies employed to examine these relationships are widely varied, as are the results. Work on this topic has been thoroughly reviewed by Dean (1992), by Jaffe and his colleagues (1995), and most recently by Jayadevappa and Chhartre (2000) . There are three major areas reviewed: research on the effects of state regulation within the United States; global analyses of comparative advantage and pollution intensity; and studies of bilateral trade and pollution.

From an economic perspective, the United States can be viewed as a conglomeration of states that have partially independent environmental regulations, while engaging in exceptionally free trade with each other. Thus the literature on the effects of regulation on domestic plant location may be relevant to the problems of international trade and the environment. It is common in American politics to make the casual assumption that environmental regulations have a significant effect on the siting of new plants in the United States. The empirical literature, however, suggests otherwise. This literature suggests that, contrary to public opinion, environmental stringency has had little impact on plant location decisions within the United States (Bartik, 1988, 1989; Levinson, 1996; Freidman, 1992).

There have been a number of widely cited studies on international trade flows and environmental regulations. It is within this literature where the results have been most varied. Depending on the methodology, studies range from concluding that the more open the economy, the less pollution intensive it is (Birdsall and Wheeler, 1993), to the exact opposite, the more open the economy, the more pollution intensive it is (Rock, 1996). As discussed elsewhere, there are a number of limitations in such studies. (Gallagher and Ackerman, 2000).

A few studies have looked at the environmental effects of liberalization of bilateral trade and investment. A study by Grossman and Krueger (1993), was widely cited during debates around the passage of NAFTA. Grossman and Krueger tested whether pollution abatement costs in U.S. industries affected imports from Mexico. That is, they asked whether dirtier U.S. industries relied more heavily on imports from Mexico, as would be expected if Mexico was functioning as a pollution haven relative to the U.S. They found traditional economic determinants of trade and investment, such as factor prices and tariffs, to be very important. In contrast, they found the impact of cross-industry differences in pollution abatement costs on U.S. imports from Mexico to be of little or no importance. A more recent study looked at the patterns of U.S. foreign investment in Mexico, Venezuela, Morocco, and Cote d'Ivoire between 1982 and 1994, to see whether it is influenced by U.S. pollution abatement costs (Eskelund and Harrison 1998). This study also rejects the hypothesis that the pattern of U.S. foreign investment in any of the recipient countries is skewed toward industries with high costs of pollution abatement.

V. Previous Research on Industrial Pollution and Economic Activity in Mexico

It is widely recognized that there is a lack of plant level monitoring of industrial pollution in the developing world. Such limitations have traditionally made it very difficult for environmental regulators in developing countries, to estimate pollution levels to set priorities and strategies for abatement. In recent years, the World Bank has created a number of tools that can be used to approximate both the scale and composition effects of industrial activity in developing countries. This literature is virtually all on the World Bank's New Ideas in Pollution Regulation Web site (World Bank, 2000).

In the early 1990s, the World Bank developed the Industrial Pollution Projection System (IPPS) "to exploit the fact that industrial pollution is heavily affected by the scale of industrial activity and its sectoral composition" (Hettige et al, 1994, 2). IPPS provides sector estimates of pollution intensity expressed as pollution per unit of output or pollution per employee. They have merged production and emissions data from a very large sample of firms in the United States in 1987. These intensities are widely used as proxies to estimate pollution loads in diverse industrial sectors in countries with insufficient data. IPPS has now been used to estimate intensities in a number of countries, including Brazil, Latvia, Vietnam, and Mexico. The method assumes constant emissions per unit of economic activity (per employee or unit of output) in detailed three-digit industry[2], and calculates changes due to scale and composition of industry. The technique effect is frozen by assumption.

Adriaan Ten Kate was the first to use the IPPS coefficients for Mexico. Using the IPPS estimates for pollution per unit of output in the U.S., and assuming that such intensities did not change over time, Ten Kate found that pollution intensive industries in Mexican manufactures increased by approximately 50 percent from 1950 to 1970 and by 25 percent from 1970 to 1989. In other words, the number of "dirty" industries grew relative to cleaner industries during this period (composition effect). This represents a marked change in the composition effect: Mexico moved toward more polluting sub-sectors over the period. Regarding total pollution (scale effect), he found that manufactures were producing 20 times as much pollution in 1989 as in 1950 (Ten Kate, 1993).

More recently, the World Bank, in conjunction with Mexico's National Institute of Ecology (INE) created a new database of intensities with actual Mexican pollution levels. The new database provides estimates for the amount of pollution intensity produced per employee by specific industry sectors in Mexico. Like the original IPPS estimates the Mexican estimates are available for a single year and therefore do not estimate not change in technique over time. The Mexican intensities merge data that was collected over the period 1987 to 1997, with the bulk of the data compiled from 1993 to 1995. The pollution intensities are for the following pollutants: particulates (PT); sulphur oxide (SOX); carbon monoxide (CO); nitrogen oxide (NOX); and hydrocarbons (HC) (World Bank, 2000).

