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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

Problems of Measuring Levels and Growth of Productivity in Manufacturing*

by Angus Maddison

I Problems in Measuring Productivity Levels

(i) Conceptual Problems in Making Value Comparisons in National Prices

The most readily collectable information on manufacturing output refers to physical product at producer prices. This kind of information is available in fairly comprehensive form in most censuses of production and can often be monitored successfully in intercensal years. This measure is usually called gross output, and refers to aggregate shipments by manufacturing establishments plus net changes in manufacturers' inventories.

However, this measure contains a good deal of duplication, and comparisons between countries on this basis can be misleading. In two countries producing a similar value added, the one with the most specialised plants will have a higher gross output because there will be more interplant shipments for intermediate processing.

In order to eliminate this type of duplication and other differences in the degree to which plants use external inputs, the concept of value added was developed, and has now become quite familiar to the general public, because tax systems, particularly in EC countries, use this concept to measure economic activity. With the value added concept, the intermediate inputs used by a manufacturing establishment are deducted before arriving at the measure of output.

Table 1 for Mexico shows how important this problem is for manufacturing. The first column shows GDP by industry of origin, which is equivalent to gross value added (gross in the sense that depreciation is not deducted). The second column shows inputs and the third column shows gross output of each sector. It is clear that manufacturing is the sector of the economy where intermediate inputs are biggest. In the Mexican case there were 409,750 million pesos of these inputs in 1975 for a gross output of 666,451 million pesos. Value added was only 256,701 million pesos or 38.5 per cent of gross output. This is a much lower share than for any other part of the economy so it is particularly important in productivity measures for manufacturing to work with an output concept which refers to value added.

In industrial censuses, it is feasible to get enough information from respondents to derive reasonable estimates of value added, but in intercensal years, this is often not possible, so the traditional annual indexes of manufacturing output are usually only proxy measures of value added. For benchmark years they have

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Table 1

Reconciliation of Production and Expenditure Approach to GDP - Mexico 1975

million pesos

	GDP by Industry of Origin	Intermediate Inputs	Gross Value of Output with Duplication	Imports c.i.f.	Distributive Costs (including import duty)	Intermediate Uses	Final Domestic Demand	Exports f.o.b.
Agriculture Forestry & Fishing	123,153	48,232	171,385	9,303	37,770	112,325	102,491	3,642
Mining	31,730	12,896	44,625	3,304	5,006	39,734	1,811	11,391
Manufacturing	256,701	409,750	666,451	69,921	273,538	419,491	567,909	22,510
Electricity	9,793	3,507	13,300	5	0	9,168	4,138	0
Construction	65,811	66,048	131,859	0	0	0	131,859	0
Commerce Restaurants & Hotels	277,033	44,849	321,882	0	0	275,706	46,177	0
Transport, Storage & Communication	62,612	30,539	93,151	2,751	0	54,092	39,527	2,283
Financial Services	104,286	12,436	116,722	3,028	0	44,312	72,843	2,595
Other Services	181,055	58,753	239,807	146	0	60,621	179,205	128
Total	1,100,050	699,133	1,799,182	105,821[a]	316,314	1,015,447	1,145,960	75,839[b]

a) includes 17,363 million pesos of imports going directly to final demand; b) includes 33,291 million of unallocated exports.

Source: Sistema de Cuentas Nacionales de Mexico, Tomo 1, Resumen General, pp. 106, 138. The figures include indirect taxes and subsidies.

value added weights, but for intercensal years reliance is placed on what are essentially measures of gross output.

In countries with sophisticated national accounts systems and multiple sources of information on economic activity from the income and expenditure side as well as from the viewpoint of production, measures of manufacturing value added at constant prices are often incorporated in the regular national accounts publications and are available annually. This is now true of most OECD countries. These measures are more complex than traditional indexes of manufacturing output, but are usually much less detailed.

One major problem which arises in reconciling the more detailed census type information and its associated indices of manufacturing value added with the national accounts, is that census definitions of value added are less sophisticated and less standardised.

Appendix I cites the definitions of value added according to "census" concepts and "national accounts" concepts. Whilst the "national accounts" concept is designed to avoid any duplication in the value added measure for the economy as a whole, the census concept is concerned mainly to avoid duplication of the measure of the industrial sector. However, the census concept of value added has very little legitimacy as a construct for avoiding duplication because manufacturing has very big inputs from the rest of the economy. There are large purchases of agricultural materials for food processing and large and increasing purchases of services such as advertising, accountancy, cleaning, transport, etc. In fact, one of the reasons why modern economies are apparently increasingly concentrated on services, is that manufacturers now purchase these services externally whereas they previously produced them within their enterprises.

For these reasons, the old "census" definitions of value added are becoming increasingly anachronistic. Furthermore, the definitions of census value added vary a good deal between countries.

Table 1

Value Added (National Census Concepts) Per Person Employed in 1975

in Brazil, Mexico and U.S.A.

	Brazil	Mexico	U.S.A.	India
Manufacturing Total	10,417	8,540	25,765	1178
Food and Beverage Products	9,245	7,445	31,538	582 (Food and Beverage and Tobacco combined)
Tobacco Products	16,486	36,703	56,388	
Textiles	7,133	6,992	17,663	827
Clothing	5,130[a]	4,086	12,149	968
Wood and Wood Products	5,715	4,256	17,612	597 (Wood and Furniture combined)
Furniture	5,899	4,088	15,884	
Paper & Allied Products	11,488	11,252	30,465	1434 (Paper and Printing combined)
Printing and Publishing	11,416	7,587	23,029	
Chemicals	46,063	15,122	56,435	2,682
Rubber and Plastic Goods	12,240	10,051	23,247	2,449
Leather and Leather Products	5,842[b]	4,396	13,280	939
Stone, Clay and Glass Products	7,569	7,746	25,210	893
Metal Products	11,105	10,357	25,766	1601
Machinery (except electric)	10,324	9,383	25,950	1,638
Electric Machinery & Equipment	12,742	8.030	22.864	2,077
Transport Equipment	11,026	9,399	28,248	1,347
Miscellaneous Manufactures	8,414	6,377	24,342	1,216

a) includes footwear; b) excludes footwear.

Source: Brazil from Censo Industrial 1975, "valor do transformacão" per person engaged; Mexico from Censo Industrial 1976: Datos de 1975, Resumen General, Tomo 1, "valor aggregado censal bruto" per person employed; USA from Annual Survey of Manufactures 1975-1976, Bureau of Census, US Dept. of Commerce, May 1979, "value added by manufacture" per person employed. Exchange rates from IMF, International Financial Statistics, Brazil 8.13 cruzeiros per US dollar, Mexico 12.5 pesos per US dollar, India 8.376 rupees per US dollar.

India net value added and employment from Annual Survey of Industries 1975-6, Summary Results for the Factory Sector, CSO, New Delhi, part II.

Table 2 compares the level of labour productivity in Brazil, India, Mexico and the U.S.A. by branch and for manufacturing as a whole in 1975 using national "census" concepts of value added. These concepts correspond to what is published in the UN Yearbook of Industrial Statistics, Vol. I, General Industrial Statistics.

Except for India, the census concepts in table 2 have a broader definition of output than the national accounts, i.e. not all intermediate inputs are deducted. However, the "census" definition of value added varies between countries. The Brazilian and U.S. definitions are fairly similar in that they deduct all raw materials, semi-finished goods, parts, containers, electric energy and fuels. But in Mexico the "census" concept of value added ("valor aggregado censal bruto") is netter because it excludes some other items e.g. sales commissions and advertising costs (see annex for definitions). In the case of India the industrial census definition of value added is the same as that used in the national accounts. However, Indian practice in both the census and the national accounts is to show "net" value added, i.e. net in the sense that depreciation is excluded, whereas the other countries' standard practice is to show gross value added.

