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EVOLUTION OF TOTAL FACTOR PRODUCTIVITY IN THE MANUFACTURING SECTOR IN MEXICO, 1963-1981

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RESUMEN

El estudio contiene los resultados de la estimación de las fuentes del crecimiento del producto en algunas industrias mexicanas seleccionadas durante el periodo 1963-1981. Con la información disponible se calculan indicadores de la tasa de crecimiento de la productividad factorial total (PFT), medidos como la diferencia entre la tasa de crecimiento del volumen de la producción menos la tasa ponderada de crecimiento de los insumos totales. La evidencia muestra que, en términos generales, la evolución de la PFT ha sido satisfactoria si se hacen comparaciones internacionales; sin embargo, se ha encontrado también gran variabilidad inter-industrial en productividad. Las industrias analizadas se ordenan en términos de su productividad y se comparan con la evidencia disponible para otros países.

ABSTRACT

This paper presents estimation results concerning the sources of output growth in selected Mexican manufacturing industries for the period 1963-1981. Using available data, measures of total factor productivity (TFP) growth -the difference between the rate of growth of output and the weighted rate of growth of total inputs- are obtained. The evidence shows that overall the evolution of TFP has been within acceptable international standards, but substantial inter-industry variation has been detected. The industries analyzed are ranked in terms of productivity performance and compared with available evidence for other countries.

THE EVOLUTION OF TOTAL FACTOR PRODUCTIVITY IN THE MANUFACTURING SECTOR IN MEXICO, 1963-1981*

INTRODUCTION

The topic of economic achievement by sector has been extensively discussed in relation to the design of industrial and export development policies in developing countries. A careful analysis of productivity change is necessary to understand observed levels of industrial competitiveness and to evaluate the convenience of specific policies of industrial promotion. The most common measure of the level of productivity in a sector is the index of total factor productivity (TFP) 1/, which is given by a ratio of output to total inputs in a productive process. Hence the rate of growth of TFP -the difference between the growth of output and factor inputs- shows the evolution of productivity in a given industry.

The analysis of total factor productivity (TFP) indicators is therefore essential to understand the evolution of compar

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ative advantages, and hence of international competitiveness, in the manufacturing sectors of developing countries. It is also an important element for the study of the impact of diverse trade regimes upon the incentives to producers to reduce costs (see Nishimizu and Robinson (1982))2/. The evaluation of the impact of protective schemes, such as those proposed under the infant industry argument (see Krueger and Tuncer (1980) 3/, can be handled also by comparing the dynamics of productivity measures across sectors and countries. Likewise, TFP indicators have been used to compare the economic efficiency of public and private sector-operated enterprises (see Caves and Christensen (1980))4/.

In the case of Mexico, a social accounting framework has been used to identify the sources of growth of aggregate national product (see Correa (1970) and Elias (1978), who also report results for other Latin-American countries). However, no attempt has been made to estimate TFP measures by means of disaggregated data.

The purpose of this study is to obtain TFP indicators for the manufacturing sector of Mexico at the 4-digit SIC level. A number of selected manufacturing sectors have been analyzed for the period 1963-1981. These results will be used as inputs for further stages of a project on productivity and international competitiveness in Mexico. In particular, the analysis of dynamic domestic resource costs by sector requires the measurement of TFP (see Page and Nishimizu (1984))[5/] and, as mentioned above, the evaluation of the impact of observed trade regimes on productivity can also be handled by the appropiate use of TFP measures.

The plan of the paper is as follows. Section I reviews the theoretical foundations of TFP indicators and their interpretation in terms of production theory. Since the characteristics of the available data are central to the analysis, section 2 describes the sources and definitions of the variables used as well as their shortcomings. Section 3 presents estimation results, paying special attention to the sources of growth by manufacturing sector. Finally, a concluding section summarizes the main findings of the study.

