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Midiendo el crecimiento en la productividad total de los factores de la manufactura mexicana: la historia antes y después de la liberalización comercial

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El artículo se enfoca en la medición y análisis del crecimiento de la PTF en la manufactura mexicana durante el período 1970-2003, y su importancia como fuente del crecimiento del ingreso. El horizonte temporal abarca los eventos más importantes de apertura comercial en la historia económica mexicana: GATT (1986) y TLCAN (1994), lo cual nos permite visualizar el comportamiento de la PTF en la manufactura antes y después de los eventos de liberalización comercial. La estimación del crecimiento en PTF se realiza a nivel de subsectores, utilizando el Método de dos deflactores de Harberger. Los hallazgos del artículo señalan que la liberalización comercial, que fue principalmente conducida por el TLCAN, ha mejorado la productividad de la manufactura en México. Los resultados de nuestra estimación muestran que la tasa de crecimiento promedio anual en PTF para la manufactura durante el período pre-TLCAN fue negativa, mientras que la tasa de crecimiento promedio anual en PTF para el período pos-TLCAN fue positiva.

Clasificación JEL: O4, O47, F13, N6.

Palabras clave: productividad total de los factores, productividad en México, productividad en manufactura, liberalización comercial en México, TLCAN.

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The paper focuses on measuring and analyzing TFP growth in Mexican manufacturing during the period 1970-2003 and its importance as a source of growth in income. The analysis time span covers the most important events of trade openness in Mexican economic history: GATT (1986) and NAFTA (1994), and this allows us to visualize TFP behavior in manufacturing before and after the trade liberalization events. TFP growth estimation is done at subsector level of desegregation and using Harberger's Two Deflator Method. The paper's findings indicate that trade liberalization, which was mainly driven by NAFTA, has enhanced manufacturing productivity in Mexico. Our estimation results show that annual average TFP growth rate in manufacturing was negative during the pre-NAFTA period while the post-NAFTA annual average TFP growth rate was positive.

JEL Classification: O4, O47, F13, N6.

Keywords: total factor productivity, productivity in Mexico, productivity in manufacturing, trade liberalization in Mexico, NAFTA.

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…Increased productivity has historically been the most reliable path to poverty reduction, and hence merits a position of high priority in national and international efforts.

Arnold C. Harberger, 2005

One of the most important components of GDP growth for any country is total factor productivity (TFP) growth or real cost reduction. Moreover, economists view productivity as the main engine for economic growth. The traditional methodology applied for TFP measurement and analysis is based on the one designed by Griliches-Denison-Jorgenson (GDJ), whose main characteristic is the vast amount of information required to estimate productivity advance. On the other hand, regression-based (and in general parametric) methods for TFP estimation have been questioned because of the underlying assumptions about a specific functional form for the production function. In the last decade, Arnold C. Harberger has found a very simple and robust method to estimate productivity advances whose results are very similar to those presented by GDJ. Harberger's method is called the two deflators method (2D), and it has the particular advantage of requiring a significantly less amount of information to calculate productivity growth, and the required data is easily available in most of the cases.

This paper focuses on measuring and analyzing the evolution of TFP growth in Mexican manufacturing during the period 1970-2003 and its importance as a source of growth in income. The paper particularly aims at applying and spreading Harberger's 2D method that can be used at any level of aggregation, making the calculation of productivity growth easier. The breakdown of the growth rate into its component parts will allow us to analyze the "anatomy" of growth in manufacturing that Mexico experienced during the period of analysis.

The time span in the analysis covers the most important events of trade openness in Mexican economic history: GATT (1986) and NAFTA (1994), and this allows us, in a way, to visualize the TFP behavior in manufacturing before and after the trade liberalization events. The estimation for TFP growth is done at subsector level of disaggregation which will help to a better understanding of how trade opening has affected TFP in the manufacturing industry. Because data sources for this research are the Mexican Industrial Censuses, a reclassification of industrial classes was necessary in order to obtain homogeneous industrial subsectors comparable trough time.

The paper's findings indicate that trade liberalization, which was mainly driven by NAFTA, has enhanced manufacturing productivity. Our estimation results show that aggregate TFP growth rate in manufacturing was negative during the pre-NAFTA period while the post-NAFTA aggregate TFP growth rate was positive. This is particularly important if we consider the poor performance that the Mexican economy as a whole experienced during the decade 1993-2003.

The paper is organized as follows. The next section provides a theoretical background on the TFP concept and estimation methods and presents arguments to justify the use of Harberger's 2D method as estimation procedure. The paper then describes the methodology used in measuring TFP in Mexican manufacturing and discusses the estimation results per period highlighting the TFP aggregate behavior before and after NAFTA. The paper concludes with final remarks.

I. THE CONCEPT OF TOTAL FACTOR PRODUCTIVITY GROWTH

Total Factor Productivity (TFP) growth can be understood as that part of GDP growth that is not explained by the increase in the use and quality of factor inputs. Alternatively, TFP growth can be defined as the GDP growth that occurs when the quantitative and qualitative change in factors of production is zero. Abramovitz (1962, pp. 762-766) defines the change in TFP as the effect of 'costless' advances in applied technology, managerial efficiency and industrial organization, where the concept of 'costless' should be interpreted as that effect obtained above the costs of factor inputs (which should be understood as the employment of scarce resources with alternative uses).

Most economists view TFP improvements in a production function framework. They think of the improvements as shifts of the production function and usually associate the shifts with inventions, with new technologies and research and development (R&D) expenditures (Harberger, 1998b). Conversely, TFP improvements can also be viewed as movements along the same production function. According to Jorgenson (1967, pp. 249-255) TFP growth may be identified with shifts of the production function as opposed to movements along the production function if this function is characterized by constant returns to scale and if we add the necessary conditions for producer equilibrium —all marginal rates of transformation between pairs of inputs and outputs are equal to the corresponding price ratios—. However, if the production function incorporates the effects of increasing returns to scale, externalities and disequilibrium, then TFP changes could be interpreted as movements along the production function.

But, if TFP changes come from a shift or from a movement along the production function (or both), is not the big issue in reality. The fact is that, for those involved in the production process (entrepreneurs or production managers), is really hard to figure out and describe the production function for their business or enterprise, and even harder to find out if the productivity improvement was due to a shift in the production function or it was a simple movement along the curve. For business executives, production managers, etc., it is easier to visualize TFP growth as Real Cost Reduction (RCR), because it is a concept on their minds at some point or another in any given week, month or year. As mentioned by Harberger, "RCR is something every business executive understands and identifies with. For a businessperson to seek to reduce costs is just as natural and self-justifying as for consumers to look for ways to increase satisfaction they get out of their income and their assets" (2005, p. 4) […]. "RCR is a major path to profit in good times, and a major defense against adversity in bad times" (1998a, p. 3). Therefore, Harberger suggests that increases in TFP are equally well described by the term "real cost reductions", making these two terms equivalent, although with different connotations.

If we recognize that all economic growth takes place at the level of the productive enterprise, then it makes sense to locate the origin of TFP growth or RCR at the level of the productive enterprise too. So, the entrepreneur and/or production manager are key agents for the important task of developing and implementing activities focused on real cost reduction. RCR is multifaceted and can take a thousand forms. For example, we can computerize payrolls, downsize operations, downsize the product catalog (number of models), outsource goods and services, change management styles, change inputs, introduce incentive bonuses for employees, or move to piece wage rates, or install a background music system at the workplace. It is clear then that the origin of TFP growth is located in the enterprise. However, we cannot leave aside the analysis of this important concept at a higher level of data aggregation, since economists should search for and implement those economic policies that foster economic growth. It is then on our special interest, to go into the analysis and measurement of TFP growth at subsector level.

II. ON MEASURING TFP GROWTH

For a better understanding of this important concept of growth accounting, we can start with the familiar breakdown of the growth rate (Harberger, 1998a):

$$\frac{\Delta Y}{Y} = \left(\frac{\bar{w}L}{\bar{p}Y}\right)\left(\frac{\Delta L}{L}\right) + \frac{(\bar{\rho}+\delta)K}{\bar{p}Y}\left(\frac{\Delta K}{K}\right) + R \tag{1}$$

where ΔY = change in output (GDP); ΔL = change in labor input; ΔK = change in capital stock; $\bar{p}$ = initial general price level; $\bar{w}$ = initial real wage; $\bar{\rho}$ = initial real rate of return to capital; δ = real rate of capital depreciation; R = growth residual or growth unexplained by increases in quantitative and qualitative use of traditional inputs.

Equation (1) provides a very helpful mathematical expression to understand that the five principal ways to generate growth are: using more labor (ΔL), using labor of greater skill and capacity (w), adding capital via net investment (ΔK), finding investments of higher real rates of return (ρ), and continually finding new ways to reduce real costs (R).

The residual of growth (R) is alternatively referred to as technical change, TFP improvement or RCR as defined by Harberger. It represents a very important source of output growth, since typically this measured residual accounts for half or more of the output growth rate. Understood as TFP improvement, the residual of growth can make us think of externalities of different kinds, like economies of scale, spillovers, or systematic complementarities (Harberger, 1998a), all of them working together to generate output growth. And understood as RCR the residual can take a wide variety of forms like the ones previously explained, all of them related to the concept of saving resources to produce at least the same output level. In our opinion, this vision of the residual of growth results very simple, understandable and convenient. In spite of its complexity, real cost reduction can be reduced to a single metric and can be made additive, characteristics that do not follow so easily from the labels technical advance and TFP (Harberger, 1998a, pp. 3-5). To clarify these ideas, we can work out an example. Let us assume a simple economy with three industries A, B and C; assume, also, that TFP grew by 50%, 40% and 30%, in industries A, B and C, respectively, during a five year period. If the initial value added amounted to 200 billions of pesos for industry A, 300 billions of pesos for industry B and 500 billions of pesos for industry C, then we can say that real cost reduction of industry A was 100 billions of pesos, and of industries B and C, 120 and 150 billions of pesos respectively during the quinquennium. Moreover, for our simple economy of three industries, we can say that, measured at initial prices, the overall real cost reduction was 370 billions of pesos. It is important to mention here that, if TFP growth (or RCR) happens to be negative for a particular industry, then we would say that the industry suffered real cost augmenting.

III. TFP ESTIMATION METHODS

For years economists have debated about the concept of TFP growth and how to measure it. As a result, the economic literature has shown different methodologies for TFP growth measurement, and two main approaches can be distinguished. One of them is the parametric approach, which involves the specification of technology, either through the specification of a production or cost function. Under this approach we find methodologies based on neoclassical growth models and endogenous growth models, as well as econometric techniques for TFP growth estimation. The alternative is the non-parametric approach, which does not involve any functional specification of technology.

The methodology designed by Griliches-Denison-Jorgenson (GDJ) has been considered by some authors as one of the most careful contemporary techniques for estimation of TFP growth. This methodology has been applied to US data in several research studies on growth. Pioneered by Griliches (1960, 1963) it was also utilized by Denison (1967), Kendrick (1973) and Jorgenson (1995). GDJ methodology has been also applied by Cárdenas (1978, 1987) to measure and analyze Mexico's TFP growth during the period 1950-1975 and during the Great Depression period. However, this methodology has the characteristic of requiring a vast amount of information when computing the labor contribution to growth. Specifically the complication on this step arises because the labor force needs to be broken down into a huge number of categories if one wants to correctly capture the contribution of human capital into the labor term of growth accounting. The fine breakdown of the labor force is not available in many cases and particularly when working with high levels of data aggregation, hence limiting the application of GDJ methodology.

Other techniques based on the neoclassical growth model and endogenous growth models, became popular in economic literature during the last two decades and have been utilized very recently on data for a variety of countries. For example Meza and Quintin (2006) calculate TFP growth in Mexico and East-Asian countries to explain TFP drastic fall during financial crises; Cavalcanti, De Abreu and Veloso (2006) calculate TFP for 18 Latin American countries (Mexico among them) to compare the average TFP in Latin America with the US TFP. Bergoeing *et al*. (2002) calculate TFP for Mexico and Chile using this methodology with data from IFS, World Bank and Penn-World to show evidence that the crucial determinant of differences in "after crises recovery path" between these two countries was a faster productivity growth in Chile. Despite its popularity, this methodology has been questioned by other authors because of the restrictive assumptions it relies on, like neutral technological change, perfect competition in goods and factor markets, Cobb-Douglas production function and constant returns to scale. Likewise, regression based methods have been also questioned because of the underlying assumptions on functional form of the production function (should the production function be the same for all plants, branches, sectors or industries?) and on market conditions. Additionally, estimation problems using regression methods for TFP usually become more severe when using plant-level data. Specifically, attrition problems arise resulting in a sample selection bias,[1] and simultaneity[2] problems can also be present in the estimation procedure.[3] This technique has been recently applied at firm-level TFP studies for Mexican manufacturing (López-Córdoba, 2003) and Brazilian manufacturing (Muendler, 2004).

