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INTERNATIONAL COMPARISON OF PURCHASING POWER, REAL OUTPUT AND LABOUR PRODUCTIVITY: A CASE STUDY OF BRAZILIAN, MEXICAN AND U.S. MANUFACTURING, 1975

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This study has a twofold objective: (a) a substantive analysis of purchasing power parities (PPP's), real output and labour productivity in Brazil, Mexico and the U.S.A.; and (b) a methodological survey of the analytic problems in measuring PPP's from the production side, rather than the expenditure approach used by the United Nations (ICP). Our main substantive findings were that PPP's for manufacturing did not vary greatly from the 1975 exchange rates, that labour productivity was surprisingly high in the two Latin American countries, and that there are substantial differences in the coverage of national accounts between Mexico and Brazil. We found census concepts of value added to be rather anachronistic, particularly in the U.S.A.; we developed a new short-cut matching procedure for industries with a complex product structure; and we found the unit value approach not inferior to the specification pricing practiced by ICP.

1. INTRODUCTION

The most direct way of comparing levels of output in different countries is to use the official exchange rate to convert GDP in one country's prices into the prices of another country, and, in multicountry comparisons, to use some key currency, such as the U.S. dollar, as a numéraire. However, exchange rates do not indicate the average purchasing power of currencies over all goods and services, but mainly reflect their purchasing power over tradeables. Furthermore exchange rates are subject to fluctuation, and capital movements play a major role in determining their level, so even for tradeables, they could be substantially misleading as indicators of purchasing power. Hence measurement of real output across countries is closely intertwined with the assessment of purchasing power.

Research on purchasing power parities (PPP's) has been under way for over three decades in international agencies concerned with burden sharing or with the relative need for aid. Hence the early work of OEEC (1954, 1958, 1959) for Western countries, of Gosplan (1965) for the CMEA countries, and ECLA (1963)

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for Latin America. This kind of measure is also useful in analysing military or geopolitical potential: see the CIA studies of Block (1981) and Schroeder and Edwards (1981); and U.S. Congress Joint Economic Committee studies (1981) and (1982) on Eastern Europe and the U.S.S.R.

Most of the above studies develop PPP's for final demand components (consumption, investment, etc.) The largest and most sustained scholarly effort using this "expenditure approach" was the International Comparisons Project (ICP) of the United Nations. The results of the first four phases are published in Kravis, Kenessey, Heston and Summers (1975), Kravis, Heston and Summers (1978) and (1982), and UN (1986). ICP methods are now used on a regional basis by Eurostat (1983) and OECD (Ward, 1985).

The expenditure approach is useful for analysis of macreconomic performance, but cannot be directly used for sectoral analysis since it does not show real product by industry. This handicaps comparative structural analysis, work on labour or total factor productivity, growth accounting, and studies of technological performance. This latter group of problems is better illuminated by the alternative "industry of origin" approach which we use here.

This study has a twofold objective:

(a) substantive analysis of manufacturing output levels, purchasing power parities, and labour productivity in Brazil, Mexico and the U.S.A.;

(b) a methodological survey of the analytical problems inherent in such an exercise for any group of countries, in order to facilitate the task of researchers who may wish to replicate our approach.

The present study is part of a series of comparative industry of origin investigations in which we and our colleagues have been engaged. Houben (1988) covers the mining sector in Brazil, Mexico and the U.S.A. Comparisons for the manufacturing sectors for India/U.S.A. (Van Ark, 1987) and Brazil/U.K. (Van Ark, 1988) are available, and others are underway for Japan, Korea, France and The Netherlands. A fourteen country comparison is available for agriculture by Van Ooststroom and Maddison (1985). The 1975 benchmark was chosen to facilitate comparison with the third phase of the ICP. The basic source is censuses of manufacturing which provide quantitative indicators of output levels in considerable detail as well as information on employment, gross output, value added, and inputs at national prices.

2. Previous Real Product Comparisons for Manufacturing

Some economists have manipulated real expenditure PPP's to produce proxy estimates of real output levels by sector (see Table 1). Thus Simon Kuznets (1972) used OEEC and ECLA real expenditure studies to derive estimates of real output for agriculture and industry. Jones (1976) used Kravis, Kenessey, Heston and Summers (1975) expenditure PPP's to estimate manufacturing output levels, A. D. Roy (1982) used the same procedure with Kravis, Heston and Summers (1978), and Prais (1981) followed a more detailed procedure, using about half of the expenditure items listed in Kravis, Kenessey, Heston and Summers (1975) to derive a weighted average PPP for manufacturing. Klodt (1984), Jorgenson,

TABLE 1

PROXY COMPARISONS OF REAL OUTPUT LEVELS IN MANUFACTURING USING ANALOGOUS ICP EXPENDITURE COMPONENTS

Kuznets (1972)	Used reweighted OEEC and ECLA expenditure PPP's to estimate sector PPP's for large groups of countries.
Jones (1976)	Used reweighted Kravis, Kenessey, Heston and Summers (1975) expenditure PPP's to derive sector PPP's.
Prais (1981)	Used reweighted Kravis, Kenessey, Heston and Summers (1975) expenditure PPP's to derive PPP's for 10 manufacturing industries in Germany, U.K. and U.S.A.
Roy, A. D. (1982)	Used reweighted Kravis, Heston and Summers (1978) expenditure PPP's to derive sector PPP's.
Klodt (1984)	Applied Kravis, Heston and Summers (1978) PPP's to 16 branches of manufacturing for Germany, Japan and U.S.A., 1960, 1970 and 1978.
Guinchard (1984)	Uses Kravis, Heston and Summers (1982) expenditure PPP's (with adjustment for taxes and trade margins) to derive PPP's for some branches of manufacturing. For intermediate products he used the exchange rate.
Jorgenson, Kuroda and Nishimizu (1986)	Applied "remapped" Kravis *et al.* (1975, 1978) PPP's to estimate productivity differentials in Japan and U.S.A. (1960-79).
Roy, D. J. (1987)	Used reweighted expenditure PPP's from ICP IV, derived from a tape provided by UNSO, for 60 countries for 1980.

Sources: See bibliographic references.

Kuroda and Nishimizu (1986), and D. J. Roy (1987) are the latest in this tradition.

Procedures of this type need to be crosschecked with independent estimates by industry of origin such as we present here. Until this is done for a reasonable sample of countries, one must be sceptical about the value of such proxies.

The initial impetus to "industry of origin" comparisons was given by Rostas (1948). The studies of Maddison (1952), Galenson (1955), Frankel (1957) and Yukizawa (1978) replicated his method for measuring real output, which concentrated on comparisons of "physical" gross output of different countries. The most ambitious studies in terms of sample size were those of Paige and Bombach (1959), Kudrov (1969), West (1971), Smith, Hitchens and Davies (1982), and Smith (1985). Table 2 shows their coverage so far as we could determine. Another indicator of the adequacy of their sample is the number of items matched. On the latter criterion, our study is amongst the most comprehensive. Some of the studies cited used a mixed methodology, in the sense that they combined independently determined PPP's by industry of origin with some proxy PPP's derived from expenditure studies. This was true of Paige and Bombach, and to smaller extent also of Smith, Hitchens and Davies (1982) and Smith (1985). In our study we kept strictly to the industry of origin approach, without using proxy PPP's. It should be noted that Table 2 is not exhaustive. See also Heath (1957), Maizels (1958), Frank (1977), Davies and Caves (1987), van Ark (1988), Szirmai and Pilat (1989), as well as the short-cut approach of Shinohara (1966) and Maddison (1970).

3. Comparisons of Purchasing Power, Real Output and Labour Productivity for Brazil/USA and Mexico/USA

Our analysis covered 17 industries, which were assumed to be representative for total manufacturing. The sample accounted for about 40 percent of gross value of output in Brazil and Mexico, and almost 28 percent in the U.S.A.