In the case of India, Brazil and Mexico, the censuses do give enough information to derive a measure of value added equal to the national accounts concept, but this is unfortunately not the case with the U.S. census. Therefore if we wise to make standardised comparisons between these countries sticking entirely to the census, value added would have to be measured on a "U.S. census" basis. However, this is not a very desirable measure because it fails to deduct a wide range of purchased services (see Appendix 2 below on Brazilian census terminology for detailed reference). Even when the definitional cut-off is the same for all the countries, the degree to which such outside services are actually purchased by manufacturers will vary from country to country. In general, the U.S., which is a more sophisticated and specialised economy, has a manufacturing sector which purchases proportionately more of such outside services.

There is therefore a strong case for standardising on the national accounts measure of value added rather than on the cruder "census" concept.

Table 3

Value Added (National Accounts Concept) Per Person Employed in 1975 in Brazil, Mexico and U.S.A.

	U.S. dollars converted at official exchange rate			
	Brazil	Mexico	U.S.A.	India[c]
Manufacturing Total	8,954	8.236	18,240	1,336
Food and Beverage Products	7,430	7,219	18,657	) 656
Tobacco Products	15,490	36,287	37,342	)
Textiles	6,234	6,842	11,172	909
Clothing	4,546[a]	3,896	8,810	1,038
Wood & Wood Products	4,735	4,096	14,914	) 653
Furniture	4,975	3,917	11,464	)
Paper and Allied Products	9,481	11,000	21,449	) 1,616
Printing and Publishing	9,886	7,291	15,883	)
Chemicals	41,066	[illegible],417	28,256	3,235
Rubber and Plastic Goods	10,722	9,684	15,872	2,861
Leather & Leather Products	5,004[b]	4,254	9,769	1,018
Stone, Clay and Glass Products	6,217	7,536	17,417	1,036
Metal Products	9,190	9,973	20,625	1,869
Machinery (except electric)	9,036	9,007	19,786	1,815
Electric Machinery & Equipment	11,377	7,634	16,616	2,261
Transport Equipment	9,587	9,965	23,795	1,497
Miscellaneous Manufactures	6,956	6,110	15,601	1,322

a) includes footwear; b) excludes footwear: c) "factory" sector only

Source: Brazil and Mexico as for table 2, with output adjusted to a "national accounts" concept, along lines laid out in Appendix 2. U.S.A. output figures supplied by U.S. Dept. of Commerce, employment figures (full and part time employees plus self employed) from National Income and Product Accounts of the U.S., 1929-76, pp. 264 and 252. India net value added plus depreciation, and employment from Annual Survey of Industries 1975.76, Summary Results for the Factory Sector, CSO, New Delhi, Part II, pp. 2-3, in fact the output figures in this source for India differ very slightly from those in the national accounts, but as the adjustment is made on an employment coefficient in the national accounts, the productivity figures are identical. The Indian factory sector excludes firms of less than 20 employees (without power) and less than 10 employees with power.

Table 3 shows labour productivity for the four countries in terms of the national accounts concept of value added. In the case of Brazil, India, and Mexico, this measure of output was derived from census information, whereas for the U.S., the information was provided by the national accounts division of the U.S. Dept. of Commerce.

Although the overall ranking of the four countries is the same in table 3 as in table 2 (with the U.S. in first position, Brazil second, Mexico third, and India fourth), the productivity ratios are changed substantially. Thus in table 2 the productivity level in manufacturing as a whole in Brazil was 40 per cent of that in the U.S.A., whereas in table 3 Brazilian performance is higher, at 49 per cent of the U.S.A. Although in both tables the concepts of output are similar for Brazil and the U.S.A., the grosser census measure favours the U.S.A. because it has higher service inputs than Brazil. When these are deducted in a similar way for both countries, the U.S. advantage is smaller. When looking at manufacturing output in the context of the economy as a whole, the national accounts concept of value added is preferable because it eliminates duplication - the purchased services we deduct from manufacturing are already counted as output in the service sector.

Mexico's relative standing in table 3 improves more than that of Brazil. In table 3 Mexico's productivity in manufacturing as a whole is 45 per cent of the U.S.A., compared with 33 per cent in table 2. In the case of India, the improvement is bigger still, i.e. 7.3 per cent of the U.S.A. as compared with 4.5 per cent.

It should be mentioned that though the figures in table 3 represent the standardised national accounts definition of value added, they are not quite equivalent to the manufacturing contribution to GDP. The standard national accounts system recommended by the United Nations and used by most countries, involves a final global adjustment for all sectors for their use of banking services. In the case of Brazil, Mexico and the U.S.A. it is, however, possible to break down the use of bank services by industry branch, as shown in table 4. This does not have much impact on relative productivity standing.

Table 4

Value Added (National Accounts Concept Minus Bank Service Charges) Per Person Employed in 1975 in Brazil, Mexico and U.S.A.

US dollars converted at official exchange rate

	Brazil	Mexico	U.S.A.
Manufacturing Total	8,733	7,756	17,689
Food and Beverage Products	7,199	6,788	16,226
Tobacco Products	15,331	34,936	35,449
Textiles	5,959	6,372	10,831
Clothing	4,384	3,805	8,659
Wood and Wood Products	4,591	3,903	14,303
Furniture	4,782	3,859	11,239
Paper and Allied Products	9,196	10,246	20,908
Printing and Publishing	9,629	7,099	15,773
Chemicals	40,341	13,658	27,068
Rubber and Plastic Goods	10,448	9,390	15,358
Leather & Leather Products	4,735	4,111	9,470
Stone, Clay and Glass Products	6,094	7,036	16,892
Metal Products	8,940	9,277	20,106
Machinery (except electric)	8,884	8,256	19,411
Electric Machinery & Equipment	11,147	7,242	16,055
Transport Equipment	9,435	9,040	22,502
Miscellaneous Manufactures	6,849	5,847	15,208

a) includes footwear; b) excludes footwear

Source: As for Table 3

(ii) Employment Measures Appropriate for Productivity Analysis

There are two major sources of employment data which tend to be used in productivity estimates. One is the information derived in industrial censuses from establishments which report on the number of people they employ. Usually there is an attempt to get average employment for the year as a whole, but the information may refer to the situation at end year or at a specific reporting date. This information is gathered from the same establishments which report on output, and employment data of this kind are the most obvious source for estimates of manufacturing productivity, though there are some problems of how to treat headquarters staff, or in the fact that the information refers to job-holders and not persons. Insofar as people are multiple job holders, they will be counted more than once, but this is not likely to be a large problem. The biggest problem with this information is that it is not available on an annual basis.

The other major source of employment information is from household surveys such as population censuses or the recurrent labour force sample surveys which are now rather general in developed countries. This kind of information will not tally exactly with industrial census information, for several reasons. First of all, the respondents are private individuals replying for themselves and their family members, and they may not classify themselves in the same branch of activity as their employer would. There will be people with a marginal job attachment in the informal sector who will report on activity which the industrial census does not cover, and there may be people (family workers or self employed) who do not draw wages but report themselves to be employed. Of course, there will also be marginal workers of this kind who will not report on their activity in household surveys because they may wish to conceal some of their sources of income.