Using the new estimates to evaluate the air pollution intensity of Mexican manufactures, Rhys Jenkins found contrary results to Ten Kate. Where Ten Kate found a 25 percent increase in pollution intensity in Mexican manufactures from 1970 to 1989, Jenkins' research found no general increase in pollution intensity over the period. Jenkins was also able to examine pollution intensity from 1988 to 1995. Here, Jenkins observed a reduction in the air pollution contaminants. The rest of his paper resorts back to the U.S. based coefficients. He finds that for almost all pollutants, the pollution intensity of Mexico's export oriented manufactures in 1990 is greater than the pollution intensity of protected industries in 1979 (Jenkins, 1998).

VI. Limitations of Existing Research

[2] ISIC codes and "digits" are used interchangably in this chapter and refer to International Standard Industrial Codes (ISIC), a standardized categorization of the world's industrial sectors developed by the United Nations.

IPPS has proved to be a very useful tool in estimating industrial pollution, especially in the context of the enormous data limitations in the developing world. While such estimates cannot be conclusive, they can suggest general directions and trends. The fact that the literature discussed above came to contrasting conclusions highlights the limitations still present with existing approaches. There are four limitations that make the above literature problematic in estimating industrial pollution in Mexico during the era of trade liberalization: assuming that pollution intensities in developing countries are equal to those in the United States; using pollution per unit of employment as the variable for economic activity; holding pollution intensity constant over time; and lacking sufficient post-NAFTA data to evaluate Mexico's full transition to openness.

The World Bank and many of the users of IPPS make note of the limitations of using U.S. based pollution intensities to estimate those in developing countries (Hettige et al, 1994). The U.S. is known for having some of the most stringent environmental regulations in the world today and developing countries are just beginning to enact comparable policies. All developed by the World Bank, the new Mexican intensities described above, in addition to intensities provided for China, show how drastic this assumption really is. Table 1 shows comparable intensities in for SOX in China, Mexico, and the United States for manufactures (two-digit ISIC codes). On average, Mexican intensity is twice the U.S., while the Chinese intensity for SOX is 68 times the U.S.

Table 1. Pollution Intensity for SOX in China, Mexico and U.S.

	China	**Mexico**	**US**
(Food, Beverages, and Tobacco Manufactures)	15.89	1.71	0.50
(Textiles, Wearing Apparel and Leather Tanneries)	11.50	1.56	0.35
(Wood and Wood Products Manufactures)	43.04	0.68	0.36
(Paper, Printing, and Publishing Products)	26.63	5.67	2.33
(Chemicals, Petroleum, Coal, Rubber, and Plastic)	84.52	2.80	3.16
(Non-Metallic Mineral Products)	44.38	1.96	6.19
(Basic Metals -Iron and Steel, Non-ferrous Metals	n.a	1.12	11.89
(Fabricated Metals, Machinery, and Equipment)	4.30	0.08	0.15
(Other Manufacturing)	9.67	0.15	0.03

Source: World Bank, New Ideas in Pollution Regulation, www.worldbank.org/nipr.

The existence of the China and Mexico intensities are a marked improvement. It puts the three countries into better perspective. While both are developing countries, Mexico is much closer to the US than China. In addition, analysts now have three countries to choose from to estimate the pollution intensity of developing country industry. Indeed, in a recent paper the Mexican coefficients were used to examine the pollution intensity of Brazilian industry (Dasgupta et al, 1998).

The second limitation of the existing research, and the hardest to alleviate, is the reliance on coefficients for a fixed point in time. Because there is only one data point, each of the earlier studies had to assume that pollution per employee was constant over time. Thus, the appearance of sector wide intensity changes over time are actually changes in the composition effect over time. The U.S. estimates were collected during a period when pollution control measures had been in place for quite some time, where in developing countries such measures have been largely ignored until recently. With either the U.S. or Mexico based estimates it is safe to assume that when forecasting backward in time, analysts are underestimating pollution intensity (Ten Kate, 1993).

Another limitation is the use of employment as the measure of economic activity. Indeed, in the technical papers describing IPPS, the World Bank says that the "volume of output would be the ideal unit of measurement." (Hettige et al, 1994). They acknowledge that in many countries such data are not available and require a number of conversions that make manipulating the data more difficult. Employment data is more prevalent and recommended as a proxy.

This poses a problem, particularly for nations undergoing trade liberalization. Employment levels are not measures of economic performance, and can vary independently from output levels. During transition or crisis firms can shed workers to maintain productivity, without changing production technique in any way that affects emissions. Thus, using pollution per unit of employment as the measure of economic performance can further skew one's picture of pollution because such estimates may be tracking large employment losses rather than actual changes in economic activity (see Appendix A for further discussion).

This has been shown to be exactly the case in Mexico during the period 1988 to 1995, the era during which Jenkins found a significant decrease in pollution intensity. Jonathan Heath has shown that from 1988 to 1995 manufactures productivity increased approximately 6 percent each year, where employment growth was largely negative during the same period. He concludes that "the data strongly suggest an all-out improvement (in productivity) in Mexican manufacturing as a direct result of trade liberalization." (Heath, 1998, 188). Depending on the rate of productivity increases in different industries, one might expect that the decrease in pollution intensity from 1988 to 1995 may not be as drastic.