The methodology developed by Harberger and called the two deflator method (2D) falls within the non-parametric approach and is a very simple and robust method for TFP advance estimation, whose results are very similar to those presented by GDJ. The particular advantage of this method consists of a significantly less (compared to

1 The reason is that less productive plants are more likely to exit the sample, leaving only the most productive plants in the sample.

2 Simultaneity bias may arise because, even though TFP is not observed by researchers, plant managers might observe TFP or make inferences about plant's productivity level, choosing plant's inputs based on this (see López-Córdoba, 2003 and Muendler, 2004).

3 Olley and Pakes (1996) propose an estimation procedure that addresses both issues.

GDJ) amount of information requirements to calculate productivity growth, with the required data being easily available in most cases (Harberger, 1999). Additionally, the 2D method can be used at any data aggregation level. Harberger (1990) applied the 2D method to US data to calculate TFP improvement among US industries during the period 1958-1967, and more recently the 2D method has been used by Robles (1997) who calculated TFP growth for US manufacturing sector over four successive five-year periods (1970-1995). The 2D method has been also applied to calculate TFP growth in Mexican manufacturing.[4] In particular, Torre (2000) calculated TFP growth rates for period 1984-1994 at firm level using data from a sample of 1893 establishments that were divided into 44 branches of industry. Torre's results show an annual average TFP growth rate of -0.89% in the whole manufacturing industry for the analyzed period, and the winner branches were soft drinks with 2.04% of TFP growth rate (annual average), cement with 1.59% and other wood products with 0.26%. The "loosing" branches during this period were spinning, wearing apparel and synthetic resins with -3.95%, -3.8% and -3.77% of annual average TFP growth rate respectively.[5]

In order to show the reliability of his methodology and avoid reluctance in granting acceptance to something that was new (or at least different), Harberger's 1998b paper was focused on making comparisons between the 2D and GDJ methods. His analysis is carried out using data at the national level and at the level of industries/sectors in the United States. The main conclusion of this author's work is that, once the 2D and GDJ methods were put on comparable basis with respect to output definition, their results were highly correlated, and this similarity applied regardless of which quantity variable was used. Additionally, country by country comparisons between the two methods were presented in the same research paper, surprisingly showing how similar the results are.

The estimation of TFP in the present paper is done at subsector level (so the subscript *j* in the equations refers to subsector instead of sector) using Harberger's 2D method, and in order to have a better understanding of this methodology we should start with a basic TFP growth expression. Algebraically, TFP growth is represented as:

4 Angulo and Guillermo (2005) also applied 2D method to analyze TFP growth in Mexican manufacturing for the period 1929-1944.

5 See Torre (2000) for more details on TFP growth rates in other branches.

$$TFP_{jt} = \frac{\Delta y_{jt}}{y_{jt-1}} - \frac{(\rho_{jt-1} + \delta_j)\Delta K_{jt}}{y_{jt-1}} - \frac{w^*_{t-1}\Delta L^*_{jt}}{y_{jt-1}} \qquad (2)$$

where TFP_{jt} = total factor productivity growth for subsector j in period t; $\Delta y_{jt} / y_{jt-1} =$ real output (value added) growth rate for subsector j in period t; $\left(\rho_{jt-1} + \delta_j\right)\Delta K_{jt} / y_{jt-1} =$ contribution of capital to the growth rate for subsector j in period t; $w^*_{t-1}\Delta L^*_{jt} / y_{jt-1} =$ contribution of labor to the growth rate for subsector j in period t.

The main computational characteristics of the methodology can be summarized as follows:

> The two-deflator method is characterized by the use of a single numeraire-deflator (say, the GDP deflator), by the treatment of the quantum of output as value added divided by the numeraire-deflator, and the use of a standard wage w^* and a quantum of labor L^* equal to the wages bill divided by w^*. […] the two-deflator method is rough. But is also tremendously robust and easily applied Harberger (1998b, pp. 47).

As previously explained, the data sources of our research are the Mexican Industrial Censuses and the analysis time span makes us deal with three different classification systems for the censuses: Mexican Classification of Activities and Products (MCAP), North American Industrial Classification System (NAICS) and International Standard Industrial Classification (ISIC). Because of these different methods of classification, the branches and classes of each census are not comparable through time. For this reason, we regrouped the classes in order to obtain homogeneous groups which we call subsectors. An example of the regrouping task is presented in Appendix B at the end of the paper. As result, we finally grouped the classes into 38 subsectors for the whole manufacturing industry. The description of each subsector can be found in Appendix C.

The 2D method has two principal ingredients. The first one is the estimation of the rate of return on capital (RRC), defined as the ratio that income from capital bears to capital stock. The output growth imputed to the increase in capital input (or capital contribution's to the growth rate), can then be represented as $\left(\rho + \delta\right)\Delta K / y$. The second part of the 2D method is focused on the estimation of income imputed to the increase in the "raw labor" as well as the estimation of income imputed to human capital accumulation (i.e. expertise, education, training, etc.). This step is basically done by computing a representative real wage (w^*) for relatively unskilled labor (raw labor). It should be remarked here that the separation of these two sources of labor income enables us to avoid the problem of counting the contribution of labor improvement to the increase in labor productivity as a rise in TFP. In order to estimate labor's contribution to growth through the 2D method, we need to select the representative real wage (w^*) for relatively unskilled labor. Using w^*, we can attribute to the change in any given category of labor ΔL_{ij} a contribution to the growth of output (or value added) equal to w^* (for raw labor) plus (w_{ij} - w^*) (for the human capital contribution to growth) times the change in the number of workers ΔL_{ij}. In the following sections, the two parts of the 2D method will be explained with more detail, but before going through those sections, it is convenient to see that equation (2) can be manipulated to obtain an expression like equation (4):

$$TFP_{jt} = \frac{\Delta y_{jt}}{y_{jt-1}} - \left(\frac{(\rho_{jt-1} + \delta_j)K_{jt-1}}{y_{jt-1}}\right)\left(\frac{\Delta K_{jt}}{K_{jt-1}}\right) - \left(\frac{w^*_{t-1}L^*_{jt-1}}{y_{jt-1}}\right)\left(\frac{\Delta L^*_{jt}}{L^*_{jt-1}}\right) \quad (3)$$

and

$$TFP_{jt} = gy_{jt} - sk_{jt-1}gk_{jt} - sl_{jt-1}gl_{jt} \quad (4)$$

where *gy*, *gk* and *gl* are the growth rates, over the period under study, of output (value added), capital stock and labor respectively, while *sk* and *sl* are the shares of capital and labor in the output (value added).

IV. ESTIMATION OF THE RRC: THE ROLE OF THE FIRST DEFLATOR

As stated above, the estimation of RRC is necessary in order to compute the capital's contribution to the growth rate. To measure the RRC, both the numerator (real pesos of return) and denominator (capital stock), must be expressed in the same units. Following Harberger's 2D method, the most effective way to do this is to measure output (value added) and capital stock in units of the GDP deflator. This is precisely the role of the first deflator in the 2D method.

By definition the gross RRC $(\rho + \delta)$ can be estimated by subtracting from real output, the total payments (in real terms) to other inputs different from capital, and dividing this result by the capital stock in real terms. That is:

$$\rho_{jt} + \delta_j = \frac{q_{jt} - rm_{jt} - w_{jt}L_{jt}}{K_{jt}} \tag{5}$$

where q_{jt} is real output in subsector j at time t; $w_{jt}L_{jt}$ is the real payment to labor input in subsector j at time t; rm_{jt} is the real payment to all raw materials used in the production process of subsector j at time t; δ_j is the real rate of depreciation to capital in subsector j, and K_{jt} is the real capital stock of subsector j at time t. In this paper, the capital stock is calculated from gross total assets data and all the variables included in equation (5) are expressed in real terms using GDP deflator. This step is essential when computing the RRC, since numerator and denominator must be expressed in the same units. On the other hand, one key difference between Harberger's 2D and GDJ methods is the units in which capital stock is expressed (Harberger, 1998b, p. 10). GDJ's traditional approach thinks of capital stock as a quantity of machines, buildings and inventories, while the 2D approach thinks of it as "an amount of real purchasing power allocated to the purpose of generating future income", as Harberger mentions:

> It is important to realize that this attribute of the two-deflator method is not an aberration. It is exactly the way the same problem has always been handled in standard investment analysis, where the entire profile of cash flows of an investment project is put into real terms by deflating all flows (the negative flows of the investment years and the positive flows of the production years) by the same deflator. This is necessary in order to derive the internal rate of return (or calculate the net present value). For a real rate of return, the flow of income (the numerator) must be expressed in the same real units as the denominator (the capital stock) (Harberger, 1998b, pp. 10-11).

V. ESTIMATION OF LABOR CONTRIBUTION TO GROWTH: THE ROLE OF THE SECOND DEFLATOR

The labor contribution to output growth in subsector j at time t, is given by the term $\left(w_t^* \Delta L_{jt}^* / y_{jt}\right)$ in equation (2). To capture the great heterogeneity of the labor factor it is necessary to have a fine breakdown of labor categories. The labor contribution is $\Sigma_i w_{ij,t} \Delta L_{ij,t}$, where $w_{ij,t}$ represents the real wage of category i, in subsector j at time t, and $\Delta L_{ij,t}$ the change in hours worked by category i in subsector j at time t. However, the number of relevant labor categories can be big, turning this task into more complicated the more disaggregated the labor categories are. To avoid such a complication in the calculation of the labor contribution to growth, the 2D method uses a standard wage w^* assigned to "standard labor" or "raw labor", and as explained by Harberger (1998a, pp. 29), the excess of any worker's actual wage over w^* is attributed to human capital. The returns to education, training, and experience are included into this "excess wage" under this interpretation. The w^* variable is in fact the second deflator. It is meant to avoid the huge complication involved in finding the labor contribution to the growth rate when the Jorgenson-Griliches method is used, because there is no need to split the labor force into a huge number of categories (male, female, young, old, experienced, etc.). The wage of relatively unskilled workers (w^*) is then used as a numeraire, in the sense that, if we have the number of hours worked (h) for a certain individual and his/ her hourly wage, then hw^* will be the "pure" labor earnings and $(w - w^*)h$ are the labor earnings imputed to human capital. In the present research paper, the computation of the second deflator (w^*) is performed by dividing the wage bill for the "blue collar" workers in subsector j at time t by the number of blue collar workers in the same subsector and time, which will give us a w^*_{jt}. Both, blue collar workers' wage bill and number, are data directly reported in the censuses. Once we have the w^*_{jt} for each subsector, the overall w_t^* (the second deflator) is computed as the median across the subsectors[6] for time t. Algebraically:

$$w^*_{jt} = \frac{bcwagebill_{jt}}{bcn_{jt}} \text{ and } w^*_t = Median\left(w^*_{jt}\right)$$

where $bcwagebill_{jt}$ is the total wage bill paid to blue collar workers, and bcn_{jt} is the number of blue collar workers in subsector j at time t. The next step in the TFP estimation corresponds to the calculation of L^*_{jt}, which represents the quantum of labor (standard or raw labor). This calculation is straightforward since all we have to do is to divide the total wage bill for each subsector at time t by w_t^* (the labor deflator). That is $L^*_{jt} = total\ wage\ bill_{jt} / w_t^*$.

6 Using the median of w^*_{jt} as the standard wage or the relatively unskilled workers wage, is statistically correct if we want w^* to be the wage in the middle of the distribution of the w^*_{jt}'s (50th percentile) for each t. In our sampling data case, the median and mean values of w^*_{jt} for each t are very close to each other, which also guarantees to have a w^* value very close to the center of gravity of the w^*_{jt}'s sampling distribution. Actually, if the distribution of w^*_{jt} is symmetric, the mean and median values are the same. Additionally, the choice of w^* as the mean or the median of w^*_{jt} does not affect the measurement of human capital differences between subsectors. w^* represents only a numeraire. Hence, if subsector A pays higher wages because workers on average have better skills (more human capital) compared to sector B, the choice of w^* will not affect the relative difference in human capital between subsectors A and B.