There is an increasing tendency for the national accounts to include estimates of employment by sector and for branches of manufacturing. In 1984 this practice was adopted in OECD national accounts, but there is as yet no clearly defined standard definition of employment in these accounts. In practice, national accountants merge both establishment and household sources of information together with social security and other

Table 5

Alternative Estimates of Employment in Manufacturing

	Industrial Census (000s)	National Accounts (000s)	Population Census
Brazil (1950)	1,145	n.a.	1,608
(1980)	4,839	n.a.	6,939
Mexico (1975)	1,648	2,002	n.a.
(1980)		2,422	2,575
		National Accounts (000s)	Labour Force Statistics (000s)
France (1980)		5,320	5,492
Germany (1980)		8,995	8,842
Japan (1980)		14,057	13,670
U.K. (1980)		7,038	7,085
U.S.A. (1980)		20,770	21,942

Source: OECD countries from OECD, National Accounts 1972-1984, Paris, 1986, and Labour Force Statistics 1964-1984, Paris, 1986.

administrative records. There are some discrepancies for OECD countries between this new source of employment information, and the series available in OECD Labour Force Statistics which are generally based on household or population surveys and are standardised according to ILO recommendations (see ILO, 1976).

Table 5 shows the two major sources of information on manufacturing employment which are most frequently used in international comparisons of labour productivity growth in OECD countries. There are still discrepancies between the two sources, and some differences between countries in the cut-off points for exclusion of young or old workers or people with a part-time or intermittent economic activity (see OECD, 1979), but the discrepancies are not really too disturbing in size.

In developing countries, the spread between the alternative employment figures used in productivity measurement can be much bigger than in the OECD countries cited in table 5. In Brazil the population census regularly shows figures for manufacturing employment over 40 per cent higher than does the industrial census. Perhaps because of this huge discrepancy, the Brazilian national accounts do not provide estimates of employment, but as their benchmark estimates of manufacturing output are taken directly from industrial census results, it would clearly be inappropriate to use the population census figures for manufacturing employment in combination with the national accounts measure of manufacturing output. However, the discrepancy in employment reporting does suggest that there may be a substantial amount of informal manufacturing activity which is not covered by the Brazilian national accounts and by the industrial census.

In Mexico, the national accounts do contain estimates of employment, based on a merger of information from different sources. The national accounts estimate of manufacturing employment is somewhat smaller than that of the population census, but is a good deal higher than the figures in the industrial census. For 1975, the national accounts figure for employment in manufacturing was 19.8 per cent higher than that in the industrial census.

Mexican National Accounts Estimates of Employment, Value Added, and Output per Employee as a Ratio of the Same Magnitudes as Recorded by the Industrial Census in 1975

	Employment	Value Added (National Accounts Concept)	Value Added Per Employee
Food Products	133.0	235.6	177.1
Beverages	136.0	154.8	113.8
Tobacco	109.2	100.6	92.1
Textiles	113.8	140.5	123.5
Clothing	123.7	266.4	215.3
Footwear & Leather	245.9	302.6	123.1
Lumber & Wood	176.9	205.5	116.2
Furniture & Wood Products	115.7	224.8	195.3
Paper & Allied Products	107.6	129.8	120.7
Printing & Publishing	112.5	121.1	107.6
Petroleum Refining & Petrochemicals	630.6	1,092.6	173.3
Chemicals & Allied Products	105.2	110.6	105.1
Rubber Products	117.1	132.1	112.8
Plastic Products	101.5	104.2	102.6
Stone, Clay & Glass Products	128.8	150.6	116.9
Iron & Steel	104.5	105.1	100.5
Other Primary Metals	72.9	78.9	108.2
Metal Products	92.8	101.0	108.9
Machinery, except Electric	103.1	107.8	104.6
Electrical Machinery & Equipment	108.7	120.8	111.1
Motor Vehicles & Equipment	102.4	108.5	106.0
Other Transport Equipment	98.6	102.1	103.6
Other Manufacturing	121.3	214.6	176.9
Total	121.5	151.3	124.5
Total excluding Petroleum refining and Petrochemicals	119.8	144.4	120.6

a) The national accounts figure includes petroleum refining and basic petrochemicals which are not included in the industrial census figure.

Source: The figures in the national accounts, Sistema de Cuentas Nacionales de Mexico Tomos I-VII, and particularly tomo III, vols. 1 and 2, SPP., Mexico, 1981, were compared with figures in Resumen General, X Censo Industrial, Datos de 1975, S.P.P., Mexico, 1979. The census figures we used were "Valor aggregado censal bruto" minus payments for patents, licenses etc., rental costs of machinery and other rental costs.

In fact the Mexican national accounts . make a large imputation for manufacturing output in the informal sector. As can be seen in table 6, the overall result in 1975 was to blow up the industrial census result by 44.4 per cent. This is a good deal more than the difference in employment levels between the two sources, which, if we are to interpret the differences in the two sources as an allowance for informal activity, shows that the implicit productivity level assumed for the informal sector is a good deal higher than in the formal sector.

One can conclude from our analysis so far:

a) that the national accounts concept of value added involves less duplication and is more standardised across countries than the census concept of value added;

b) that in OECD countries with sophisticated national accounts, one can use national accounts output and employment estimates for comparative analysis of productivity trends in manufacturing, and if one has reasonable estimates of purchasing power parity (see below) one can use this kind of source to compare productivity levels;

c) if one wants to compare manufacturing productivity levels in other countries, it is wise to stick to industrial census sources, which often provide enough information to adjust the output concept to a national accounts basis, and which are much more likely to have the necessary compatibility between the output and employment estimates than is the case when one conflates different sources of information on output and employment.

iii) Measurement of Output per Manhour

In labour productivity analysis it is desirable to make allowance for differences in hours worked. Over the past century, working hours per year in the advanced OECD countries have generally fallen by half and if we ignore this, the rise in productivity is understated. Similarly, there are significant differences in working hours between countries at a given point of time.

Information on working hours is not collected as a standard item in industrial censuses, and estimates are not provided in the national accounts, so that if a measure of output per man hour is required, it is necessary to merge employment data from one source with separate information from the special earnings and hours inquiries which are often conducted on a regular basis in developed countries (see Maddison, 1980)

Table 7 shows the outcome of such a data merge in estimates of working hours in OECD countries. The complexity of the problem is clear when one remembers the multiple dimensions of working time with substantial differences in national practice on the length of vacations and sickness absence as well as differences in the length of the standard working day, overtime etc. It is clear from the table that working time is a good deal longer in Japan than in the European countries or the U.S.A.

Unfortunately information of this kind is much scarcer for developing countries, but information on Mexico, where, in 1983, average working hours were 44.11 per week suggests that annual working hours there are substantially higher than in the U.S.A., and not too far below those in Japan. Therefore, all we can conclude in relation to the comparisons of output per employee in Brazil, Mexico and the U.S.A., is that they are probably less favourable to the U.S.A. than output per man hour figures would be.

Table 7

Breakdown of Analysis of Average Time Worked Per Person in Developed Countries in 1983

	Number of Days in Year	Weekend Days Off	Public Holidays	Vacations	Sickness Strikes Bad Weather & Other Absence	Days Worked	Net[a] Hours Worked Per Day	Hours Worked Per Year
France	365.0	105.0	10.0	30.0	14.0	206.0	7.570	1,560
Germany	365.0	105.0	9.0	29.1	10.5	211.5	7.953	1,682
Japan	365.0	62.3	12.0	12.0	8.0	267.8	7.956	2,131
U.K.	365.0	105.0	8.0	25.0	21.2	205.8	7.344	1,512
U.S.A.	365.0	105.0	9.0	11.4	8.4	231.3	7.000	1,619

a) includes impact of overtime, involuntary short-time and voluntary part-time working.

Source: Maddison (1987).