TABLE 2

13 Studies of Real Output Levels in Manufacturing

Author	Number of Products Sampled	Size of Sample	Country Coverage	Reference Years
Rostas (1948)	108	22 percent of 1937 U.S. employment	U.K./U.S.A.	1935 to 1939
Maddison (1952)	34	15 percent of Canadian, 14 per-cent of U.K., and 8 percent of U.S. employment in 1935	Canada/U.K./ U.S.A.	1935
Galenson (1955)	23	17 per cent of U.S. industrial gross output in 1939[a]	U.S.S.R./U.S.A.	1936 to 1939
Frankel (1957)	50[b]	18 percent of 1947 U.S. employment, 16 percent of U.K. 1948 employment	U.K./U.S.A.	1948/7
Paige and Bombach (1959)	380	51 percent of U.K., and 48 percent of U.S. manufacturing value added	U.K./U.S.A.	1950
Mensink (1966)	78	14 percent of U.K. 1958 employment	Netherlands/U.K.	1958
Kudrov (1969)	224[c]	substantial, but not stated	U.S.S.R./U.S.A.	1963
Czech Statistical Office/INSEE (1969)	113	substantial, but not stated	Czechslovakia/ France	1962 and 1967
West (1971)	150[b]	31 percent[d] of U.S. shipments	Canada/U.S.A.	1963
Yukizawa (1978)	60	26 percent of Japanese and 24 percent of U.S. value added in 1972	Japan/U.S.A.	1958/9, 1963 1967, 1972
Smith, Hitchens and Davies (1982)	487[ce] 350	substantial, but not stated	U.K./U.S.A. Germany/U.K.	1968/7 1967/8
Smith (1985)	386[ce]	55 percent of U.K. value added and 53 percent of U.S. value added	U.K./U.S.A.	1977
Maddison and Van Ark (present study)	171-372 192-342 200-157	33 percent of value added in Brazil, 39 percent in Mexico, 20 percent in U.S.A	Brazil/U.S.A. Mexico/U.S.A. Mexico/Brazil	1975 1975 1975

[a]Galenson includes three mining industries (coal, iron ore, oil and natural gas).

[b]In the absence of information from the authors, these are rough estimates.

[c]Information supplied by the authors.

[d]West does not say how his sample is, but we derived this figure by comparing the large industry codes he uses (pp. 59-61) with 1963 information in the *General Summary* volume of the *1977 Census of Manufactures.*

[e]Refers to number of "matches" instead of number of matched products.

The basic procedure involved weighting physical output of individual commodities by a common set of price weights. These "prices" were unit values derived from production censuses[1] by dividing gross value of output by corresponding quantities. Two sets of binary comparisons were made, i.e. Brazil/U.S.A. and Mexico/U.S.A.[2] Each involved (a) unit value weights of country X (Brazil or Mexico) to compare gross volume of output of that country with that in the United States:

$$\frac{\sum (Q_y^X * P_y^X}{\sum (Q_y^U * P_y^X)} \tag{1a}$$

and each (b) used the unit value weights of the U.S.A. to derive a quantity ratio between country X and the United States as follows:

$$\frac{\sum (Q_y^X * P_y^U)}{\sum (Q_y^U * P_y^U)} \tag{1b}$$

with Q_y = quantity of product y, P_y = unit value of product y, X = country X. U = United States.

It is usually not possible to make these quantitative comparisons for all products of an industry, because:

(a) one cannot match each product with a corresponding one in the U.S. Census;

(b) some products are only specified by value and not by quantity.

In the Brazil/U.S.A. comparison 171 Brazilian product items and 372 U.S. product items were matched; and in the Mexico/U.S.A. comparison 192 Mexican product items and 342 U.S. product items were matched. Table 3 shows the ratios of covered output to total gross value of output for each of the 17 industries. In only two cases, i.e. the Brazilian motor vehicle industry and petroleum refining industry, was the coverage below 40 percent—because of the unusually large amount of "non-specified" output. On average the sample coverage ratios were between 58 and 73 percent.

There are two alternative procedures to move from the "covered output" comparison to one for the industry as a whole. It can be assumed that the quantity relationship between matched output in country X and country U applies to the industry as a whole, or that the price (unit value) relationship for covered output is representative for the entire industry. These two alternatives have been extensively discussed in the literature on measurement of production trends since Mills first raised the issue (Mills, 1932). Burns (1934, pp. 260-261) stressed that prices of different commodities are likely to be under the general influence of "common monetary factors", whereas there is no such "single dominant force acting pervasively" on quantitative movements for different commodities. Fabricant (1940) also preferred price indicators because "prices probably move together within closer limits than do quantities." Stone (1956) stated that completeness of coverage is of less importance with price indicators compared to quantity

[1]For an extensive discussion of the scope of the production censuses in Brazil, Mexico and the U.S.A. see Maddison and Van Ark (1987).

[2]In fact we also made a binary comparison of Brazil/Mexico, which is not shown here.

TABLE 3

COVERAGE RATIOS: GROSS VALUE OF MATCHED ITEMS AS A PERCENTAGE OF TOTAL GROSS VALUE OF OUTPUT (NATIONAL CURRENCIES)

	Brazil/U.S.A.		Mexico/U.S.A.	
	Brazil (1975)	U.S.A. (1977)	Mexico (1975)	U.S.A. (1977)
Grain Mill Products	83.17	58.06	65.51	59.89
Sugar and Sugar Products	94.83	72.41	85.68	72.41
Malt and Malt Beverages	88.05	93.67	89.08	93.67
Tobacco and Tobacco Products	90.15	94.19	98.05	89.76
Textiles	86.37	83.13	42.11	82.18
Footwear and Leather Products	56.28	52.29	53.72	61.01
Pulp and Paper	77.78	75.62	66.23	81.79
Soap and Detergents	94.79	48.84	81.57	61.51
Paints	45.32	44.83	69.30	44.83
Agricultural Fertilizers	82.68	83.90	66.88	83.90
Petroleum Refining and Products	38.19	86.60	75.42	82.01
Tires and Inner Tubes	79.48	58.11	48.72	53.58
Cement	86.64	65.00	59.22	66.04
Bricks	51.73	47.17	70.07	45.08
Iron and Steel	53.86	58.02	72.50	57.31
Radio and TV Receivers	62.17	64.80	68.75	63.23
Motor Vehicles	34.21	68.86	59.86	66.68
Weighted Average 17 industries	57.61	72.78	67.23	71.32

Note: For details on matching for individual industries see "Statistical Appendix" to our original, much larger, research report (Maddison and Van Ark, 1987).

indicators, because "prices charged for close substitutes by different firms or in different parts of a country are likely, in many cases, to show similar movements even if their absolute level is a little different." We agree with the statements above. Therefore our coverage adjustments are entirely based on the price indicator method.

As a result the price ratios (or PPP's) for an industry as a whole were assumed to be similar to the derived PPP's for the covered part of output. PPP's were either weighted by quantities of the United States, i.e.

$$\frac{\sum (Q_y^{U} * P_y^{X})_c}{\sum (Q_y^{U} * P_y^{U})_c} = \frac{\sum (Q_y^{U} * P_y^{X})}{\sum (Q_y^{U} * P_y^{U})} = PPP^{U} \tag{2a}$$

or by quantity weights of country X:

$$\frac{\sum (Q_y^{X} * P_y^{X})_c}{\sum (Q_y^{X} * P_y^{U})_c} = \frac{\sum (Q_y^{X} * P_y^{X})}{\sum (Q_y^{X} * P_y^{U})} = PPP^{X}. \tag{2b}$$

with "c" indicating covered output

PPP^X = purchasing power parity using quantity weights of country X

PPP^U = purchasing power parity using quantity weights of the U.S.A.