So far we have explained the procedures used for TFP growth estimation for each subsector in our study. Our next task is to estimate and analyze the change in TFP for the aggregate manufacturing industry. The aggregate TFP growth rate for an industry consisting of *N* subsectors can be calculated as follows:

$$TFP_t^* = \sum_{j=1}^{N}\left[\left(\frac{y_{jt-1}}{y_{t-1}}\right)TFP_{jt}\right] \quad (6)$$

where TPF_t^* is the aggregate TFP growth rate for manufacturing at time *t*, and the TFP growth rate for each subsector is weighted by its original share of total output (or value added). It is important to mention that all the equations can be used for any aggregation level (where the subscript *j* can represent an industry, a sector, subsector, branch, class or even an enterprise). Equation (6) will be the base for the construction of productivity diagrams, which in our research study will allow us to understand how each subsector is contributing to the aggregate productivity growth of the industry.

VI. TFP GROWTH ESTIMATION RESULTS

As mentioned, the analysis time span (1970-2003) covers the most important events of trade openness in Mexican economic history: GATT (1986) and NAFTA (1994). TFP growth rates were estimated for each five-year period except 1980-1988 period.[7] Annual average growth rates were calculated (to make them comparable through time) for each period, and results are summarized in Table 1. This table shows that, for each period of time, some subsectors experienced TFP improvement or RCR, while some others experienced productivity drop or real cost augmenting. In other words, for each and all of the sub-periods under study, we can find winners and losers. This is a very natural result if we understand that TFP improvement happens at the level of the firm, and firms from a specific subsector may have different ways to respond to innovations and new challenges, compared to firms in other subsectors. This is the reason why some subsectors (and more specifically, firms) end up winners and others end up losing. While analyzing TFP growth per subsector could lead us to a very interesting study about the "openness effect", for this paper purposes we will

7 Due to the 1985 earthquake in Mexico city, some of the census data for that year were missed. This is the reason why the National Institute of Statistics, Geography and Information (INEGI) made another census just three years later (1988). To avoid any bias because of this reason, we decided to take an eight-year period from 1980 to 1988.

Table 1
Annual Average TFP Growth Rates per Subsector in Manufacturing
(percentage)

	Subsector	1970-1975	1975-1980	1980-1988
1	Production, processing and preservation of meat and poultry	-4.60	1.90	-0.69
2	Fish and crustacean products	0.13	-7.33	4.99
3	Vegetables, fruits and foods	3.19	-6.29	4.05
4	Oils and fats	-3.94	0.76	1.05
5	Dairy products	0.04	-0.37	-1.00
6	Milling and grain products	1.09	-8.42	16.92
7	Wheat and corn products	1.99	-10.84	4.45
8	Sugar production	0.44	3.22	-6.14
9	Cocoa and chocolate products, candies	5.32	-8.14	0.83
10	Prepared animal food	-6.60	-0.24	0.67
11	Alcoholic beverages	14.13	-18.83	-1.72
12	Soft drinks, water and sodas	2.65	-5.13	-2.85
13	Tobacco	6.55	-10.66	10.54
14	Other foods	-1.41	-1.38	-0.33
15	Fibers, spinning	2.13	-4.57	-0.83
16	Textiles	0.20	-3.66	-0.91
17	Confection of textiles products	3.49	-7.69	-5.38
18	Clothing	0.85	-2.27	-0.82
19	Wardrobe accessories	0.32	-3.13	-2.81
20	Leather products	4.25	-6.69	-0.81
21	Shoes	1.14	-3.50	-2.28
22	Wood and wood products	2.53	-3.30	-2.03
23	Cellulose and paper products	2.38	-2.56	0.08
24	Printed products	2.73	-5.93	1.13
25	Oil refinery, petrochemical products	1.57	4.33	-10.25
26	Chemical products	2.57	-5.82	0.43
27	Pharmaceutical products	1.49	-4.92	2.59
28	Plastic and rubber products	0.46	-5.12	-0.83
29	Glass and glass products	1.96	-1.22	-1.88
30	Non-metallic mineral products	2.98	-3.86	-0.15
31	Basic metal industry	4.00	-8.87	-4.88
32	Metal products	3.32	-7.28	0.51

	1988-1993	1993-1998	1998-2003	1970-1993	1993-2003
	-2.67	5.38	-2.41	**-1.56**	**1.86**
	-4.40	-0.74	11.76	**-0.72**	**5.89**
	-4.36	-1.88	6.04	**-0.21**	**2.64**
	-20.56	14.62	0.38	**-4.76**	**7.61**
	3.56	-1.79	7.91	**0.24**	**3.62**
	-29.11	3.08	3.06	**-2.15**	**3.44**
	-4.19	2.12	1.44	**-1.24**	**2.41**
	1.49	1.63	7.36	**-0.95**	**3.48**
	7.63	-8.13	-2.22	1.25	-4.55
	-0.56	-0.98	3.09	**-1.70**	**1.72**
	11.91	-1.38	-4.21	0.81	-2.11
	9.65	-3.14	7.53	**0.28**	**2.82**
	6.68	-20.24	18.01	3.89	-0.10
	4.85	-5.71	-0.43	0.41	-2.55
	-6.23	4.61	-1.35	**-2.20**	**3.57**
	-2.89	-0.92	-1.64	-1.83	-0.58
	7.57	-7.56	4.01	-1.09	-1.32
	-0.17	-3.09	7.07	**-0.67**	**2.45**
	2.66	0.84	1.77	**-1.36**	**1.30**
	-5.36	2.74	2.69	**-2.05**	**3.44**
	-1.05	-0.42	4.27	**-1.66**	**2.15**
	-3.17	3.10	4.25	**-1.72**	**4.14**
	-10.83	4.22	5.27	**-2.40**	**5.26**
	-1.41	-4.09	3.87	**-0.81**	**0.38**
	10.17	-33.19	26.43	-0.15	-2.37
	1.03	1.52	2.14	**-0.41**	**2.54**
	2.81	-3.22	11.53	**0.49**	**4.77**
	-2.18	4.36	0.08	**-1.98**	**2.92**
	-2.26	1.03	9.10	**-1.02**	**5.75**
	3.59	-2.78	7.22	**0.40**	**2.88**
	-0.12	10.42	-8.03	**-2.95**	**2.21**
	-3.37	5.49	0.92	**-1.53**	**3.44**

Table 1 (continued)
Annual Average TFP Growth Rates per Subsector in Manufacturing
(percentage)

Subsector	1970-1975	1975-1980	1980-1988
33 Production of machinery and equipment	7.16	-5.95	-2.11
34 Production of communication and measurement equipment, electric machines and their components	2.70	-5.90	-0.76
35 Automotive industry	-1.22	5.70	-1.28
36 Other equipment of transportation	-4.39	1.61	-5.59
37 Furniture production	1.20	-2.46	-3.06
38 Other manufacturing	2.38	-5.92	-1.76
Aggregate manufacturing industry (weighted average)	2.36	-5.22	-1.54

Source: Author's calculations with data from censuses, Banxico and INEGI.

focus on the performance of the manufacturing industry as a whole. Hence we will proceed with the calculation of aggregate TFP growth rates (applying equation 6) for each period of analysis.

VII. SUNSET-SUNRISE PRODUCTIVITY DIAGRAM

Harberger (1998a) has proposed an innovative method of visually depicting the distribution of productivity sectors or subsectors of the industry. Productivity diagrams summarize the TFP contribution to growth of each subsector and allow us to easily find the aggregate TFP growth rate for a particular period of time. To construct the diagram, we first sort the industrial subsectors and their corresponding initial VA shares by TFP growth rates in descending order (that is, listing the most productive first). Then, we calculate the TFP contribution to growth for each subsector *j* given by the term $\left(\frac{y_{jt-1}}{y_{t-1}}\right)TFP_{jt}$. Tables A.1 through A.8 located in Appendix A contain all the necessary information for construction of period specific productivity diagrams that show the annual average TFP distribution of the industry. For a clear understanding about how the productivity diagram is elaborated, let us take as example the TFP growth estimation results for period 1970-1975 presented in Table A.1, Appendix A. As explained, for each subsector TFP contribution to output growth is calculated by multiplying the subsector's TFP growth

	1988-1993	1993-1998	1998-2003	1970-1993	1993-2003
	-0.80	5.24	2.59	-0.56	4.19
	-0.94	1.36	5.99	-1.30	3.82
	-1.46	1.18	2.74	-0.19	2.57
	-3.43	10.59	2.48	-3.47	6.59
	0.51	-1.37	6.41	-1.31	2.85
	2.68	-1.58	5.71	-0.75	2.65
	-0.52	-2.58	3.62	-1.03	1.94

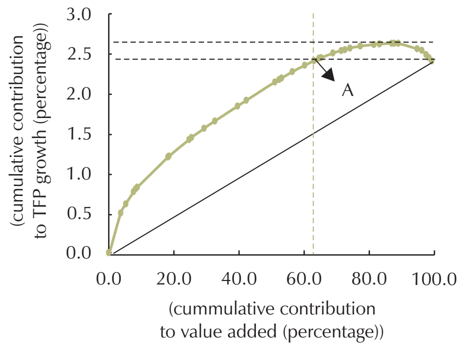
rate with its corresponding VA share. Column F in Table A.1 shows the cumulative TFP contribution to growth, and the sunrise productivity diagram[8] is created by plotting the last two columns of the table. Graph 1 depicts the resulting sunset-sunrise diagrams for each one of the six sub-periods of analysis.

For period 1970-1975, the aggregate (all 38 subsectors included) annual average TFP growth rate was 2.36%. The magnitudes and distributions of each subsector TFP growth rates determine the shape of the sunrise diagram. The part of the curve showing rising slope is the result of cumulative contributions of those subsectors with positive TFP growth rates, while the falling slope part of the curve is the result of cumulative contributions of the negative productive subsectors (only six in this case). In column E of Table A.1 we can observe that the maximum TFP growth rate was 2.63%. This is the TFP growth rate that could have been achieved if negative productive subsectors were removed from the industry. It is interesting to note also that subsectors that cumulatively produced 88.94% of VA in this period, had positive TFP growth rates. Another point of interest to be mentioned here is point A, which is called the 100% point. The meaning of this point is that, with just the first 60.2% of

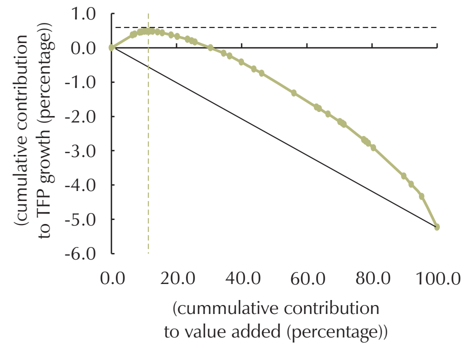
8 Note that, the productivity diagram is called sunrise diagram if final or aggregate TFP growth rate is positive, and is called sunset diagram if the aggregate TFP growth rate is negative.

