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THE DYNAMICS OF PRODUCTIVITY PERFORMANCE IN MEXICAN MANUFACTURING, 1984–90

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INTRODUCTION

THE analysis of the efficiency of resource utilization is a topic that has generated a great deal of interest among students of Mexico's economic development. Various estimates exist of the growth of total factor productivity and labor productivity for certain periods. It is worth noting that the measurement of productivity growth is very sensitive to the method of estimation, the information sources used, and the selection of the base year. Nonetheless, independent of the estimated magnitudes, there seems to be agreement among different authors regarding the low dynamism of productivity during the period of import substitution, even compared with other countries at similar stages of development.

As has been known since 1982—the year in which structural economic problems were felt most strongly—the Mexican economy has undergone significant changes in its economic policy as import substitution policies were left behind in favor of export promotion. Among the most important actions undertaken were: the freeing up of external trade, the elimination of subsidies, and the promotion of direct foreign investment, all of which have affected the productive environment through changes in prices and in quantities or qualities of inputs and outputs.

Nearly ten years after the start of this new economic orientation, the manufacturing industry (whose significance in the development of prior periods is indisputable) is increasingly faced with becoming more competitive internationally; consequently, the central question of this article is the following: To what extent has a behavioral change evolved at the microeconomic level in response to the urgent demands of this new environment and leading to increased productivity?

The objective of this paper is to analyze the growth of productivity in the manufacturing industry for the period from 1984 to 1990, using the "Annual Industrial Survey" produced by the National Institute of Statistics, Geography and Informatics (INEGI).[1] Of specific interest are the following: (1) presentation

We would like to thank Lic Abigail Durán from the National Institute of Statistics, Geography and Informatics (INEGI) for having made available the information used for the productivity indices, as well as his comments and suggestions.

[1] The selection of the period beginning in 1984 is due to the availability of comparable data, because in 1984 the sample of the "Annual Industrial Survey" [10] was changed. Strictly speaking, the period of industrial transition began in 1983. Nonetheless, given that 1983

of the results of the measurement of total factor productivity and labor productivity; (2) analysis of patterns of behavior of the productivity growth by industrial sectors and subsectors and according to size of establishments; and (3) exploration of the determining factors in productivity growth.

The importance of the productivity estimates carried out by the "Annual Industrial Survey" [10] lies in that it contains a selected sample of the most important industrial firms in the country. This survey covers 70 per cent of the gross value of production within the national accounts. As will be seen further on in this paper, the behavior of productivity is determined for the most part by the activity of large companies. This clearly indicates the relevance of a detailed examination of this sample.

This paper consists of five sections and concluding statements. Section I discusses the methodology used. Section II presents the principal results of the evolution of productivity in the period examined. We will show that productivity growth is considerably greater than during other periods, particularly if one takes into account that GNP growth in the study period (1984–90) was on the average very moderate. We will highlight the disparities that exist in the productivity indicators between the industrial sectors and subsectors. Section III analyses the differential patterns of productivity behavior among sectors and the trade regime. The behavior of the principal components of the index of total factor productivity are examined in Section IV, and Section V analyzes productivity growth by establishment size. It will be shown that productivity growth is determined by establishments with more than 500 employees. The final section presents the study's conclusions.

I. THEORETICAL CONSIDERATIONS AND METHODOLOGY

The total factor productivity (TFP) is the relationship between the product and its inputs. The analytical framework for the measurement of TFP is based on the theory of production. Recently there have been important advances in this field. These include the theory of duality, the theory of index numbers, and the development of flexible functional forms, which imply distinct methods of estimation. The differences among these methods are as much theoretical as statistical. We have selected the Kendrick index [8] as the analytical tool for this paper because this method has been used to measure TFP for the Mexican economy (see [6] [7]), and as such the results that are presented here can be compared with earlier estimates.

Beginning with a production function such as $Q = f(X_1, \ldots, X_n)$, where $Q =$ value added of the production process and $(X_1, \ldots, X_n) =$ tangible factors that are used in production, Kendrick constructed a TFP index that quantifies the productivity of the manufacturing industry in the United States from 1889 to 1953.

For Kendrick, the TFP is a relationship between real product and inputs. In its formulation, the following hypotheses of the neoclassical theory of production

corresponded to a profound and atypical recession, to take this year as the base year for estimates would have resulted in a definite bias toward greater growth rates in productivity.

are implicit: (1) conditions of perfect competition, and, as a consequence, the factors demonstrate returns according to marginal production; (2) neutral technological progress; and (3) constant returns to scale.

Kendrick begins with a combination of factors and a technological structure from a base year, reflected in relative prices of the products and factors. In this way, in order to maintain prices constant relative to products and factors in the subsequent periods, the modifications in TFP reflect the technical change in the full sense described above.

The index proposed by Kendrick to measure the TFP is:

$$\Pi = \frac{Q_t/Q_0}{\alpha_0 L_t/L_0 + \beta_0 K_t/K_0},$$

where

Q_0 = product in base year,
Q_t = product in year t,
L_0 = number of hours worked in base year,
L_t = number of hours worked in year t,
K_0 = capital assets in base year,
K_t = capital assets in year t,
α_0 = participation in profits from the product in base year, and
β_0 = participation in profit earnings in base year.

In order to develop productivity estimates, capital assets are estimated with the method of perpetual inventories.[2] For labor inputs, the number of employee hours and number of worker hours are used (see Appendix for details). A warning must be given: productivity indices are very sensitive to the methodology with which the series are constructed, in particular price indices.[3]

Before presenting the results of the evolution of productivity, it is necessary first to devote a few lines to the interpretation of this index. Given the hypotheses with which it was developed—which are clearly restrictive—the growth of the product is a consequence of the growth of inputs plus the component of technical progress. Thus, the TFP is the output growth rate not explained by the growth of the inputs.