(iv) Comparisons at Exchange Rates versus comparison at Purchasing Power Parity

Although table 3 is satisfactory on the conceptual level it still suffers from the disadvantage that the output levels are converted into a common unit in terms of the official exchange rate. It is well known that the purchasing power of a currency can differ substantially from the exchange rate, and this has led to a number of sophisticated efforts to produce "purchasing power parity" ratios. The International Comparison Project (ICP) of the United Nations is the best known of these efforts and has now gone through 4 phases, see Kravis and Associates (1975), (1978) and (1982), and UN (1986). These studies are based on elaborate collection of price data for comparable items of final demand (see penultimate column of table 1 above for Mexico), which enables a revaluation of one country's output in another country's prices, or measurement of GDP levels of several countries in a common set of prices.

Although these comparisons of real GDP are a great improvement on comparison at exchange rates, they are available only for expenditure categories like consumption and investment and not for sectors of output such as manufacturing. Some authors have tried to derive proxy PPPs for production sectors by reweighting some of the commodity PPPs in ICP type studies, e.g. Kuznets (1972), Jones (1976), Prais (1981), Nodt (1954) Roy (1982), and Jorgenson, Kuroda, and Nishimizu (1986), but this is a dubious procedure. One can see how dubious it is by looking at table 1; what these short-cut procedures are doing is using prices derived from column 7 of the Mexican table to apply as proxies for column 1.

It is therefore highly desirable to measure real levels of output and purchasing power parities across countries directly by comparing the detailed information in the censuses of manufacturing for benchmark years.

Over the past four decades, there have been significant studies which have included international comparisons of levels of output in manufacturing (see table 8). The most ambitious of these in terms of sample size were the estimates of Paige and Bombach (1959), and Smith, Hitchens and Davies (1982). The others generally covered somewhat less than a quarter of manufacturing employment or output. Only three of them (Rostas, Paige and Bombach, Maddison, van Ark and Blades) give detailed information on methods of calculation but they all make use of census of manufactures material. They are all restricted to two or three countries, except Shinohara who managed to cover 89 countries, using UN industrial production figures with weights drawn from the British, Japanese and US censuses of manufactures. The Maddison (1970) study which covered 29 countries was derived from Shinohara's estimates.

Table 8

14 Studies of Real Output Levels in Manufacturing

Author	Number of Separately Specified Items	Size of Sample	Country Coverage	Reference Years
Rostas (1948)	29 industries[a]	22 percent of 1937 US employment	UK/USA	1935-9
Maddison (1952)	12 industries	15 percent of 1935 Canadian employment	Canada/UK/USA	1935
Frankel (1957)	34 industries	18 per cent of 1947 US employment	UK/USA	1947-8
Paige and Bombach (1959)	150 industries	substantial	UK/USA	1950
Shinohara (1966)	53 commodities	not clear	89 countries	1958
Mensink (1966)	10 industries	14 per cent of UK 1958 employment	Netherlands/UK	1958
Kudrov (1969)	11 branches	substantial	USSR/USA	1963
Maddison (1970)	all manufacturing	substantial	29 countries	1965
West (1971)	30 industries	not stated	Canada/USA	1963
Yukizawa (1978)	60 commodities	20-23 percent of US employment	Japan/USA	1958-72
Prais (1981)	10 industries	28 percent of UK 1973 net output	Germany/UK/USA	circa 1970
Smith, Hitchens and Davies (1982)	117 industries	substantial	Germany/UK/USA	1967-8
Blades (1982)	54 commodities	not stated	USSR/USA	1970, 75, 78
Maddison, van Ark and Blades (1986)	10 industries	20 per cent of value added in Brazil, 26 percent in Mexico, 12 percent in USA	Brazil/Mexico/USA	1975

a) Rostas actually presents figures for 31 industries, but for machinery his value figure is simply an exchange rate conversion, and for steelworks he simply quotes a preliminary estimate by D.L. Burn whose mode of calculation is not described.

Table 9

International Comparisons of Real Output Levels Using Exchange Rates or PPP Proxies

EXCHANGE RATE COMPARISONS

Sadler and Grossman (1982)	Output per Man Hour and Joint Factor Productivity, main economic sectors and 10 branches of manufacturing in U.S.A. and Japan. 1970-80 in 1975 prices converted to U.S. dollars at 1975 exchange rates
Sadler (1986)	Updates former to 1983.
Asian Productivity Organisation (1986)	Output per Employee in main economic sector (including manufacturing as a whole) for 12 Asian countries, 1971-83 in 1975 prices converted to U.S. dollars at 1975 exchange rates.
U.S. Bureau of Labor Statistics	Periodic Reports on manufacturing output per man hour in 12 OECD countries.

PROXY COMPARISONS

Kuznets (1972)	Used reweighted OEEC and ECLA expenditure PPPs to estimate sector PPPs for large groups of countries.
Jones (1976)	Used reweighted Kravis *et al.* (1975) expenditure PPPs to derive sector PPPs.
Prais (1981)	Used reweighted Kravis *et al.* (1975) expenditure PPPs to derive PPPs for 10 manufacturing industries in Germany, U.K. and U.S.A.
Roy (1982)	Used reweighted Kravis *et al.* (1978) expenditure PPPs to derive sector PPPs
Klodt (1984)	Applied Kravis *et al.* (1978) PPPs to 16 branches of manufacturing for Germany, Japan and U.S.A. 1960, 1970 and 1978.
Jorgenson, Kuroda and Nishimizu (1986)	Applied "remapped" Kravis *et al.* (1975, 1978) PPPs to estimate productivity differentials in Japan and U.S.A. 1960-79.

All these studies used the "single" indicators approach, i.e. they generally compared quantities of output weighted by value added. Paige and Bombach give a good deal of space to a discussion of the alternative "double" indicator method, i.e. separate measurement of output and inputs, but they use it only for agriculture and part of transport. For manufacturing they use "single" indicators with a global adjustment for fuel inputs for 8 consolidated branches. West (1971) and Yukizawa (1978) made similar global adjustments of this kind, and Smith, Hitchens and Davies (1982) experiment with them. Maddison, van Ark, and Blades (1986) also found it impossible in practice to use the double indicator approach for manufacturing, but made extensive adjustments for differences in inputs, using ratios at national prices from census material.

It is clear from these past studies that an attempt to use the double indicator approach in a broad comparison for a number of countries would involve a monumental amount of work because censuses of production in different countries give different degrees of detail, different measurement units, often refer to different years, and define industry boundaries differently for a huge and heterogeneous number of products. Analysis of this information for the double indicator approach cannot be mechanised but requires careful labour-intensive research by skilled investigators. In practice therefore, large scale comparisons must continue to be based on the single indicator method, with crosschecks on intercountry input-output variations for sample products from national input-output tables and from the branch ratios of value added to gross output which are published in Volume I of the UN Industrial Statistics Yearbook.

It is also clear that the coverage of the industrial sample cannot be nearly so comprehensive as is possible for agriculture. On the basis of past experience it would seem that a minimum coverage of 20 per cent of manufacturing value added would be feasible and acceptable, and the sample should include items from as many of the 28 ISIC branches specified in the UN Yearbook of Industrial Statistics, as possible.

Until more comprehensive work is done to refine international comparisons of productivity levels on the lines of the studies listed in table 8, many analysts will continue to use exchange rate comparisons or proxy comparisons of the type listed in Table 9.