I. THEORICAL FRAMEWORK FOR TOTAL FACTOR PRODUCTIVITY ANALYSIS

This section shows that TFP measures can be obtained either from accounting identities corresponding to a firm or nation, or from the structure of production, coupled with standard behavioral assumptions about markets. Since, by definition, the rate of growth of TFP is given by the difference between the rate of growth of real product and the rate of growth of real factor input, it will be demonstrated that starting from the basic accounting framework or from production function theory, the measures of TFP coincide.

Accounting Framework for TFP Indicators

For a multi-product firm, the basic accounting identity may be written as 6/:

$$(1) \quad \Sigma\ p_i\ X_i = \Sigma\ W_j\ Y_j$$

$$i=1,\ldots,n;\ j=1,\ldots,m$$

where p_i : price of the i-th product

X_i : quantity of the i-th product

W_j : price of the j-th factor service

Y_j : quantity of the j-th factor service

Differentiating (1) with respect to time yields:

$$(2) \qquad \Sigma \; p_i \; \frac{dxi}{dt} + \Sigma x_i \; \frac{dpi}{dt} = \Sigma \; W_j \; \frac{dyj}{dt} + \Sigma \; Y_j \; \frac{dwj}{dt}$$

And dividing both sides by the corresponding total value results in:

$$(3) \qquad \Sigma \frac{p_i \; X_i}{\Sigma p_i X_i} \; \frac{\dot{X}_i}{X_i} + \Sigma \frac{p_i \; X_i}{\Sigma p_i X_i} \; \frac{\dot{p}_i}{p_i}$$

$$= \Sigma \frac{W_j \; Y_j}{\Sigma W_j Y_j} \; \frac{\dot{Y}_j}{Y_j} + \Sigma \frac{W_j \; Y_j}{\Sigma W_j Y_j} \; \frac{\dot{W}_j}{W_j}$$

where $\dot{z} \equiv \frac{dz}{dt}$,

or more compactly:

$$(4) \qquad \Sigma \; S_i \left(\frac{\dot{X}_i}{X_i} + \frac{\dot{p}_i}{p_i} \right) = \Sigma \; V_j \left(\frac{\dot{Y}_j}{Y_j} + \frac{\dot{W}_j}{W_j} \right)$$

where $Si \equiv \frac{p_i \; X_i}{\Sigma p_i X_i}$ and $V_j \equiv \frac{W_j \; Y_j}{\Sigma W_j Y_j}$

are the shares of the value of product i in the total value of production and the share of factor j in total factor income, respectively, with:

$$(5) \qquad \Sigma \; S_i = \Sigma \; V_j = 1.$$

The rate of growth of a Divisia index of the volume of total output is defined as:

$$(6) \qquad \frac{\dot{X}}{X} = \Sigma \; S_i \; \frac{\dot{X}_i}{X_i}$$

and the corresponding rate of growth of the index of total input as:

$$(7) \quad \frac{\dot{Y}}{Y} = \Sigma\ V_j \frac{\dot{Y}_j}{Y_j} \ .$$

Similarly, the rates of growth of Divisia price indices for products and prices are:

$$(8) \quad \frac{\dot{p}}{p} = \Sigma\ S_i \frac{\dot{p}_i}{p_i}\ , \quad \text{and}$$

$$(9) \quad \frac{\dot{W}}{W} = \Sigma\ V_j \quad \frac{\dot{Y}_j}{Y_j} \ .$$

Since productivity is usually measured as a ratio of weighted averages of outputs and inputs, a natural definiti of the TFP index is:

$$(9) \quad TFP = \frac{X}{Y}\ ,$$

and taking its rate of growth gives:

$$(10) \quad \frac{\dot{TFP}}{TFP} = \frac{\dot{X}}{X} - \frac{\dot{Y}}{Y}$$

$$\text{or} \quad \frac{\dot{TFP}}{TFP} = \Sigma\ S_i \frac{\dot{X}_i}{X_i} - \Sigma\ V_j \frac{\dot{Y}_j}{Y_j}$$

Similarly, in terms of prices:

$$(11) \quad \frac{\dot{TFP}}{TFP} = \frac{\dot{W}}{W} - \frac{\dot{p}}{p}$$

or $$\frac{\dot{TFP}}{TFP} = \Sigma \; v_j \frac{\dot{W}_j}{W_j} - \Sigma \, s_i \frac{\dot{P}_i}{P_i} \; .$$

These results show that the rate of growth of TFP can be obtained as the difference between rates of growth of product and factor quantities or as the difference between the corresponding rates of growth of prices.