Table 4 presents the 1975 PPP estimates in terms of the number of currency units of country X to the U.S. dollar for the 17 individual industries and compares

TABLE 4

PURCHASING POWER PARITIES, BRAZIL/U.S.A. (CRUZEIROS TO THE U.S.$) AND MEXICO/U.S.A. (PESOS TO THE U.S.$), 1975

	PPP: Cruzeiros/U.S. $			PPP: Pesos/U.S. $		
	U.S. Quantity Weights (1)	Brazil Quantity Weights (2)	Geometric Average (3)	U.S. Quantity Weights (4)	Mexico Quantity Weights (5)	Geometric Average (6)
Grain Mill Products	7.58	6.94	7.25	13.13	12.34	12.73
Sugar and Sugar Products	2.48	2.14	2.30	3.74	3.62	3.68
Malt and Malt Beverages	8.10	7.73	7.91	17.66	17.66	17.66
Tobacco and Tobacco Products	4.94	4.38	4.65	9.35	7.64	8.45
Textiles	13.33	9.81	11.44	18.69	17.45	18.06
Footwear and Leather Products	5.62	4.77	5.18	12.85	11.32	12.06
Pulp and Paper	10.53	8.24	9.31	22.77	19.83	21.25
Soap and Detergents	8.45	4.39	6.09	11.55	9.07	10.24
Paints	4.07	4.39	4.23	15.41	14.76	15.08
Agricultural Fertilizers	12.01	11.77	11.89	8.40	7.61	8.00
Petroleum Refining and Products	14.56	14.39	14.47	11.02	10.76	10.89
Tires and Inner Tubes	13.17	11.64	12.38	32.68	29.29	30.94
Cement	9.90	9.90	9.90	12.18	12.11	12.14
Bricks	4.03	3.62	3.82	9.79	13.60	11.54
Iron and Steel	8.95	7.27	8.07	14.09	11.25	12.59
Radio and TV Receivers	7.72	7.64	7.68	8.92	11.39	10.08
Motor Vehicles	6.49	6.32	6.40	13.74	13.55	13.64
Exchange Rates	8.13	8.13	8.13	12.50	12.50	12.50

Source and note: Includes adjustments for indirect taxes and subsidies for malt and malt beverages tobacco and tobacco products and petroleum refining and products in the Mexico–U comparison, and for quality differences in the motor vehicles industry in both country comparisons.

them with the official 1975 exchange rates, i.e. 8.13 cruzeiros to the U.S. dollar and 12.5 Mexican pesos to the U.S. dollar.

Thus the PPP's in the first and fourth columns of Table 4 are weighted by U.S. quantities, and those in the second and fifth columns by the quantities of each of the Latin American countries. Geometric averages (Fisher indices) of the two PPP's are also presented in the third and sixth columns. In the Brazil/U.S.A. comparison 31 of the 51 PPP's were below the exchange rate, and in the Mexico/U.S.A. comparison 27 of the 51 PPP's.[3]

Corresponding quantity relatives can be derived by applying the PPP's of Table 4 to the gross value of output at national prices, because price and quantity relatives are complementary to each other. The value ratio between country X and base country U is divided by a Laspeyres price ratio, i.e. using quantity

[3]At this stage the 1977 U.S. census figures were adjusted to a 1975 basis. Volume adjustment were derived from the *1982 Industrial Outlook*, in which gross value of output is shown at constant 1972 U.S.$ for separate product groups. These ratios were applied to the 1977 U.S. census gross value of output. The resulting 1975 figures at 1977 prices were compared with the product group figures for 1975 at 1975 prices derived from the *Annual Survey of Manufactures 1975-1976* (ASM). From this latter comparison we derived our unit value indices for 1975 relative to 1977.

weights of the base country (see formula (2a)). Thus the derived quantity ratio is of the Paasche type, i.e. using unit value weights of country X (see formula 1a):

$$\frac{\sum (Q_y^X * P_y^X)}{\sum (Q_y^U * P_y^U)} \Big/ \frac{\sum (Q_y^U * P_y^X)}{\sum (Q_y^U * P_y^U)} = \frac{\sum (Q_y^X * P_y^X)}{\sum (Q_y^U * P_y^X)}. \tag{3a}$$

The same is true for a combination of a Paasche price index and a Laspeyres quantity index, i.e.:

$$\frac{\sum (Q_y^X * P_y^X)}{\sum (Q_y^U * P_y^U)} \Big/ \frac{\sum (Q_y^X * P_y^X)}{\sum (Q_y^X * P_y^U)} = \frac{\sum (Q_y^U * P_y^X)}{\sum (Q_y^U * P_y^U)}. \tag{3b}$$

Thus far the procedure described relates to gross value of output, but in order to avoid double-counting in aggregating the individual industry results, we must move on to derive quantity relatives for value added. The best way to do this would be to make separate comparison of outputs and inputs (so-called "double deflation"). Unfortunately, the production censuses do not give figures for individual inputs at the product level, so we had to tackle the problem by making a proportionate adjustment at national prices of the ratio of gross output to value added.

It would be desirable to adjust the value added concept used in the censuses to a national accounts basis. The "national accounts" concept of value added avoids all duplication, because it deducts all inputs. The Brazilian and Mexican censuses provide enough detailed information to reconcile census value added to a national accounts basis, but this was not possible for the U.S.A.

In the detailed value added comparisons for the 17 industries, we were therefore obliged to adjust the value added specifications in the three production censuses to a common basis using the "U.S. census concept" of value added. According to this concept only inputs directly related to the production process (i.e. raw materials, energy consumption, and packing expenses) are deducted from gross output.[4]

Table 5 shows Brazilian and Mexican value added ("U.S. census concept") converted to U.S. dollars at the official exchange rate, compared with the 1975 U.S. figures for value added derived from *Annual Survey of Manufactures.* Tables 6 and 7 show the results of applying the PPP's from Table 4 to the figures of value added in order to convert them to a common currency unit for the Brazil/U.S.A. and Mexico/U.S.A. comparison respectively. The first two columns show the results of the calculations in Brazilian and Mexican unit values respectively, and the fourth and fifth columns show value added at U.S. unit values. The third and last columns show the ratios of value added in Brazil and Mexico to the U.S.A.

[4]For the estimates at branch level and manufacturing as a whole we were able to use the "former national accounts" concept of value added, which is completely free of duplication. The "former" concept is preferred, because it deducts inputs of financial services at the branch level, whereas this particular input is usually deducted on a global basis for the economy as a whole in present national accounting practice.

TABLE 5

VALUE ADDED (U.S. CENSUS CONCEPT) IN BRAZIL, MEXICO AND THE U.S.A. IN 1975, AT OFFICIAL EXCHANGE RATES (1975 U.S. DOLLARS)

	Brazil (million dollars)	Mexico (million dollars)	U.S.A. (million dollars)
Total Manufacturing Value Added	37,748.2	17,585.6[ab]	442,485.2
Grain Mill Products	236.0	207.3	1,587.8
Sugar and Sugar Products	571.4	257.3	933.9
Malt and Malt Beverages	248.7	550.0[a]	2,129.8
Tobacco and Tobacco Products	395.0	145.3[a]	3,721.5
Textiles	1,260.4	669.2	6,217.3
Footwear and Leather Products	583.8	266.4	2,941.6
Pulp and Paper	571.6	502.3	7,626.1
Soap and Detergents	169.7	216.3	2,419.7
Paints	350.8	127.8	2,126.3
Agricultural Fertilizers	445.5	180.9	3,306.1
Petroleum Refining and Products	1,883.0	684.9[ab]	9,332.3
Tires and Inner Tubes	388.6	236.4	3,462.8
Cement	382.3	276.0	1,332.9
Bricks	542.2	69.4	715.7
Iron and Steel	2,223.8	1,082.8	15,783.2
Radio and TV Receivers	447.3	205.3	1,542.5
Motor Vehicles	1,772.6	1,163.3	21,465.9
Total in our sample	12,472.8	6,840.9	86,645.4
as % of Total Manufacturing	33.04	38.90	19.58

Source: Figures for Brazil from *Censo Industrial*, figures for Mexico from *Resumen General* (except for figures mentioned under footnotes (a) and (b)), and figures for U.S.A. from the *Annual Survey of Manufactures 1975-1976.*

Note: Figures are converted at the exchange rate of 8.13 cruzeiros to the U.S. dollar and 12.5 pesos to the U.S. dollar.