Graph 1
Sunset-Sunrise Productivity Diagrams
Mexican Manufacturing Industry

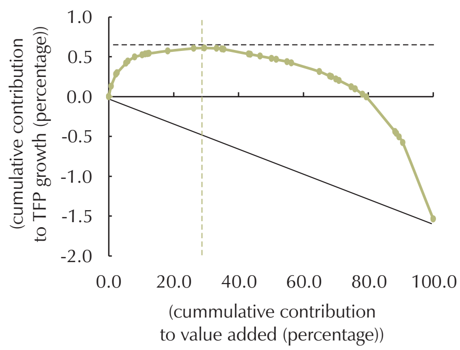
A. 1970-1975



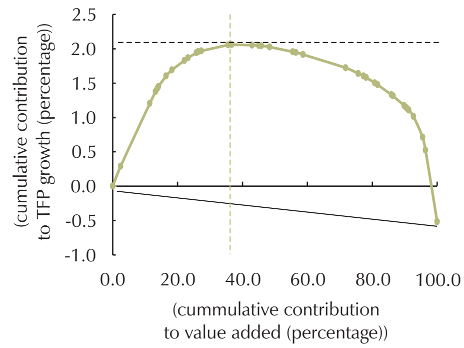
B. 1975-1980



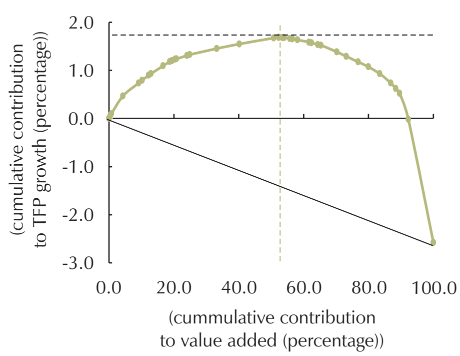
C. 1980-1988



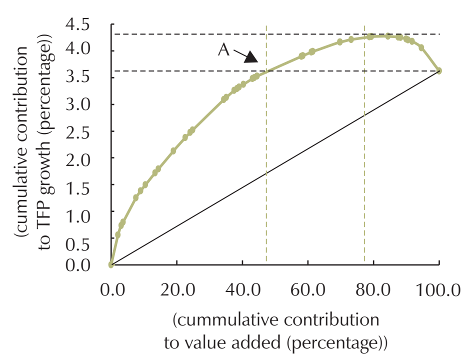
D. 1988-1993



E. 1993-1998



F. 1998-2003



Source: Author's calculations with data from censuses, Banxico and INEGI.

VA share (in this case), the cumulative TFP growth rate has already reached the final aggregate TFP growth rate of 2.36%. TFP's contributions to VA growth of the remaining 39.8% of the VA share just cancel each other out. This TFP improvement in manufacturing is also explained by the small fall on capital input (-1.13% on average per year) which translates into negative capital contribution to growth, all these implying resource savings joined to VA increase. The first three winning subsectors for this period were alcoholic beverages, production of machinery and equipment and tobacco. And the losing subsectors were: automotive, other foods, oils and fats, other equipment of transformation, production and processing of meat and poultry and animal food.

Sunset-sunrise diagrams also tell us which subsectors have bigger share in output described by the distance between two points. So for example, the longer the distance between any two points *a* and *b*, the bigger the share in value added for the subsector associated to point *b*. For our first period of analysis (see Table A.1), basic metal industry, metal products, production of communication and measurement equipment, electronic machines and their components, automotive and chemical industries, had a big contribution to the aggregate TFP growth rate due to their high value added share (these five subsectors alone, accounted for 37% of VA in manufacturing).

As it can be noted in Graph 1, the uprising part of the productivity diagram for 1970-1975, is basically due to the heavy industry which describes the key element of the prevailing development model called industrialization by imports substitution (IIS).[9] In contrast, the low performance of the automotive industry could be explained by the strong protection that lasted almost until late 90s. In Graph 1 we can also observe that periods with aggregate TFP advance or RCR were 1970-1975, and 1998-2003.

In regard 1975-1980, Graph 1 and Table 1 show an aggregate TFP growth rate of -5.22% on average per year. Unlike previous period, almost all sub-sectors in manufacturing experienced TFP fall (or real cost augmenting). Table A.2 in Appendix A shows that subsectors experiencing TFP advance were only 6. The maximum TFP advance that could have been reached for this period was 0.48% (on average per year). Just like the previous quinquennium, the IIS model prevailed during 1975-1980 but with evident signs of exhaustion. The important real cost augmenting experienced

9 This development model dominated Mexico´s economic history from the 40s till the crisis of the 80s. It was characterized by intensive industrialization, public investments, high custom rates, strict protection of internal economy and limitations on foreign investment. From the 60s, the government supported basically the production of machines for production and in general the heavy industry.

by the whole manufacturing industry, is explained by the fact that increase in quantity and quality of capital and labor inputs was beyond the increase in VA, implying an important efficiency loss in the use of factor inputs. In particular, real capital input in manufacturing grew by 12% on average per year, as a response to the increase in the nation wide economic activity which, at the same time, was highly motivated by the important increase in government expenditures (GDP annual growth rate in real terms was 6.6% on average during de quinquennium, while government expenditures were growing at the rate of 14.63% on average per year). The first three TFP winners of this period were: automotive industry, oil refinery and sugar production. The three big losers were tobacco, wheat and corn products and alcoholic beverages. An interesting point for this period is the downturn of the heavy industry, which now shows an important efficiency loss (or real cost augmenting).

The following three periods under study, showed negative aggregate TFP growth rates in manufacturing: -1.54%, -0.52% and -2.58% on average per year for 1980-1988, 1988-1993 and 1993-1998 respectively. Almost all subsectors in manufacturing had real cost augmenting. In particular, around 70% of VA share (25 subsectors) contributed negatively to TFP growth during 1980-1988, and 23 subsectors accounting for 63.3% of VA share also had a negative contribution to TFP growth during 1988-1993. For both periods, real cost augmenting is basically explained by an important increase in the use of factor inputs which outweigh the positive growth rates in VA (graphs 2 and 3).

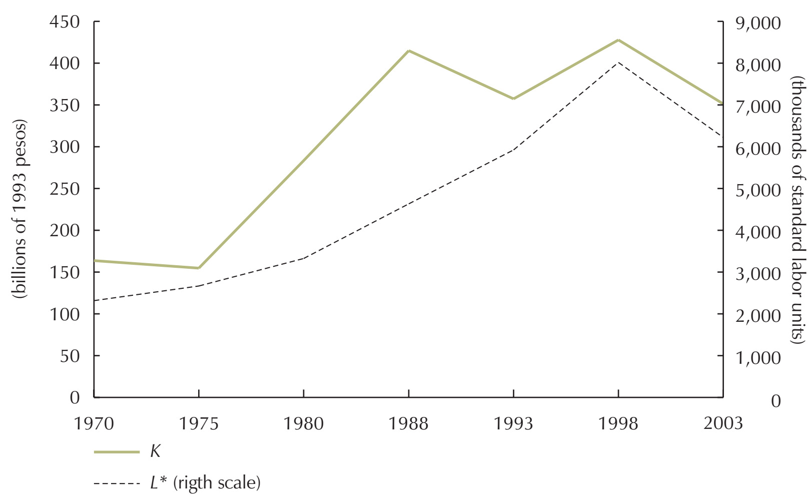
The 1980-1988 period is a very interesting one as it includes all the changes that led to Mexico's actual development model. These 8 years embrace two crisis (1982 and 1985-1986), change of economic model from IIS to commercial, financial and regulatory liberalization; Mexican currency was devaluated 77.6% on average per year, annual inflation rates of 77% on average[10] (which reached three digits in 1986 and 1987) and two oil shocks that paralyzed the Mexican public finances. All these facts together resulted in an important increase in the cost of use of factor inputs, hence into real cost augmenting. The most important steps toward opening up the borders of Mexico were made between 1985 and 1988: maximum custom rate was reduced from 100% to 20%, average custom rate was reduced from 25% to 10%, tariff categories were progressively reduced from 16 to 3, are the main achievements of trade liberalization. However, openness effects are expected to be seen in the coming periods, and this is the reason why it is not surprising that aggregate TFP growth rate

10 The CPI inflation rate for the eight-year period (1980-1988) was 9,649%.

Graph 2
Real Value Added for the Mexican Manufacturing Industry
(using agregate data for the whole industry)

Note: Annual average percentage change with respect to previous census year.
Source: Author's calculations with data from censuses, Banxico and INEGI.

Graph 3
Real Capital Stock (*K*) and Standard Labor (*L**)
for the Mexican Manufacturing Industry
(using agregate data for the whole industry)



Source: Author's calculations using data from censuses, Banxico and INEGI.

for 1980-1988 was -1.54% and the maximum TFP rate was low (0.61%) since only 29.5% of the manufacturing industry had real cost reduction (Table A.3). The first three winners for this period were: milling and grain products, tobacco, and fish and crustacean products. The three big losers were: other equipment of transportation, sugar industry and oil refinery.

During 1988-1993, Mexican manufacturing real cost augmenting was lower (-0.52%) compared to the previous period. This fact occurs after Mexico's initial steps to trade (2 years after the integration to GATT) and financial liberalization in 1985-1989. It was precisely during 1985-1994 that Mexico changed from being a highly closed economy to be one of the most opened economies in the world. An efficiency improvement in the use of factor inputs was an obligation in order to face the significant fall in market prices of a wide variety of manufactures, which was reflected on the slowdown of manufacturing VA growth. It is interesting to see in Graph 2 that, during the period 1988-1993, annual average real growth rate in manufacturing VA was around 0.84%, while real GDP for the whole Mexican economy was growing at an annual average rate of 3.81%. Although we do not perform any causality test in this paper, this fact suggests a positive effect of trade and financial liberalization over the Mexican economy, despites of the relatively high inflationary rates.[11] From Graph 3 we can also realize that, although real capital stock had a fall (contributing to real cost reduction during the mentioned period), labor input had an important increase. The maximum cumulative TFP growth rate was higher compared to previous periods (Table A.4): it reached 2.06% produced by 35% of the industry. This is the TFP growth rate that Mexican manufacturing industry could have reached if subsectors with negative TFP growth could have been eliminated. The first three winners of 1988-1993 were: alcoholic beverages, oil refinery and soft drinks. Oil refinery was the subsector which raised more significantly the uprising part of the curve. The three big losers of the period are: cellulose and paper products, oils and fats, and milling and grain products.

The next sub-period in our analysis is 1993-1998. Although the quinquennium was characterized by financial crisis, exchange rate devaluation of 24% on average per year, and high inflationary rates of 23.31% on average per year, the economic crisis was not as deep and prolonged as the one Mexico experienced during 1980-1988. Nonetheless, the manufacturing industry performance was affected by the country's

11 Observed CPI inflation was 123.37% during the five year period (1988-1993).

general situation. The annual average TFP growth rate in aggregate manufacturing was -2.58%, but unlike the other real cost augmenting periods previously analyzed (1975-1980, 1980-1988), the number and VA share of those subsectors with negative contributions to TFP growth, was smaller (19 subsectors showed TFP fall, accounting for 46% of VA share). The maximum aggregate TFP rate was 1.68% per year and this rate could have been achieved if the negative productive subsectors were removed from the industry (Table A.5). Negative behavior on TFP is explained again by the important increase in quantity and quality of factor inputs (in this case both, capital and labor) that outweighed the positive VA growth rate for most subsectors. The first three winners of the period were: oils and fats, other equipment of transportation, and basic metal industry. But this "victory" is shared with many others. This variety in the positive contributors list shows an important efficiency recovery of the manufacturing industry. However the also important TFP fall experienced by oil refinery and petrochemical products[12] and by the tobacco subsector (which together accounted for 10.40% of VA in manufacturing), had an important negative influence in the performance of manufacturing as a whole, hence resulting on a negative aggregate TFP growth rate. Among the big losers of the quinquennium we have confection of textiles, cocoa, chocolate products and candies, tobacco and oil refinery. Basically, the last two losers are responsible for the big declination of the productivity distribution curve.

Finally, for the 1998-2003 period, the aggregate TFP growth rate was 3.62% on average per year. Almost 85% of VA share in the industry had real cost reduction, while those sectors with negative TFP growth rates, represented only 15% of initial total VA. The maximum TFP growth rate could have been 4.27 if negatively productive subsectors were removed (Table A.6). The first three TFP winners of the period were: oil refinery, tobacco, and fish and crustacean products. Significant contributors to positive TFP growth were non-metalic mineral products, production of communication and measurement equipments, electronic equipments and their components, automotive industry, chemical products, metal products, and plastic and rubber products can be mentioned. One subgroup is responsible for an important contribution to real cost augmenting: basic metal industry. In this case, real cost reduction is explained by the important fall in factor inputs. The use of capital and

12 During the quinquennium 1993-1998, oil refinery and petrochemicals showed important positive growth rates in labor and capital inputs (16.16% and 9.51% respectively on average per year), but also showed an important fall in real VA (22.6% annual average), all these bringing an important TFP fall or real cost augmenting.

labor was importantly reduced in real terms, returning to 1993 levels approximately (see Graph 3).