The last limitation is certainly no fault of the previous authors. Data were only available until 1995 and were thus not sufficient enough to examine the effects of Mexico's full transition to liberalized trade. These limitations are improved upon in the next section.

VII. Analysis

The current analysis will improve upon three of the limitations outlined above. This study will use actual Mexican air emissions intensities, pollution per unit of output for the measuring economic activity, and economic data in Mexican manufactures from 1988 to 2000. The analysis will be in two parts. Part A will estimate pollution per unit of output in Mexico for 1997, total pollution for 1997, and create a Mexico/U.S. pollution intensity index for four air pollutants, PT, SOX, CO, and NOX. Using the 1997 estimates as constant over time, Part B will estimate the scale and composition effects in Mexican industry from 1988 to 2000.

Data from this analysis is supplied from several sources. The Mexican intensities are derived from the World Bank estimates. The original units of measurement for employment intensities are tons per employee. The pollution intensities are at 2 and 3-digit ISIC (version 2) level of industry. Statistics for output and employment for 2 and 3 digit industries are from the Instituto Nacional de Estadistica, Geographica, y Informatico (INEGI), Mexico's national institute of statistics. Exchange rate and price deflator indicators for Mexico are from the Bank of Mexico. GDP deflators for the United States are from the Bureau of Economic Analysis.

A. Pollution Intensity in Mexico and the United States

Using the 1997 Mexican intensities supplied by the World Bank, this section will determine: air pollution intensity in Mexican manufactures measured by pollution per unit of output; total pollution in Mexican manufactures measured by tons of emissions; and calculate a Mexico – U.S. pollution intensity ratio (see Appendix B for methodology).

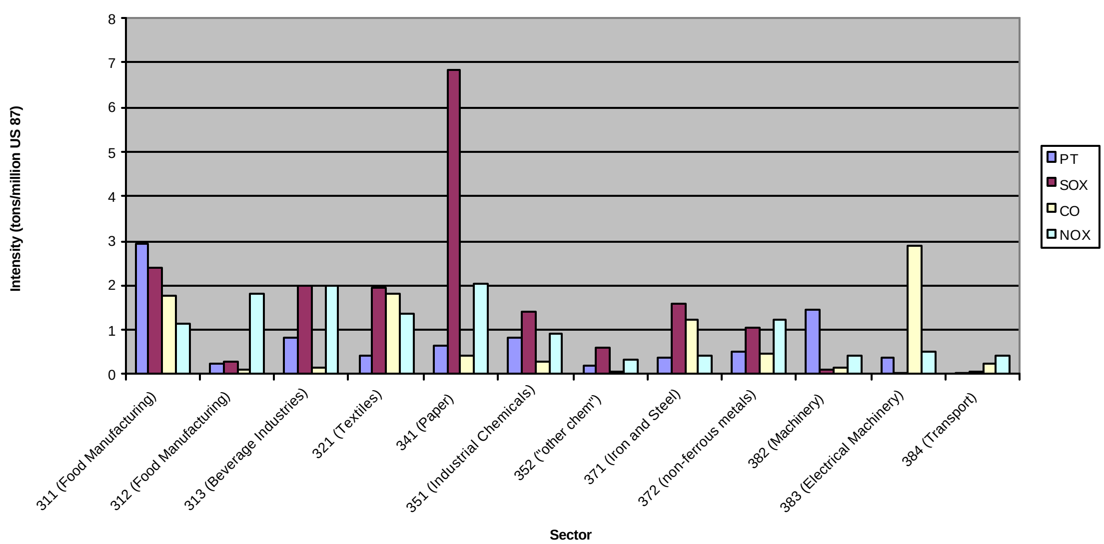
Table 2. 12 Largest Sectors in Mexican Manufactures, 1997

311 (Food Manufacturing)
312 (Food Processing)
313 (Beverage Industries)
321 (Textiles)
341 (Paper)
351 (Industrial Chemicals)
352 ("other chem, pharmaceuticals, etc")
371 (Iron and Steel)
372 (non-ferrous metals)
382 (Machinery)
383 (Electrical Machinery)
384 (Transport)

Table 2 lists the twelve largest sectors in Mexican manufacturing for 1997 (measured in output terms). These firms represent 89 percent of all of Mexican manufacturing. The two largest sectors are the Transport (384) and Food Manufactures (311) sectors, representing 23 percent of the top 12 total. Based on earlier studies, the six dirtiest industries in the world economy are Iron and Steel, Petroleum (353 and not included in this data set), Non-Ferrous Metals, Food Manufactures (311), Industrial Chemicals, and Paper (Mani and Wheeler, 1999).