The question then arises whether the growth of this "residual" necessarily implies the occurrence of a technical change due to the shift of the production function by the implementation of a new generation of technical knowledge. This suggests the need to consider aspects which are included in the TFP index. In the first place, it must be remembered that the index was created based on the assumption of constant returns to scale, which implies that for those sectors in which large scale economies are important, the increase of a "residual" cannot

[2] We would like to acknowledge the invaluable contributions of Lic. L. H. Villapando Hernández to the methodology for the building of capital assets.

[3] The deflator used in this case was the price index of capital issued by Bank of Mexico [1]. This is the only reliable source, since it is based on data drawn from a yearly survey of firms. The price index of capital contained in the national accounts does not distinguish between the different types of capital assets.

be separated from the effect of economies of scale. On the other hand, as Nelson [11] notes, technology is more than machines, tools, and equipment. It may also be incorporated in workers and managers, in the physical characteristics of the material inputs, or in the organization which determine how the distinct inputs are combined. Finally, it can be incorporated into new products. As a consequence, the changes in the Kendrick index can result from any type of change in the broad interpretation of the concept of technology. Apart from the changes in the productive realm, for example, government policy can also affect productivity performance. In the case of the Mexican economy, the major economic policy changes during the study period, entailing a radically different evironment for industry, have already been mentioned. They are expected to alter the competitiveness of industry in the long run, but they can also certainly have an important impact in the short term during the process of adjustment to the new setup.[4]

Along these lines, the TFP estimates can be broadly interpreted to include changes in the response to disturbances in the production process that affect the utilization of capacity in the short term. Now, these measurements deal with the units of production as a black box: we measure the inputs and the production but without trying to describe what occurs in the firm. In order to investigate what takes place at the company level, another type of investigation is needed. Diverse case studies exist to this end. Researchers have remarked on the modernization of Mexico's northern regions. They have concentrated primarily on large export firms in the automotive and electronics industries, showing the specific modalities of technical change occurring in these firms.[5]

The wealth of information brought out by case studies regarding technical change within companies is undeniable. Nonetheless, given the fact that the results are naturally qualitative and given the limited coverage they have, it is not possible to generalize with regard to the industry as a whole and, consequently, they cannot respond by themselves to the question posed at the outset regarding the relationship between macroeconomic change and substantial improvements in productivity. This requires an examination of the behavior of industry based on a broader sample such as that contained in the "Annual Industrial Survey."

II. EVOLUTION OF PRODUCTIVITY IN THE MANUFACTURING INDUSTRIES, 1984–90

Annual TFP growth estimated with the "Annual Industrial Survey" was 4.8 per cent and that of labor productivity (LP) was 3.3 per cent between 1984 and 1990.

Various estimates for the import substitution period are available. Chenery [3] presents a measure of annual growth of 2.0 per cent and 3.0 per cent for the TFP and LP between 1950 and 1974. Hernández Laos and Velasco [7], on

[4] For a similar interpretation of the productivity estimates based on residuals, see Nishimizu and Robinson [12].

[5] For case studies, see Ramirez [13], Domínguez [4], Micheli [9], Brown and Domínguez [2].

TABLE I

ESTIMATES OF THE GROWTH OF TOTAL FACTOR PRODUCTIVITY AND LABOR PRODUCTIVITY IN THE MEXICAN MANUFACTURING INDUSTRY

(%)

Period	Total Factor Productivity	Labor Productivity	GDP	Source	Author
1950–74	2.0	3.0	9.6	National accounts	Chenery [3]
1960–80	1.1	3.4	7.0	National accounts	H. Laos and Velasco [7]
1963–81	3.6	6.0	7.0	Annual industrial survey	Samaniego [15]
1983–89	5.3	2.1	3.6	National accounts	H. Laos [6]
1984–90	4.8	3.3	3.3	Annual industrial survey	Domínguez and Brown [5]

the one hand, calculate TFP and LP at 1.1 per cent and 3.4 per cent, respectively, for the entire period from 1960 to 1980. Finally, Samaniego [15] estimates that TFP grew at 3.6 per cent annually and the LP at 6.0 per cent on average between 1963 and 1981.[6] The authors are in agreement that the growth of productivity in this period was extensive, given the high growth of the GDP in this period (see Table I).

Finally, Hernández Laos [6] estimates TFP and LP annual growth rates at 5.3 per cent and 2.1 per cent per year using information from the national accounts for 1983–89. This is consistent with the tendencies osberved in this investigation relative to the increase of productive efficiency in this period.

In order to compare estimates of different periods, it must be borne in mind that the period under study was characterized by a moderate average annual growth of value added by the sample (3.3 per cent) accompanied by important changes in economic policy as well as by great instability in economic activity with alternating phases of stagflation, ending with a period of moderate product growth and a substantial drop in inflation.[7] Taking into account that previous periods were characterized by high GDP growth rates, this TFP increase deserves attention in terms of the path that brought about this estimate and to what extent the government policy of liberalization contributed to this end, a topic taken up in Section III.

Another aspect that may seem intriguing is the inverse pattern between LP and TFP rate observed in Table I. As will be seen in Section IV, the stark contrast of investment trends and capital assets during the period under study

[6] The source of Chenery's estimates as well as those of Hernández Laos and Velasco are the national accounts. Samaniego's estimates are the same as ours, i.e., the "Annual Industrial Survey," although it must be emphasized that the sample is not strictly comparable.

[7] From 1984 to 1987 GDP grew at 0.15 per cent with yearly inflation rates reaching a peak of 160 per cent in 1987. During the next three years GDP grew at 2.9 per cent and inflation rate dropped to 30 per cent in 1990.

