TOTAL FACTOR PRODUCTIVITY IN THE BOGOTA MANUFACTURING INDUSTRY, 1985-2005

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Abstract: The objective of this article is to measure and to analyze total factor productivity –TFP- growth in the Bogota manufacturing industry over the period 1985-2005. From the early 90s Colombia applied several policy actions aiming at increasing trade openness of its economy. Taking this into account, this article analyzes performance of several subsectors of the Bogota manufacturing industry before and after trade liberalization. TFP growth is measured by using Harberger's Two-Deflator Method, which although it is a robust method, is not difficult to use, and the amount of data needed for calculations is easier to handle with, compared with traditional methods. The results of the paper show most of the subsectors analyzed had positive TFP growth rates during the period 1990-2005, which corresponds to a period of more openness of the Colombian economy, compared to eight out of the twenty subsectors with negative TFP growth rates in the period pre - trade liberalization, 1985-1990. On this basis, the results suggest a possible positive effect of trade liberalization of the Colombian economy on TFP of manufacturing industry of Bogota.

Keywords: Economic Growth, Growth Accounting, Manufacturing Industry, Total factor productivity, Two-Deflator Method.

INTRODUCTION

According to the literature on economic growth and, particularly, the branch corresponding to what is known as growth accounting, taking a production function that uses capital and labor as inputs, it would be expected that increases of output were explained by increases of these inputs. However, a great amount of empirical studies shows that increases of inputs or productive factors explains only a part of economic growth, which is quite often equal to or lower than a half.

The part of the growth of output that is not explained by the quantitative and qualitative increases of factors of production is associated with growth of what is conventionally known as total factor productivity (TFP). The TFP has been related in the literature to technical change and to accumulation of human capital (for example, Solow [20]), to the presence of externalities and / or economies of scale. The recent literature establishes that the TFP is also explained by several factors that do not have a relationship, at least directly, with technology. Some examples of those factors are institutions, macroeconomic environment, etc. (Easterly and Levine [9], Angulo and Guillermo [3], Harberger [16, 17], Hall and Jones [15], Acemoglu *et al*., [1, 2])

In agreement with Harberger [16] this 'residual' or part of growth that is not explained by changes in factors of production can be associated with ' technical change ', 'improvement in TFP' and a 'real costs reduction (RCR)'. The author argues that the term ' technical change ' drives most of economists to think about inventions, results of research and development, and what can be called technical innovations. On the other hand, ' improvements in TFP ', once 'cleaned' of changes in quality of the inputs used and/or of the direct contribution of human capital, can be explained for the presence of several kinds of externalities (economies of scale, spillover effects and systematic complementarities). Finally, a 'real costs reduction', drives one to think as an entrepreneur or a production manager.

Among the three options commented above, Harberger decides to take a RCR as a standard label for the 'residual' or the part 'unexplained' of growth. It is very likely that in some occasions a RCR is in the mind of the majority of the business executives and managers of production. Persons in these charges are generally responsible for the design and application of policies for the company in order to achieve a RCR, that is to say, an increase of TFP.

This conception of TFP growth as a RCR, which is present in every company in different ways, gives us some evidence of the need to analyze the evolution of this important determinant of output growth in a disaggregated way. Thus, it is possible to analyze TFP growth for different branches of economic activity, for several sectors of a specific branch or, even for each of the companies of a specific sector. Following this line, this study aims to evaluate the evolution of TFP in 20 subsectors of the Bogota manufacturing industry during the period 1985-2005. During this period, specifically from the early 90s, Colombia applied several policy actions aiming at increasing trade openness of its economy. On this basis, this study uses Harberger's conception of TFP growth to analyze the performance of Colombian manufacturing industry before and after trade liberalization.

As stated by Eslava *et al*. [11], the average nominal tariff declined from 27 percent to 10 percent overall, and from 50 percent to 13 percent in manufacturing industry, between 1984 y 1998. It happened a considerable decrease in effective tariffs and in the dispersion of them between 1990 and 1992. The average effective tariff fell down from 62.5 percent in 1989 to 26.6 percent in 1992. The average and dispersion of effective tariffs remain nearly the same after 1992 (Eslava *et al*. [11]).