Table 10

Value Added (National Accounts Concept) Per Employee in Brazil, Mexico and U.S.A. in 1975 at Exchange Rate and Adjusted for Real Purchasing Power

All Manufacturing

	Brazil	Mexico	U.S.A.
Value Added (National Accounts Concept) per Employee, US dollars converted at exchange rate	8,954	8,236	18,240
Productivity Ratios (at exchange rates, USA = 100)	49.1	45.2	100.0
Exchange Rate (national units per $)	8.13	12.50	1.00
Purchasing Power of Currency over a Sample of Manufacturing Industries	6.24	11.80	1.00
Ratio of Exchange Rate to PPP	130.3	105.9	1.00
Value Added (National Accounts Concept) Per Employee, US dollars at PPP rate	11,667	8,721	18,240
Productivity Ratios (with PPP adjustment)	64.0	47.8	100.0

10 Industry Sample

	Brazil	Mexico	U.S.A.
Percent of Gross Output	21.6	26.4	15.7
Percent of Value Added (US Census Concept)	20.2	26.3	12.2
Percent of Value Added (National Accounts Concept)	20.2	26.3	12.2
Value Added (National Accounts Concept) per Employee, US dollars converted at exchange rate	9,220	11,579	22,397
Productivity Ratios (at exchange rate USA = 100)	41.2	51.7	100.0
Ratio of Sample to Average Productivity	103.0	140.6	122.8

Source: Maddison, van Ark and Blades (1986)

Table 10 shows the outcome of a recent direct study (Maddison, van Ark and Blades, 1986) of PPPs and real productivity levels for manufacturing in Brazil, Mexico and the U.S.A. and applies the sample results to estimate real productivity levels for manufacturing as a whole. The results must be regarded as preliminary but they indicate rather conclusively that international comparison based on exchange rates can be misleading, for in Brazil the PPP differs from the exchange rate by a rather significant margin of 30.3 per cent.

The implication of these results is that average manufacturing productivity in Brazil was 64 per cent of U.S. levels in 1975, and in Mexico 48 per cent of U.S. levels.

It is at first sight surprising that real productivity levels in Brazilian and Mexican manufacturing are as high as they appear in table 10, but 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 advanced OECD countries.

This is clear from table 11 which shows Brazilian productivity in manufacturing to be two and threequarters times as high as in the rest of the economy, and Mexican productivity twice as high. In the five OECD countries in Table 11, the differences between manufacturing and non-manufacturing productivity levels are very modest, and, in Germany and the U.K., manufacturing levels are actually lower than the average for the rest of the economy. In this OECD group, Japan is the extreme case, with a productivity level in manufacturing a quarter above that in the rest of the economy, but the Japanese situation is closer to the OECD norm than it is to the two Latin American countries.

There are several reasons for this relatively high level of manufacturing productivity in Brazil and Mexico, and, one might infer, in developing countries in general, as distinct from the advanced group.

One reason 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, for productivity spreads within manufacturing are biggest in such countries (see last column of table 11). However, a large part of industrial

Table 11

Comparative Characteristics of Manufacturing Activity in 1980

	Manufacturing Share of GDP at Factor Cost	Labour Productivity Level in Manufacturing Relative to Non-Manufacturing	Range of Labour Productivity Levels Between Major Branches of Manufacturing
Brazil	27.1	278.8	9:1
Mexico	22.8	199.9	9:1
France	27.8	119.8	4:1
Germany	33.9[a]	97.1	3:1
Japan	28.2	124.6	7:1
U.K.	26.0	91.2	n.a.
U.S.A.	21.3	102.0	4:1

a) The German definition of manufacturing is somewhat broader than in the other countries with respect to repair services and quarrying.

Source: Brazil, output from Contas Nacionais do Brasil: Metodologia e Tabelas Estatisticas, Vargas Foundation, Rio 1984, employment in manufacturing from IBGE, Censo Industrial, Dados Gerais, 1980, Rio, 1984, non-manufacturing employment from Anuario Estastico do Brasil, IBGE, Rio, 1985. Last column derived from table 3 above. Mexico, INEGI, Sistema de Cuentas Nacionales de Mexico: Principales Variables Macroeconomicas, Periodo 1970-1982, Mexico, 1983 and last column from table 3 above. U.S.A. from U.S. Dept. of Commerce, Survey of Current Business and table 3 above. Other countries from OECD, National Accounts 1972-1984, Paris, 1986.

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 Latin American manufacturing is the importance of policies which protect domestic markets and which subsidise capital inputs. As a result, scarce capital is funnelled by priority towards industry. These policies are probably operative to a greater degree in Latin America than in the OECD countries.

The third reason for relatively high manufacturing productivity in Latin America is the backward character of an important part of non-manufacturing. In the two Latin American countries, the continued existence of a large low productivity agriculture explains a good deal of the backwardness of non-manufacturing productivity.

There is a general habit of referring to the 5 OECD countries in Table 11 as "industrialised", in contrast to the situation in developing countries, but in terms of output shares, these OECD countries are not predominantly oriented towards "industry". On average, manufacturing output represented only 27.4 per cent of their GDP in 1980, which is the same situation as in Brazil. In Mexico, manufacturing activity is relatively smaller than in Brazil, but it is slightly higher than in the U.S.A. However, the distinction between the two groups of countries is much more marked for employment than for output. In Brazil and Mexico, the share of manufacturing in total employment is markedly lower than its share of output.

II Techniques for Analysing Growth Performance

Most of the measurement problems we have discussed in connection with measuring productivity levels across countries apply in some degree to measuring productivity growth over time, particularly if the analysis is intended to be comparative. In general, however, the measurement problems are easier than with the level comparisons, because national statistical authorities have devoted more effort to refining the information and concepts for measuring development over time of their national economies than they have to standardisation for purposes of international comparison .

Table 12 presents some summary estimates of the growth of output, employment and output per employee in manufacturing in our two Latin American economies and five OECD countries. Manufacturing output and employment have on average grown faster in the two Latin American countries but productivity performance has been weaker than in some OECD countries.

It is true that the two Latin American countries have been high growth performers and have participated in the postwar "catch-up" or convergence process in the sense of narrowing the gap between themselves and the lead country, the U.S.A., but they have been hampered by two major considerations:

a) a considerable part of the effort they have made to accumulate capital and accelerate the growth in their capital stock has been absorbed by "capital-widening", (i.e. provision of productive facilities for new workers), and less has been available for "capital-deepening", which is fundamental for the growth of labour productivity. Unfortunately, lack of capital stock estimates for the two Latin American countries makes this difficult to quantify, but the close correlation between capital accumulation and growth is very clear in Table 13.

b) Unlike Japan, Latin American countries have a labour force with much lower levels of education than the lead country, so that they would have faced great skill bottlenecks if they attempted to replicate the Japanese scale of capital accumulation. Even though average education levels are increasing fast (as is clear from table 14) the gap between the Latin American and OECD situation is still very big.

Table 12

Comparative Growth of Manufacturing Output, Employment and Output per Employee Since 1950

annual average compound growth rates

	Manufacturing Value Added (National Accounts Concept) at Constant Prices	Manufacturing Employment	Manufacturing Output Per Employee
Brazil (1950-80)	8.4	4.9	3.3
Mexico (1950-80)	7.9	3.1	4.6
France (1950-84)	5.1	0.2	4.8
Germany (1950-84)	5.5	0.8	4.6
Japan (1950-84)	11.6	3.0	8.4
U.K. (1950-84)	1.8	- 0.9	2.8
U.S.A. (1950-84)	3.2	0.7	2.5
Five Country (OECD) Average	5.4	0.8	4.6

Source: Brazil and Mexico from national sources, OECD countries from US Bureau of Labor Statistics, Office of Productivity and Technology, July 30, 1986.