[a]Indirect taxes and subsidies are deducted (see Table 2.3).

[b]Includes 571.8 million U.S. dollars (excl. indirect taxes and subsidies) for petroleum refining, not shown in the census, but taken from *Sistema de Cuentas Nacionales de Mexico.*

BLOWING UP OUR SAMPLE TO MAKE ESTIMATES FOR MANUFACTURING AS A WHOLE

Previous investigators have followed different options in order to blow up their sample for manufacturing as a whole. Rostas (1948), Maddison (1952), Galenson (1955), Frankel (1957), Mensink (1966), and Yukizawa (1978) simply assumed that their sample results were representative for manufacturing as a whole (either explicitly or implicitly). They gave the overall result in terms of labour productivity, not output or PPP's. Sometimes, as with Rostas and Yukizawa, the sample aggregate result was derived by using labour weights.

Three studies explicitly discuss the aggregation problem in all three dimensions (output, PPP's and labour productivity), i.e. Paige and Bombach (1959), the Czech Statistical Office/INSEE (1969) and West (1971), but they each followed different methods.

TABLE 6

QUANTITIES (VALUE ADDED, U.S. CENSUS CONCEPT), BRAZIL/U.S.A., 1975

	At Brazilian "Prices"			At U.S. "Prices"		
	Brazil 1975 (1975 Cr. million)	U.S.A. 1975	Brazil U.S.A. (%)	Brazil 1975 (1975 U.S.$ million)	U.S.A. 1975	Brazil U.S.A. (%)
Grain Mill Products	1,918.7	12,038.2	15.94	276.5	1,587.8	17.41
Sugar and Sugar Products	4,645.4	2,320.0	200.24	2,167.8	933.9	232.13
Malt and Malt Beverages	2,021.9	17,259.0	11.72	261.4	2,129.8	12.27
Tobacco and Tobacco Products	3,211.7	18,392.9	17.46	733.2	3.721.5	19.70
Textiles	10,246.9	82,852.7	12.37	1,044.6	6,217.3	16.80
Footwear and Leather Products	4,746.0	16,531.3	28.71	994.4	2,941.6	33.80
Pulp and Paper	4,647.5	80,326.6	5.79	564.1	7,626.1	7.40
Soap and Detergents	1,379.8	20,504.5	6.73	314.5	2,419.7	13.00
Paints	2,852.3	8,654.5	32.96	649.4	2,126.3	30.54
Agricultural Fertilizers	3,621.5	36,696.6	9.12	307.6	3,306.1	9.30
Petroleum Refining and Products	15,309.0	135,912.4	11.26	1,064.0	9,332.3	11.40
Tires and Inner Tubes	3,159.1	45,600.3	6.93	271.4	3,462.8	7.84
Cement	3,107.7	13,194.5	23.55	313.9	1,332.9	23.55
Bricks	4,408.5	2,884.2	152.85	1,217.2	715.7	170.07
Iron and Steel	18,079.7	141,222.5	12.80	2,487.0	15,783.2	15.76
Radio and TV Receivers	3,636.9	11,902.2	30.56	475.8	1,542.5	30.84
Motor Vehicles	14,411.4	139,258.3	10.35	2,279.4	21,465.9	10.62
Total in our sample	101,404.1	788,550.7	12.86	15,422.2	86,645.4	17.80

Note: Includes adjustment for quality differences in the motor vehicles industry.

Paige and Bombach covered about half of output in their two countries, i.e. the U.K. and the U.S.A., and their average result is very similar to that for their sample, as they predominantly assumed their quantitative relationships to be representative (see p. 102). They got their total for manufacturing by blowing up the industries they covered to represent the situation by major branch (using quantity relationships of their sample in 59 percent of cases, PPP relatives for 19 percent, other price information for 10 percent, and employment for 12 percent).

West did not make estimates by major branch, but assumed the average PPP for his sample (with value added weights) was representative for the non-sampled industries, using the sample average PPP to derive real output in the non-covered sector (see p. 26). His overall labour productivity result was significantly lower than that for his sample.

The authors of the Czech-French study used an unweighted average of their sample PPP's (by branch) to get a PPP for each branch, with output derived for the branch by applying this PPP to calculate branch value added in real terms. Their manufacturing total was derived by summing branch totals. A similar procedure was used by Smith, Hitchens and Davies (1982), and Smith (1985).

TABLE 7

QUANTITIES (VALUE ADDED, U.S. CENSUS CONCEPT), MEXICO/U.S., 1975

	At Mexican "Prices"			At US "Prices"		
	Mexico 1975 (1975 Ps. million)	U.S.A. 1975	Mexico U.S.A. (%)	Mexico 1975 (1975 U.S.$ million)	U.S.A. 1975	Mexico U.S.A. (%)
Grain Mill Products	2,591.8	20,842.0	12.44	210.0	1,587.8	13.22
Sugar and Sugar Products	3,216.1	3,490.8	92.13	888.3	933.9	95.12
Malt and Malt Beverages	6,874.8	37,615.8	18.28	389.2	2,129.8	18.28
Tobacco and Tobacco Products	1,816.8	34,777.7	5.22	237.9	3,721.5	6.39
Textiles	8,364.7	116,206.3	7.20	479.4	6,217.3	7.71
Footwear and Leather Products	3,329.5	37.784.9	8.81	294.1	2,941.6	10.00
Pulp and Paper	6,278.8	173, 674.5	3.62	316.6	7,626.1	4.15
Soap and Detergents	2,704.2	28,005.9	9.66	298.1	2,419.7	12.32
Paints	1,597.0	32,770.7	4.87	108.2	2,126.3	5.09
Agricultural Fertilizers	2,261.7	27.775.3	8.14	297.1	3,306.1	8.99
Petroleum Refining and Products	8,561.7	102,884.8	8.32	795.9	9,332.3	8.53
Tires and Inner Tubes	2,954.4	113.178.8	2.61	100.9	3,462.8	2.91
Cement	3,449.5	16,239.0	21.24	284.9	1,332.9	21.38
Bricks	867.2	7,009.2	12.37	63.8	715.7	8.91
Iron and Steel	13,535.1	222,453.8	6.08	1,203.2	15,783.2	7.62
Radio and TV Receivers	2,565.7	13,751.5	18.66	225.2	1,542.5	14.60
Motor Vehicles	14,541.6	295,020.1	4.93	1,073.5	21,465.9	5.00
Total in our sample	85,510.9	1,283,481.2	6.66	7,266.2	86,645.4	8.39

Note: Includes adjustments to exclude indirect taxes and subsidies for malt and malt beverages, tobacco and tobacco products and petroleum refining and products, and for quality differences in the motor vehicles industry.

