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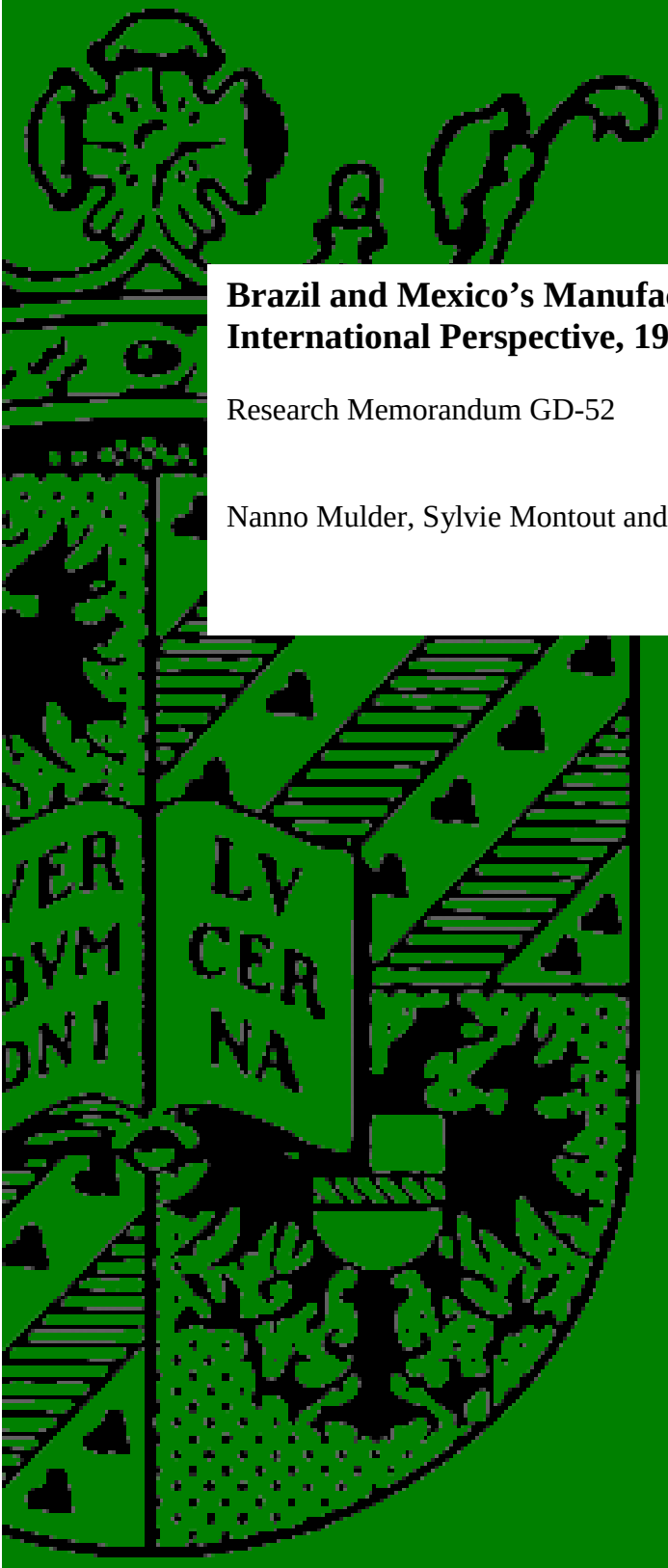

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RESEARCH MEMORANDUM

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Abstract

This paper studies the labour productivity performances of Brazil and Mexico in international perspective by comparing them with the United States, one of the international productivity leaders, during the period 1970-99. Brazil and Mexico are compared separately with the USA, in 1985 and 1988 respectively using the International Comparisons of Output and Productivity (ICOP) method. With ICOP, detailed sectoral-specific conversion factors (unit value ratios, UVRs) are estimated to express value added per person engaged in a common currency. Brazilian productivity was 43 per cent of the US level in 1985 and that of Mexico 27 per cent of the US in 1988. The extrapolation to the 1970-99 period shows that the productivity gaps of the Latin countries with the USA widened, in particular in the 1980s. In the 1990s, Brazil managed to stabilise the productivity differential, whereas Mexico continued to loose ground relative to the USA. The paper also checks the validity of the benchmark results by confronting them with the national accounts. Moreover, the quality of the extrapolations is assessed by comparing them with benchmark comparisons for 1975.