The two-deflator method (2DM)

This study uses the two-deflator method (2DM) developed by Harberger [16] in order to estimate the TFP for 20 sectors of manufacturing industry in Bogota. The 2DM has two important characteristics. The first one consists of deflating all the flows and nominal stocks that are considered in the analysis of growth using the same deflator (that of the GDP) in order to express all nominal variables in terms of the same basket of goods and services. The other characteristic of the 2DM has to do with the utilization of a 'deflator of labor', which consists of a standard salary assigned to standard or 'unskilled' workers.

Thus, the quantity of any worker's labor, regardless how qualified he is, is calculated dividing his income by the standard salary of an 'unskilled' worker. The excess wage of any worker on the standard wage of an 'unskilled' worker is assumed to be attributable to human capital (Harberger [17]). The return to education, training, and experience is supposed to be included in this 'excess wage'. Under these characteristics, the 2DM does well the task of 'cleaning' the residual that is obtained in the estimation of a production function, which is generally associated to changes of TFP, of effects that come from factors other than a real costs reduction, such as training of workforce. Actions of this type originate an increase of labor marginal productivity and not necessarily TFP growth.

The 2DM departs from a production function, whose inputs are capital and labor. Output obtained is distributed between these two factors, according to their respective returns remunerations, as follows:

$$Y = wL + (\rho + \delta)K \quad (1),$$

where
Y = Real output (value added)
L = Labor
K = Capital stock
w = Wage
ρ = Return rate of the capital
δ = Depreciation rate of capital

If the return of production factors is assumed to be given by their marginal products, an increase of the real output is distributed as follows: one part is attributable to an increase of labor force, another one to an increase of capital stock and the other part will be attributable to TFP growth. In terms of the different sectors of manufacturing industry that are analyzed in this study, the previous statement is expressed in the following way:

$$\frac{\Delta y_{jt}}{y_{jt-1}} = \frac{w_t^* \Delta L_{jt}^*}{y_{jt-1}} + \frac{(\rho_{jt} + \delta_{jt})\Delta K_{jt}}{y_{jt-1}} + TFP_{jt} \quad (2)$$

where:

$\frac{\Delta y_{jt}}{y_{jt-1}}$ = Real output (value added) growth rate for industry sector *j* in period *t*.

$\frac{w_t^* \Delta L_{jt}^*}{y_{jt-1}}$ = Contribution of labor to the growth rate of growth for industry sector *j* in period *t*.

ρ_{jt} = Return rate of capital for industry sector *j* in period *t*.

δ_{jt} = Depreciation rate of capital for industry sector *j* in period *t*.

$\frac{(\rho_{jt} + \delta_{jt})\Delta K_{jt}}{y_{jt-1}}$ = Contribution of capital to the growth rate of industry sector *j* in period *t*.

TFP_{jt} = Total factor productivity growth for industry sector *j* in period *t*.

Rearranging terms, an expression for TFP growth for each of the sectors to analyze is obtained:

$$TFP_{jt} = \frac{\Delta y_{jt}}{y_{jt-1}} - \frac{w_t^* \Delta L_{jt}^*}{y_{jt-1}} - \frac{(\rho_{jt} + \delta_{jt})\Delta K_{jt}}{y_{jt-1}} \quad (3)$$

As mentioned by Guillermo and Tanka [14], the principal computational characteristics of the 2DM 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 [17]

With regard to the two deflators used by the Harberger's 2DM, we now describe their main characteristics:

A. The deflator of nominal variables

In order to obtain the contribution of capital to the growth rate of each of the industry sectors (the third part of the right side of equation 3), it is necessary to consider first the capital return rate (CRR), which is defined as the return obtained due to utilization of a certain stock of capital divided by that capital stock. The estimation needs that both the numerator (monetary units of return) and the denominator (capital stock) are expressed in the same units. To do that, the 2DM proposes that the part of value added that corresponds to the return attributable to capital as well as his stock, should be measured up in monetary units and then deflated using the same price index, the GDP deflator.

Gross CRR (ρ+δ) can be obtained by subtracting from real output all the payments to other inputs different from capital, and dividing the result by the capital stock expressed in the same units that output, that is to say, in monetary units of the year that is taken as a base when using GDP deflator. That is:

$$\rho_{jt} + \delta_j = \frac{Y_{jt} - rm_{jt} - w_{jt} L_{jt}}{K_{jt}} \quad (4)$$

where rm_{jt} corresponds to the real payment to raw materials used in the process of production of sector *j* in period *t*, whereas the other variables are defined in the same way as in equations (1) and (2), with the only difference that in this case both the numerator and the denominator of the right side of the equation are measured in the same units, that is to say in 'baskets of GDP' of any year that is taken as the base.