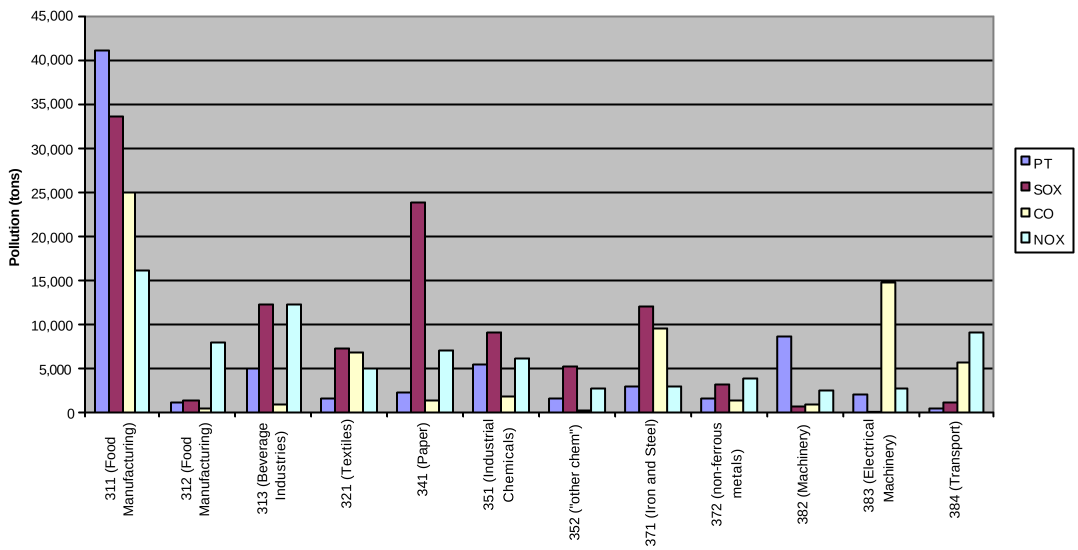
Pollution intensities for these twelve sectors are depicted in Figure 2. Consistent with previous studies, Food Manufactures (311) is the most pollution intensive industry for three of the four air pollutants. For PT, Machinery is the second most pollution intensive. The Paper industry is the most pollution intensive for SOX, Food Manufactures (311) follows. For CO, Electrical Machinery and Textiles are also among the most pollution intensive for CO. Food Manufactures (312), Beverages, Paper, and Non-ferrous Metals are the most pollution intensive for NOX. These results are consistent with previous studies except in the case of Textiles. Textiles, considered in many studies as one of the cleaner industries in the world economy, is near the top of the list for SOX, and CO intensity in Mexico.

Figure 2. Pollution Intensity of 12 Largest Mexican Manufactures, 1997



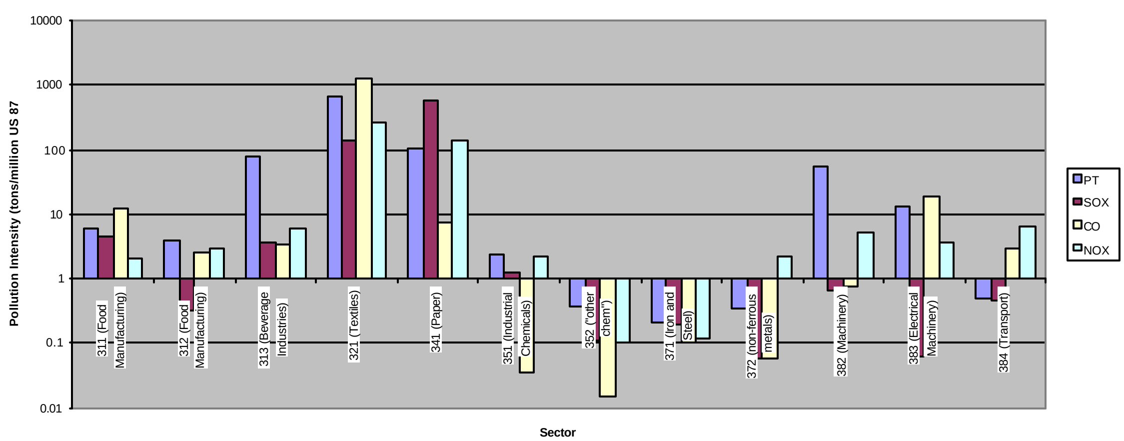
Total pollution in these twelve sectors is shown in Figure 3. Food Manufactures (311), the second largest sector in Mexico, is the largest polluter in all categories. In fact, as a proportion of total pollution in the twelve sectors, Food Manufactures (311) contributes 55 percent of all PT, 30 percent of all SOX, 36 percent of all CO, and 20 percent of all NOX. Following this sector, Paper is the largest SOX emitter, Machinery is the largest CO emitter, and the Beverage industry is the runner up for NOX.

Figure 3. Total Pollution in 12 Largest Mexican Manufacturing Industries, 1997



The most interesting of these calculations is the Mexico – U.S. pollution intensity ratio, shown in Figure 4. Most striking are the ratios for Textiles (which are 137 to 1225 times as dirty in Mexico depending on the pollutant), and Paper (which are 70 to 592 times as dirty). If those two are taken out of the sample then the twelve largest Mexican industries are on average 6.23 times dirtier than U.S. industries. In addition to Textiles and Paper, the Food and Beverage industries range from 2 to 10 times worse than those in the U.S. PT in the Mexican Machinery industry is close to 100 times as dirty as Machinery in the U.S. Electrical Machinery is over 10 times dirty for PT and CO.