Our approach comes closest to that of the Czech-French study. We assumed that the PPP's for our sample were representative for the non-sampled industries in the same manufacturing branch. For reasons already explained above, we feel that the PPP relationships are more representative than the quantitative relationships which Paige and Bombach predominantly used to establish their aggregate result. Unlike the Czech-French study, we used a weighted average of our individual industry PPP's to arrive at the PPP for each branch. For example our PPP for the food products branch is the average of the price ratios for grain mill and sugar and confectionery products weighted by value added (U.S. census concept). Table 8 shows our PPP's by manufacturing branch. They were used to convert branch value added at national prices to a common currency unit (see the quantity relatives in Tables 9 and 10).

LABOUR PRODUCTIVITY

One of the major purposes of our approach is to estimate comparative levels of labour (and ultimately of total factor) productivity. Labour productivity is here expressed as output per person engaged. Figures on working hours are

TABLE 8

PURCHASING POWER PARITIES BY MAJOR BRANCH OF MANUFACTURING BRAZIL/U.S.A. (CRUZEIROS TO THE U.S. DOLLAR) AND MEXICO/U.S. (PESOS TO THE U.S. DOLLAR), 1975

	PPP: Cruzeiros/U.S. dollar			PPP: Pesos/U.S. dollar		
	U.S. Quantity Weights	Brazil Quantity Weights	Geometric Average	U.S. Quantity Weights	Mexico Quantity Weights	Geometric Average
Food Products	5.69	2.69	3.91	9.65	5.29	7.14
Beverage Products	8.10	7.73	7.92	17.66	17.66	17.66
Tobacco Products	4.94	4.38	4.65	9.35	7.64	8.45
Textiles and Wearing Apparel	13.33	9.81	11.43	18.69	17.45	18.06
Footwear and Leather Products	5.62	4.77	5.18	12.85	11.32	12.06
Wood and Paper Products	10.53	8.24	9.32	22.77	19.83	21.25
Chemical Products	11.92	9.92	10.87	11.14	10.09	10.60
Rubber and Plastic Products	13.17	11.64	12.38	32.68	29.28	30.94
Stone, Clay and Glass Products	7.85	4.91	6.21	11.35	12.38	11.85
Metal Products	8.95	7.27	8.07	14.09	11.25	12.59
Electrical Machinery	7.72	7.64	7.68	8.92	11.39	10.07
Machinery and Transport Equipment	6.49	6.32	6.40	13.74	13.55	13.64
Other	8.79	6.26	7.42	14.92	10.94	12.77
Total	8.79	6.26	7.42	14.92	10.94	12.77

Source and note: PPP's from Table 4. The PPP for food products is the weighted average for grain mill products and sugar and confectionery products. The PPP for chemical products is a weighted average for soap and detergents, paints, agricultural fertilizers and petroleum refining and products. The PPP for stone, clay and glass products is a weighted average for cement and bricks. In all cases value added (U.S. census concept) was used as weights. The Cruzeiro/U.S. dollar PPP's and Peso/U.S. dollar PPP's for "Other Manufacturing" and "Total Manufacturing" are derived from the sum of the branch values in Tables 9 and 10, respectively.

generally not available for Brazil, and there are only rough figures for Mexico. In 1975, average working hours in Mexico were 44.05 per week compared with 39.50 for production and non-supervisory workers in U.S. manufacturing.[5] Reliable comparative information on time off for holidays and sickness is not available, so output per man hour cannot be calculated with any accuracy, but it seems probable that aggregate hours per person engaged were longer in Brazil and Mexico than in the U.S.A., perhaps around 10 percent higher.

The labour productivity ratios presented here do not account for activities of head offices and auxiliaries in any of the three counties. We do not believe that the ratios would change significantly by including such activity. The head office share of total manufacturing employment was 14 percent in both Brazil and Mexico and 16 percent in the U.S.A.

Table 12 presents ratios of value added per person engaged in manufacturing branches for the Brazil/U.S.A. and the Mexico/U.S.A. comparison. The produc-

[5]For Mexico, see INEGI (1985), Vol. 1, p. 60; for the U.S.A., see *Employment and Earnings*, December 1978, p. 85.

TABLE 9

QUANTITIES (VALUE ADDED, FORMER NATIONAL ACCOUNTS CONCEPT) BY MAJOR BRANCH OF MANUFACTURING, BRAZIL/U.S.A. 1975

	At Brazilian "Prices"			At U.S. "Prices"		
	Brazil 1975 (1975 Cr.million)	U.S.A. 1975	Brazile U.S.A. (%)	Brazil 1975 (1975 U.S.$ million)	U.S.A. 1975	Brazil U.S.A. (%)
Food Products	27,759	144,744	19.18	10,337	25,421	40.66
Beverages	4,565	41,774	10.93	590	5,155	11.45
Tobacco Products	2,987	12,203	24.48	682	2,469	27.62
Textiles and Wearing Apparel	22,940[a]	270,854	8.47	2,339	20,325	11.51
Footwear and Leather Products	3,977[a]	13,145	30.26	833	2,339	35.63
Wood and Paper Products	27,696	482,290	5.74	3,362	45,788	7.34
Chemical Products	42,511	388,781	10.93	4,286	32,627	13.14
Rubber and Plastic Products	10,260	121,560	8.44	881	9,231	9.55
Stone, Clay and Glass Products	15,365	84,899	18.10	3,130	10,817	28.93
Metal Products	31,176	470,798	6.62	4,289	52,617	8.15
Electrical Machinery	15,437	211,184	7.31	2,020	27,369	7.38
Machinery and Transport Equipment	44,231	513,071	8.62	6,996	79,087	8.85
Other	8,109	132,811	6.11	1,295	15,099	8.58
Total	257,012	2,888,112	8.90	41,039	328,343	12.50

Source: Brazil value added in national currencies from *Censo Industrial*, U.S. value added in national currencies from *National Income and Products Accounts of the United States: 1929-76 Statistical Tables* (1981c) after adjustment for inventories indirect taxes and subsidies and net interest. PPP's from Table 8.

Note: The breakdown between food products and beverages for the U.S. on a national accounts basis was assumed to be proportionately the same as on a U.S. Census basis (1975 figures derived from *Annual Survey of Manufactures*).

[a]The footwear industry (2,675.9 million cruzeiros) was reallocated from wearing apparel to footwear and leather.

tivity ratios show a very clear U.S. productivity advantage over both the other countries.

In the Brazil/U.S.A. comparison labour productivity (the geometric "Fisher" index) varied between 33 percent of the U.S. for wood and wood products to 76 percent for food products, with a weighted average of 49 percent for manufacturing as a whole. The average Mexico/U.S.A. ratio is below that for Brazil/U.S.A., namely 39 percent, with a minimum of 22 percent of the U.S. level for wood and paper products and a high of 48 percent for food products.

4. REVIEW OF THE RESULTS

The most interesting feature of our results is that our PPP's (Table 13) do not vary greatly from the exchange rate.[6]

[6]It should be stressed that the PPP's in Table 13 are our preferred summary measures, and are not unique in character. As in all such studies the final outcome can be stated in alternative ways, i.e. the price relations can be measured with the "quantity" weights of either one of the two countries involved in each binary comparison. In complementary fashion, our quantity relations (see Table 15) can be measured using the "price" weights of either one of the countries involved in each binary comparison. The measure we show in Table 13 is a geometric (Fisher) average of these alternatives.