B. The deflator of labor

As mentioned previously, the deflator of labor force is given by the standard wage of an 'unskilled' worker. This deflator is used in order to express all the labor force that is used in each of the industry sectors in terms of standard or unskilled workforce. The quantum of labor force of any worker, regardless how skilled he is, is calculated by dividing his income by the above mentioned standard wage. This procedure constitutes a relatively easy and completely understandable way of obviating the frequent lack of information sufficiently disaggregated of labor force in developing countries, such as Colombia.

Estimation of TFP of different subsectors of the Colombian manufacturing industry

A. The deflator of nominal variables

To estimate the TFP of 20 subsectors of the Bogota manufacturing industry, we start by calculating the contribution of capital to the growth rate of sector *j* in period *t*, which is given by the third component of the right hand side of equation (3). To do that, it is necessary first to calculate the gross CRR given by equation (4). The different components of the right hand side of this equation are obtained directly from the Manufacturing Annual Survey (Encuesta Anual Manufacturera) from the National Administrative Department of Statistics (DANE). For the first part of the numerator, value added is the variable to be used. For the second one, the value corresponding to intermediate consumption, which includes raw materials, consumption of electric power and other intermediate consumption. For the third and last part of the numerator, the total payment to workforce is used. To quantify the variable that appears in the denominator, capital stock, we take, like in other studies, the value of assets. This procedure has been used in some studies because of the lack of more accurate estimations of capital stock, especially at regional level and in a disaggregated way, as the case that corresponds to this study. The estimation of the contribution of capital needs besides the gross RRC, the stock of capital and value added, variables that were all mentioned before. It should be remembered that both the numerator and the denominator are measured in monetary units (pesos) and that have been considered in real terms, by using the GDP deflator.

B. The deflator of labor

Another necessary step for calculation of TFP requires an estimation of the contribution of labor to the growth rate of growth of sector *j* in period *t*, which is given by the second term of the right hand side of equation (3). In order to do that, we need first to calculate a standard salary (w*) of the 'unskilled' workforce, which is done by dividing total payments to “blue collar” workers in sector *j* and period *t* by the number of “blue collar” workers of that sector in the same period. Both variables, as well as others that are used in this section are obtained also from the EAM of DANE. Once obtained the standard salary for every sector of the industry (w^*_{jt}), the second deflator (w^*_t) is equal to the median of all the w^*_{jt} . It is to say:

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

Then, it is necessary to express all the labor force of every sector in terms of 'unskilled' workers. This 'standardized' labor force is denoted as L^*_{jt} , and is calculated by dividing the total wage bill for every sector in period t by the deflator of the labor force (w^*_t).

C. Sunrise- Sunset productivity diagrams

Productivity diagrams of this type, proposed by Harberger [16], show the distribution of productivity of the analyzed sectors. In our case, diagrams show the contribution of TFP to the growth of each of the subsectors of the Bogota manufacturing industry and allow us to find an easy way to analyze the aggregated TFP growth rate for a specific period of time. As described in Guillermo and Tanka [14], in order to make these diagrams, it is necessary first to arrange the sectors and their corresponding initial participations in value added, by considering their TFP growth rates in a descending order.

Then, we can calculate the contribution of every sector *j* to TFP growth for the whole manufacturing industry, which is equal to $(Y_{jt-1}/Y_{t-1})PTF_{jt}$. The Sunrise- Sunset productivity diagrams are built on a Cartesian plane with cumulative contribution of TFP of the different sectors to TFP growth of the whole industry on the vertical axis, and the cumulative contribution of output (value added) of the sectors to total output in the horizontal axis. These accumulated contributions for the five-year period 1985-1990 appear in the third and fourth columns of table 1.