Production Function Framework for TFP Indicators

With linearly homogeneus production functions, competitive output and input markets, and maximizing behavior of economic agents, a shift in the production function corresponds to a change in TFP. This can be shown as follows.

Consider a constant returns to scale production function in implicit form:

(12) $$f \, (X_1, X_2, \ldots, X_m; Y_1, Y_2, \ldots, Y_n) = 0.$$

Differentiation with respect to time yields:

(13) $$\dot{f} = \Sigma f_i \dot{X}_i + \Sigma f_j \dot{Y}_j = 0$$

$$i = 1, \ldots, n; \; j = 1, \ldots, m.$$

or

(14) $$\frac{\dot{f}}{F} = \Sigma \frac{f_i X_i}{\Sigma f_i X_i} \frac{\dot{X}_i}{X_i} - \Sigma \frac{f_j Y_j}{\Sigma f_j Y_j} \frac{\dot{Y}_j}{Y_j}$$

where

(15) $$F \equiv \frac{1}{\Sigma f_i X_i} = - \frac{1}{\Sigma f_j Y_j}$$

and $f_i \equiv \frac{\partial f}{\partial X_i}$, $f_j = \frac{\partial f}{\partial Y_j}$.

Imposing the optimizing condition that all marginal rates of transformation between inputs and outputs correspond to market price ratios:

(16.1) $$\frac{\partial X_i}{\partial Y_j} = - \frac{f_j}{f_i} = \frac{W_j}{p_i}$$

(16.2) $$\frac{\partial X_i}{\partial X_k} = - \frac{f_k}{f_i} = \frac{p_i}{p_k}$$

and

(16.3) $$\frac{\partial Y_j}{\partial Y_\ell} = - \frac{f_\ell}{f_j} = \frac{W_\ell}{W_j}$$

for $i,k=1,\ldots,m;\ j,\ell = 1,\ldots,n;$,

gives:

(17) $$\frac{df}{F} = \Sigma W_i \frac{dx_i}{x_i} - \Sigma V_j \frac{dy_i}{y_i} = \frac{\dot{TFP}}{TFP}$$

which implies that the rate of growth of TFP is zero <u>only if</u> the production function does not shift.

Although there has been some disagreement about the possibility of the TFP growth rate being zero by definition (see Denison (1966))[7] it should be clear that it is not. Grilliches and Jorgenson (1967)[8] argue convincingly that, even for a production function characterized by constant returns to scale and all factors being paid their marginal products, the rate of growth of real product may be greater (less) than the rate of growth of real factor input.

Although the definition of TFP is quite straighforward conceptually, there remains a myriad of complex problems in correctly measuring the flows of product quantities and factor services that enter that definition. Even when a detailed discussion of those problems is beyond the scope of this paper[9], attention will be paid to the consequences of the main measurement errors. This will be discussed when the variables used for the calculations are described in the next section.

II. DESCRIPTION OF THE DATA

The data for this study was gathered from one main source, the Estadística Industrial Anual (EIA), the statistical yearbook of the Mexican Manufacturing sector. The EIA is based on the classification of the industrial census of Mexico, which is published with a five-year periodicity. It contains summary economic data of those industrial establishments that contribute more substantially to the value of production of the main 4-digit manufacturing sectors (or <u>clases industriales</u>). The coverage of the EIA is approximately 51 percent of the value of production in each sector.