TABLE II

GROWTH RATES OF TOTAL FACTOR PRODUCTIVITY AND LABOR PRODUCTIVITY

	1984–87 (%)	1987–90 (%)	1984–90 (%)	Std. Dev. 1984–90
Total factor productivity:				
Food, beverages, and tobacco	−2.0	11.6	4.6	4.3
Textiles, apparel, and leather	0.2	0.8	0.5	3.1
Wood industries	2.3	0.8	1.6	1.4
Paper, printing, and publishing houses	6.2	3.4	4.8	3.4
Chemical substances, cork, rubber and plastic	−2.5	4.7	1.0	4.1
Nonmetal mineral products	5.7	5.4	5.6	2.6
Basic metals industries	2.8	8.9	5.8	0.3
Metal products, machinery, and equipment	1.2	13.9	7.3	6.1
Industry total	0.8	10.5	4.8	
Labor productivity:				
Food, beverages, and tobacco	−4.4	7.3	1.3	5.3
Textiles, apparel, and leather	−0.9	1.3	0.2	2.7
Wood industries	−0.5	−3.7	−2.1	1.4
Paper, printing, and publishing houses	5.3	1.2	3.2	3.2
Chemical substances, cork, rubber and plastic	−2.2	3.8	0.7	4.4
Nonmetal mineral products	3.0	2.2	2.6	1.7
Basic metals industries	5.1	3.6	4.3	2.3
Metal products, machinery, and equipment	4.5	11.0	7.7	7.2
Industry total	0.7	5.9	3.3	

Source: Calculations are based on data in "Annual Industrial Survey" [10].

and the previous one may give a clue to understanding the lower growth rate of labor productivity.

One of the most distinguishing characteristics of the evolution of TFP during the recent period is the large disparity among the industrial sectors and subsectors. The sectors with the greatest TFP increase were: metal products, machinery, and equipment; basic metals industries; and nonmetal mineral products. Regarding the productivity of labor, the following sectors stand out: metal products, machinery, and equipment; basic metals industries; and paper, printing, and publishing houses. In fact, excluding these sectors, the resulting reduced increase of labor productivity is disturbing. This fact may be explained as much by insufficient investment as by the economic instability of the period which was reflected, as will be seen further on, by insufficient output growth for most of

TABLE III

SUBSECTORS WITH GREATEST AND LEAST GROWTH OF TOTAL FACTOR PRODUCTIVITY AND LABOR PRODUCTIVITY GROWTH RATES, 1984–90

(%)

	Total Factor Productivity	Labor Productivity
Subsectors with highest total factor productivity growth:		
Automobiles	18.3	18.4
Animal food	11.7	11.3
Canned fruit and vegetables	9.7	6.5
Meat and milk products	8.4	5.7
Glass and related products	7.3	3.9
Other food products	6.9	8.6
Automotive parts and bodies	6.6	6.3
Nonferrous metals	6.4	0.8
Cement	6.3	2.6
Paper and cardboard	5.8	4.2
Basic iron industries	5.7	5.5
Alcoholic beverages	5.5	5.3
Other textile industries	4.8	2.5
Metal furniture	4.6	4.7
Subsectors with least total factor productivity growth:		
Fertilizers	−10.9	−11.3
Metallic structural products	−4.7	−4.8
Transportation equipment and material	−4.5	4.1
Leather and footwear	−3.8	−4.6
Electrical machinery and appliances	−2.1	−5.5
Electrical equipment and appliances	−1.8	−4.1
Milled flour and assoc. products	−1.5	−4.5
Printing and editorial houses	−1.1	−2.1
Garments	−0.8	−1.2
Medical products	−0.3	0.7
Basic chemicals	−0.02	−1.6
Plastic products	0.09	0.4
Other wood industries	0.19	−3.3
Soft drinks	0.30	−4.5

Source: The same as in Table II.

the industrial sectors. Also, it must be noted that, excluding wood industries; paper, printing, and publishing houses; and nonmetal mineral products which registered a fall, the TFP increase was concentrated in the sub-period of 1987–90, coinciding with the recovering of economic activity (see Table II).

The results of the measurements of TFP and LP in terms of the industrial subsectors reveal that heterogeneity remains prevalent.[8] Among subsectors within the sectors: metal products, machinery, and equipment; food, beverages, and

[8] Our estimation is based on forty branches out of forty-seven in manufacturing. Due to problems with data, the following were eliminated: milled corn flour, coffee processing, beer production, tobacco, oil derivates, and other industries.

tobacco; and chemical substances, cork, rubber, and plastic, had the greatest standard deviation between 1984 and 1990.

Table III shows a list of the subsectors with the greatest and least TFP and labor productivity growth from 1984 to 1990. The subsectors belonging to the automobile industry stand out for high rates of average annual growth TFP and LP (first and seventh place), followed by several subsectors of the food industry. On the opposite end of the spectrum are fertilizers, metallic structural products, transportation equipment and material, leather and footwear, and electrical machinery and appliances with the lowest levels of TFP and LP. The last two industries have been adversely affected by the opening of trade in recent years.

III. DIFFERENTIAL PRODUCTIVITY BEHAVIOR AND THE INTERNATIONAL TRADE REGIME

If we group the subsectors together according to their rate of growth of TFP, LP, and value added, we note that those of high dynamism, expressed by growth rates superior to the industry average, contributed fundamentally to the greatest percentage of productivity increase observed at the level of industry as a whole (Table IV). Thus by eliminating the twelve subsectors whose TFP was equal to or greater than the industry average, the growth of TFP diminished from 4.8 per cent to an average annual rate of 1.3 per cent, that is to say, more than three times less than the average. In contrast, the group of twelve branches with greatest productivity registered a growth in TFP of 9.0 per cent. In the same manner, the average growth rate of LP decreased from 3.3 per cent to 0.3 per cent within the group of low dynamism; in other words, 91 per cent lower than average.

On the other hand, the thirteen subsectors that registered an annual LP growth rate greater than the overall industry average registered rates of 8.7 per cent and 7.6 per cent for TFP and LP, respectively. Eliminating this group of subsectors, the annual growth rate of TFP falls to 1.2 per cent and that of LP to -0.4 per cent.