TABLE 10

QUANTITIES (VALUE ADDED, FORMER NATIONAL ACCOUNTS CONCEPT) BY MAJOR BRANCH OF MANUFACTURING, MEXICO/U.S.A., 1975

	At Mexican "Prices"			At U.S. "Prices"		
	Mexico 1975 (1975 Ps. million)	U.S.A. 1975	Mexico U.S.A. (%)	Mexico 1975 (1975 U.S.$ million)	U.S.A. 1975	Mexico U.S.A. (%)
Food Products	20,446	245,296	8.34	3,866	25,421	15.21
Beverages	8,170[a]	91,046	8.97	462	5,155	8.97
Tobacco Products	1,177[a]	23,073	5.10	154	2,469	6.24
Textiles and Wearing Apparel	15,334	379,890	4.04	879	20,325	4.32
Footwear and Leather Products	2,472	30,044	8.23	218	2,339	9.34
Wood and Paper Products	13,121	1,042,762	1.26	662	45,788	1.44
Chemical Products	26,226[ab]	363,469	7.22	2,600	32,627	7.97
Rubber and Plastic Products	6,264	301,708	2.08	214	9,231	2.32
Stone, Clay and Glass Products	8,857	122,755	7.21	715	10,817	6.61
Metal Products	23,949	741,602	3.23	2,129	52,617	4.05
Electrical Machinery	9,557	243,997	3.92	839	27,369	3.06
Machinery and Transport Equipment	19,423	1,086,945	1.79	1,434	79,087	1.81
Other	2,494	225,228	1.11	228	15,099	1.51
Total	157,488	4,897,816	3.22	14,401	328,343	4.39

Source: Mexican value added in national currencies from *Resumen General*, U.S. value added in national currencies from *National Income and Products Accounts of the United States: 1929-76 Statistical Tables* (1981c) after adjustment for inventories indirect taxes and subsidies and net interest. PPP's from Table 8.

Note: The breakdown between food products and beverages for the U.S. on a national accounts basis was assumed to be proportionately the same as on a U.S. Census basis (1975 figures derived from *Annual Survey of Manufactures*).

[a]Indirect taxes and subsidies are deducted.

[b]Includes 3,831.7 million pesos (excl. indirect taxes and subsidies) for petroleum refining, not shown in the census *Resumen General*, but taken from *Sistema de Cuentas Nacionales de Mexico.*

In fact the purchasing power of the Brazilian currency was somewhat greater for manufactured products than suggested by the exchange rate, while in Mexico the reverse situation prevailed. These conclusions seem quite plausible. After the first OPEC shock Brazil took steps to make its effective exchange rate more competitive in 1974 and 1975, whereas the Mexican currency is generally held to have been overvalued in 1975, since the exchange rate had been unchanged since 1954. The currency was substantially devalued in 1976.

Our PPP's and exchange rate deviation indices (Table 13) are quite different from those of the ICP for GDP. This in itself does not mean that they are incompatible as the ICP figures are strongly affected by services where their exchange rate deviation index is particularly extreme.

Although the ICP authors have never used their results to derive proxy estimates for sectors of output, several other investigators have done so (see Table 1). Using the same technique as such analysts, we can use ICP material to derive the PPP's for manufacturing in Table 14. The proxy PPP for manufactur-

TABLE 11

PERSONS ENGAGED IN MANUFACTURING IN 1975

	Brazil	Mexico	U.S.A.
Food Products	482,434	309,651	1,321,400
Beverages	52,080	69,392	203,800
Tobacco Products	23,965	8,645	66,200
Textiles and Wearing Apparel	507,593[a]	229,027	2,049,300
Footwear and Leather Products	129,231[a]	48,101	239,700
Wood and Paper Products	524,402	164,595	2,642,700
Chemical Products	177,920	157,170[b]	983,100
Rubber and Plastic Products	120,866	53,363	585,000
Stone, Clay and Glass Products	311,361	100,714	588,800
Metal Products	429,539	206,509	2,505,800
Electrical Machinery	170,425	114,382	1,523,600
Machinery and Transport Equipment	595,580	178,678	3,571,200
Other	146,260	34,113	893,200
Total Manufacturing	3,671,656	1,674,340	17,173,800[c]

Source: Brazil from IBGE, *Censo Industrial* (1981a), Mexico from SPP, *Resumen General* (1979a), USA from U.S. Dept. of Commerce, *Annual Survey of Manufactures 1975-76* (1979).

[a]Employment in the footwear industry (95,358 employees) was reallocated from wearing apparel to footwear and leather.

[b]Includes 25,989 employees in petroleum refining which are not covered by the industrial census *Resumen General*, but taken from SPI, 1981.

[c]Excludes employees in administrative offices and auxiliaries, i.e. 152,682 in Brazil, 69,448 in Mexico, and 1,128,200 in the U.S.A.

ing is identical with our average PPP result in the Brazil/U.S.A. comparison, but substantially different for the Mexico/U.S.A. comparison.

Apart from the possible shortcomings of proxy PPP's, there is also a substantial problem when they are applied (see D. J. Roy, 1987) to the respective national accounts at national prices, without adjustment for differences in the coverage of such accounts. The Mexican national accounts make a very large imputation for manufacturing activity in the informal sector, whereas the Brazilian accounts make virtually no adjustment. As there is no reason to expect the relative size of the informal sector to be much different in the two countries, use of inconsistent national accounts can have serious results. The typical shortcut proxy procedure would overstate Mexico's output position relative to Brazil's for two reasons:

(a) by overstating the relative PPP of the peso, and

(b) overstating Mexico's output in national currency terms vis-à-vis Brazil.

Table 15 shows the quantitative results (geometric averages) of our study for the Brazil/U.S.A. and Mexico/U.S.A. comparison. The figures show clearly that Brazil had a better performance than Mexico both in terms of labour productivity and output per head of population, but it appears that the Latin American performance per head of population is much lower than the productivity standing, because manufacturing employment is relatively smaller than it is in the U.S.A.

Table 16 compares our labour productivity results for Brazil, Mexico and the U.S.A. with those of analogous studies for other countries. The studies of Paige and Bombach for 1950, Smith, Hitchens and Davies for 1967-68, and Smith

TABLE 12

PRODUCTIVITY RATIOS (VALUE ADDED, FORMER NATIONAL ACCOUNTS CONCEPT) PER PERSON ENGAGED BY MAJOR BRANCH OF MANUFACTURING, BRAZIL/U.S.A. AND MEXICO/U.S.A., 1975

	Brazil/U.S.A.			Mexico/U.S.A.		
	Brazil Unit Value Weights	U.S.A. Unit Value Weights	Geometric Average	Mexico Unit Value Weights	U.S.A. Unit Value Weights	Geometric Average
Food Products	52.53	111.37	76.49	35.57	64.90	48.05
Beverages	42.76	44.80	43.77	26.35	26.35	26.35
Tobacco Products	67.61	76.28	71.82	39.06	47.80	43.21
Textiles and Wearing Apparel	34.19	46.45	39.85	36.12	38.69	37.38
Footwear and Leather Products	56.12	66.08	60.90	41.00	46.52	43.68
Wood and Paper Products	28.94	37.00	32.72	20.20	23.20	21.65
Chemical Products	60.42	72.59	66.23	45.13	49.84	47.43
Rubber and Plastic Products	40.85	46.22	43.45	22.76	25.40	24.05
Stone, Clay and Glass Products	34.22	54.72	43.27	42.18	38.67	40.39
Metal Products	38.63	47.55	42.86	39.19	49.10	43.86
Electrical Machinery	65.35	65.97	65.66	52.17	40.82	46.15
Machinery and Transport Equipment	51.69	53.04	52.36	35.71	36.24	35.97
Other	37.29	52.37	44.19	28.99	39.55	33.86
Total Manufacturing	41.62	58.64	49.33	32.98	44.99	38.52

Source: Value added from Tables 9 and 10 for the Brazil/U.S.A. and Mexico/U.S.A. comparison respectively. Persons engaged from Table 11.