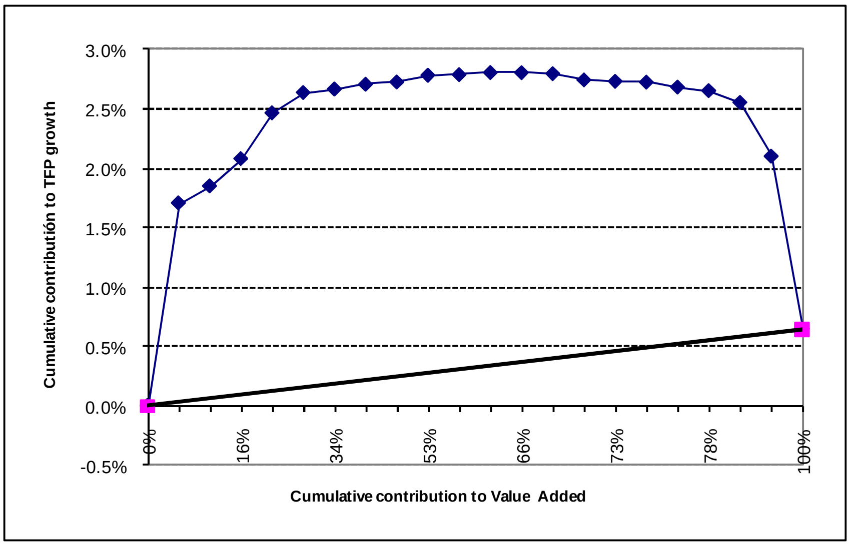
During this period, as seen in Figure 1, TFP growth of the aggregated manufacturing industry (20 divisions considered here) was positive (0.6 %). The increasing part of the graph shows the accumulated contribution of the industrial divisions with positive TFP growth rates (twelve in total) to TFP of the whole manufacturing industry. The diminishing part, on the other hand, is the contribution to TFP growth of the industry of ten divisions with negative growth rates. It is important to indicate that the four subsectors with major rates of TFP growth generated 27.7% of the value added of the manufacturing industry and achieved an accumulated TFP growth of 2.5%.

Table 1. Cumulative cintributions of the subsectors of the Manufacturing Industry to TFP growth and to Value Added, Bogota 1985-1990

Subsector	Average annual TFP growth	Cumulative contribution to TFP growth	Cumulative contribution to value added
Equipment of transportation	18.7%	1.7%	9.1%
Oil and petrochemical products and coal	10.4%	1.9%	10.5%
Metal products except machinery and equipment	4.5%	2.1%	15.6%
Other chemical products	3.2%	2.5%	27.7%
Printed products	3.0%	2.6%	33.3%
Furniture production	2.8%	2.7%	34.3%
Dairy products	1.8%	2.7%	36.6%
Production of machines except electric ones	0.7%	2.7%	39.5%
Food products except drinks and sodas	0.4%	2.8%	52.6%
Rubber products	0.4%	2.8%	53.8%
Textiles	0.3%	2.8%	60.2%
Plastic products	0.0%	2.8%	65.5%
Celulose and paper products	-0.6%	2.8%	66.8%
Other manufacturing	-1.0%	2.7%	72.0%
Leather products except shoes	-1.2%	2.7%	72.9%
Basic metal industry	-1.2%	2.7%	73.6%
Clothing except shoes	-1.4%	2.7%	76.4%
Chemical products	-2.4%	2.7%	77.7%
Shoes	-6.4%	2.6%	79.2%
Production of machinery and equipment	-7.0%	2.1%	85.7%
Soft drinks, water and sodas	-10.2%	0.6%	100.0%
Source: Own calculations with data from the EAM, DANE			

The following subsectors, arranged in a descending order by their TFP growth rates, generated approximately 50% of the value added of the manufacturing industry and, practically, did not do any contribution to the TFP growth of the manufacturing industry, provided that in this range of cumulative value added (fourth column), cumulative TFP growth reach a maximum of 2.7% and then, it returned to be located approximately in 2.1 %. The two remaining divisions (production of machinery and equipment, and soft drinks) had negative and very high TFP growth rates, -7 % and -10.2%, respectively. This implies that they contributed negatively and in a considerable enough way to the evolution of TFP of the whole industry. Special attention deserves in this case, the soft drinks division, since due to his high participation in the output of the industry (21%) and his negative TFP growth rate during this period, it dragged the TFP growth rate for the aggregated industry up to a value of 0.6 %.