It may be noted that in the cases just seen, the growth of value added falls very close to zero in the subsectors with low productivity growth. Moreover, in the last line of Table IV, we can observe a coincidence in the behavior of the groups with high productivity and value-added growth. It has been said—not without certain validity—that the growth of productivity cannot be considered in the absence of a growth in the demand that stimulates it. That is, productivity and market growth are intimately related due to the external and internal economies of a growing market and the effect that it causes. Nonetheless, it must be remembered that demand growth may be a prerequisite but not a sufficient condition for productivity improvement. Thus, in the past periods of high GDP growth, productivity did not show a similar growth dynamic (See Table I).

With regard to the relation of differential behavior of productivity and the trade regime, there are various aspects that must be taken into account. On the one hand, the liberalization of external trade began in 1983 and accelerated

TABLE IV

CONTRIBUTION OF MOST DYNAMIC SUBSECTORS TO THE INCREASE IN TOTAL FACTOR PRODUCTIVITY AND LABOR PRODUCTIVITY, 1984–90

	Industrial Subsectors	Value Added (%)	Labor Productivity (%)	TFP (%)	Exports/ GDP	Imports/ Demand	LIC (%)
Total	40	3.3	3.3	4.8	22.0	17.9	−36.0
TFP<TFP*	28	0.5	0.3	1.3	18.6	18.5	−29.3
LP<LP*	27	0.09	−0.4	1.2	18.9	17.9	−33.2
VA<VA*	28	−0.14	0.22	1.9	20.0	18.7	−34.8
TFP>TFP*	12	6.7	6.7	9.0	33.0	18.1	−37.0
LP>LP*	13	6.8	7.6	8.7	30.0	19.1	−32.6
VA>VA*	12	8.7	8.0	9.2	28.0	16.1	−28.7

Sources: For value added, labor productivity, and TFP, estimates are based on "Annual Industrial Survey" [10]. For exports/GDP and imports/demand, estimates are based on national accounts (National Institute of Statistics, Geography and Informatics, *Sistema de cuentas nacionales de México, 1980–1991* [Mexico City, 1992]). For LIC (the change in the production percentage covered by import licences), estimates are based on Ten Kate and De Mateo [16].

* Average.

between 1985 and 1987. By 1988 it was extended to all sectors of the economy with few exceptions.[9] On the other hand, the devaluation of the Mexican currency was significant, particularly from 1984 to 1987.[10] We would expect to see a direct relationship between productivity growth rate and export orientation, the competition with imports, and trade liberalization.

The final columns in Table IV show the average export and import coefficients and the estimated decrease in the production percentage covered by import licences (LIC) between 1985 and 1988 for groups of subsectors with high and low productivity growth. There are some differences between the groups classified as more dynamic and the rest of the groups with regard to their insertion in the international market and the change in trade regimes. The former's export coefficients are significantly higher—meaning that subsectors with dynamic productivity growth export a larger proportion of their value added—than the group with low productivity growth. With regard to the import coefficient, the differences are minor and do not allow the drawing of conclusions. On the other hand, regarding TFP, the decline in LIC was larger for the dynamic subsectors, but regarding LP and VA, the decline is smaller. This would suggest that there is not a clear relation between productivity and the opening of the economy.

[9] By 1988 Mexico had a relative weighted average tariff of 5.3 per cent—one of the lowest in the world—with a tariff structure of 0.5, 10, 15, and 20 per cent as a maximum, and practically no products remained under import licensing requirement, in spite of the fact that agreements under GATT still allowed import licences for priority industrial sectors and agricultural products, and tariffs to continue as high as 50 per cent.

[10] The exchange rate went from U.S.$0.0047 to U.S.$0.00045 in 1987 and U.S.$0.00034 in 1990.

Undertaking an exhaustive demonstration of the determinants of the TFP is beyond the scope of this study. Nonetheless, given the results shown in this table, we think it worthwhile to investigate the statistical relationship of the TFP with these variables. A regression can be estimated taking the TFP as the dependent variable and the rate of growth of the GDP, the coefficients of exports and imports, and the rate of change of the coverage of import licenses as independent variables.[11]

The only significant statistical variable was the growth of GDP. Surprisingly, as opposed to what is suggested by Table IV, neither the external trade nor the trade regime variables turn out to be significant. Moreover, the sign of the import coefficient is contrary to what was expected. Thus, we can infer three important points. (1) The growth of productivity in Mexican manufacturing has a markedly unequal character. That is to say, although there is a positive and significant change in productivity, this was not characteristic of all industrial subsectors and in fact was true for less than a third of them. (2) The relationship between the growth of the market and the behavior of productivity, although it is not a linear relationship, is an important component. (3) The variables of external trade do not turn out to be significant; nonetheless, a relationship between the growth of productivity and greater export orientation (exports/GDP) is observed in the extreme values.

IV. GROWTH OF PRODUCT, CAPITAL ASSETS, AND HOURS WORKED

According to the "Annual Industrial Survey," during 1984–90, the increase of the TFP can be explained principally by the intensive use of labor and capital inputs, given an increase in the value added. As can be observed in Tables V and VI, the value added increased at an annual rate of 3.3 per cent, the hours worked remained constant, and capital assets registered a decrease of 2.2 per cent on a yearly average.

There are several differences among the industrial sectors and subsectors which should be noted. (1) In relation to the value added, Table V indicates that in wood industries, and textiles, apparel, and leather, there was a decrease. On the other hand, metal products, machinery, and equipment, and food, beverages, and tobacco registered a significant increase in value added (8.0 per cent and 3.2 per cent respectively). (2) There was an important drop in hours worked in textiles, apparel, and leather, wood industries, and basic metals industries. In contrast,

[11] The estimated regression is as follows:

$$TFP = \underset{}{2.4} + \underset{(3.2)}{0.72}GDP + \underset{(11.3)}{0.01}LIC + \underset{(0.9)}{0.79}CEXP - \underset{(-1.0)}{2.6}CIMP, \quad \underset{(0.35)}{}$$

$$R^2=0.79,\ D.W.=1.43,\ F=38.62,$$

where GDP is the rate of growth in each branch in the sample from 1984 to 1989, LIC is the level of change in the production covered by import licences between 1985 and 1988, $CEXP$ is the average of the export coefficient, and $CIMP$ is the average of the import coefficient from 1984 to 1989. The t-statistics are in parentheses.