Table 13

Rates of Growth of Capital Stock, Employment, Capital Per Employee, GDP, and GDP per Employee

annual average compound growth rates

	Gross Fixed Non Residential Capital Stock	Employment	Capital per Employee	GDP	GDP per Employee
France (1950-84)	4.1	0.3	3.8	4.2	3.8
Germany "	4.9	0.5	4.4	4.5	4.0
Japan "	8.5	1.4	6.9	7.5	6.0
U.K. "	3.1	0.2	2.9	2.4	2.2
U.S.A. "	3.3	1.7	1.6	3.3	1.6
Brazil (1950-80)	n.a.	3.1	n.a.	7.3	4.0
Mexico (1950-80)	n.a.	2.9	n.a.	6.6	3.6

Source: O.E.C.D. countries from Maddison (1987). Brazil and Mexico from national statistics. The above figures are for the economy as a whole and not for manufacturing.

Table 14

Average Years of Primary and Secondary Education Per Employee

	1950	1980
Brazil	1.8	3.9
Mexico	2.3	4.4
France	8.0	9.6
Germany	8.4	9.2
Japan	8.0	10.3
U.K.	9.3	10.3
U.S.A.	9.0	10.7

Source: All estimates are ultimately derived from population censuses. Brazil 1950 from C.G. Langoni, Distribucâo de Renda e Desenvolvimento Economico do Brazil, Expressâo e Cultura, Rio, 1978, p. 67, 1980 from Censo Demografico 1980, Mexico 1950 from Marcelo Selowsky, "Education and Economic Growth, Some International Comparisons" Chicago Ph.D. thesis, 1967. 1980 from INEGI, X Censo General de Poblacion y Vivienda, 1980, Resumen General Abreviado, Mexico 1984, p. 51. Other countries from OECD, Education, Inequality and Life Chances, Paris, 1975, and underlying worksheets for that study.

It is clear from the rather simple aggregative figures in tables 12-14, that quite a lot of interesting and policy-relevant insights can be obtained from comparative growth analysis, even in situations where the measures of intercountry levels of performance are not strong. In the past twenty years there has been a revolution in the techniques of comparative growth analysis for developed countries, which is based on improvements in basic data on output, employment, and capital stock, and changes in the quality of inputs, e.g. improvements in the quality of education. A "joint factor productivity" approach was first developed in a major empirical study for the U.S.A. by Kendrick (1961), and was expanded into a broader concept of growth accounting on an international scale by Denison (1967). Important contributions to a disaggregated approach for individual branches of manufacturing have been made by Jorgenson and his associates (see Gollop and Jorgenson, 1980; and Jorgenson, Kuroda and Nishimizu, 1986). At the heart of the new growth accounting approach is the notion of joint factor productivity i.e. a broadening of old-fashioned labour productivity analysis to incorporate the role of capital. Statistical information for manufacturing has now reached a stage where it is reasonable to take seriously the possibility of applying these new modes of analysis on a disaggregated level.

We can illustrate this as follows:

In measuring labour productivity levels, we need information on value added (O) and labour input (L), which may be measured either in employment terms or man hours. Thus the labour productivity level (π) is equal to value added (O) divided by labour input (L):

$$\pi = \frac{O}{L}$$

When we turn from this to measure labour productivty <u>growth</u>, we have to divide the change in output by the change in labour input (from the base year "1" to the end year "n"):

$$\frac{\pi_n}{\pi_1} = \frac{O_n}{O_1} \div \frac{L_n}{L_1}$$

In order to summarise the results, it is handy to express the growth of labour productivity, output and inputs as compound rates, putting dots over the symbols to indicate this, as follows:

$$\dot{\pi}^1 = \dot{O} - \dot{L}$$

When capital stock (K) estimates are available they can be introduced into the explanatory schema, and we can measure capital productivity, as follows:

$$\dot{\pi}^2 = \dot{O} - \dot{K}$$

The next step is to combine labour and capital together in measures of joint factor productivity:

$$\dot{\Pi}^3 = \dot{O} - a\dot{L} - (1 - a)\dot{K}$$

In order to incorporate both of these factors (labour, and capital) jointly into the analysis, they are each given weights (a) and (1- a) which are their shares in value added in some benchmark year, or for an average of years.

An illustrative application of this type of analysis is shown in tables 15-19 for the U.S.A., disaggregated for 21 branches of manufacturing, and using the newly available estimates of capital stock by branch. This same type of analysis is now feasible for Germany, Japan and the U.K. as well, thanks to the development of estimates of capital stock, but it is not yet feasible for many OECD countries in this disaggregated form, nor is is possible for developing countries, though there are a number of more aggregative studies for developing countries which use a similar growth accounting approach (Langoni (1974) for Brazil, Selowsky (1967) for Mexico, Chile and India, Dholakia (1974) for India, and Kim and Park (1985) for Korea).

In terms of the symbols used above, table 15 provides a measure of O in year 1 (1950) and year n (1980), and also of $\dot{O}$, the compound growth rate from year 1 to year n. Table 16 shows employment, L in the two benchmark years, as well as information on the length of the working week in the two benchmark years. These figures on employment and weekly hours can be combined into a crude measure of labour input in terms of working hours (with for the correction for the number of weeks or days worked per year, which we made in table 7); when this is done we can measure $\dot{L}$ in the second column of table 18. Labour productivity $\dot{\Pi}^1$ is shown in the third column of table 18.

Table 17 shows gross capital stock (K) for the two benchmark years and the compound growth rate between the two benchmark years, $\dot{K}$. This latter magnitude is also reproduced, with 2 decimals, in column 4 of table 18. Capital productivity ($\dot{\Pi}^2 = \dot{O} - \dot{K}$) is shown in the fifth column of table 18.

In order to calculate joint factor input, the labour inputs (column 2 of table 18) are multiplied by the labour shares (the last column of table 16), and the capital inputs (column 4 of table 18) are multiplied by the reciprocal of the labour shares. Thus in food and kindred products $\dot{L}$(-0.15) is multiplied by .7151 and $\dot{K}$(1.57) is multiplied by .2849, which, when added together, is equal to the 0.34 shown in the sixth column of table 18.

The final column of table 18 shows the growth of joint factor productivity $\dot{\pi}^3 = \dot{O} - a\dot{L} - (1-a)\dot{K}$.

In all cases the growth of joint factor productivity is slower than the growth of labour productivity, because capital input has in all cases grown faster than labour input, and capital inputs indeed grew faster than output in 17 out of the 21 industries. The nature of technical progress was always labour saving, as there were no cases where labour productivity declined over this 30 year period. In general, technical progress tends to be capital neutral (see table 13) but, in the US case, capital productivity was mostly negative for 1950-80, partly because 1980 was a year of recession in which capacity use was abnormally low.

In growth accounting practice, the next step after estimating joint factor productivity, is to augment the estimate of labour ($\dot{L}$) by analysing the impact of educational improvements (see table 14) on the quality of labour inputs. This can be done by weighting employees with different qualifications by the earnings differentials which are associated with different levels of education. There may also be adjustments for other differences in labour "quality" as measured by age and sex structure, which are also weighted by the associated earnings differentials. Those growth accounting analysts who feel that a significant part of technical progress is realised through "embodiment" of technology in the capital stock, will also make adjustments for differences in the quality of capital stock over time because of improvements in technology which make successive vintages of capital formation more productive.

Thus we arrive at a fourth measure:

$$\dot{\pi}^4 = \dot{O} - a\dot{L}* - (1-a)\dot{K}*$$

of "augmented" joint factor productivity, in which the asterisk (*) indicates that each of the two production factors has been weighted to allow for quality change, e.g. in the education of labour, or successive vintages of capital.

The final stage in growth accounting is to add supplementary elements of causal explanation which are not related to labour and capital inputs.