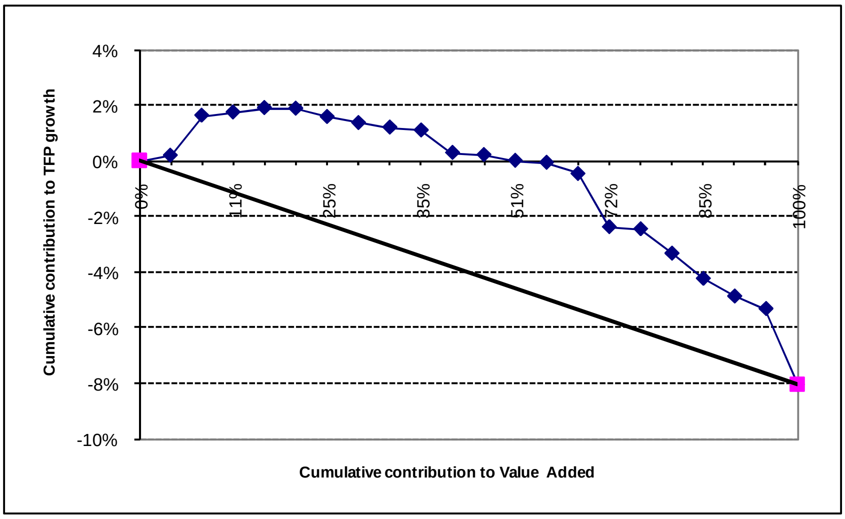
Figure 1:
Sunrise Productivity Graph for manufacturing industry of Bogota, 1985-1990



On the other hand, the following five-year period, 1990-1995, shows a negative TFP growth rate for the aggregated manufacturing industry, -8% (Figure 2). These results are in line with those found by Loayza, Fajnzylber, & Calderón [19], Clavijo [7] and Cárdenas [5], since the studies found that TFP growth in Colombia was negative for the 1990's.

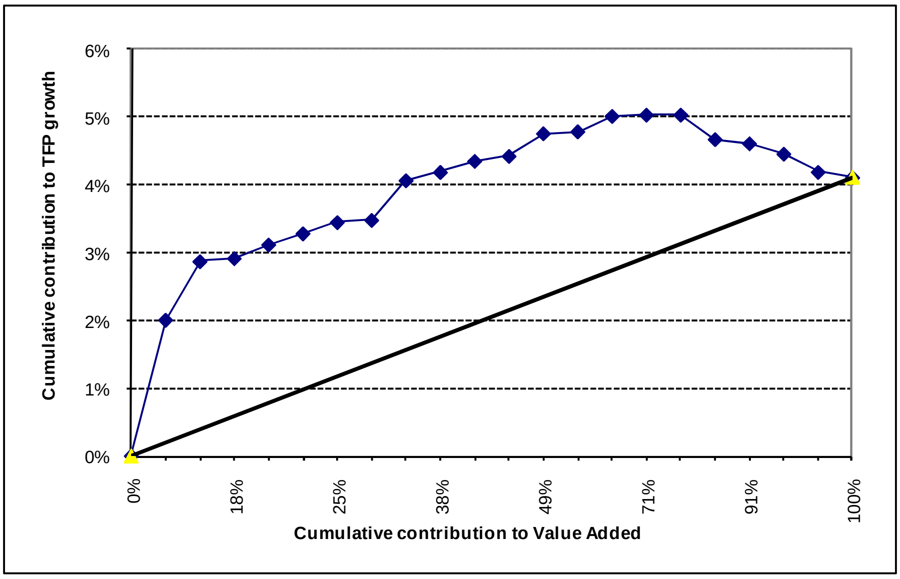
Figure 2 shows that only four industrial subsectors, which generated approximately 15% of value added of the industry, showed positive TFP growth rates, that is to say, real costs reductions (RCR). The remaining subsectors contributed in a negative way to the aggregated TFP growth rate of the manufacturing industry. In other words, they had a negative TFP growth rate, which corresponds to increases in their real costs.

Figure 2
Sunset Productivity Graph for manufacturing industry of Bogota, 1990-1995



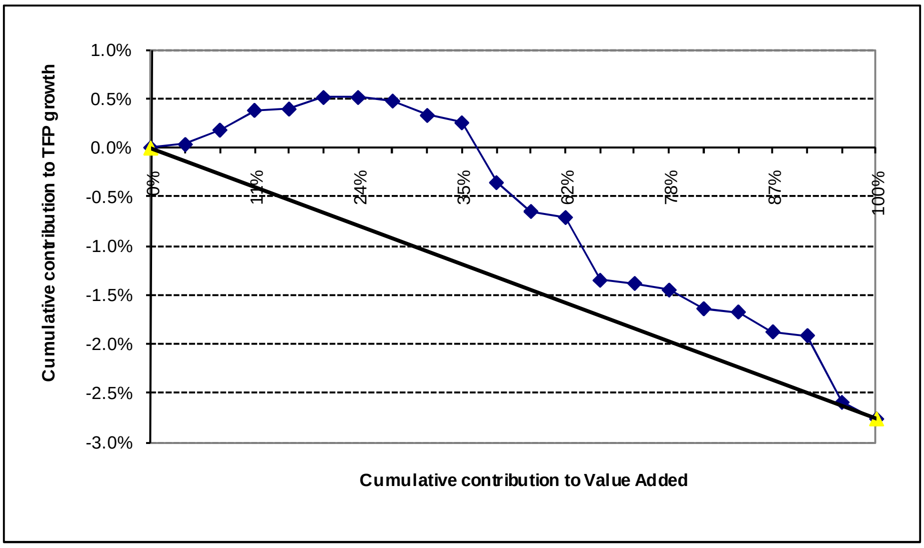
During the following five-year period, 1995-2000, the aggregated TFP of the manufacturing industry grew 4.1 % (Figure 3). Three quarters of the industrial divisions, which generated approximately 71% of value added of the industry, showed positive TFP growth rates or, within this framework, real costs reductions.