TABLE V

RATES OF GROWTH OF VALUE ADDED AND INPUTS, 1984–90

(%)

	Value Added	Hours Worked	Capital Assets
Food, beverages, and tobacco	3.2	1.7	−2.5
Textiles, apparel, and leather	−0.1	−0.4	−1.5
Wood industries	−3.8	−1.7	−8.8
Paper, printing, and publishing houses	2.5	−0.6	−3.0
Chemical substances, cork, rubber, and plastic	1.0	0.2	−0.3
Nonmetal mineral products	2.9	0.2	−3.8
Basic metals industries	0.2	−3.8	−5.9
Metal products, machinery, and equipment	8.0	0.3	0.7
Industry total	3.3	0.07	−2.2

Source: The same as in Table II.

in food, beverages, and tobacco there was an increase of 1.7 per cent. Eighteen out of forty subsectors registered negative growth rates and the rest positive; the subsector with the greatest growth rate was automobiles (6.6 per cent). (3) Finally, capital assets decreased in all but one of the sectors. Wood industries and basic metals industries had the greatest fall (−8.8 per cent and −5.9 per cent), while metal products, machinery, and equipment registered a slight increase (0.7 per cent).

The reduction in capital assets is significant. This tendency is characteristic of the period, because up to 1982 assets had grown, as implied by the information of the *Survey of Capital Formation and Capital Assets* [1]. There is a rationale for this drop, since the period prior to 1982 saw a rapid increase in capital accumulation, resulting in overcapacity after that year. This reduction of capital assets doubtlessly represents a significant change that explains the increase in the TFP in this period, as compared with prior periods during which growth was of an extensive nature.

It is important to emphasize that the reduction in capital assets does not imply that there were no new fixed capital investments during the period under consideration. Many new companies were created in the *maquiladora* export industry, new plants were built in the automobile sector, the iron and steel industry was restructured, etc. In fact, after 1987 real gross investment grew at 11.9 per cent on average, reaching as much as 25 per cent per year in several subsectors among which fruits and vegetables, publishing and printing, and automobiles were the most outstanding. This investment was influenced in part by the change in economic policy toward moderate growth and the success in fighting inflation and also by multinational corporations investment policy in export projects; there was no other specific policy to stimulate investment scrapping. There is no doubt that the new trends in investment implied a qualitative change

TABLE VI
CAPITAL ASSETS AND GROSS INVESTMENT

(%)

	Capital Assets			Gross Investment		
	1984–87	1987–90	1984–90	1984–87	1987–90	1984–90
Machinery	−2.0	−3.8	−2.9	−7.9	18.9	4.6
Construction	0.6	−0.2	0.2	−2.0	9.2	3.5
Transport	−8.4	−27.8	−18.7	−3.4	7.9	2.1
Others	7.8	1.6	4.6	35.8	2.1	17.8
Total	−1.0	−3.3	−2.2	1.2	11.9	6.4

Source: The same as in Table II.

in the relations between old and new assets which may have affected TFP and LP positively. However, one must not be misled by these high rates. It should be taken into account, given the dramatic fall in investment after 1982, that the initial levels in 1987 were very low. Moreover, increases in capital formation were concentrated in a small number of subsectors. In any case, this reduction in capital assets indicates that new investment was inadequate to check the depreciation of existing assets and the scrapping of equipment, as shown in Table VI.

To sum up, the period under study is characterized by the important reduction in capital assets and hours worked, as well as by a recovery in the rate of growth of the value added in the final years. In fact, as shown in Section II, the behavior of value added is central to understanding the productivity dynamics as well as the differentials both between the two subperiods and among subsectors.

V. PRODUCTIVITY GROWTH BY SIZE OF BUSINESSES

As a point of department it is important to point out the basic aspects of the structure of the sample. We classified the enterprises in five groups according to size: small, from 25 to 50 employees; medium, from 51 to 100 employees; large, from 101 to 250 employees; very large, from 251 to 500 employees; and huge, with more than 500 employees. We will begin the analysis of productivity growth by size classifications, starting with the small establishments (Table VII).

(1) Small businesses (25–50 employees): The coverage of the sample in relation to the total number of small enterprises is very limited; nonetheless, we considered the contrast in their behavior with that of the other groups to be important. They made up 14 per cent of the total number of businesses in this sample. The average growth of their TFP was −2.3 per cent and of LP, 0.3 per cent. The sectors with the lowest TFP and LP were: basic metals industries (−15.5 per cent and −6.4 per cent), and wood industries (−12.1 per cent and −12.2 per cent). On the other hand, paper, printing, and publishing houses and chemical substances, cork, rubber, and plastic had positive rates, although lower than the industry average (4.8 per cent and 3.3 per cent).