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1. Introduction

The manufacturing sectors in Brazil and Mexico underwent large changes in the past two decades. Until the mid-1980s, they were still highly protected against foreign competition, received large subsidies and part of manufacturing was state-owned. The debt-crisis of the 1980s meant the bankruptcy of these import substitution policies and marked the beginning of more outward-oriented policies. In the late 1980s and 1990s, these policies completely changed the institutional environment, led to the privatisation of state enterprises, and reinforced competition. Moreover, foreign trade was liberalised by reducing tariffs and eliminating quotas and licences. Both countries reinforced their multilateral and in particular regional trade relations through free trade agreements. The increased exposure to foreign competition on the home market and abroad provided an important stimulus for firms to improve their productivity and cost performances. This process was reinforced by a large influx of foreign direct investment.

This paper assesses whether the changed environment in these two countries in the past decades has led to an improvement of their manufacturing performances in international perspective. It complements other studies which only assessed performance over time. Although these latter studies indicate changes in productivity, they fail to indicate how far each branch and industry in Brazil and Mexico is from the "best practice" world-wide and how this productivity gap changed over time. We present two level comparisons, comparing Brazil and Mexico separately with the USA – the international technology leader -, for 1985 and 1988. The level comparisons are combined with time series to assess changes in the productivity gaps between Brazil and Mexico on the one hand and the United States on the other during the period 1970-99. In this paper we focus on labour productivity due to the absence of reliable estimates for capital stocks in Brazil and Mexico.

First major trends are presented in employment, value added and labour productivity growth the three countries in each of the three countries. Subsequently we present the methodology used to compare output and productivity across countries. Section 4 presents the results of the comparisons for our benchmark years 1985 and 1988 in terms of the product matches and their results. The representativeness of the comparisons is assessed by confronting census estimates of value added and employment with those of the national accounts (section 5). The labour productivity results are presented for the benchmark years in section 6 and for the 1970-99 period in section 7. The competitiveness of Brazil and Mexican manufacturing is assessed by combining productivity estimates with labour compensation data in section 8 and section 9 concludes.

2. Manufacturing in Brazil, Mexico and the United States

Brazil, Mexico and the United States represent the largest economies of the Americas. Brazil and Mexico are middle-income countries with manufacturing sectors that are still developing, whereas the USA is a high-income country with a highly matured manufacturing sector. Brazil and Mexico are in many ways comparable, not only in terms of size but also in terms of the industrial and macro-economic policies followed in the past decades. Both countries tried for a long time to develop their industries by protecting them from foreign (and domestic) competition and the provision of massive subsidies. The debt crisis in the 1980s marked the bankruptcy of these policies. Since the late 1980s