Figure 4. Mexico/US Pollution Intensity Ratio for Manufacturing, 1997



There are different explanations for the high ratios in Textiles and Paper. Since pollution intensity data is only available at the three-digit level, the high pollution intensity in Mexican Textiles may be a reflection of differences in the composition of US and Mexican Textiles manufacturing beyond the three-digit level. Mexico participates in more pollution intensive forms of textile production. The Textiles industry Mexico has a significant presence in synthetic fibers and finishing. In synthetic fibers Mexico is considered to be quite competitive (Botella, Garcia, and Giral, 1991). Synthetic fibers is one of the most air pollution intensive sectors of the textiles industry (OECD, 1991; Bartzokas and Yarime, 1997). Further research is needed to determine if the differences in the composition of "clean" and "dirty" industries within the textiles sector are due to trade policies between Mexico and the US (methodologies have been developed in Gallagher and Ackerman, 2000).

Air emissions in the Paper industry are not determined by core technology, but by pollution control technology. The last significant wave of innovation in basic technologies in paper production occurred from the late eighteenth to the mid-twentieth centuries (Smith, 1997). Controling air emissions then, has been left to the development of "end of pipe technologies" which are often imposed by governments or civil society (Smith, 1997, Hartman, Huq, and Wheeler, 1997). Thus, in the Mexican case, relatively high pollution intensity in the paper industry could be due to the degree of Mexican legal and institutional commitment toward air pollution in the Paper sector. If there are lax regulations or enforcement in this sector, substitution effects may occur where the Paper industry would spend their money on factors other than pollution control. As shown in Figure 7, at Mexico's highest period of plant level inspections, it was only visiting six percent of all establishments in manufacturing.

Perhaps what is most surprising are the industries that are as clean or cleaner than those in the United States. Other Chemicals (pharmaceuticals, cosmetics, film, etc.), Iron and Steel, and Non-Ferrous Metals each fall into this category –some of the very industries deemed the dirtiest in the world economy! Mexican plants are relatively newer than in the US, since Mexico's industrial growth is recent. If pollution intensity depends primarily on plant vintage, and is hard to vary after installation, Mexico may benefit from newer, cleaner plants in these sectors. While it is known that significant FDI has flowed to Mexico since NAFTA, sectoral FDI data is difficult to obtain. A recent OECD study however, indicates that most of new FDI has gone into Petrochemicals, Chemicals, Fertilizer, and Steel (OECD, 1998). It is likely that the new FDI in Chemicals and Steel has been in the form of the cleanest technology. This is the case in the Mexican steel sector, which has experienced diffusion of electric technology (Reppelin-Hill, 1999).

Another possibility, but less plausible, relates to the data. The World Bank reports that 25 of the dirtiest polluters were omitted from the sample because they caused an outlier problem. It is possible that these 25 plants account for a large share of the output in the apparently cleanest sectors.

B. Industrial Pollution In Mexican Manufactures, 1988 – 2000

This section estimates the composition and scale effect in Mexican manufactures over time. Using actual emissions data from Mexico and using pollution per unit of output as the variable for productions puts the analysis in a slightly better position to forecast with a fixed coefficient backward and forward in time. It must still be noted that there is reason to believe that using 1997 pollution intensity as a constant is underestimating the Mexican case.

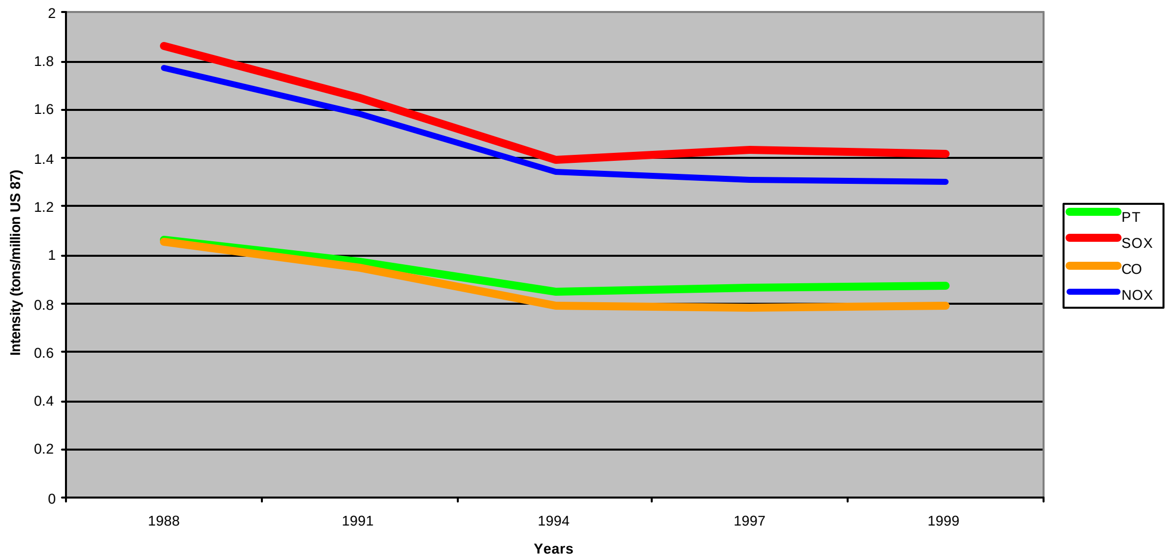
This part of the analysis is conducted using 2 digit classification codes for Mexican industry from 1988 to 2000. The methodology for determining total pollution intensity (or the composition effects), and therefore total pollution is shown in Appendix C. Table 3 lists the nine 2-digit industries for Mexico.