TABLE VII

RATES OF GROWTH ACCORDING TO SIZE OF ESTABLISHMENT, 1984–90

	Value Added (%)	Hours Worked (%)	Capital (%)	TFP (%)	Labor Productivity (%)	No. of Establishments	Share in Value Added, 1990 (%)
Food, beverages, and tobacco:							
Small	−6.4	−6.9	−2.8	−3.0	0.5	69	1.5
Medium	−5.3	−3.5	−3.0	−2.3	−1.9	109	5.3
Large	3.3	−2.5	−3.0	6.4	6.0	141	21.6
Very large	3.4	2.1	−1.7	4.2	1.3	76	16.5
Huge	4.4	3.6	−2.6	5.2	0.8	89	55.1
Textiles, apparel, and leather:							
Small	−6.0	−7.7	−4.2	−0.5	1.9	52	1.7
Medium	−8.5	−5.7	−3.2	−4.6	−3.2	98	3.6
Large	−2.1	−0.3	−1.6	−1.1	−1.8	134	14.2
Very large	−0.3	−0.5	1.4	−0.9	0.2	93	30.7
Huge	1.5	0.6	−2.6	2.6	0.9	57	49.8
Wood industries:							
Small	−11.9	0.4	0.1	−12.1	−12.2	16	2.1
Medium	−10.2	−8.9	−11.8	−0.2	−1.4	24	6.4
Large	−6.0	−2.1	−7.9	−0.7	−4.0	30	29.1
Very large	−3.7	0.6	−8.0	0.3	−4.3	14	40.6
Huge	4.6	0.0	−9.7	8.8	4.6	3	21.8
Paper, printing, and publishing houses:							
Small	0.2	−2.8	0.5	0.9	0.2	23	0.8
Medium	3.9	−3.2	−4.0	7.8	7.3	36	3.7
Large	1.0	−0.3	−3.8	3.5	1.3	66	16.2
Very large	4.5	0.5	−1.9	5.5	4.0	36	33.2
Huge	1.7	−1.3	−3.2	4.3	3.0	19	46.1
Chemical substances, cork, rubber, and plastic:							
Small	−1.1	−3.9	−0.9	0.5	2.9	80	1.4
Medium	3.5	0.6	−0.8	3.9	2.8	114	3.8

Table VII (Continued)

	Value Added (%)	Hours Worked (%)	Capital (%)	TFP (%)	Labor Productivity (%)	No. of Establishments	Share in Value Added, 1990 (%)
Large	−0.9	−0.9	0.9	−1.5	0.0	172	13.9
Very large	0.0	0.1	2.7	−2.0	−0.1	108	22.6
Huge	1.7	0.8	−1.5	2.5	0.9	88	58.2
Nonmetal mineral products:							
Small	0.3	−1.4	2.5	−0.4	1.8	27	0.7
Medium	−3.7	−1.7	−6.7	0.1	−2.1	38	1.2
Large	−0.3	−0.6	−4.0	2.4	0.4	27	3.4
Very large	2.3	0.2	−2.2	3.8	2.0	27	14.0
Huge	3.2	0.3	−4.2	6.4	2.9	42	80.6
Basic metals industries:							
Small	−20.3	−14.8	−3.6	−15.5	−6.4	6	0.1
Medium	1.9	−8.2	−8.1	10.9	4.5	16	1.1
Large	−0.2	−1.5	−5.7	4.2	1.3	36	4.1
Very large	−0.2	−0.9	−3.7	3.0	0.8	25	11.0
Huge	0.4	−4.3	−6.1	6.3	4.9	37	83.7
Metal products, machinery, and equipment:							
Small	−11.3	−10.0	−5.9	−4.2	−1.5	104	0.5
Medium	−6.5	−4.4	−2.3	−3.7	−2.2	116	1.2
Large	−0.8	−2.2	−4.4	2.8	1.4	181	5.3
Very large	0.3	−2.2	−3.0	3.1	2.5	125	11.0
Huge	11.0	1.7	2.4	8.7	9.2	149	82.0
Industry total:							
Small	−6.3	−6.6	−3.0	−2.3	0.3	377	0.9
Medium	−3.2	−3.3	−3.6	0.3	0.4	551	2.7
Large	0.3	−1.4	−2.4	2.5	1.8	787	10.8
Very large	1.0	−0.3	−0.8	1.6	1.2	504	17.0
Huge	5.1	0.9	−2.4	6.4	4.1	484	68.6

Source: The same as in Table II.

A drop of −6.6 per cent can be observed in the hours worked, double that of the next largest category. Capital assets fell at −3.0 per cent. Finally, this group lost participation in relation to total value added from 1.4 per cent in 1984 to 0.9 per cent in 1990, with a dramatic drop in value added of −6.3 per cent.

(2) Medium-sized businesses (51–99 employees): This category comprised 20 per cent of the total establishments and 2.7 per cent of the total sample's value added. The average growth of TFP was 0.3 per cent and of LP, 0.4 per cent. The sectors with the lowest TFP were: textiles, apparel, and leather (−4.6 per cent) and metal products, machinery, and equipment (−3.7 per cent). Those with highest TFP and LP were: basic metals industries (10.9 per cent and 4.5 per cent) and paper, printing, and publishing houses (7.8 per cent and 7.3 per cent).

This category also lost participation in relation to the total value added from 3.9 per cent in 1984 to 2.7 per cent in 1990. Hours worked fell −3.3 per cent and assets −3.6 per cent.

(3) Large businesses (100–250 employees): This category contained the largest number of enterprises in the sample (29 per cent). The average TFP and LP were 2.5 per cent and 1.8 per cent, respectively. The divisions with the lowest rate of growth of TFP were: chemical substances, cork, rubber, and plastic (−1.5 per cent), textiles, apparel, and leather (−1.1 per cent), and wood industries (−0.7 per cent). Food, beverages, and tobacco (6.4 per cent), basic metals industries (4.2 per cent), and metal products, machinery, and equipment (2.8 per cent) had the highest TFP rates. As opposed to the smaller categories, here we observe a slight growth of value added and a minor decrease in hours worked. Nonetheless, the participation of value added in this category to the total value added also dropped. Finally, the rate of growth of capital assets was −2.4 per cent.

(4) Very large businesses (251–500 employees): With 19 per cent of the businesses sample and 17 per cent in total value added, these establishments had lower TFP and LP (1.6 per cent and 1.2 per cent) in comparison to the previous category. On the other hand, there were no differences among the divisions.