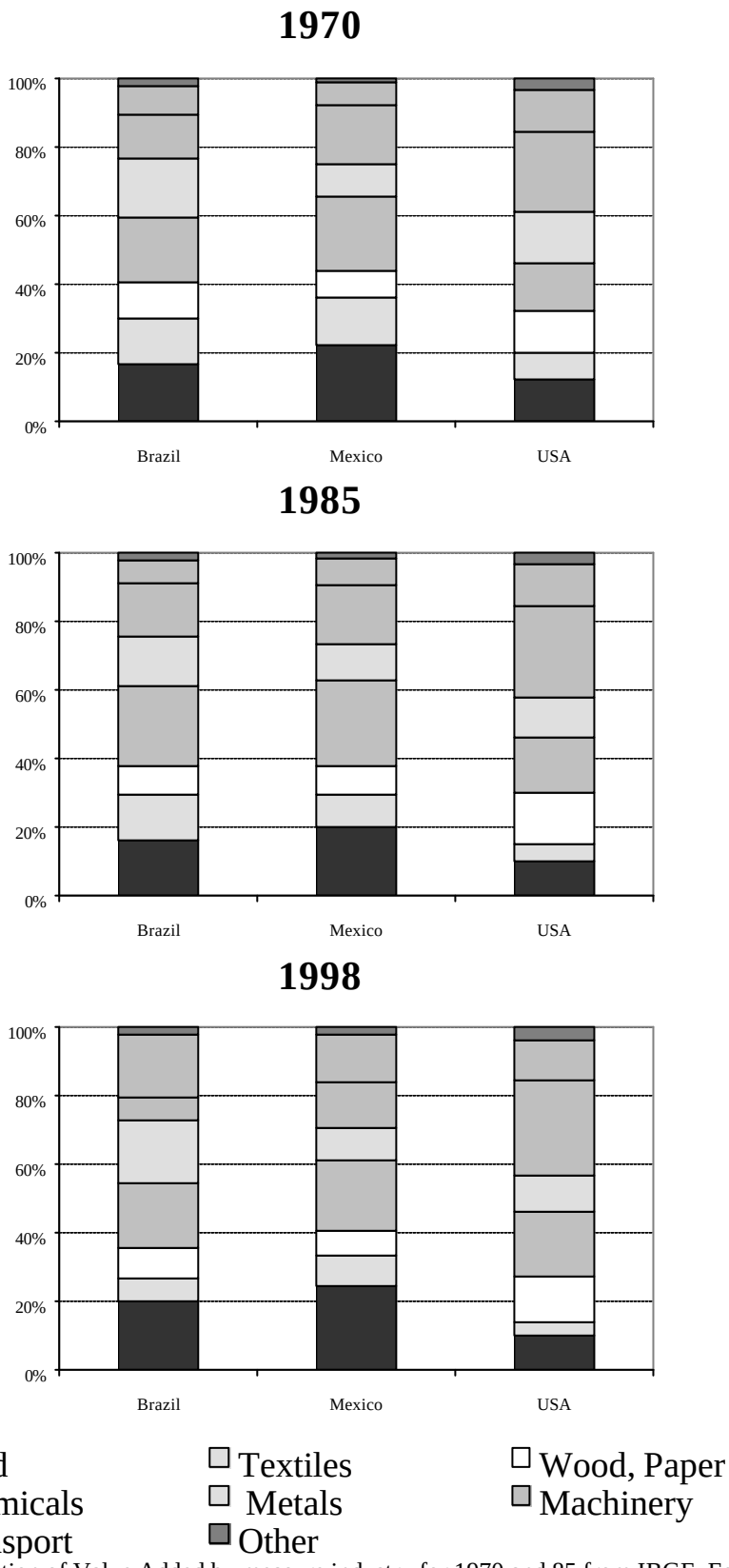
and in particular in the 1990s, both countries completely changed their policies: they privatised most state enterprises, eliminated subsidies, and opened their borders for foreign products. Important acts in terms of regional integration are the memberships of Mexico to NAFTA and Brazil to Mercosur.
Figures 1 and 2 show some key characteristics of manufacturing in each country. Figure 1 shows the composition of manufacturing value added by industry in Brazil, Mexico and United States from 1970-99. The composition of value added is relatively stable in the USA. In contrast, in Brazil and Mexico important changes took place: the share of transport equipment increased mostly at the expense of the shares of textiles and chemicals. Throughout the period the USA had smaller shares of food products and textiles, and a larger share of machinery relative to Brazil and the USA.