There may be quite a variety of these supplementary elements which can be accommodated within a growth accounting framework, e.g. allowance for economies of scale, for structural change, for the big changes in the price of energy inputs which followed the two OPEC shocks, or for the drag on productivity arising from government regulations to reduce pollution or increase safety.

After allowing for these supplementary influences we arrive at a fifth and final measure of productivity growth:

$$\dot{\Pi}^5 = \dot{O} - a\dot{L}* - (1-a)\dot{K}* - \dot{S}$$

where (S) refers to the impact of these supplementary influences. This final $\dot{\Pi}^5$ is usually called the "residual" and is often taken as a very crude proxy measure for unembodied technical progress.

Table 15

Value Added (National Accounts Concept) in US Manufacturing

1950-80 in 1972 Prices

	1950 $ million	1980 $ million	1950-80 Annual Average Compound Growth Rate
Food & Kindred Products	14,973	33,566	2.7
Tobacco Products	2,452	4,337	1.9
Textile Mill Products	4,074	10,795	3.3
Apparel, Other Textile Products	5,406	12,262	2.8
Lumber & Wood Products	4,593	10,653	2.8
Furniture & Fixtures	2,483	5,426	2.6
Paper & Allied Products	5,090	12,863	3.1
Printing & Publishing	7,200	16,983	2.9
Chemicals, Allied Products	5,582	28,774	5.6
Petroleum and Coal Products	3,471	7,858	2.8
Rubber, Miscellaneous Plastic Products	2,642	11,224	4.9
Leather & Leather Products	2,079	2,126	0.1
Stone, Clay, Glass Products	5,420	10,304	2.2
Primary Metal Industries	17,245	20,390	0.6
Fabricated Metal Products	9,835	24,333	3.1
Machinery, Except Electric	13,418	44,275	4.1
Electric, Electronic Equipment	5,573	39,826	6.8
Motor Vehicles & Equipment	10,775	21,291	2.3
Other Transportation Equipment	4,166	16,825	4.8
Instruments, Related Goods	2,185	11,422	5.7
Miscellaneous Manufactured Goods	2,403	5,455	2.8
Total	131,065	350,988	3.3

Source: Information supplied by U.S. Dept. of Commerce.

Table 16

Employment, Weekly Hours, and Labour Share of Value Added in U.S. Manufacturing

	Employment (000s) 1950	Employment (000s) 1980	Weekly Hours 1950	Weekly Hours 1980	Share of Labour Compensation (Wages & Salaries plus Supplements) in Gross Value Added at Factor Cost in 1950 (Percent)
Food & Kindred Products	1,779	1,712	41.5	39.7	71.51
Tobacco Products	97	68	37.9	38.1	49.90
Textile Mill Products	1,256	850	39.6	40.1	79.98
Apparel, Other Textile Products	1,201	1,267	36.4	35.4	88.59
Lumber & Wood Products	822	695	41.0	38.6	66.15
Furniture & Fixtures	359	457	41.9	38.1	80.54
Paper & Allied Products	485	691	43.3	42.3	59.50
Printing & Publishing	740	1,258	38.8	37.1	76.60
Chemicals, Allied Products	621	1,115	41.5	41.5	48.28
Petroleum & Coal Products	217	203	40.9	41.8	77.27
Rubber, Miscellaneous Plastic Products	323	727	40.9	40.1	86.61
Leather & Leather Products	396	236	37.6	36.7	92.14
Stone, Clay, Glass Products	551	666	41.2	40.8	64.77
Primary Metal Industries	1,188	1,151	40.8	40.1	65.45
Fabricated Metal Products	1,086	1,614	41.4	40.4	74.06
Machinery, Except Electric	1,217	2,485	41.8	41.0	71.21
Electric, Electronic Equipment	964	2,107	41.1	39.8	72.76
Motor Vehicles & Equipment	801	798	(41.0 (combined with Other Transportation Equipment)	(40.6 (combined with Other Transportation Equipment)	52.62
Other Transportation Equipment	454	1,106			82.96
Instruments, Related Goods	272	707	41.2	40.5	82.89
Miscellaneous Manufactured Goods	403	424	41.0	38.7	54.03
Total	15,232	20,337	40.5	39.7	69.82

Source: Employment (full and part-time) from National Income and Product Accounts of the United States 1929-76, U.S. Dept. of Commerce, 1981 and Survey of Curren Business, U.S. Dept. of Commerce. Weekly hours of production and non-supervisory workers from Monthly Labor Review, U.S. Dept. of Labor, August 1952 and October 1981. Labour share derived from information supplied by the U.S. Dept. of Commerce.

Table 17

End Year Gross Capital Stock in Constant 1982 Dollars

1950-80 in U.S. Manufacturing

	1950 $ billion	1980 $ billion	Annual Average Compound Growth Rate 1950 - 80
Food & Kindred Products	70.1	112.0	1.6
Tobacco Products	2.2	5.9	3.3
Textile Mill Products	30.0	38.0	0.8
Apparel, Other Textile Products	3.9	12.4	3.9
Lumber & Wood Products	10.3	32.2	3.9
Furniture & Fixtures	3.9	9.9	3.2
Paper & Allied Products	22.7	77.2	4.2
Printing & Publishing	12.3	39.7	4.0
Chemicals, Allied Products	41.0	158.6	4.6
Petroleum & Coal Products	28.4	76.3	3.4
Rubber, Miscellaneous Plastic Products	7.5	39.2	5.7
Leather & Leather Products	2.5	3.0	0.6
Stone, Clay, Glass Products	19.7	52.7	3.3
Primary Metal Industries	54.4	159.1	3.6
Fabricated Metal Products	17.6	76.3	5.0
Machinery, Except Electric	26.1	105.0	4.8
Electric, Electronic Equipment	13.4	78.8	6.1
Motor Vehicles & Equipment	20.0	80.5	4.8
Other Transportation Equipment	9.9	44.9	5.2
Instruments, Related Goods	3.7	22.0	6.1
Miscellaneous Manufactured Goods	4.4	12.9	3.7
Total	404.0	1,236.4	3.8

Source: Musgrave (1986). In simple terms, the method is as follows: the capital stock estimates are built up separately for each category of assets with a different life expectation, by cumulation of annual investments at constant prices (the perpetual inventory technique). When an asset reaches its normal service life it is dropped from the gross capital stock (i.e. allowance is made for capital retirement). In the alternative, net capital stock estimate, allowance is made annually for the depreciation of each asset, instead of the retirement assumption characteristic of the gross stock measure.