The first EIA was published in 1963 and it included information on 29 sectors, with 604 establishments surveyed. By 1981, it contained information on 58 sectors, with 1311 establishments surveyed. The definitions of the concepts contained are based on the international standards of the United Nations statistical agencies.

Since one important objective of this study is to analyze the evolution of TFP in the manufacturing sector during the longest period possible, the starting data base included the original 29 sectors for the years 1963-1981. However, some of these sectors were not contained in the EIA during the whole sample period, and were omitted from the study. The level of aggregatio in other sectors also changed throughout the period, and those sectors were excluded as well. These considerations left 17 manufacturing sectors for the analysis. They are listed in Table 2.1.[9/]

TABLE 2.1

MANUFACTURING SECTORS FOR TFP ANALYSIS

Number	4-Digit Code	Name	
(1)	2012	Preparación, conservación, empacado y enlatado de carnes	(Processed meat)
(2)	2023	Fabricación de leche con-densada, evaporada y en polvo.	(Processed milk)
(3)	2032	Preparación, conservación, empacado y envase de frutas y legumbres.	(Processed fruit and vegetables)
(4)	2041	Conservación, empacado y enlatado de pescados y mariscos.	(Processed fish and seafood)
(5)	2083	Fabricación de chicles	(Chewing gum)
(6)	2093	Fabricación de aceites, margarinas y otras grasas grasas vegetales	(Vegetable oil and products)
(7)	2098	Fabricación de productos alimenticios para animales	(Food for animals)
(8)	2132	Fabricación de cerveza	(Beer)
(9)	2212	Fabricación de cigarros	(Cigarettes)
(10)	2512	Fabricación de triplay, tableros aglutinados y fibracel.	(Wood products)
(11)	2711	Fabricación de pasta de celulosa y papel	(Paper)
(12)	2712	Fabricación de cartón, láminas de cartón y cartoncillo, incluso láminas impregnadas de petróleo.	(Paper products)
(13)	3011	Fabricación de llantas y cámaras	(Tires and tubes)

Number	4-Digit Code	N a m e	
(14)	3321	Fabricación de vidrio plano, liso y labrado	(Glass)
(15)	3341	Fabricación de cemento hidráulico	(Cement)
(16)	3411	Fundición y laminación primaria de hierro y acero	(Primary steel products)
(17)	3412	Laminación secundaria de hierro y acero	(Secundary steel products)

For these 17 sectors, information was obtained in order to estimate measures of TFP growth (see equations (10) and (17)). As is clear from those definitions, two types of variables are needed: product and input quantities and prices. These variables are now described.

Production Data

The EIA reports tables of value and volume of production for the main products obtained in each sector. In each sector, data of the products that constituted approximately 80 percent of the total value of production were gathered. Next, implicit price indices and their corresponding rates of growth were calculated for each product type. The base year for all index numbers is 1970. Series of production at constant prices of 1970 were thus obtained, together with their corresponding rates of growth. Finally, by using the share of each product in the total value of production considered, Divisia price and volume indices were constructed, together with their corresponding rates of growth (equations (9) and (7)).

Input Data

According to equation (17), TFP growth is defined as the rate of growth of products minus the rate of growth of total factor input. Once a measure of the rate of growth of total product was obtained, the corresponding measure of total factor input was required. In order to obtain it, the following inputs were considered: labor, capital, raw materials, and other inputs (electricity, other energy and lubricants, containers and spare parts). The methodology for obtaining quantity and price measures for each of these categories was the following:

Labor Input

The correct measure of labor input is hours- worked adjusted for such factor as educational level, training, effort. etc by type of worker employed. Unfortunately, the EIA reports unadjusted information on the number of only two of types of workers, blue-collar (obreros) and white-collar (empleados). Besides, there is no way to obtain a measure of the unit price of each kind of labor since total fringe benefits are not disaggregated. It was decided to avoid an arbitrary descompositi of this concept at the cost of introducing an aggregation bias by considering only one type of labor input (see Grilliches and Jorgenson (1967)). The total number of workers and their corresponding wages, salaries and other fringe benefits were used to construct series of labor share and rates of growth to be used in the analysis[11].