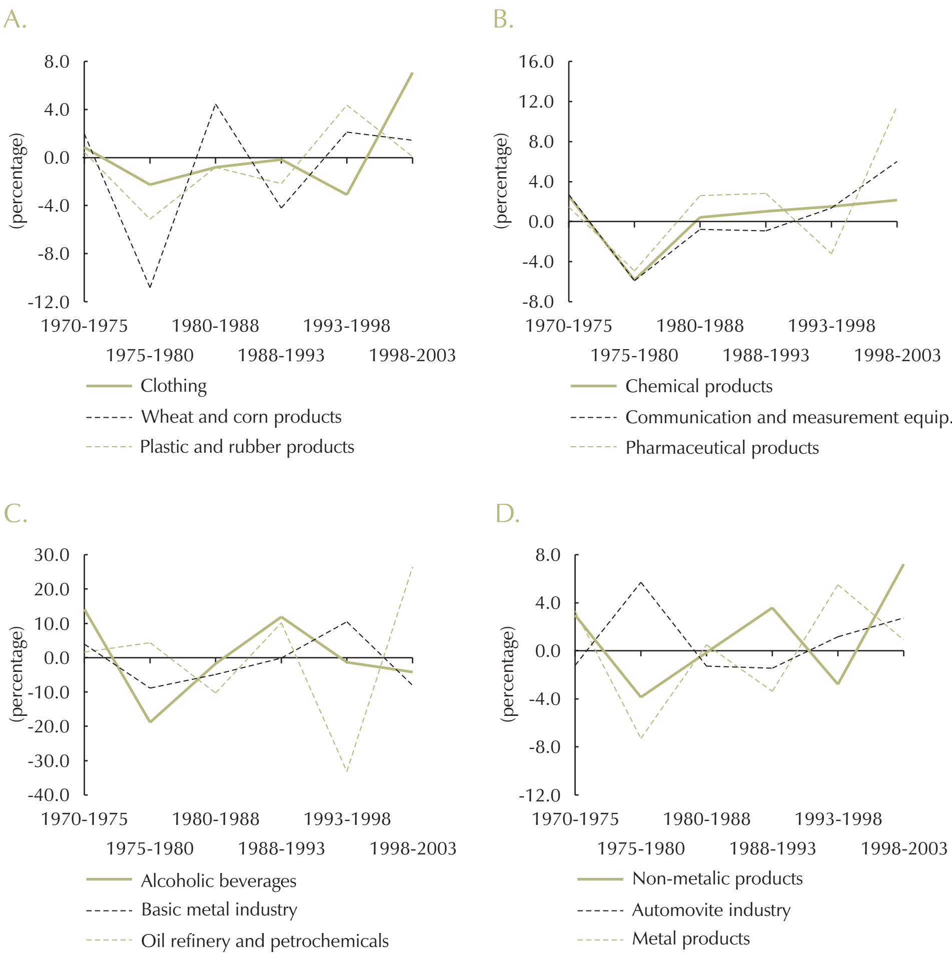
From this period-by-period analysis, we can come up with some important conclusions. First, sustaining RCR for two or more consecutive periods really is a big challenge, and this is evidenced by the TFP behavior of the different subsectors showed in Table 1, where we can observe that 15 out of 38 subsectors had only two consecutive periods of positive TFP growth rate on average per year, and this specially occurred post-NAFTA. Having RCR for more than two periods in a row is even more atypical. Only four subsectors could sustain RCR for three or four consecutive periods (oils and fats, sugar production, wardrobe accessories and chemical products). In general, for the subsectors under study, TFP change went from positive to negative and vice versa, without any specific pattern over time. For the analysis time span, winners and losers changed period by period: many times winners became losers and losers became winners. This result is compatible with TFP studies in the U.S. economy, where industries that win the RCR race in one decade typically do not in the next.[13] Graph 4 shows the TFP growth behavior over time for those subsectors that had at least 3% of VA share in manufacturing (on average during 1970-2003), and we can observe that, even though TFP growth was changing sign from one period to another, for ten out of twelve most influencing subsectors in manufacturing, TFP growth was positive during the last quinquenium under study. The second interesting observation then is that, big VA share does not guarantee neither positive nor big TFP growth rate.

VIII. THE PRE AND POST NAFTA OVERVIEW

Given that one of our objectives is to analyze the behavior of manufacturing TFP growth before and after trade liberalization rather than finding causality between TFP growth and trade openness, and given that NAFTA (North America Free Trade Agreement) represented a watershed in Mexico's trade history, we have now split the analysis time span into two periods: 1970-1993 which represents the pre-NAFTA period, and 1993-2003 representing the post-NAFTA part of the story. TFP growth rate estimations for these two periods of interest are presented in Table 1 (and in tables A.7 and A.8 of appendix A in a more detailed version) and the

13 See Harberger (2005), p 5.

Graph 4
TFP Growth for Subsectors with at Least 3% of VA Share in Manufacturing

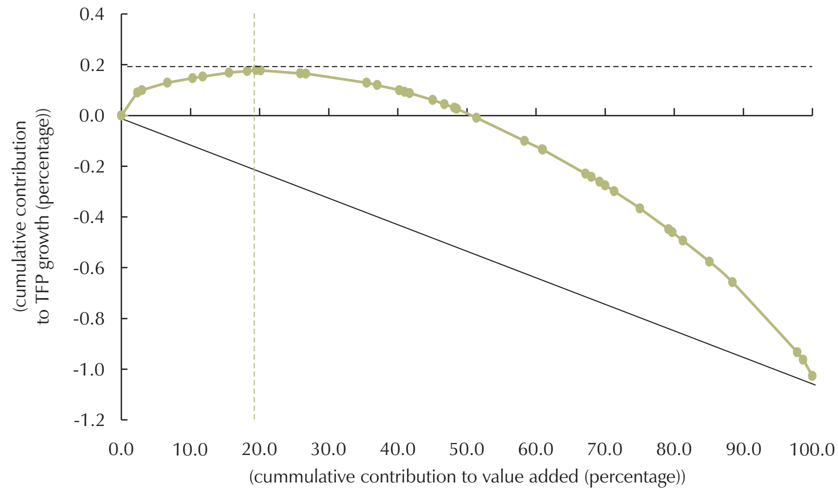


Source: Author's calculations with data from censuses, Banxico and INEGI.

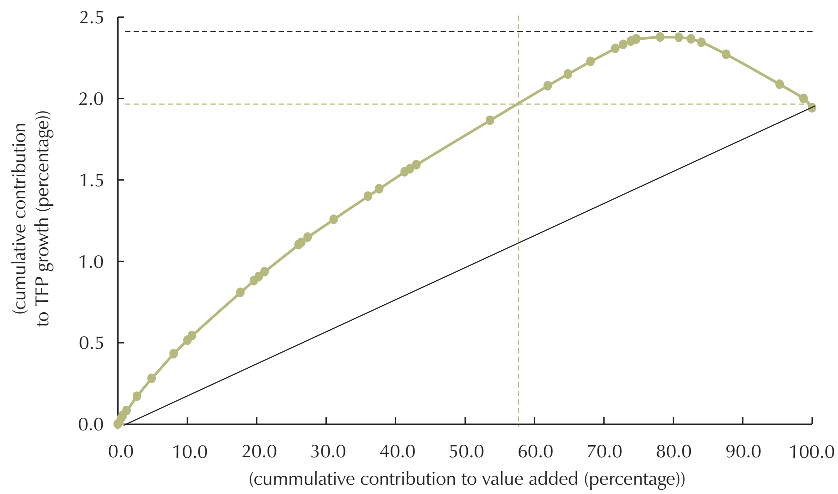
corresponding productivity diagrams are presented in Graph 5. In the long run, aggregate TFP growth rate in manufacturing was negative during the pre-NAFTA period (-1.03% on average per year), while the post-NAFTA aggregate TFP growth rate was positive, with an annual average growth rate of 1.94%. But also, during the pre-NAFTA period, the number and VA share of those subsectors with RCR is significantly lower compared to the post-NAFTA period. Last two columns of Table 1

Graph 5
Sunset-Sunrise Productivity Diagrams
Mexican Manufacturing Industry

A. 1970-1993



B. 1993-2003



Source: Author's calculations using data from censuses, Banxico and INEGI.

show that 30 out of 38 subsectors in manufacturing had TFP improvement during the decade 1993-2003. The majority of subsectors in manufacturing went from a negative TFP growth rate before NAFTA, to a positive TFP growth rate after NAFTA, or went from a low positive TFP growth rate to a higher one.

Once more, the analysis suggests that trade liberalization had a positive impact on Mexican manufacturing, and this evidence is in accordance with the message of open market economics: *free trade permits an economy to make better use of its resources*. In contrast, highly protected economies (as it was the Mexican case during the IIS model) may be free from the challenges of competitors and free from the incentives for efficiency improvement, granting protected industries to enjoy a relatively easy life while import tariffs and restrictions guarantee safe, steady profits.

IX. GROWTH ACCOUNTING

As a final topic in our analysis, we present the growth accounting table which separates the sources of growth for each period under study. The breakdown of the growth rate into its component parts allows us to analyze the "anatomy" of growth in manufacturing that Mexico experienced. Table 2 then shows how production factors and TFP contributed to VA growth.

Table 2
Growth Accounting
Decomposition of Annual Average Changes
(percentage)

	1970-1975	1975-1980	1980-1988	1988-1993	1993-1998	1998-2003	1970-1993	1993-2003
Change in VA	2.37	2.74	2.68	-0.67	1.81	-1.35	2.15	1.05
TFP contribution to growth	2.36	-5.22	-1.54	-0.52	-2.58	3.62	-1.03	1.94
Physical capital contribution to growth	-0.87	6.44	2.61	-1.37	2.30	-3.00	1.77	-0.81
Labor contribution to growth	0.88	1.52	1.60	1.21	2.09	-1.97	1.40	-0.08
a) Due to raw labor	0.28	1.16	0.69	0.55	1.02	-0.09	0.72	0.46
b) Due to human capital	0.60	0.36	0.91	0.67	1.07	-1.88	0.68	-0.54

Note: The computation of each growth component was done as outlined in equations 3 and 4, and where gy, gk and gl are annual average growth rates (calculated as logarithmic changes) in VA, capital and labor respectively.
Source: Author's calculations with data from censuses, Banxico and INEGI.

It is convenient to remember that labor contribution to growth (see equation 3) can be separated into a component due to increases in raw labor $\left(\frac{w^*_{t-1}N_{jt-1}}{y_{jt-1}}\right)\left(\frac{\Delta N_{jt}}{N_{jt-1}}\right)$ and a component due to increases in human capital $\left(\frac{w^*_{t-1}L^*_{jt-1}}{y_{jt-1}}\right)\left(\frac{\Delta L^*_{jt}}{L^*_{jt-1}}\right)-\left(\frac{w^*_{t-1}N_{jt-1}}{y_{jt-1}}\right)\left(\frac{\Delta N_{jt}}{N_{jt-1}}\right)$, where N_{jt} and ΔN_{jt} are the level and change in the number of workers (raw labor) in subsector j at time t, respectively. According to Table 2, physical capital contribution to growth was negative during three quinquennial periods, while labor contribution to growth was always positive except for the last period (1998-2003), in which the human capital component was also negative. In regard the long-term growth analysis, the balance for 1970-1993 shows positive contribution to growth of both factor inputs, together with TFP fall or real cost augmenting. For the post-NAFTA period however, physical capital and labor contributed negatively to growth. In particular, human capital contribution was negative and big enough to offset the positive labor contribution to growth due to raw labor.

X. CONCLUDING REMARKS

Using disaggregated data at the industrial subsector level and applying Harberger's 2D method, this paper examined the distribution of productivity across 38 subsectors in manufacturing during the period 1970-2003. Throughout, the analysis showed the relevance of productivity advance or real cost reduction as a source of growth in the economy. Also, the paper presented some theoretical arguments that make us think of Harberger's 2D method as a very convenient and understandable methodology to measure TFP growth at any data aggregation level. In our opinion, throughout his several studies on growth process, Harberger had developed one of the most understandable approaches to TFP growth. It is not only the way he understands TFP growth, but also the simplicity of his methodology to measure TFP growth, what makes his approach an important contribution to economic theory.