Table 18

Growth Accounts for U.S. Manufacturing 1950-80

annual average compound growth rates

	Value Added at Constant Prices	Labour Input	Labour Productivity	Capital Input	Capital Productivity	Joint Factor Input	Joint Factor Productivity
Food & Kindred Products	2.72	- 0.15	3.01	1.57	1.13	0.34	2.38
Tobacco Products	1.92	- 1.16	3.11	3.34	- 1.38	1.09	0.83
Textile Mill Products	3.30	- 1.25	4.61	0.79	2.49	- 0.84	2.46
Apparel, Other Textile Products	2.77	0.09	2.68	3.93	- 1.12	0.53	2.24
Lumber & Wood Products	2.85	- 0.76	3.63	3.87	- 0.99	0.75	2.10
Furniture & Fixtures	2.64	0.49	2.14	3.15	- 0.50	1.00	1.64
Paper & Allied Products	3.14	1.10	2.01	4.16	- 0.99	2.33	0.81
Printing & Publishing	2.90	1.63	1.25	3.98	- 1.04	2.18	0.72
Chemicals, Allied Products	5.62	1.97	3.57	4.61	0.96	3.33	2.29
Petroleum & Coal Products	2.76	- 0.15	2.92	3.35	- 0.57	0.64	2.12
Rubber, Miscellaneous Plastic Products	4.94	2.67	2.21	5.67	- 0.69	3.07	1.87
Leather & Leather Products	0.07	- 1.79	1.90	0.61	- 0.53	- 1.60	1.67
Stone, Clay, Glass Products	2.16	0.60	1.55	3.33	- 1.13	1.56	0.60
Primary Metal Industries	0.56	- 0.16	0.72	3.64	- 2.98	1.16	- 0.60
Fabricated Metal Products	3.06	1.25	1.80	5.01	- 1.85	2.23	0.83
Machinery, Except Electric	4.06	2.34	1.68	4.75	- 0.66	3.04	1.02
Electric, Electronic Equipment	6.77	2.53	4.13	6.08	0.65	3.50	3.27
Motor Vehicles & Equipment	2.30	- 0.05	2.35	4.75	- 2.34	2.22	0.08
Other Transporation	4.77	2.98	1.74	5.17	- 0.38	3.35	1.42
Instruments, Related Goods	5.66	3.18	2.41	6.12	- 0.43	3.69	1.97
Miscellaneous Manufactured Goods	2.77	- 0.02	2.79	3.65	- 0.85	1.67	1.10
Total	3.34	0.90	2.42	3.76	- 0.44	1.76	1.58

Source: Derived from Tables 15 & 17.

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Appendix 1

United Nations Definitions of Value Added

Abstract of paras. 162-7 of United Nations, Statistical Papers, Series M No. 71 (Part 1), Recommendations for the 1983 World Programme of Industrial Statistics, Part One, General Statistical Objectives, New York, 1981

"Value added is the increment to the value of commodities and services that is contributed by the producing establishment, that is, the value created by the establishment. Aggregated for all establishments in a given industry, value added is the incremental value of goods and services attributable to that industry".

"Value added avoids the duplication in the value of shipments (or production) which results from the inclusion of shipments of establishments producing materials and components together with the shipments of establishments producing finished products. Therefore, value added is considered to be the best value measure for comparing the relative economic importance of different industries and geographical areas."

"Census" Value Added

"Respondents do not report value added but rather the items required for the calculation of value added. Value added, in the census concept, is defined as the value of output less the cost of materials and industrial services used. The calculation of value added is made by the national statistical organisation in the processing of the establishment data."

National Accounts Concept of Value Added

"Value added, defined in the above manner, is not net value created in relation to the economy as a whole but is net only in terms of the agricultural and industrial sectors of the economy. To derive a wholly net value added, it is necessary to exclude, in addition to the cost of materials and purchased industrial services, the purchases of non-industrial services, and to include non-industrial receipts. This additional calculation moves towards value added in the national accounting sense. The national income concept in the national accounts also excludes depreciation charges, that is, the consumption of fixed capital."

"The collection of data on the cost of non-industrial services at the establishment level is, however, fraught with difficulty in the case of multi-unit enterprises In such enterprises, data are only available at that level for certain non-industrial services, such as communication costs and rental payments. Other non-industrial services, such as advertising or legal, accounting and other professional services, are charged at the enterprise or divisional level. Such charges might be allocated back to the individual establishments of the enterprise, either according to the proportion of total enterprise wages and salaries or value added represented by each establishment, or by assigning to each establishment of the multi-unit enterprise estimated costs for the specified service as reported by single-unit enterprises of similar size and in the same type of industry. Alternatively, total payments for non-industria services might be estimated by the national accounts staff. To some extent, the same situation exists in relation to the collection of data on receipts for non-industrial services, and corresponding solutions should be attempted."

Appendix 2

Derivation of Major Output Concepts from the Census Material

United States

1) Gross Value of Output = Gross Value of Shipments
2) US Value Added = Value of Shipments minus Cost of Materials
   US Cost of Materials =
   a) all raw materials, semi-finished goods, parts, containers, scrap, and supplies put into production or used as operating supplies and for repair and maintenance during the year;
   b) electric energy purchased;
   c) fuels consumed for heat, power or generating electricity;
   d) work done by others on materials or parts furnished by manufacturing establishments (contract work);
   e) products bought and resold in the same condition;
3) No National Accounts Concept of Value Added derivable from the census;

Brazil

1) Gross Value of Output = "Valor de Producão"
2) US Value Added Concept = "Valor de Transformacao Industrial";
   "Valor de Transformacao Industrial" = "Valor de Producão" minus "Despesas, com as operacoes industriais"
   "Despesas, com as operacoes industriais" = US Cost of Materials concept
3) In order to arrive at the National Accounts concept of value added, we must deduct 15 of the 20 items which the Brazilian census calls "Despesas Diversas". These are not shown in detail but only for the 24 major industry branches, so we must use branch ratios to derive a rough estimate of these inputs for industries within each branch.
   These 15 items are:
   a) "Alugeis e Arrendamentos" (rents);
   b) "Royalties" (royalties);
   c) "Manutencão e Reparacão de Equipamentos e Instalacões" (repair and maintenance";
   d) "Manutencão de meios de transporte proprio" (maintenance of the enterprise's own transport equipment);
   e) "Publicidade e Propaganda" (advertising);
   f) "Despesas com comunicacão" (expenses for communications);
   g) "Fretes e carretos" (freight and carriage);
   h) "Servicos Professionais e de Assistencia Tecnica" (professional services and technical assistance);
   i) "Premios de Otros Seguros" (insurance for other risks);
   j) "Despesas com viagens e representacão" (travel and entertainment costs);
   k) "Indenizacão por dispensa" (reimbursement of expenses);
   l) "Imposto Predial e Territorial Urbano" (urban real estate taxes);
   m) "Impostos e taxas" (excise duty and other indirect taxes);
   n) "Combustiveis e Lubrificantes consumidas no transporte proprio" (gasoline and oil consumption for enterprise vehicles);
   o) "Outros despesas" (other costs);
4) In order to arrive at the former national accounts concept of value added we must further deduct "Juros e correcaão monetaria e despesas bancarias" (interest and monetary correction payments and bank service charges);

Mexico

1) Gross Value of Output = "Produccion Bruta Total"
2) US Value Added Concept = "produccion Bruta Total" minus the following four items:
   a) "Materias Primas y Auxiliares Consumidas";
   b) "Envases y Empaques";
   c) "Combustibles y Lubricantes";
   d) "Energia Electrica";
   Together these four items correspond to the US Cost of Materials Concept (see table 19 of Resumen General)
3) In order to arrive at the national accounts concept of value added we must first deduct five items which the census includes under the heading "Otros Insumos". These are:
   a) Refacciones Accessorios y herriamientas;
   b) Pagos por Maquila;
   c) Pagos por comisiones sobre rentas (sales commissions);
   d) Pagos por Servicios de Propaganda (advertising costs);
   e) Otros bienes y servicios" (other goods and service inputs);
   When these five items are deducted, we arrive at the Mexican census concept of value added ("Valor Aggregado censal bruto), but this concept is grosser than what we want for national accounts purposes, so we must further deduct three items:
   a) "Gastos por Uso de Patentes y Marcas, Asistencia Tecnica y Transferencia de Technologia" (cost of patents, licences, technical assistance and transfer of technology);
   b) "Gastos por alquiler de maquineria y equipo" (costs of renting machinery and equipment);
   c) "Gastos por otros alquileres" (other rental costs);
4) In order to arrive at the former national accounts concept of value added, we must further deduct the item "Gastos por intereses sobre creditos y prestamos" (interest costs of credits and loans);

In the Mexican case all this detailed information is available for individual industries (see tables 19 and 20 of Resumen General).