The main trends in output, employment and productivity growth in manufacturing in the 1970s to 1990s are shown in Figure 2. Brazil and Mexico show very different trends compared to the USA, in particular in terms of employment growth. During the entire 1970-99 period, the US experienced positive output and labour productivity growth, even though these rates were relatively low in the 1970s. Productivity growth accelerated in the second half of the 1990s, in particular in machinery.[2]
In contrast, Brazil and Mexico lived periods of up and downturns in employment and output growth. Value added grew at relatively high rates in the 1970s and the 1990s. In the second half of the 1990s, Mexico benefited from a increased demand from the USA which boosted its output growth. The most important downturns in output growth were during the debt-crisis of the 1980s, in particular in Brazil. Both countries show very different trends in employment growth. In Brazil, employment grew in the 1970s and between 1983 and 1989 and fell around 1980 and in the 1990s. In Mexico, employment growth was relatively constant over time, with a deceleration in the first half of the 1980s and acceleration in the second half of the 1990s.

As Figure 2 illustrates, labour productivity growth was slightly higher in Mexican compared to Brazilian manufacturing, except for food and transport equipment in which Brazil outperformed Mexico. Both Latin countries showed significantly lower productivity growth than the USA. In addition to growth rates, we should also take into account productivity *levels*. Some countries may register high growth rates because they have low *levels* of productivity which allows them to benefit from the large catch-up potential or productivity gap. This paper aims to check whether a link exists between the growth rates and levels of productivity.

[2] The spectacular productivity growth of this branch originates almost exclusively from the computer hardware branch, which volume of production exploded due to rapid price declines. Employment remained almost constant throughout the period, except for textiles and clothing which experienced a substantial decline.

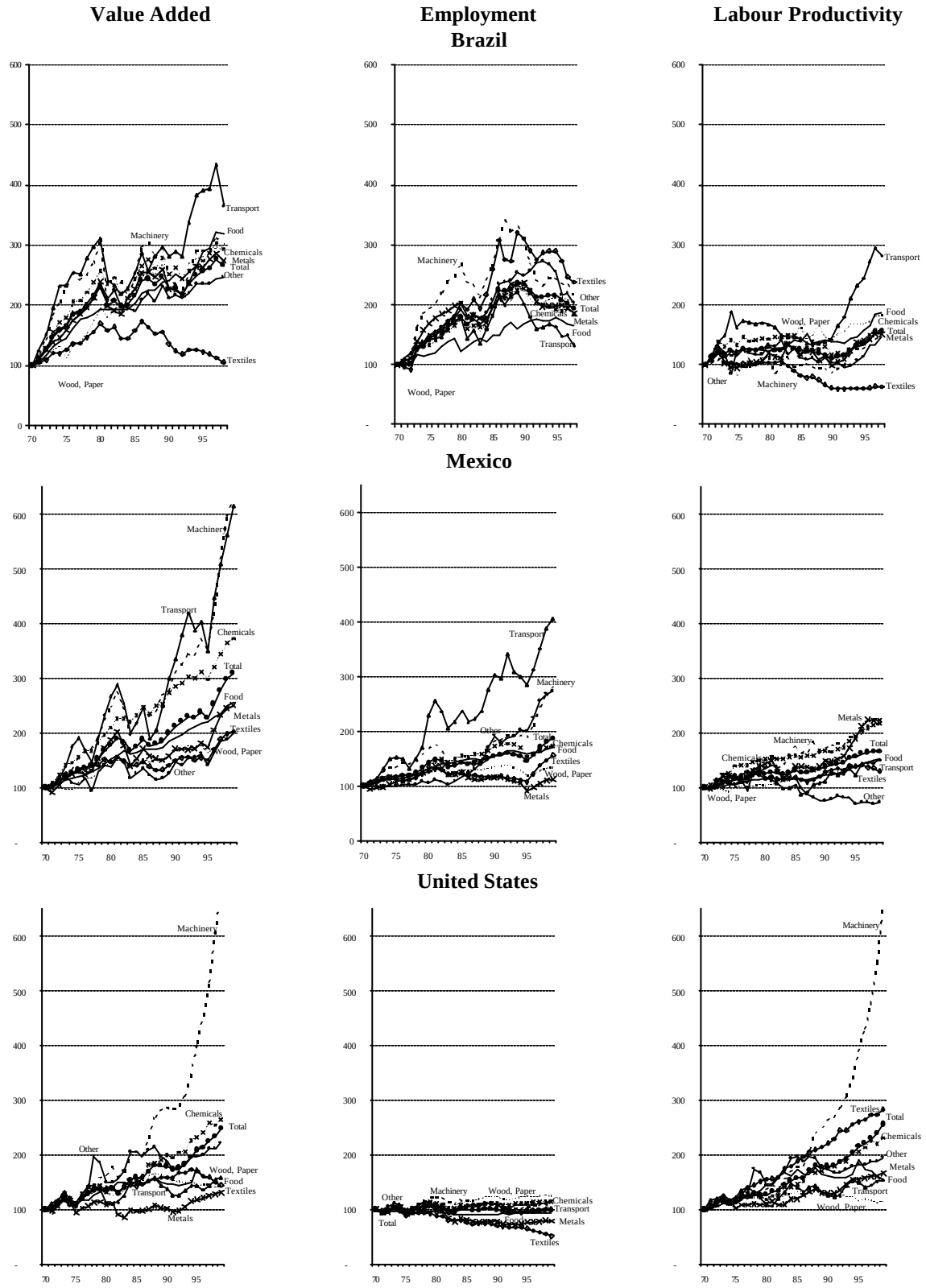
Figure 1
Composition of Manufacturing Value Added by Industry at Current Prices