(5) Huge businesses (more than 500 employees): This group made up 18 per cent of the businesses in the sample and 68.6 per cent of the total value added. This category had the greatest rates of growth in TFP as well as LP, which were superior to the industry average (6.4 per cent and 4.1 per cent). The highest rates were for the businesses in the divisions of wood industries (8.8 per cent and 4.6 per cent) and metal products, machinery, and equipment (8.7 per cent and 9.2 per cent),[12] while the divisions with the least growth were chemical substances, cork, rubber, and plastic (2.5 per cent and 0.9 per cent) and textiles, apparel, and leather (2.6 per cent and 0.9 per cent). In contrast with the other categories, the value added registered an elevated growth rate (5.1 per cent) and the hours worked grew nearly 1 per cent, without a significant difference in relation to the behavior of capital assets.

[12] Note, however, that there are only 3 establishments in this category in wood industries, while there are 149 in metal products, machinery, and equipment.

In summary, there is a certain relationship between the growth of the TFP and LP and the size of the businesses. The small enterprises had the lowest growth rate in productivity indicators while the huge had the largest. Very large businesses seem to be the exception in Table VII.

In order to analyze the year to year differential behavior of establishments by category of size, a data base of TFP annual indices was built for each year under study. In total there are 240 observations (five size categories in each of the eight industrial sectors during six years). Regression analysis reported the following average indices for each size category:

$$TFP = \underset{(2.9)}{2.4} + \underset{(16.8)}{70.4}DSMALL + \underset{(21.3)}{89.1}DMED + \underset{(22.3)}{93.3}DLARGE + \underset{(23.6)}{98.4}DVLARGE + \underset{(26.4)}{110.4}DHUGE,$$

$R^2 = 0.3$, $F = 19.9$, $D.W. = 1.9$,
(t-statistics are in parentheses)

where TFP denotes annual TFP indices (1984 = 100), and the "D" before the name of the size group denotes a dummy variable.

We can observe from these results a positive relation between size and TFP indices. However, these results show not only that size matters, which was expected from the analysis in Table VII, but that the TFP index among huge establishments was on average above that of the base year (1984 = 100), while those of the rest were below. In other words, there is a gap between the huge establishments and the other groups. Both the TFP and the LP of the huge establishments are significantly higher: more than four times the growth of TFP and more than three times the growth of LP with respect to the establishments in the very large category.

The difference in behavior not only depends upon the productivity indicators, but also on the behavior of value added. As noted above, value added grew among the huge establishments, not only faster than the industry average, but five times greater than that of the category of very large establishments. This suggests that the economic instability, of which we spoke at the beginning, had a smaller effect on the huge establishments than on the others.

We can see that the capital assets decrease at similar rates in all groups, except for the very large establishments. On the other hand, the behavior of hours worked is very dissimilar.

There is such a difference in the productivity indicators that the high rate of growth of the industry can be explained for the most part by the group of huge establishments. In other words, in a way similar to what occurs at the subsector level, the growth of productivity is concentrated in a relatively small number of businesses with more than 500 employees.

CONCLUSIONS

Prior to reflecting upon our results, it is important to reiterate that the interpretation of these indices does not necessarily imply the occurrence of a technical change in the sense of a displacement of the production function. Other aspects inseparable from the index must also be taken into account, in particular, the advantage of the economies of scale, changes in material inputs, the organization, the technical managers, and better products. Just as important, we must take into account the changes in the productive environment, for example, government policy, which can affect these variables and the conditions of production and the utilization of capacity in the short term. The principal conclusions of this paper are as follows.

First, the statistical evidence shows that the growth of productivity during this period was directly influenced by the growth of demand and to a lesser degree by the changes which occurred in external trade. This suggests the need to guarantee the stability of economic activity.

Second, our results on the selectivity of productivity growth in some subsectors are congruent with the results of the case studies of automobiles and electronics in businesses dependent upon exports. The evidence shows that the bulk of the exports is undertaken by a small nucleus of businesses, mostly with foreign participation which, we suspect, are responsible for the increase in productivity. It has been shown that productivity changes are linked to a very selective introduction of modern microelectronic machinery or the installation of electronic controls into existing equipment, that aim for regularity and quality of work, more than labor cost savings. On the other hand, there is an evident change in the organization of production applying diverse systems ("just in time," quality circles, and statistical control of production) which reduce inventory costs and in order to create quality awareness attain important savings in working capital. In contrast, in traditional sectors such as the footwear industry, whose structural problems of low productivity have been reinforced by the fall in demand due to the drop in purchasing power and rising imports in recent times, there is a definite lag and only in a very incipient manner has a process of change began within the area of reorganizing the productive process [5].

Third, the reduction in capital assets is a response as much to microeconomic as macroeconomic conditions during the period. On the one hand, the economy as a whole had been overcapitalized in the prior period; on the other, at the micro level, nonprofitable production lines—which would have survived in other times—were closed. This simultaneous reduction in capital assets with the growth of gross investment is consistent with the selective introduction of automation machinery mentioned above. It seems clear nevertheless that for a nation to be competitive, the reduction in capital assets as a factor of productivity is only valid in the short term. In the long term, these capital goods should be replaced by more and better machines and equipment that raise labor productivity and generate new businesses or new production lines, which in turn create conditions

for more jobs to replace those destroyed. For now, it is uncertain whether this will occur in Mexico's manufacturing industry.

Fourth, the behavior of the small and medium enterprises can be explained not only by the financial vulnerability of these businesses in the face of the economic instability of the period, but also by the problems that these businesses face in their technological capacities, as has been highlighted by recent studies. On the one hand, the vast majority of their work force lack basic preparation; on the other hand, contrary to new and current strategies for technological modernization, very little value is attributed to training within and outside the business or the hiring of technicians as a means of improving technology.[13] This is reflected in the absence of basic elements of modern administration that would permit managers to recognize their needs in the area of technology, such as cost systems, productive process manuals, and informatics tools. Therefore, production controls are not undertaken in a systematic way due to the lack of know-how, and also due to limited financial means to implement a system giving adequate control and evaluation.