Figure 3
Sunrise Productivity Graph for manufacturing industry of Bogota, 1995-2000



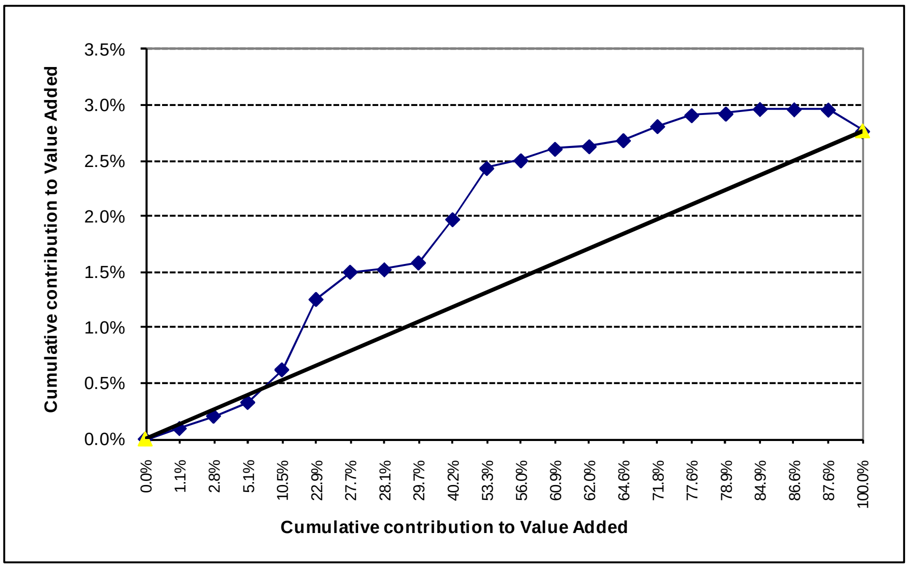
Finally, the period 2000-2005 shows a negative aggregated TFP growth rate of 2.8 % (Figure 4). Just five industry divisions, which generated approximately 24% of value added of the industry, showed positive TFP growth rates, in other words, real costs reductions (RCR). The remaining fifteen divisions contributed in a negative way to the aggregated TFP growth rate of the manufacturing industry. In other words, they had a negative TFP growth rate, which corresponds to increases in their real costs.

Figure 4
Sunset Productivity Graph for manufacturing industry of Bogota, 2000-2005



During the whole period 1990-2005, which corresponds to a period of more openness of the Colombian economy, the aggregated TFP of the manufacturing industry grew 2.8 %, as seen in figure 5. Most of the divisions showed positive TFP growth rates (RCR). Only three of them had negative ones.

Figure 5
Sunrise Productivity Graph for manufacturing industry of Bogota, 1990-2005



CONCLUSION

This paper uses an understandable and easily usable method to estimate TFP growth in a disaggregated way, the Harberger's Two-Deflator Method. In so doing, we estimate changes in TFP across 20 subsectors of the manufacturing industry of Bogota, Colombia. The results show that most of the subsectors considered here had positive TFP growth rates during the period 1990-2005, which corresponds to a period of more openness of the Colombian economy, compared to eight out of the twenty subsectors with negative TFP growth rates in the period pre - trade liberalization, 1985-1990. On this basis, the results suggest a possible positive effect of trade liberalization of the Colombian economy on TFP of manufacturing industry of Bogota. However, this statement should be taken with caution, provided that such a TFP performance could be originated by other factors different from trade liberalization.

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