TABLE 13

CONFRONTATION OF OUR PPP'S FOR MANUFACTURING WITH THE EXCHANGE RATE AND WITH THE PPP'S OF ICP FOR 1975

	Brazil/U.S.A. (Cr./U.S.$)	Mexico/U.S.A. (Ps./U.S.$)
Our PPP's for Manufacturing (weighted by major branch)	7.42	12.77
ICP (Augmented Binary) PPP's for GDP	5.40	7.17
Exchange Rate	8.13	12.50
Our Exchange Rate Deviation Index for Manufacturing	1.10	0.98
ICP Exchange Rate Deviation Index for GDP (augmented Binaries)	1.51	1.74

Source: Our PPP's for Brazil/U.S.A. derived from Table 9 and for Mexico/U.S.A. from Table 10, respectively; ICP augmented binaries from Kravis, Heston and Summers (1982), pp. 255, 272. In fact the preferred ICP PPP's are multilaterally weighted, but we have shown their augmented binaries here because they are conceptually closer to ours. The multilaterally weighted PPP's of ICP did not vary greatly, i.e. 5.20 and 7.40, respectively for 1975 (see Kravis, Heston and Summers, 1982, p. 177). Exchange rates from IMF.

Note: The exchange rate deviation index is the ratio of the exchange rate to the PPP.

TABLE 14

CONFRONTATION OF OUR PPP'S FOR MANUFACTURING WITH THE PROXY PPP'S DERIVED FROM THE ICP 1975 AUGMENTED BINARY RESULTS

	Brazil/U.S.A. (Cr./U.S.$)	Mexico/U.S.A. (Ps. /U.S.$)
Our PPP's for Manufacturing (weighted by major branch)	7.42	12.77
Proxy PPP's for Manufacturing Derived from ICP Augmented Binaries	7.42	10.66
Ratio of Our PPP/Proxy ICP PPP	1.00	1.20

Source: Top line from Table 13; Second line derived from Kravis, Heston and Summers (1982), pp. 255, 272 and 313 as follows: the ICP III augmented binary PPP's for expenditure on the consumer items food, beverages, tobacco, clothing, footwear, furniture, appliances and transport equipment, and for producer durables were used to make the weighted average. These are the ICP PPP's which are conceptually closest to our type of comparison. The preferred PPP's of the ICP itself are in "international dollars."

TABLE 15

SUMMARY RESULTS FOR MANUFACTURING OUTPUT AND PRODUCTIVITY BRAZIL/U.S.A. AND MEXICO/U.S.A. (1975)

	Brazil/U.S.A.	Mexico/U.S.A.
Value Added (Former National Accounts Concept) as a Percentage of the U.S.A.	10.55	3.76
Value Added (Former National Accounts Concept) per Person engaged as a Percentage of the U.S.A.	49.33	38.52
Value Added (Former National Accounts Concept) per Head of Population as a Percentage of the U.S.A.	21.72	13.48
Persons Engaged in Manufacturing as a Percentage of the U.S.A.	21.38	9.75
Population as a Percentage of the U.S.A.	48.55	27.85

Source: Value added from Tables 9 and 10; value added per person employed from Table 12; population figures for Brazil from IBGE, *Censo Demografico* (1983), Mexico from Bank of Mexico, *Indicadores Economicos* (1986), U.S.A. from OECD, *Labour Force Statistics* (1987).

Note: Figures in the three upper lines are geometric averages.

for 1977 all found the U.K. productivity ratio to the U.S.A. (value added per person employed) to be similar to what we found for Mexico/U.S.A. for 1975, and below the Brazil/U.S.A. ratio we obtained for 1975.

Confirmation of the rather high level of productivity in Brazilian manufacturing can be found in a recent direct comparison by Van Ark (1988) of labour productivity in Brazil and the United Kingdom for 1975. Using the same methods as this study for a larger sample of 23 industries, it showed average Brazilian output per person engaged to be not far from that of the U.K. in 1975.

It is at first sight surprising that real productivity levels in Brazilian and Mexican manufacturing are as high by international standards as they appear. However, evidence from estimates at national prices appears to confirm that Brazil and Mexico have much higher productivity levels in manufacturing compared with the rest of the economy than is the case in the more advanced countries.

TABLE 16

RESULTS OF PREVIOUS STUDIES AND OUR STUDY OF OUTPUT PER PERSON ENGAGED IN MANUFACTURING AS A WHOLE, AS A PERCENTAGE OF THE U.S.A.

	At Local Prices	At U.S. Prices	Geometric Average
		Brazil/U.S.A. (1975)	
Present study	41.6	58.5	49.3
		Mexico/U.S.A. (1975)	
Present study	33.0	45.0	38.6
		U.K./U.S.A. (1950)	
Paige and Bombach (1959)	34.2	39.1	36.6
		U.K. (1968)/U.S. (1967)	
Smith, Hitchens and Davies (1982)	36.2	39.7	37.9
		U.K./U.S.A. (1977)	
Smith (1985)	38.3	41.5	39.9
		U.S.S.R./U.S.A. (1963)	
Kudrov (1969)	33.6	36.8	35.3
		Japan/U.S.A. (1972)	
Yukizawa (1978)	78.2	62.1	69.9
		Canada/U.S.A. (1963)	
West (1971)	64.4	68.5	66.4

Sources: See bibliographic references.

There are several reasons for this relatively high level of labour productivity in the manufacturing sectors of Brazil and Mexico. One is that in many sectors of manufacturing, the nature of technology is such that it is often rational to use processes which are labour saving and capital intensive, even in countries with low wages. Low income countries do have some leeway in adapting technology to a situation of low labour costs, but a large part of industrial technology was developed in countries where labour is more expensive, and there are problems in adapting it to different factor cost situations.

A second reason for relatively high labour productivity in Brazilian and Mexican manufacturing is the importance of policies which subsidize capital inputs. As a result, scarce capital is funnelled by priority towards industry. These policies are probably operative to a greater degree than in the OECD countries.

A few additional remarks should be added on the relatively high productivity standing of Brazil and Mexico compared to the other countries. Firstly, the Latin American standing in terms of output per man hour, which could not be measured accurately, is probably lower than the productivity ratio in terms of output per person engaged, because working hours appear to be higher than in the U.S.A. Secondly, in comparison with the U.S.A. there is probably a greater amount of informal manufacturing activity outside the scope of the census in Latin America where productivity is lower. Thirdly, as already noted, Latin American performance per head of population is much lower than their productivity standing, because manufacturing employment is relatively much smaller than it is in the U.S.A.

The present article deals with two binary comparisons, one between Brazil and the U.S.A. and the other between Mexico and the U.S.A., and made some inferences about the relative productivity standing of Brazil/Mexico from the

two other binaries. In fact we also made a direct binary comparison between Brazil and Mexico, without using the U.S.A. as an intermediary, but have not presented the details here as the quantitative results were not substantially different from the inferential comparison. The geometric average of the Mexico/Brazil ratio of value added per person engaged was 82.70 percent in the direct binary comparison against 78.09 percent according to the inferential comparison (which can be derived from Table 12).

5. Results of Methodological Endeavours

One of the objectives of the present study was to provide a systematic methodological survey of the analytical problems inherent in the industry of origin approach, with whatever pragmatic contribution or recommendations we could make to mitigate or solve those which characteristically emerge.

(a) *An Integrated Three-Dimensional Approach*

We tried to give full attention to each of the three main dimensions of international comparison—real output, PPP's and productivity, and to set out their interrelation and complementary character clearly. Here our exposure to ICP methodology was very useful, as its rigour in this respect is exemplary. We feel that a good deal of previous work on industry-of-origin lines has suffered from concentrating only on the productivity aspects (this is true of all studies listed in Table 2 except Paige and Bombach, the Czech/INSEE study and that of West).

(b) *Reconciliation with the National Accounts Framework*

There are obvious advantages in making sectoral output and productivity studies of this kind in a conceptual framework compatible with the national accounts. We made a careful confrontation between the census and the national accounts, from which it appeared that the Mexican national accounts make extensive (and perhaps excessive) allowance for informal activity not recorded in the manufacturing censuses.