Capital Input

Again, the theoretical measure of capital input is the flow of machine-hours adjusted for such factors as age, quality, etc. of the capital assets by type. Using the standard assumption concerning the proportionality of capital services to the stocks of assets, measures of capital services were obtained for four types of capital: buildings and installations, machinery and equipment, transport equipment, and office equipment[12]. The corresponding capital stocks were obtained by taking the value of stocks in 1970 and by adding (subtracting) from this year gross investments (including the change in inventories of raw materials and other inputs, products in process and finished products) adjusted by estimates of the depreciation of each type of asset.

The price of each capital factor service was obtained by means of capital goods price indices by type of asset for 2-digit manufacturing sectors or by the general capital goods price indices by type of asset, when the former were not available. Admitedly, this is a very rough measure of the capital service cost of utilization, since it does not take account of the issues concerning fiscal treatment of depreciation, capital gains, or the rate of return on capital. The pertinent adjustments are contemplated in further stages of the project.

Raw Materials Input

The methodology for obtaining measures of aggregate raw materials inputs is parallel to the one described for the case of products. The main raw materials in each sector were considered (again, approximately 80 percent of the total value was used as the criterion for choosing the raw materials to be analyzed). Series of current and constant value, and price indices were calculated. From them, the corresponding Divisia volume and price indices were built to be used in the index of factor input.

Other Inputs

To obtain indices of other inputs, the current value of electrici other energy and lubricants, containers and spare parts was obtained from the EIA. Series of electricity consumption (in KWH) are also available in the publication. From them, electricity price indices were estimated and, together with price indices for the other categories of inputs, the desired measures of aggregate quantity and price were obtained through the use of the Divisia methodology.

III. EVOLUTION OF TOTAL FACTOR PRODUCTIVITY GROWTH RATES

The results of the estimation of TFP growth rates are now pre sented. Tables 3.1 through 3.3. below show results of the descomposition of the sources of growth of the 17 manufacturing sectors analyzed in this study. For each sector, the tables contain the average rates of growth of output and of capital, labor and material inputs. Total factor productivity is shown to be the difference between the rate of growth of output and the share-weighted rates of growth of factor inputs.

Note that the rate of growth of gross output has been high, averaging 10.25 percent for the 17 sector considered. The highest rate of growth (17.83 percent) corresponds to sector 3011 (Tires and Tubes) and the lowest (4.49 percent) to sector 2212 (Cigarettes).

Capital input has grown on average at a rate of 3.80 percent per year. Capital acumulation has been fastest (9.46 percent) in Sector 2041 (Fish and Seafood) and was actually negative (-0.20 percent) in Sector 3321 (Glass).

With respect to labor input, the mean rate of growth was 4.30 percent per year. Sector 2041 (Fish and Seafood), as in the case of capital, shows the fastest rate of growth of labor (7.52), while Sector 2212 (Cigarettes) actually decreased employment (-0.14 percent).

TABLE 3.1

SOURCES OF GROWTH

INDUSTRIAL SECTOR

1963-1981

(in percent per year)

	SECTOR	2012	2023	2032	2041	2083
1.	GROSS OUTPUT	8.93	8.42	11.61	9.04	7.93
2.	CAPITAL INPUT	4.91	2.27	4.11	9.46	3.89
3.	LABOR INPUT	5.21	2.93	6.45	7.52	6.02
4.	MATERIAL INPUT	9.42	6.44	9.09	7.83	7.07
5.	SHARE-WEIGHTED CAPITAL INPUT*	0.52 (5.85)	0.64 (7.59)	1.19 (10.28)	0.63 (6.95)	1.48 (18.61)
6.	SHARE-WEIGHTED LABOR INPUT*	0.38 (4.22)	0.29 (3.44)	0.60 (5.17)	1.41 (15.62)	0.91 (11.48)
7.	SHARE-WEIGHTED MATERIAL-INPUT*	7.53 (84.27)	3.90 (46.30)	5.28 (45.51)	5.65 (62.53)	3.12 (39.31)
8.	TOTAL FACTOR PRODUCTIVITY CHANGE	0.50 (5.65)	3.59 (42.67)	4.53 (39.04)	1.35 (14.89)	2.43 (30.61)

NOTE: Importance of various growth rates as a percent of output growth is shown in parenthesis.