Both the heterogeneity in productivity performance among industrial sectors and subsectors and size groups are reasons of concern. In particular, the situation of firms in the lower size groups may have important implications for the future of the economy, since they are important generators of employment: firms with 500 workers or more cover at most 35 per cent of total industrial employment. It is important to emphasize that the presence of large-scale businesses of a technologically competitive nature is not a sufficient condition for productivity spillover effects to the rest of the economy. In a context in which the small and medium businesses are scarcely connected to the rest—as is the case in Mexico—it is not at all clear that this will happen.

Nonetheless, we must emphasize that the relative inefficiency of the smallest enterprises is not necessarily a characteristic of all the industrialization processes, since there are successful cases in which the small and medium businesses play an important role and have high productivity rate. In our opinion, this is not a case of an irreversible process and, consequently, the limitations that small and medium businesses face in Mexico must receive attention of an urgent and integral nature that macroeconomic policy fails to address explicitly.

[13] The following statistics illustrate this point: 65 per cent of a sample of small and medium businesses now have employees with a high school education; 79 per cent do not have any employees with vocational-technical degrees; and 96 per cent have no employees with a university education. With regard to the means of modernizing, only a small percentage conceded the importance of training or hiring of technicians, giving major importance to the purchase of machinery. See Ruíz and Zubirán [14].

REFERENCES

1. Bank of Mexico. *Survey of Capital Formation and Capital Assets* (Mexico City, 1993).
2. BROWN, F., and DOMÍNGUEZ, L. "Nuevas tecnologías en la industria maquiladora de exportación," *Comercio exterior,* Vol. 39, No. 3 (March 1989).

3. CHENERY, H. "Growth and Transformation," in *Industrialization and Growth,* by H. Chenery et al. (New York: Oxford University Press for the World Bank, 1986).
4. DOMÍNGUEZ, L. "Mexico," in *Microelectronics in the Third World Industries,* ed. S. Watanabe, ILO Series (London: Macmillan, 1993).
5. DOMÍNGUEZ, L., and BROWN, F. "Employment and Income Effects of Structural and Technological Changes in Footwear Manufacturing in Mexico," Working Paper WEP-22/wp. 224 (Geneva: International Labour Office, 1992).
6. HERNÁNDEZ LAOS, E. "Tendencias recientes de la productividad industrial en México," *Investigación económica,* No. 198 (December 1991).
7. HERNÁNDEZ LAOS, E., and VELASCO, E. "Productividad y competitividad en las manufacturas mexicanas, 1960–1985," in *Industria y trabajo en México,* ed. J. Wilkie and J. Reyes Heroles (Mexico City: Universidad Autonoma Metropolitana-Atzcapotzalco, 1990).
8. KENDRICK, J. *Productivity Trends in the United States* (Princeton, N.J.: Princeton University Press, 1961).
9. MICHELI, J. *Globalización y producción de automóviles en México* (Master's thesis, Faculty of Economics, National Autonomous University of Mexico, 1991).
10. National Institute of Statistics, Geography and Informatics (INEGI). "Annual Industrial Survey" (Mexico City, various years).
11. NELSON, R. "Research on Productivity Growth and Productivity Differences: Dead Ends and New Departures," *Journal of Economic Literature,* Vol. 19, No. 3 (September 1981).
12. NISHIMIZU, N., and ROBINSON, S. "Productivity Growth in Manufacturing," in *Industrialization and Growth,* by H. Chenery et al. (New York: Oxford University Press for the World Bank, 1986).
13. RAMIREZ, J. C. "La nueva industrialización en Sonora: El caso de los sectores de alta tecnología" (Hermosillo: El Colegio de Sonora, 1988).
14. RUÍZ DURÁN, C., and ZUBIRÁN, C. *Cambios en la estructura industrial y el papel de las micro, pequeñas y medianas empresas en México,* Biblioteca de la Micro, Pequeña y Mediana Empresa No. 2 (Mexico City: Nacional Financiera, 1992).
15. SAMANIEGO, R. "La evolución de la productividad total de factores en el sector manufacturero, 1963–1981," Serie de Documentos de Trabajo (Mexico City: El Colegio de México, 1984).
16. TEN KATE, A., and DE MATEO, F. "Apertura comercial y estructura de protección en México: Estimaciones cuantitativas de los ochentas," *Comercio exterior,* Vol. 39, No. 4 (April 1989).

APPENDIX

NOTES ON THE METHODOLOGY OF CAPITAL AND LABOR ESTIMATION

1. *Capital*

The estimation of capital assets was made on the basis of the perpetual inventories method using the following formula:

$$A(T) = I(T) + (1 - d)A(T - 1),$$

where

A = real capital assets,

d = loss of value due to the wear and tear and obsolescence of capital goods, and

I = gross capital formation.

Real capital assets time series were calculated using the price index of capital issued by the *Survey of Capital Formation and Capital Assets* [1]. Depreciation allowances are based on the information given for the number of years of the lifetime for each type of capital goods (machinery, office equipment, construction, and transport equipment) for each industrial class provided by the same source.

The "Annual Industrial Survey" [10] provides the value of capital estimated in terms of replacement value net of accumulated depreciation, using information from the above source.

Gross capital formation (I) for each establishment and for each type of asset was estimated in the following manner.

$$I_t = AF_t + AP_t + AM_t - AV_t,$$

where

AF_t = yearly asset acquisition,
AP_t = assets which are produced internally,
AM_t = value of improvements on the same assets, and
AV_t = sales of fixed assets.

2. *Labor*

The number of hours worked per year were used for labor. As the "Annual Industrial Survey" [10] distinguishes between direct and indirect labor, each was weighted by its share in the wage bill.

$$L = \delta_E \cdot HT_E + \delta_0 \cdot HT_0,$$

where

HT_E = Number of employee (white-collar worker) hours,
HT_0 = Number of worker (blue-collar worker) hours,
δ_E = wages of employees/total wage bill, and
δ_0 = wages of workers/total wage bill.