Table 3. 2 Digit ISIC Manufactures Industries

31 (Food, Beverages, and Tobacco Manufactures)
32 (Textiles, Wearing Apparel and Leather Tanneries)
33 (Wood and Wood Products Manufactures)
34 (Paper, Printing, and Publishing Products)
35 (Chemicals, Petroleum, Coal, Rubber, and Plastic)
36 (Non-Metallic Mineral Products)
37 (Basic Metals -Iron and Steel and Non-ferrous Metals)
38 (Fabricated Metals, Machinery, and Equipment)
39 (Other Manufacturing)

Pollution intensity, calculated bi-annually from 1988 to 2000, is shown in Figure 5. One can observe a dip from 1988 to 1994. This is the composition effect. Since pollution per unit of output is held constant fluctuations in pollution intensity over time reflects changes in the composition of industries. During the period of the Economic Solidarity Pact and leading up to the NAFTA one can see a slight composition effect toward cleaner industries. From 1988 to 2000 overall output dropped but dropped less in cleaner industries. Figure 6 also shows that the composition of Mexican industry did not change very much at all after NAFTA was signed in 1994.

Figure 5. Pollution Intensive Composition of Mexican Manufactures, 1988 - 1999



Where pollution intensity shows at the composition effect over time, total pollution levels allow one to observe the scale effect. Again, total pollution is calculated by multiplying total output by pollution intensity, and is thus in large part a reflection of output growth. Figure 6 shows total pollution in Mexican manufactures from 1988 to 2000. One can witness close to a 10 percent drop in overall emissions for each pollutant from 1988 to 1994. From 1994 until the present however, total pollution almost doubles. As discussed earlier in the paper, using a fixed coefficient for pollution intensity may underestimate pollution intensity previous to 1997. Further research is needed to determine the spatial distribution of these industries. If total pollution is concentrated in just a few areas in Mexico, critical health thresholds may be in jeopardy.

Estimates of a technique effects (changes in resource extraction and production technologies that lead to a decline in pollution per unit of output) over time are not possible with the available data. If pollution intensity was available for more than one year, it would be simple to track changes in pollution intensity in manufacturing sectors from one year to the next. However, we do know many of the variables that traditionally cause reductions in pollution intensity. Based on these factors it can be hypothesized that Mexican industry in 1997 is cleaner in pollution intensity terms than in it was ten or fifteen years ago.