*/ Weighted by actual output elasticities (shares).

TABLE 3.2

SOURCES OF GROWTH

INDUSTRIAL SECTOR

1963-1981

(in percent per year)

	SECTOR	2093	2098	2132	2212	2512	2711
1.	GROSS OUTPUT	11.97	10.23	8.83	4.49	6.78	9.52
2.	CAPITAL INPUT	3.65	4.46	4.76	4.56	3.99	2.49
3.	LABOR INPUT	3.90	5.91	4.56	-0.14	3.93	3.68
4.	MATERIAL INPUT	5.89	11.50	10.46	2.31	11.34	8.61
5.	SHARE-WEIGHTED CAPITAL INPUT*	-0.07 (-0.62)	0.95 (9.31)	1.51 (17.13)	1.86 (41.38)	1.46 (21.48)	0.72 (7.53)
6.	SHARE-WEIGHTED LABOR INPUT*	0.21 (1.73)	0.25 (2.47)	1.53 (17.35)	0.00 (0.02)	0.82 (12.10)	0.62 (6.48)
7.	SHARE-WEIGHTED MATERIAL-INPUT*	4.80 (40.08)	9.45 (92.45)	5.48 (62.08)	0.62 (13.85)	4.89 (72.05)	4.90 (51.46)
8.	TOTAL FACTOR PRODUCTIVITY CHANGE	7.04 (58.80)	-0.43 (-4.22)	0.30 (3.44)	2.01 (44.76)	-0.38 (-5.63)	3.29 (34.52)

NOTE: Importance of various growth rates as a percent of output growth is shown in parenthesis.

*/ Weighted by actual output elasticities (shares).

TABLE 3.3

SOURCES OF GROWTH

INDUSTRIAL SECTOR

1963-1981

(in percent per year)

SECTOR	2712	3011	3321	3341	3411	3412
1. GROSS OUTPUT	15.51	17.44	17.83	9.67	8.39	7.60
2. CAPITAL INPUT	0.71	4.17	- 0.20	4.29	3.14	3.35
3. LABOR INPUT	0.72	4.79	3.69	4.76	6.65	2.45
4. MATERIAL INPUT	12.32	9.00	11.30	8.08	8.48	9.15
5. SHARE-WEIGHTED CAPITAL INPUT*	0.30 (1.92)	1.75 (10.01)	-0.04 (-0.24)	1.91 (19.72)	0.40 (4.76)	0.71 (9.36)
6. SHARE-WEIGHTED LABOR INPUT*	0.09 (0.60)	1.03 (5.91)	0.91 (5.13)	0.83 (8.60)	0.72 (8.55)	0.33 (4.34)
7. SHARE-WEIGHTED MATERIAL-INPUT*	7.03 (45.31)	3.49 (20.02)	3.57 (20.05)	3.11 (32.16)	6.39 (76.17)	6.32 (83.20)
8. TOTAL FACTOR PRODUCTIVITY CHANGE	8.09 (52.17)	11.17 (64.06)	13.38 (75.06)	3.82 (39.51)	0.88 (10.53)	0.24 (3.10)

NOTE: Importance of various growth rates as a percent of output growth is shown in parenthesis.

*/ Weighted by actual output elasticities (shares).

Finally, materials show the highest mean rate of growth among inputs (8.20 percent) Sector 2712 (Cardboard) presents the greatest rate of change of materials (12.32 percent), while Sector 2212 (Cigarettes) shows the most modest increase (2.31 percent).