It is also clear that census definitions of value added vary between countries, and need adjustment to bring the comparisons for the three countries to a common conceptual basis as is used in national accounting. The "national accounts" concept of value added is obviously preferable to the census concepts, which are becoming increasingly anachronistic by neglecting to deduct service inputs in measuring value added.

(c) *Adjustment to a Common Benchmark Year*

Our study meets the problem of comparing countries whose census dates fall in different years. Our adjustment procedures have general applicability, and they were applied here to the U.S.A., whose performance is often a yardstick for comparison in such studies. In fact, using our approach, U.S. data can be adjusted to any intercensal year needed for purposes of international comparison.

(d) *A Systematic Shortcut Procedure for Matching*

None of the previous studies mentioned in Table 2 used a systematic procedure to select the particular "representative" products on which price and quantity comparisons are ultimately based. We therefore developed criteria for a systematic matching procedure which is economical in terms of time and effort.

Exact-matching is difficult to realize because strictly identical products are only rarely available in two or more countries at the same date. In consequence, lower degrees of product comparability have to be accepted for international comparisons than for inter-temporal comparisons within a single country. This is true not only for the present product-based study, but also for expenditure-based studies such as the ICP.

The maximalist approach tries to match as many items as possible, but often results in very wide ranges of PPP's within an industry. These widely divergent PPP's for different products are a signal to the possibility that some of the matches are false. In spite of having similar (or even identical) descriptions, we inferred that some of these outliers were, in reality, different products.

For complex multiproduct industries, we therefore developed a procedure which confines matching to the most important products. Only products that accounted for more than 1 percent of the gross value of output of an industry were considered for matching. Smaller items were only included when they matched a similar product of importance in the other country, or when they were required to complete a "match" with an important product.

The advantages of a systematic matching procedure is important, when one has to deal with:

—a large industry with many product items, for example, textiles or footwear and leatherware, and/or

—a technically complicated industry producing items difficult for a technically inexperienced researcher to characterize, for example motor vehicles or iron and steel.

In these cases, an important risk of mismatching occurs when a less systematic approach is used. For smaller, simpler industries the maximalist approach was used.

(e) *The Unit Value Approach is not Inferior to Specification Pricing*

It is sometimes suggested that unit values such as we derived from census information are inherently inferior to specification pricing as practiced by ICP, but we do not believe this to be the case.

Specification pricing involves meticulous characterisation of the items chosen as representative, whereas our "prices" are unit values derived by confrontation of census information on values and quantities of product. In practice the "products" may be a mix of items and qualities and be very far from the ideal of specification pricing, but there are compensatory advantages in the industry of origin approach:

(1) the unit values are average transaction values for the whole year for all producing locations of the countries compared, whereas ICP prices are quotes, shelf, list or monitored prices for one point in the year in a limited number of locations,

(2) with the census one can judge the representativity of the "unit values" which are selected from a much wider range of information than ICP had at its disposal. For instance, our 17 industry sample yielded 1,434 Mexican unit values from which 192 were chosen to match with the U.S.A., and 543 Brazilian unit values of which 171 were matched with the U.S.A. ICP, by contrast, had to use what it got from national statistical offices (at least for consumption goods). For Mexico it received only 284 of the much larger number of consumer prices it requested, as compared with 359 for Brazil and 571 for the U.S.A. (Kravis, Heston and Summers, 1982, p. 45).

Our unit value specification was particularly poor in the case of motor vehicles, largely because of census confidentiality rules. The census information was therefore supplemented in this case by using information on output and consumer price structures from trade sources. *Automotive News* provides figures furnished by trade associations from trade sources which are reasonably reliable (see the "Statistical Appendix" in Maddison and Van Ark, 1988). Producer prices would have been preferable to consumer prices, but the U.S. producer price index is based on information for only a limited number of models, and is as confidential as the census itself. Our method of handling the problem produced a reasonable, though not an optimal, adjustment for quality. In any case, we would stress that our approach is not inferior to that of ICP for this particular industry. As the ICP approach is a multilateral one, its products have to be "representative" in a global sense. ICP III used passenger car models which were characteristic across its 34 countries, and its comparison for Brazil/U.S.A. and Mexico/U.S.A. was based largely on Japanese and European models which were quite unrepresentative of the situation in these three markets.

(f) *The Adequacy of the Sample*

Our sample size (39 percent of Mexican, 33 percent of Brazilian and 20 per cent of U.S. value added) was certainly large enough to illustrate most of the methodological problems one is likely to encounter in this kind of study and to help elaborate pragmatic solutions to them. Except as noted under (g) below, the only failure in this respect was the problem of unique products, such as atomic weaponry, guided missiles and space vehicles, which are unique to the U.S.A. and for which it would be difficult to derive dummy Brazilian and Mexican prices. There are also industries which are not unique, but near enough to impede comparison (such as aircraft, computers, oil drilling and other specialized machinery). These unique and quasi-unique industries were about 7 percent of total U.S. manufacturing output in 1975. Otherwise, there are very few industries which are truly comparison resistant, particularly if one makes supplementary inquiries with trade associations (which we did for motor vehicles, paints, petroleum products and bricks) where there were national idiosyncracies in measurement units or gaps in the census due to confidentiality rules. From the point of view of our other objective of comparing output, productivity and PPP outcomes for the three countries, the results can always be improved by increasing the sample size, but we felt that there was already reasonable coverage of major

industry branches in Brazil and Mexico, and weaknesses only for food products and electrical machinery for the U.S.A.

(g) *Approaches to the Problem of Double Deflation*

The important unsolved problem in this study is that of double deflation. Virtually all analysts who have used the industry of origin approach have been unable to find separate PPP's for inputs. The double deflation approach is feasible for agriculture (van Ooststroom and Maddison 1985), but it was not feasible for manufacturing for these three countries, because the Brazilian and Mexican censuses give global value figures on inputs with no detailed quantitative information, and the U.S. census gives detailed figures only for energy consumption, contract work and inputs directly related to the production process.

In agriculture the difference between the gross output PPP's and the double deflated PPP's was rather small. For Brazil the 1975 PPP (Brazil quantity weights) was 7.35 cruzeiros to the U.S. dollar, 6.63 for inputs and 7.57 for value added. For Mexico the 1975 PPP (Mexican weights) was 13.46 pesos to the U.S. dollar, 13.68 for inputs and 13.36 for value added.

In manufacturing, inputs are much bigger in relation to gross output than in agriculture, but in the U.S.A. 60 percent of these are from manufacturing itself and in Mexico 48 percent. For manufacturing as a whole therefore, it does not seem *a priori* likely that the PPP's resulting from "double deflation" would be very different from those in our study, but for particular branches they might vary a good deal more.

Previous investigators who have discussed this problem, have been able to make only very partial adjustments for inputs. Paige and Bombach did this for fuel inputs on an aggregate basis, and Smith, Hitchens and Davies made some illustrative calculations (whose basis is not clear) for fuels and raw materials. However, a close look at the input-output tables which are available for Mexico (SPP, 1981) and the U.S.A. (U.S. Dept. of Commerce, 1984a and 1984b) shows that fuel and raw material inputs are only a small part of the problem in most industries.

Our analysis of the relation of census to GDP concepts of value added helps to clarify the nature of double deflation because it demonstrates the need to deal with all inputs. Further progress can best be made, when industry of origin studies such as the present one are available for all the major sectors of the economy, i.e. for agriculture, mining, manufacturing, utilities, construction and services. With this information and input-output tables for each of the countries under comparison, one can return to the problem of double deflation much better equipped to do a thorough job. In the case of Mexico and the U.S.A., input-output tables are available for the census years we covered, and the 1975 table for Brazil is due to be published soon, so for these three countries, this work should be feasible.

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