Figure 6. Estimates for Air Emissions in Mexican Manufacturing, 1988-1999

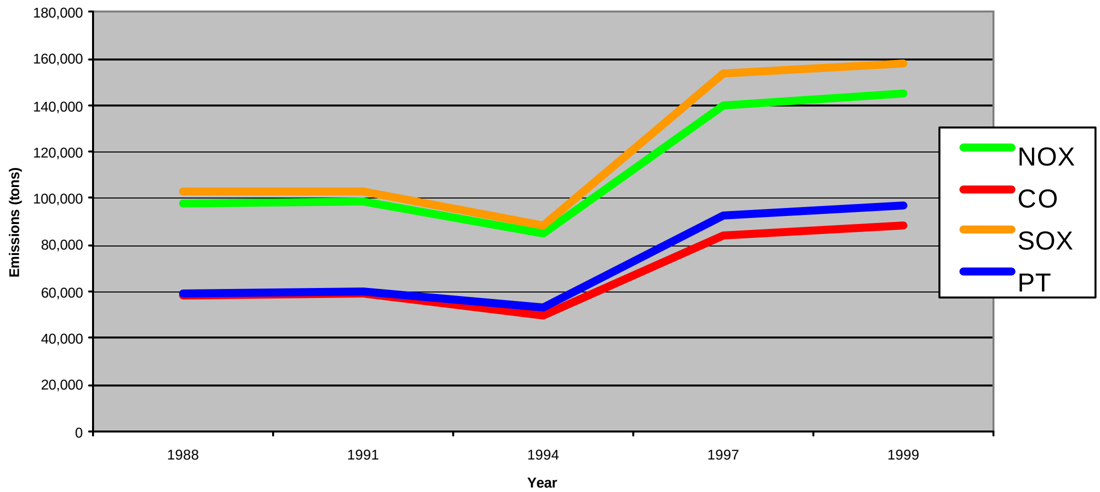
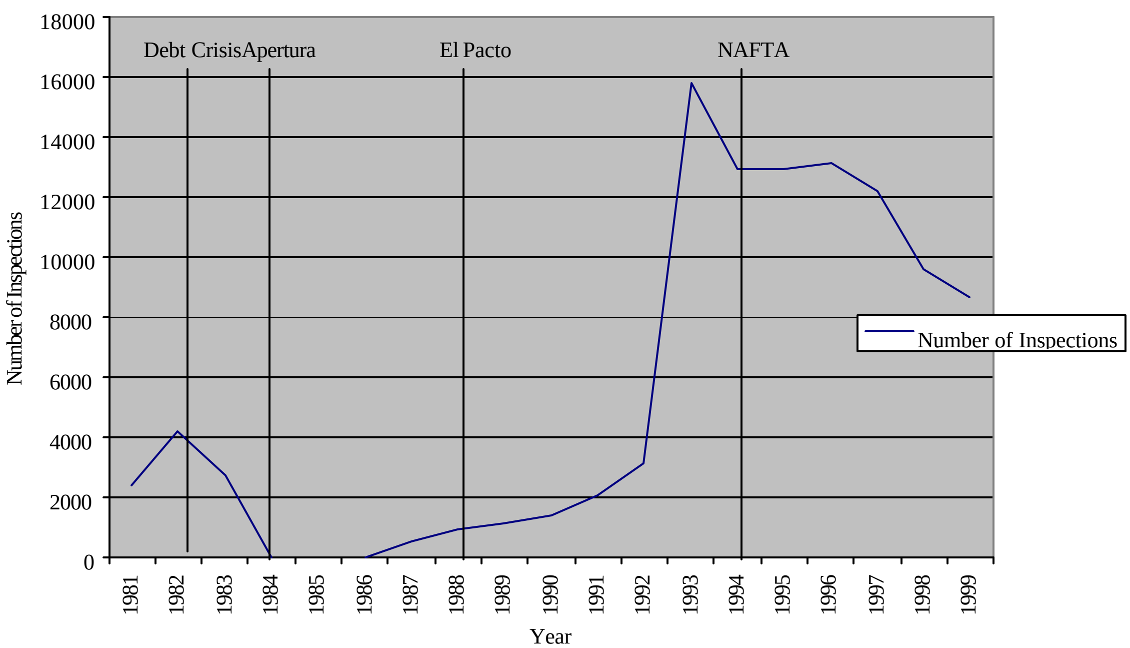


Figure 7. Plant Level Environmental Inspections by Mexican Authorities, 1981-1999
source: PROFEPA, 2000



In the 1990s Mexico began to step up its system of enforcement and created a system of citizen complaints (OECD, 1998). Mexico's environmental enforcement record, shown in Figure 7 has risen sharply since its inception in the late 1980s (although it has dropped of considerably in recent years). In addition, Mexico has established a formal system of citizen complaints. In 1992 1, 281 were filed, in 1997 there were 5,644. During the 1990s, it has also been documented that a number of environmental initiatives have been sparked by the private sector. The Latin American chapter of the World Business Council for Sustainable Development was established in Mexico City in 1993. In 1992, Mexico's National Council of Ecological Industrialists (CONIECO) was created as an organization of manufacturers and resellers of products that can help clean the environment. Finally in 1994, the Center for Private Sector Studies for Sustainable Development (CESPEDES) was formed (Barkin, 1999). As a result of all these efforts, the OECD concludes that large firms now meet environmental standards, but small and medium sized firms do not (OECD, 1998).

VIII. Summary and Conclusions

Mexico's transition from a closed economy to one of the most open economies in the world has not been without environmental consequence. While the extreme pollution problems, particularly with air pollution, in Mexico have been well known for some time, this study has developed a methodology to better understand how industrial economic activity contributes to these problems.

Using this methodology, pollution intensity and total pollution in Mexican manufactures industry has been estimated for 1997 and compared to the United States. The most pollution intensive industries in Mexico are Food Manufactures (311), Beverages, Industrial Chemicals, Textiles, and Paper. Each of these, except for Textiles, is considered one of the most pollution intensive industries in the world economy.

The creation of a Mexico – U.S. pollution intensity index for 1997 yields striking results. On average, the 12 largest Mexican industries are considerably dirtier than their U.S. counterparts. This is largely due to Paper and Textiles Manufacturing, which are dirtier than the same industries in the U.S. by orders of magnitude. However, what may be more striking is the fact that Other Chemicals (pharmaceutics, etc.), Iron and Steel, and Non-Ferrous Metals are as clean or cleaner than their U.S. counterparts.

From 1988 to 1994, the scale of Mexican industry dropped, with cleaner industries dropping less than dirty ones –resulting in a slightly cleaner composition of industry. Total pollution however, while slowing from 1988 to 1994, has close to doubled since.

This research has only focused on the scale and composition effects of Mexican manufactures. An important next research step would be to estimate the changes in the composition of Mexican industry relative to changes in the composition of the U.S. Such estimates would allow one to examine the so-called 'pollution haven' effect. This research is already underway (Gallagher and Ackerman, 2000).