We turn now to the analysis of the evolution of productivity. Table 3.4 lists the manufacturing sectors in order of their average TFP growth rates over the whole sample period. The mean average rate of growth is 3.64 percent and the dispersion of TFP growth rates, as measured by their standard deviation is 4.02. The coefficient of variation shows a substantial variability of performances in terms of productivity.

TABLE 3.4

TFP GROWTH: SUMMARY STATISTICS

Rank	Code	Sector	Average TFP Growth	
(1)	3321	Vidrio	13.38	(Glass)
(2)	3011	Llantas y Cámaras	11.17	(Tires)
(3)	2712	Cartón	8.09	(Cardboard)
(4)	2093	Aceites Vegetales	7.04	(Vegetable Oils)
(5)	2032	Frutas y Legumbres	4.53	(Fruit and Vegetables)
(6)	3341	Cemento	3.82	(Cement)
(7)	2023	Leche Condensada	3.59	(Condensed milk)
(8)	2711	Papel	3.29	(Paper)
(9)	2083	Chicles	2.43	(Chewing gum)
(10)	2212	Cigarros	2.01	(Cigarettes)
(11)	2041	Pescados y Mariscos	1.35	(Fish and Seafood
(12)	3411	Laminación Primaria Hierro	0.88	(Primary Iron)
(13)	2012	Carnes	0.50	(Meat)
(14)	2132	Cerveza	0.30	(Beer)
(15)	3412	Laminación Secundaria Hierro	0.24	(Secondary Iron)
(16)	2512	Triplay	- 0.38	(Wood Panels)
(17)	2098	Alimentos para Animales.	- 0.43	(Food for Animals

MEAN: 3.64

STANDARD DEVIATION: 4.02

This overall measure of TFP growth compares well with those obtained for Japan, Korea, Turkey and Yugoslavia, where it takes values of 2.04, 3.71, 1.33 and 0.48, respectively (see Nishimizu and Robinson (1982)). Any comparison, however, should be taken with care since the coverage and sample periods of the studies available differ substantially.

It is interesing to note that the best performing sectors (Glass, Tires, and Cardboard) have rates of growth of productivit which are extremely high even for international standards. On the other hand, five sectors show practically nil advances in productivity (these sectors are Meat, Beer, Secondary Iron, Wood Panels and Food for Animals). In fact, for the last two sectors, the TFP growth measure is negative.

Finally, in order to compare the sectoral TFP performance with that observed in other countries, Table 3.5 contains the ratios of TFP to gross output growth rates for selected industries and countries. Note that, except for lumber and wood, the TFP performance of Mexican manufacturing sectors has been satisfactor (ranking first in paper and basic metals).

Unfortunately, those were the only sectors for which similar evidence was readily available. Moreover, the different levels of aggregation and time periods considered make it difficult to make any strong statement about the differential TFP performances in the various countries.

TABLE 3.5

RATIO OF TFP TO GROSS OUTPUT GROWTH RATES

-SELECTED COUNTRIES AND SECTORS-

	Sector/Country	Japan	Korea	Turkey	Yugoslavia	Mexico
	Period:	(1955-73)	(1960-77)	(1963-76)	(1965-78)	(1963-81)
(1)	Food Processing	23.5	32.6	22.6	- 9.0	19.86 a/
(2)	Lumber and Wood	14.1	34.4	- 16.2	- 5.5	- 0.38 b/
(3)	Paper	14.4	23.3	10.4	0.6	34.52 c/
(4)	Basic Metals	7.9	7.2	5.8	-10.4	10.53 d/

Source: Nishimizu and Robinson (1982). (Except Mexico).

(a) Average of Meat, Fish and Seafood, and Fruits and Vegetables.