The TFP growth analysis developed here for the Mexican manufacturing industry showed some evidence that TFP behavior improved after the most important Mexican trade liberalization event took place, suggesting a positive effect of trade opening on Mexican manufacturing. Aggregate TFP growth rate was negative during the pre-NAFTA period while the post-NAFTA aggregate TFP growth rate was positive. During the pre-NAFTA period, the number and VA share of those subsectors with

RCR is significantly lower compared to the post-NAFTA period. It was shown that 30 out of 38 subsectors in manufacturing had TFP improvement on average during the decade 1993-2003, while only 8 subsectors did so during the pre-NAFTA period (1970-1993). This evidence supports the theory that free trade permits an economy to make better use of its resources.

Another important conclusion derived from the analysis is that, sustaining RCR for two or more consecutive periods really is a hard task. Taking shorter periods, in general, for the subsectors under study, TFP change went from positive to negative and vice versa, without any specific pattern over time. In addition, it was evidenced that big VA share does not guarantee neither positive nor big TFP growth rate.

REFERENCES

1. Angulo, J.; Guillermo, S. “Analyzing Productivity Growth in México during the Period 1929-1944”, paper presented at Lacea, 8th Annual Meeting, October, 2003.

2. Angulo, J.; Guillermo, S. “Análisis del avance en productividad en la industria manufacturera mexicana: 1929-1944”, *Revista de Historia Económica*, vol. XXIII, no. 3, 2005.

3. Bergoing, R.; Kehoe, P. J.; Kehoe, T. J.; Soto, R. “Policy-Driven Productivity in Chile and Mexico in the 1980s and 1990s”, *NBER* working paper, no. W8892, 2002.

4. Bergoing, R.; Kehoe, P. J.; Kehoe, T. J.; Soto, R. “A Decade Lost and Found: Mexico and Chile in the 1980s”, *NBER* working paper, no. W8520, 2000.

5. Cavalcanti, P.; De Abreu, S.; Veloso, F. “The Evolution of TFP in Latin America”, *Ensaios Econômicos*, no. 620, Río de Janeiro, Brazil, Escola de Pós Graduação em Economia da Fundação Getulio Vargas, 2006.

6. Cárdenas, E. “El crecimiento económico de México, 1950-1975”, tesis de licenciatura, Centro de Investigaciones, ITAM, 1978.

7. Cárdenas, E. *La industrialización mexicana durante la gran depresión*, México, El Colegio de México, 1987.

8. Cho, M. “The Asian Miracle and the Asian Economic Crisis: A Desaggregated Analysis of Productivity Growth”, Ph. D. Dissertation, Los Angeles (CA), UCLA, 2000.

9. Denison, E. *Why Growth Rates Differ: Post-war Experience in Nine Western Countries*, Washington, D. C., Brookings Institution, 1967.

10. Griliches, Z. “Measuring Inputs in Agriculture: A Critical Survey”, *Journal of Farm Economics*, vol. 42, no. 5, December, 1960.

11. Griliches, Z. “The Sources of Measured Productivity Growth: United States Agriculture, 1940-1960”, *Journal of Political Economy*, vol. 71, no. 4, 1963.

12. Harberger, A. C. “Reflexions on the Growth Process”, working paper, World Bank, 1990.

13. Harberger, A. C. “A Vision of the Growth Process”, *The American Economic Review*, vol. 88, no. 1, 1998a.

14. Harberger, A. C. “Studying the Growth Process: A Primer”, paper prepared for a Conference in Capital Formation and Economic Growth: The Hoover Institution, Stanford University, December, 1998b.

15. Harberger, A. C. “On the Process of Growth and Economic Policy in Developing Countries”, issue paper, 13USAID, Bureau for Policy and Program Coordination, December, 2005.

16. Jeong, H.; Townsend, R. M. “Discovering the Sources of TFP Growth: Occupation Choice, Capital Heterogeneity and Financial Deepening”, Institute of Economic Policy Research, Working Paper 05.19, University of Southern California, 2005.

17. Jorgenson, D. W.; Griliches, Z. “The Explanation of Productivity Change”, *Review of Economic Studies*, vol. 34, no. 3, July, pp. 249-280, 1967.

18. Kendrick, J. W. *Postwar Productivity Trends in the United States*, New York, Columbia University Press, 1973.

19. López-Córdoba, E. “Nafta and Manufacturing Productivity in México”, *Economía*, vol. 3, no. 2, pp. 55-98, 2003.

20. Meza, F.; Quintin, E. “Financial Crises and Total Factor Productivity”, paper presented at LACEA, 11th Annual Meeting, November, 2006.

21. Muendler, M. A. “Trade, Technology and Productivity: A Study of Brazilian Manufacturers, 1986-1998”, Working Paper, University of California, San Diego, 2004.

22. Robles, E. “An Exploration into the Sources and Causes of Economic Growth in the United States and Fourteen Latin American Countries”, Ph. D. Dissertation, UCLA, 1997.

23. Torre, L. E. "Productivity and Profitability in the Mexican Manufacturing Sector, 1984-1994", Ph. D. Dissertation, UCLA, 2000.

APPENDIX A

Table A.1
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1970-1975
(percentage)

(A) Subsector		(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
11	Alcoholic beverages	14.13	3.68	0.52	3.68	0.52
33	Production of machinery and equipment	7.16	1.56	0.11	5.25	0.63
13	Tobacco	6.55	2.34	0.15	7.58	0.79
9	Cocoa and chocolate products, candies	5.32	0.65	0.03	8.23	0.82
20	Leather products	4.25	0.55	0.02	8.78	0.84
31	Basic metal industry	4.00	9.38	0.38	18.16	1.22
17	Confection of textiles products	3.49	0.32	0.01	18.49	1.23
32	Metal products	3.32	6.18	0.20	24.67	1.43
3	Vegetables, fruits and foods	3.19	0.78	0.02	25.45	1.46
30	Non-metallic mineral products	2.98	3.81	0.11	29.26	1.57
24	Printed products	2.73	3.33	0.09	32.59	1.66
34	Production of communication equipment, measurement equipment, electric machines and their components	2.70	6.98	0.19	39.56	1.85
12	Soft drinks, water and sodas	2.65	2.67	0.07	42.24	1.92
26	Chemical products	2.57	8.79	0.23	51.02	2.15
22	Wood and wood products	2.53	1.31	0.03	52.33	2.18
38	Other manufacturing	2.38	0.74	0.02	53.07	2.20
23	Cellulose and paper products	2.38	3.33	0.08	56.40	2.28
15	Fibers, spinning	2.13	3.82	0.08	60.22	2.36
7	Wheat and corn products	1.99	2.85	0.06	63.06	2.42
29	Glass and glass products	1.96	1.47	0.03	64.53	2.45
25	Oil refinery, petrochemical products	1.57	0.63	0.01	65.16	2.46
27	Pharmaceutical products	1.49	3.67	0.05	68.83	2.51
37	Furniture production	1.20	2.54	0.03	71.38	2.54

Table A.1 (continued)
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1970-1975
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
21	Shoes	1.14	1.17	0.01	72.55	2.55
6	Milling and grain products	1.09	1.54	0.02	74.09	2.57
18	Clothing	0.85	3.17	0.03	77.25	2.60
28	Plastic and rubber products	0.46	4.16	0.02	81.41	2.62
8	Sugar production	0.44	1.70	0.01	83.11	2.62
19	Wardrobe accessories	0.32	0.10	0.00	83.20	2.62
16	Textiles	0.20	3.70	0.01	86.90	2.63
2	Fish and crustacean products	0.13	0.76	0.00	87.66	2.63
5	Dairy products	0.04	1.28	0.00	88.94	2.63
35	Automotive industry	-1.22	5.77	-0.07	94.71	2.56
14	Other foods	-1.41	1.43	-0.02	96.14	2.54
4	Oils and fats	-3.94	1.33	-0.05	97.47	2.49
36	Other equipment of transportation	-4.39	0.86	-0.04	98.32	2.45
1	Production, processing and preservation of meat and poultry	-4.60	0.85	-0.04	99.18	2.41
10	Prepared animal food	-6.60	0.82	-0.05	100.00	2.36

Source: Author’s calculations with data from censuses, Banxico and INEGI.

Table A.2
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1975-1980
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
35	Automotive industry	5.70	6.51	0.37	6.51	0.37
25	Oil refinery, petrochemical products	4.33	0.65	0.03	7.16	0.40
8	Sugar production	3.22	1.56	0.05	8.72	0.45
1	Production, processing and preservation of meat and poultry	1.90	0.53	0.01	9.25	0.46
36	Other equipment of transportation	1.61	0.88	0.01	10.13	0.47
4	Oils and fats	0.76	0.87	0.01	11.00	0.48
10	Prepared animal food	-0.24	0.66	0.00	11.66	0.48
5	Dairy products	-0.37	1.04	0.00	12.70	0.47
29	Glass and glass products	-1.22	1.50	-0.02	14.20	0.46
14	Other foods	-1.38	1.41	-0.02	15.61	0.44
18	Clothing	-2.27	2.71	-0.06	18.32	0.38
37	Furniture production	-2.46	1.91	-0.05	20.23	0.33
23	Cellulose and paper products	-2.56	3.13	-0.08	23.36	0.25
19	Wardrobe accessories	-3.13	0.05	0.00	23.41	0.25
22	Wood and wood products	-3.30	1.26	-0.04	24.67	0.21
21	Shoes	-3.50	1.01	-0.04	25.68	0.17
16	Textiles	-3.66	4.80	-0.18	30.47	-0.01
30	Non-metallic mineral products	-3.86	4.04	-0.16	34.51	-0.16
15	Fibers, spinning	-4.57	1.80	-0.08	36.31	-0.24
27	Pharmaceutical products	-4.92	3.59	-0.18	39.89	-0.42
28	Plastic and rubber products	-5.12	3.85	-0.20	43.74	-0.62
12	Soft drinks, water and sodas	-5.13	2.43	-0.12	46.17	-0.74
26	Chemical products	-5.82	9.89	-0.58	56.07	-1.32
34	Production of communication equipment, measurement equipment, electric machines and their components	-5.90	6.95	-0.41	63.02	-1.73
38	Other manufacturing	-5.92	0.80	-0.05	63.81	-1.77
24	Printed products	-5.93	2.71	-0.16	66.53	-1.94

Table A.2 (continued)
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1975-1980
(percentage)

(A) Subsector		(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
33	Production of machinery and equipment	-5.95	3.62	-0.22	70.15	-2.15
3	Vegetables, fruits and foods	-6.29	0.79	-0.05	70.93	-2.20
20	Leather products	-6.69	0.49	-0.03	71.43	-2.23
32	Metal products	-7.28	6.06	-0.44	77.48	-2.67
2	Fish and crustacean products	-7.33	0.59	-0.04	78.07	-2.72
17	Confection of textiles products	-7.69	0.15	-0.01	78.22	-2.73
9	Cocoa and chocolate products, candies	-8.14	0.66	-0.05	78.88	-2.78
6	Milling and grain products	-8.42	1.56	-0.13	80.44	-2.91
31	Basic metal industry	-8.87	9.34	-0.83	89.78	-3.74
13	Tobacco	-10.66	2.25	-0.24	92.03	-3.98
7	Wheat and corn products	-10.84	3.23	-0.35	95.26	-4.33
11	Alcoholic beverages	-18.83	4.74	-0.89	100.00	-5.22

Source: Author's calculations with data from censuses, Banxico and INEGI.