Data restraints have made examinations of the technique effect impossible. Estimates of the pollution per unit of output before 1994 or 1988 would allow one to examine actual changes in pollution intensity over time in Mexico. Thus analysts could better pinpoint which technologies were having which kinds of effects across industries. At present it is very difficult to estimate pollution intensity over time in Mexico.

The results from this study have three important implications for the FTAA process. Trade liberalization throughout the Americas will change the nature of comparative advantage in the Western Hemisphere. Based on these new sources of comparative advantage, nations will begin to specialize in new sets (or specialize in current sets at a higher rate) of industries in order to maximize that advantage. It is hoped that significant growth will occur in such industries, and thus help raise the standard of living in those economies.

The first two implications are related to technology. If specialization occurs in sectors where pollution is in part a function of plant vintage, this study implies that those nations may be able to "leap frog" into cleaner technology in sectors where environmentally sound technological innovation has occurred. The Mexico – US pollution intensity ration used in this study showed that industrial sectors such as Iron and Steel are "cleaner" in Mexico than their counterparts in the United States. In this case, Mexico's relatively late industrialization allowed Mexico to deploy newer, cleaner mini-mill technology rather than some of the larger blast furnace technology in the US. If other nations in the Americas will specialize in industries with improved core technology, they may be able to enjoy a lower level of pollution intensity in such industries as well.

Conversely, when Latin American nations specialize in industries where pollution intensity is determined by pollution control technologies, not the vintage of core technologies, the pollution intensity of such industries will be determined by the level of environmental stringency in those nations. This has been shown to be the case in the Mexican Paper industry. Paper is one of the most pollution intensive industries in Mexico, especially for air emissions of Sulfur Dioxide. Pollution in the Paper industry is relatively less varied by core technology than by pollution control technology. This is an indication that when specialization occurs in such sectors, and environmental policy is also lax, pollution intensive industry may rise.

Perhaps the most significant implication of this study for the FTAA process is the need to stress the importance of reducing the levels of pollution intensity in manufacturing. All nations in an FTAA will be looking to increase economic growth in manufacturing. Such growth is much needed and will be most welcome to help spur the development of Latin American economies. This study has shown that unless increases in output in pollution intensive sectors are drastically accompanied by reductions in pollution intensity, total pollution will rise with such output. In Latin American regions already approaching critical environmental thresholds, such increases in total pollution may jeopardize the benefits of increasing economic activity in those areas.

VIII. Technical Appendices

A. Calculating Pollution Per Employee Estimates

(1)

$$\frac{P}{E} = \frac{P}{Y} * \frac{Y}{E}$$

Where (P) is pollution, (Y) is output, and (E) is employment. The expression Y/E then is productivity. If productivity is growing, then constant pollution per unit of output implies growing pollution per employee (or, constant pollution per employee implies falling pollution per unit of output. Constant pollution per unit of output implies holding technological change constant as well. Seen in this light, using pollution per unit of employment can further skew one's picture of pollution because such estimates may be tracking large employment losses rather than actual changes in economic activity.

B. Creating a Mexico - US Pollution Intensity Ratio

Pollution Intensity is best expressed in terms of pollution per unit of output. Using the 1997 Mexican intensities supplied by the World Bank, this section will determine: air pollution intensity in Mexican manufactures measured by pollution per unit of output; total pollution in Mexican manufactures measured by tons of emissions; and calculate a Mexico – U.S. pollution intensity ratio. Taken in full, this process, excluding the total pollution calculations, can be expressed as:

(2)

$$R_{mu} = \frac{P_m / Y_m}{P_u / Y_u} = \frac{(P_m / E_m) / (Y_m / E_m)}{P_u / Yu}$$

Where the same notation as equation (1) holds, and (m) is Mexico, (u) is the United States, and (R) is the ratio.

Output is measured in 1987 dollars: requiring both deflation and currency conversion. INEGI supplies output for Mexican manufactures in thousands of current pesos. Using Mexican producer price indexes, output is converted into 1992 pesos. 1992 pesos are converted to 1992 dollars, which are then converted to 1987 dollars with the GDP deflator (to be consistent with the published U.S. intensities). 1992 is considered a stable currency year, and also makes the figures comparable to earlier results. These output figures in each sector are divided by the number of employees. The Bank's pollution per employee estimates, are then divided by the productivity measure. Mexican pollution intensity expressed as pollution per unit of output is then divided by the U.S. intensities expressed in pollution per unit of output to determine the Mexico – U.S. ratio. To determine total pollution, pollution intensity is multiplied by total output.

C. Composition and Scale Effects Over Time

This part of the analysis is conducted using 2 digit classification codes for Mexican industry from 1988 to 2000. The methodology for determining total pollution intensity (the composition effect), and total pollution is shown in equation 3:

(3)

$$P_m / Y_m = \frac{\sum (P_i / Y_i * Y_i)}{\sum Y_i}$$

Where the same notation as the previous equations apply and (m) is for all manufactures, (I) is for industries within manufactures. To calculate total pollution (scale effect), pollution per unit of output is multiplied by output in each 2-digit industry and then added together. That total is then divided by the sum of the total output for 2 digit sectors to determine the composition effect for the entire manufactures industry.

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