(b) Wood Panels

(c) Paper

(d) Primary Steel and Iron

CONCLUDING REMARKS

Using available data for the Mexican manufacturing industries, measures of total factor productivity growth rates by sector have been obtained. The evidence shows that overall the evolution of TFP has been within acceptable international standards. However, there exists substantial variation of productivity growth rates among the sectors analyzed.

Although the information has permitted an adequate construction of product quantity and price aggregates, incomplete evidence on factor inputs and prices casts some doubt on the reliability of total factor input aggregates. Anyhow, to the extent that measurement errors and aggregation biases affect the TFP indices of various sectors in similar ways, the ranking of sectors in term of performance is still a useful element for the analysis of productivity and international competitiveness of the Mexican manufacturing sectors.

Extensions of this analysis include the calculation of TFP indices for a broader sample of 4-digit industrial sectors and the study of the evolution of productivity at the 2-digit level in order to compare Mexico's performance with that of other countries. Finally, the design of industrial promotion policies requires the study of the links between past commercial strategies and the behavior of productivity in the industrial sector.

FOOTNOTES

1/ Since productivity is measured as a ratio of outputs to inputs, there are as many indices of productivity as there are factors of production (see Nadiri, (1970)). The most often used are the partial productivity indices of labor and capital and the total of multifactor productivity index.

Symbolically, these partial indices are:

$AP_L = X/L$: average productivity of labor.

$AP_K = X/K$: average productivity of capital.

and the total index, considering only two factors, is:

$A = X/(aL+bK)$

where X,L,K are the aggregate level of output, labor, and capital, respectively; a and b are appropiate weights.

2/ Nishimizu and Robinson (1982) study the role of trade policies in increasing growth and efficiency in the industrial sectors of Korea, Turkey and Yugoslavia. They find important links between trade policies and industrial productivity performance. This performance is measured by means of TFP indices.

3/ Krueger and Tuncer (1980) examine the empirical relevance of the infant industry argument. They argue that high levels of protection for newly established industries should be defended on empirical grounds, that is, have the long-run benefits of protection justified the short-run costs of starting up an initially high-cost industry? The answer is found by comparing the evolution of costs -inputs per unit of output or the reciprocal of TFP- in protected and unprotected industries. They conclude that in the case of Turkey, protection did not bring about the sort of growth in output per unit of input which would justify infant industry protection.

4/ Using TFP measures, Caves and Christensen compare the post war productivity performance of a public and a private -- railroad company in Canada. They find no evidence of inferior performance by the government-owned railroad. The evidence contradicts the predictions of the literature on the economics of property rights, which suggest that public ownership is inherently less efficient than private ownership.

5/ Domestic Resource Costs (DRC) are defined as the domestic factor costs at shadow prices of generating a unit of value added at international prices. They are a social cost-benefit indicator used to rank activities in term of relative comparative advantage. Nishimizu and Page develop a methodology to decompose changes in the DRC ratio into relative price changes, changes is factor use and TFP change.

6/ The following discussion is based on:

Grilliches and Jorgenson (1967, pp.250-4)

7/ Denison (1966, p.76) argues that:

Since advances in knowledge cannot increase national product of one or more factors of production, they of course disappear as a source of growth if an increase in a factor's marginal product resulting from the advance of knowledge is counted as an increase in the quantity of factor input.

8/ The error in Denison's interpretation is to measure factor input as the <u>sum</u> of the increase in <u>both</u> prices and quantities.

9/ See also Grilliches and Jorgenson (1967) for a rigurous -- treatment of these issues.

10/ Note that the sectors included are mainly light industries. This is due to the lack of availability of information on heavier industries in the EIA during the 1960's.

A forthcoming study includes 20 more sectors for the period 1972-1982, concentrating on more sophisticated sectors (mainly capital goods).

11/ Although, conceivably, annual days worked could be used to adjust for labor utilization, this information was available only for part of the sample period.

12/ A proxy to adjust these measures by the rate of utilization of capital may be obtained by means of the consumption of electricity by industrial motors. This procedure will be pursued in a later analysis.

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