Table A.3
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1980-1988
(percentage)

(A) Subsector		(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
6	Milling and grain products	16.92	0.78	0.1314	0.78	0.13
13	Tobacco	10.54	1.40	0.1476	2.18	0.28
2	Fish and crustacean products	4.99	0.39	0.0197	2.57	0.30
7	Wheat and corn products	4.45	2.72	0.1210	5.29	0.42
3	Vegetables, fruits and foods	4.05	0.63	0.0256	5.92	0.45
27	Pharmaceutical products	2.59	2.07	0.0536	7.99	0.50
24	Printed products	1.13	2.36	0.0266	10.35	0.53
4	Oils and fats	1.05	0.90	0.0094	11.25	0.54
9	Cocoa and chocolate products, candies	0.83	0.69	0.0058	11.94	0.54
10	Prepared animal food	0.67	0.45	0.0030	12.39	0.54
32	Metal products	0.51	5.81	0.0295	18.20	0.57
26	Chemical products	0.43	8.00	0.0343	26.21	0.61
23	Cellulose and paper products	0.08	3.27	0.0028	29.48	0.61
30	Non-metallic mineral products	-0.15	3.75	-0.0055	33.22	0.60
14	Other foods	-0.33	1.66	-0.0054	34.88	0.60
1	Production, processing and preservation of meat and poultry	-0.69	0.58	-0.0041	35.46	0.60
34	Production of communication equipment, measurement equipment, electric machines and their components	-0.76	7.68	-0.0583	43.15	0.54
20	Leather products	-0.81	0.48	-0.0039	43.62	0.53
18	Clothing	-0.82	3.03	-0.0249	46.65	0.51
28	Plastic and rubber products	-0.83	3.56	-0.0294	50.21	0.48
15	Fibers, spinning	-0.83	1.43	-0.0119	51.64	0.47
16	Textiles	-0.91	3.36	-0.0305	55.00	0.44
5	Dairy products	-1.00	1.27	-0.0127	56.27	0.42
35	Automotive industry	-1.28	8.63	-0.1109	64.90	0.31
11	Alcoholic beverages	-1.72	3.23	-0.0556	68.13	0.26
38	Other manufacturing	-1.76	0.48	-0.0085	68.61	0.25
29	Glass and glass products	-1.88	1.43	-0.0270	70.04	0.22

Table A.3 (continued)
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1980-1988
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
22	Wood and wood products	-2.03	0.90	-0.0182	70.94	0.20
33	Production of machinery and equipment	-2.11	3.83	-0.0806	74.76	0.12
21	Shoes	-2.28	1.12	-0.0255	75.88	0.10
19	Wardrobe accessories	-2.81	0.06	-0.0016	75.94	0.10
12	Soft drinks, water and sodas	-2.85	2.28	-0.0649	78.22	0.03
37	Furniture production	-3.06	1.20	-0.0366	79.41	-0.01
31	Basic metal industry	-4.88	8.84	-0.4316	88.25	-0.44
17	Confection of textiles products	-5.38	0.43	-0.0230	88.68	-0.46
36	Other equipment of transportation	-5.59	0.82	-0.0458	89.49	-0.51
8	Sugar production	-6.14	1.13	-0.0696	90.63	-0.58
25	Oil refinery, petrochemical products	-10.25	9.37	-0.9602	100.00	-1.54

Source: Author's calculations with data from censuses, Banxico and INEGI.

Table A.4
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1988-1993
(percentage)

(A) Subsector		(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
11	Alcoholic beverages	11.91	2.46	0.29	2.46	0.29
25	Oil refinery, petrochemical products	10.17	8.95	0.91	11.41	1.20
12	Soft drinks, water and sodas	9.65	1.81	0.17	13.22	1.38
9	Cocoa and chocolate products, candies	7.63	0.54	0.04	13.75	1.42
17	Confection of textiles products	7.57	0.41	0.03	14.16	1.45
13	Tobacco	6.68	2.31	0.15	16.47	1.60
14	Other foods	4.85	1.79	0.09	18.26	1.69
30	Non-metallic mineral products	3.59	3.82	0.14	22.08	1.83
5	Dairy products	3.56	1.14	0.04	23.23	1.87
27	Pharmaceutical products	2.81	2.59	0.07	25.82	1.94
38	Other manufacturing	2.68	0.50	0.01	26.32	1.95
19	Wardrobe accessories	2.66	0.02	0.00	26.34	1.95
8	Sugar production	1.49	0.97	0.01	27.31	1.97
26	Chemical products	1.03	8.29	0.09	35.60	2.05
37	Furniture production	0.51	1.06	0.01	36.66	2.06
31	Basic metal industry	-0.12	6.33	-0.01	42.99	2.05
18	Clothing	-0.17	2.08	0.00	45.07	2.05
10	Prepared animal food	-0.56	0.78	0.00	45.84	2.04
33	Production of machinery and equipment	-0.80	2.51	-0.02	48.35	2.02
34	Production of communication equipment, measurement equipment, electric machines and their components	-0.94	7.19	-0.07	55.55	1.96
21	Shoes	-1.05	0.93	-0.01	56.47	1.95
24	Printed products	-1.41	2.17	-0.03	58.65	1.92
35	Automotive industry	-1.46	13.18	-0.19	71.82	1.72
28	Plastic and rubber products	-2.18	3.87	-0.08	75.70	1.64
29	Glass and glass products	-2.26	1.64	-0.04	77.34	1.60
1	Production, processing and preservation of meat and poultry	-2.67	0.78	-0.02	78.11	1.58

Table A.4 (continued)
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1988-1993
(percentage)

(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
16 Textiles	-2.89	2.65	-0.08	80.77	1.51
22 Wood and wood products	-3.17	0.90	-0.03	81.67	1.48
32 Metal products	-3.37	4.25	-0.14	85.91	1.33
36 Other equipment of transportation	-3.43	0.51	-0.02	86.42	1.32
7 Wheat and corn products	-4.19	3.39	-0.14	89.81	1.17
3 Vegetables, fruits and foods	-4.36	0.60	-0.03	90.40	1.15
2 Fish and crustacean products	-4.40	0.49	-0.02	90.89	1.13
20 Leather products	-5.36	0.37	-0.02	91.26	1.11
15 Fibers, spinning	-6.23	1.43	-0.09	92.70	1.02
23 Cellulose and paper products	-10.83	2.81	-0.30	95.51	0.71
4 Oils and fats	-20.56	0.91	-0.19	96.42	0.52
6 Milling and grain products	-29.11	3.58	-1.04	100.00	-0.52

Source: Author's calculations with data from censuses, Banxico and INEGI.

Table A.5
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1993-1998
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
4	Oils and fats	14.62	0.45	0.065	0.45	0.065
36	Other equipment of transportation	10.59	0.29	0.031	0.74	0.096
31	Basic metal industry	10.42	3.57	0.372	4.31	0.469
32	Metal products	5.49	4.87	0.267	9.18	0.736
1	Production, processing and preservation of meat and poultry	5.38	1.08	0.058	10.26	0.794
33	Production of machinery and equipment	5.24	1.99	0.104	12.25	0.898
15	Fibers, spinning	4.61	0.69	0.032	12.94	0.930
28	Plastic and rubber products	4.36	3.75	0.163	16.70	1.094
23	Cellulose and paper products	4.22	2.09	0.088	18.79	1.182
22	Wood and wood products	3.10	0.68	0.021	19.47	1.203
6	Milling and grain products	3.08	0.94	0.029	20.41	1.232
20	Leather products	2.74	0.39	0.011	20.79	1.242
7	Wheat and corn products	2.12	3.26	0.069	24.05	1.311
8	Sugar production	1.63	0.87	0.014	24.92	1.325
26	Chemical products	1.52	8.33	0.127	33.25	1.452
34	Production of communication equipment, measurement equipment, electric machines and their components	1.36	6.95	0.094	40.20	1.547
35	Automotive industry	1.18	10.60	0.125	50.80	1.671
29	Glass and glass products	1.03	1.52	0.016	52.32	1.687
19	Wardrobe accessories	0.84	0.04	0.000	52.36	1.687
21	Shoes	-0.42	1.16	-0.005	53.52	1.682
2	Fish and crustacean products	-0.74	0.51	-0.004	54.04	1.679
16	Textiles	-0.92	1.76	-0.016	55.80	1.662
10	Prepared animal food	-0.98	0.74	-0.007	56.54	1.655
37	Furniture production	-1.37	1.60	-0.022	58.13	1.633
11	Alcoholic beverages	-1.38	3.55	-0.049	61.68	1.584
38	Other manufacturing	-1.58	0.76	-0.012	62.44	1.572

Table A.5 (continued)
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1993-1998
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
5	Dairy products	-1.79	1.95	-0.035	64.39	1.537
3	Vegetables, fruits and foods	-1.88	0.93	-0.017	65.31	1.52
30	Non-metallic mineral products	-2.78	4.93	-0.137	70.25	1.383
18	Clothing	-3.09	2.91	-0.090	73.15	1.293
12	Soft drinks, water and sodas	-3.14	3.68	-0.116	76.84	1.177
27	Pharmaceutical products	-3.22	3.17	-0.102	80.00	1.075
24	Printed products	-4.09	3.43	-0.140	83.43	0.935
14	Other foods	-5.71	3.44	-0.197	86.88	0.738
17	Confection of textiles products	-7.56	1.50	-0.113	88.38	0.625
9	Cocoa and chocolate products, candies	-8.13	1.22	-0.099	89.60	0.526
13	Tobacco	-20.24	2.69	-0.545	92.29	-0.019
25	Oil refinery, petrochemical products	-33.19	7.71	-2.560	100.00	-2.579

Source: Author's calculations with data from censuses, Banxico and INEGI.

Table A.6
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1998-2003
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
25	Oil refinery, petrochemical products	26.43	2.11	0.5568	2.11	0.557
13	Tobacco	18.01	0.98	0.1761	3.08	0.733
2	Fish and crustacean products	11.76	0.54	0.0631	3.62	0.796
27	Pharmaceutical products	11.53	3.93	0.4538	7.56	1.250
29	Glass and glass products	9.10	1.45	0.1323	9.01	1.382
5	Dairy products	7.91	1.45	0.1150	10.46	1.497
12	Soft drinks, water and sodas	7.53	2.94	0.2216	13.40	1.719
8	Sugar production	7.36	0.98	0.0718	14.38	1.790
30	Non-metallic mineral products	7.22	4.64	0.3351	19.02	2.126
18	Clothing	7.07	3.56	0.2518	22.59	2.377
37	Furniture production	6.41	1.53	0.0978	24.11	2.475
3	Vegetables, fruits and foods	6.04	0.77	0.0464	24.88	2.522
34	Production of communication equipment, measurement equipment, electric machines and their components	5.99	9.45	0.5662	34.33	3.088
38	Other manufacturing	5.71	0.76	0.0435	35.09	3.131
23	Cellulose and paper products	5.27	2.43	0.1281	37.52	3.259
21	Shoes	4.27	0.85	0.0363	38.37	3.296
22	Wood and wood products	4.25	0.64	0.0271	39.01	3.323
17	Confection of textiles products	4.01	1.30	0.0521	40.31	3.375
24	Printed products	3.87	2.81	0.1085	43.12	3.483
10	Prepared animal food	3.09	0.53	0.0164	43.65	3.500
6	Milling and grain products	3.06	0.85	0.0262	44.50	3.526
35	Automotive industry	2.74	13.49	0.3700	58.00	3.896
20	Leather products	2.69	0.45	0.0122	58.45	3.908
33	Production of machinery and equipment	2.59	2.62	0.0678	61.06	3.976
36	Other equipment of transportation	2.48	0.39	0.0097	61.46	3.986
26	Chemical products	2.14	8.30	0.1774	69.76	4.163

Table A.6 (continued)
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1998-2003
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
19	Wardrobe accessories	1.77	0.04	0.0008	69.80	4.164
7	Wheat and corn products	1.44	3.38	0.0488	73.18	4.213
32	Metal products	0.92	5.52	0.0507	78.71	4.263
4	Oils and fats	0.38	0.67	0.0025	79.38	4.266
28	Plastic and rubber products	0.08	5.03	0.0040	84.41	4.270
14	Other foods	-0.43	3.14	-0.0136	87.56	4.256
15	Fibers, spinning	-1.35	0.66	-0.0090	88.22	4.247
16	Textiles	-1.64	1.68	-0.0276	89.90	4.220
9	Cocoa and chocolate products, candies	-2.22	0.61	-0.0135	90.51	4.206
1	Production, processing and preservation of meat and poultry	-2.41	1.27	-0.0307	91.78	4.175
11	Alcoholic beverages	-4.21	2.80	-0.1179	94.58	4.058
31	Basic metal industry	-8.03	5.42	-0.4351	100.00	3.622

Source: Author's calculations with data from censuses, Banxico and INEGI.

Table A.7
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1970-1993
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
13	Tobacco	3.89	2.34	0.0908	2.34	0.091
9	Cocoa and chocolate products, candies	1.25	0.65	0.0081	2.99	0.099
11	Alcoholic beverages	0.81	3.68	0.0300	6.67	0.129
27	Pharmaceutical products	0.49	3.67	0.0179	10.34	0.147
14	Other foods	0.41	1.43	0.0058	11.77	0.153
30	Non-metallic mineral products	0.40	3.81	0.0151	15.58	0.168
12	Soft drinks, water and sodas	0.28	2.67	0.0074	18.25	0.175
5	Dairy products	0.24	1.28	0.0030	19.53	0.178
25	Oil refinery, petrochemical products	-0.15	0.63	-0.0009	20.16	0.177
35	Automotive industry	-0.19	5.77	-0.0111	25.93	0.166
3	Vegetables, fruits and foods	-0.21	0.78	-0.0017	26.71	0.164
26	Chemical products	-0.41	8.79	-0.0358	35.49	0.129
33	Production of machinery and equipment	-0.56	1.56	-0.0088	37.06	0.120
18	Clothing	-0.67	3.17	-0.0213	40.23	0.099
2	Fish and crustacean products	-0.72	0.76	-0.0055	40.98	0.093
38	Other manufacturing	-0.75	0.74	-0.0055	41.72	0.088
24	Printed products	-0.81	3.33	-0.0268	45.05	0.061
8	Sugar production	-0.95	1.70	-0.0162	46.75	0.045
29	Glass and glass products	-1.02	1.47	-0.0151	48.22	0.029
17	Confection of textiles products	-1.09	0.32	-0.0035	48.54	0.026
7	Wheat and corn products	-1.24	2.85	-0.0353	51.38	-0.009
34	Production of communication equipment, measurement equipment, electric machines and their components	-1.30	6.98	-0.0910	58.36	-0.100
37	Furniture production	-1.31	2.54	-0.0334	60.91	-0.134
19	Wardrobe accessories	-1.36	0.10	-0.0013	61.00	-0.135
32	Metal products	-1.53	6.18	-0.0946	67.18	-0.230

Table A.7 (continued)
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1970-1993
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
1	Production, processing and preservation of meat and poultry	-1.56	0.85	-0.0133	68.04	-0.243
21	Shoes	-1.66	1.17	-0.0193	69.21	-0.262
10	Prepared animal food	-1.70	0.82	-0.0140	70.03	-0.276
22	Wood and wood products	-1.72	1.31	-0.0225	71.34	-0.299
16	Textiles	-1.83	3.70	-0.0676	75.04	-0.366
28	Plastic and rubber products	-1.98	4.16	-0.0821	79.19	-0.449
20	Leather products	-2.05	0.55	-0.0113	79.74	-0.460
6	Milling and grain products	-2.15	1.54	-0.0332	81.28	-0.493
15	Fibers, spinning	-2.20	3.82	-0.0841	85.10	-0.577
23	Cellulose and paper products	-2.40	3.33	-0.0800	88.43	-0.657
31	Basic metal industry	-2.95	9.38	-0.2766	97.81	-0.934
36	Other equipment of transportation	-3.47	0.86	-0.0297	98.67	-0.963
4	Oils and fats	-4.76	1.33	-0.0635	100.00	-1.027

Source: Author's calculations with data from censuses, Banxico and INEGI.

Table A.8
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1993-2003
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
4	Oils and fats	7.61	0.45	0.0340	0.45	0.0340
36	Other equipment of transportation	6.59	0.29	0.0194	0.74	0.0534
2	Fish and crustacean products	5.89	0.51	0.0302	1.25	0.0836
29	Glass and glass products	5.75	1.52	0.0875	2.77	0.1711
23	Cellulose and paper products	5.26	2.09	0.1100	4.87	0.2811
27	Pharmaceutical products	4.77	3.17	0.1510	8.03	0.4321
33	Production of machinery and equipment	4.19	1.99	0.0834	10.03	0.5156
22	Wood and wood products	4.14	0.68	0.0281	10.70	0.5436
34	Production of communication equipment,easurement equipment, electric machines and their components	3.82	6.95	0.2657	17.65	0.8094
5	Dairy products	3.62	1.95	0.0705	19.60	0.8799
15	Fibers, spinning	3.57	0.69	0.0247	20.29	0.9045
8	Sugar production	3.48	0.87	0.0301	21.16	0.9347
32	Metal products	3.44	4.87	0.1677	26.03	1.1023
20	Leather products	3.44	0.39	0.0134	26.42	1.1157
6	Milling and grain products	3.44	0.94	0.0323	27.36	1.1480
28	Plastic and rubber products	2.92	3.75	0.1095	31.11	1.2575
30	Non-metallic mineral products	2.88	4.93	0.1418	36.04	1.3993
37	Furniture production	2.85	1.60	0.0455	37.63	1.4448
12	Soft drinks, water and sodas	2.82	3.68	0.1040	41.32	1.5488
38	Other manufacturing	2.65	0.76	0.0201	42.08	1.5689
3	Vegetables, fruits and foods	2.64	0.93	0.0244	43.00	1.5934
35	Automotive industry	2.57	10.60	0.2727	53.60	1.8661
26	Chemical products	2.54	8.33	0.2117	61.93	2.0778
18	Clothing	2.45	2.91	0.0713	64.84	2.1491
7	Wheat and corn products	2.41	3.26	0.0785	68.09	2.2276
31	Basic metal industry	2.21	3.57	0.0789	71.66	2.3065
21	Shoes	2.15	1.16	0.0250	72.83	2.3315

Table A.8 (continued)
Annual Average Growth Rate in TFP per Subsector
and Contribution to Aggregate TFP Growth, 1993-2003
(percentage)

	(A) Subsector	(B) TFP growth rate	(C) Share of value added	(D) TFP contribution to growth (B*C)	(E) Cumulative share of value added	(F) Cumulative TFP contribution to growth
1	Production, processing and preservation of meat and poultry	1.86	1.08	0.0201	73.91	2.3516
10	Prepared animal food	1.72	0.74	0.0127	74.64	2.3643
19	Wardrobe accessories	1.30	0.04	0.0006	74.69	2.3649
24	Printed products	0.38	3.43	0.0129	78.12	2.3778
13	Tobacco	-0.10	2.69	-0.0028	80.81	2.3750
16	Textiles	-0.58	1.76	-0.0103	82.57	2.3647
17	Confection of textiles products	-1.32	1.50	-0.0199	84.07	2.3448
11	Alcoholic beverages	-2.11	3.55	-0.0749	87.63	2.2700
25	Oil refinery, petrochemical products	-2.37	7.71	-0.1829	95.34	2.0870
14	Other foods	-2.55	3.44	-0.0879	98.78	1.9991
9	Cocoa and chocolate products, candies	-4.55	1.22	-0.0555	100.00	1.9436

Source: Author's calculations with data from censuses, Banxico and INEGI.

APPENDIX B
Example of Group (subsector) Homogenization using the Three Classification Systems of Mexican Industrial Censuses

Group 1: Production, processing and preservation of meat and poultry

a. Operation of slaughterhouses
b. Packaging of meat and poultry (washing, selection, processing, packaging, freezing of meat and poultry for human consume)
c. Processing of meat and poultry (salt, dried, conserved, smoked)

Note: does not include any kind of sea food (fish or crustacean products).

Classes included in MCAP (INEGI, 1994):

311101 Slaughterhouses including any kind of tracks, extracts, wastes, bones.
311102 Freezing and packaging of fresh meat and poultry.
311104 Production of canned meat and poultry including sub products as smelted fat. It excludes all establishments which only deal with sales. They are classified in the frame 6140 or 6120 according to its case.

Classes included in NAICS (INEGI, 2002):

311611 Slaughterhouses are economic units which mainly deal with sacrificing of animals of meat and poultry.
311612 Cutting and packaging of meat and poultry are economic units which mainly deal with selection, cutting, boning, packing and freezing of meat and poultry.
311613 Preparation of meat and poultry includes economic units which mainly deal with preservation of meat and poultry for human consume by methods of stuffing, drying, salting, smoking and canning.

Clasification of ISIC 2.0[1]

3111- Slaughtering, preparing and preserving meat Abattoirs and meat packing plants; killing, dressing and packing cattle, hogs, sheep, lambs, horses, poultry, rabbits and small game for meat. Included are processing and packing activities such as curing, smoking, salting, pickling, packing in air-tight containers and quick-freezing. The manufacture of sausage casing, meat soups, meat puddings and pies, and the rendering and refining of lard and other edible animal fats are also included.

1 Detailed classes definitions for ISIC are available at UN web page: <http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=8&Lg=1>

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APPENDIX C
Subsectors Description for the Manufacturing industry
Authors' data reclassification based on MCAP, NAICS and ISIC

	Subsector	Description
1	Production, processing and preservation of meat and poultry	Operation of slaughterhouses, packaging and production of meat, salt, dried and smoked meat and poultry.
2	Fish and crustacean products	Production of fishes and crustaceans, including their packaging, deepfreezing, drying, etc. Includes prepared foods and concentrates of fishes and crustaceans.
3	Vegetables, fruits and foods	Deepfreezing, production, dehydration and packaging of vegetables, fruits and any prepared food. Includes preserves, jellies and juices as well.
4	Oils and fats	Any type of vegetable and animal oil and fat for human consumption.
5	Dairy products	Any milk product: cheese, butter, ice cream, dried or condensed milk, yogurt, etc.
6	Milling and grain products	Milling of wheat, corn, coffee, rice, beans except cacao.
7	Wheat and corn products	Biscuits, bread, cakes including tortilla and nixtamal.
8	Sugar production	Production of sugar, piloncillo and panela.
9	Cocoa and chocolate products, candies	Cocoa, chocolate candies, chewing gums and other candies based on cacao and chocolate.
10	Prepared animal food	Food for animals.
11	Alcoholic beverages	Distillation and distilled drinks, wine, sidra, pulque, beer and milling of malt, tequila, ron, cognac, etc.
12	Soft drinks, water and sodas	Soft drinks, water and ice.
13	Tobacco	Cigars, cigarettes and clear tobacco.
14	Other foods	Soluble coffee, tea, colorants, concentrates, honey and syrups, starches, mayonnaise, mustard, vinegar, spices, salt, chips of potato, of corn, powders for flan, etc.
15	Fibers, spinning	Natural and artificial fibers and their spinning, spinning for knitting and sewing, production of rugs.
16	Textiles	Weavings of fibers.
17	Confection of textiles products	Blankets, tablecloths and similar, bags of textiles and cords.
18	Clothing	External clothes, like sweaters, uniforms, skirts and so on.
19	Wardrobe accessories	Hats, ties, gloves, caps, handkerchiefs and similar products.
20	Leather products	Products prepared from natural of artificial leather including seats of cars.
21	Shoes	Shoes of any type of material except plastic (leather, wood, etc.)

Subsector		Description
22	Wood and wood products	Wood from sawmills, wood for construction, triplay, fibercel, boxes and packaging.
23	Cellulose and paper products	Cellulose and paper products.
24	Printed products	Publications like magazines, books, prospects, tickets, shares, etc.
25	Oil refinery, petrochemical products	Oil refinery, oil and carbon derivatives, asphalt, gas, lubricants, etc.
26	Chemical products	Organic and inorganic products, colorants, fertilizers, artificial resin, detergent, shampoo, soap, perfumes, ink, sensible paper, make-ups, cosmetics, paintings and similar.
27	Pharmaceutical products	Human, veterinarian, homeopathic medicine and their packaging.
28	Plastic and rubber products	Wheels, games of any kind of material, heels, gloves, plastic things for households, plastic shoes, bags, tubes, etc.
29	Glass and glass products	Mirror, glass fiber, bottles and ornaments.
30	Non-metallic mineral products	Refractory and non-refractory clay, cement, lime, plaster and stones like.
31	Basic metal industry	Manufacture of iron and steel, tubes of iron and steel, aluminum, copper and other non-ferrous metals, casting of metals.
32	Metal products	Knives and any other metal products for households, nails, screws, plates, wire, felt, small parts of machines, locks and similar.
33	Production of machinery and equipment	Machinery and equipment for different industries.
34	Production of communication equipment, measurement equipment, electric machines and their components	Computers, equipments of office, of transmission, telephones, electronic equipments, equipments for medical use, illumination, domestic equipments, conductors of electricity, accumulators, batteries and similar.
35	Automotive industry	Cars, trucks, trailers, and similar and their parts.
36	Other equipment of transportation	Railways and trains, aircrafts, boats.
37	Furniture production	Any kind of furniture.
38	Other manufacturing	Jewelry, sport items, music instruments, and any other items which are not included in the other classes.