Sources: Brazil: Composition of Value Added by measure industry for 1970 and 85 from IBGE, Estatísticas históricas do Brasil; 1998 from IBGE, Contas nacionais, 2001. Mexico for 1970, 1988 and 1999 from INEGI, Sistema de cuentas nacionales, various editions. USA: BEA, National Income and Product Accounts, various editions.

Figure 2

Indices of Value Added, Employment and Labour Productivity (1970=100)



Sources: Brazil: 1970-85 from IBGE, *Estatísticas históricas do Brasil*; 1985-99 from IBGE, *Contas nacionais*, various editions. Mexico: INEGI, *Sistema de cuentas nacionales,* various editions. USA: BEA, *National Income and Product Accounts*. Value added for 1947-1987 is at fixed 1982 prices but is reweighted at current dollar GPO every five years (1947, 1952, 1957, etc.). The series from 1987-1999 are chain weighted-series at 1992 dollars obtained from BEA (http://www.bea.doc.gov/bea/dn2.htm). Employment is full-time and part-time employees plus self-employed

3. The ICOP Methodology

International comparisons of productivity levels is more complicated than intertemporal comparisons of growth rates. Appropriate converters are required to express values of two or more countries in a common currency. Exchange rates are unsuitable for this purpose, as they represent at best the relative price of tradables, and not that of non-tradable sectors. Moreover, often they are not even representative for relative prices of tradables, as the exchange rates tend to be affected by capital movements, monetary policy and speculation.

Purchasing power parity (PPP) is an alternative conversion factor. There are two approaches to estimate PPPs: (a) use of prices by category of final expenditure, and (b) comparison of producer prices by sector of the economy. The former approach was followed in the International Comparisons Project (ICP) (Kravis, Heston and Summers, 1982), and was also adopted by EUROSTAT and the OECD. Benchmark expenditure PPPs are available for 1970, 1975, 1980, 1985, 1990 and 1993 and 1996.

Expenditure PPPs have been used as a proxy for producer prices in international productivity comparisons by various authors. However, there are major objections to this approach. Firstly, ICP PPPs are based on consumption prices of domestically produced goods AND imports, and exclude goods produced for export. Secondly, ICP excludes price ratios of intermediate sectors which form a substantial part of manufacturing output. Thirdly, expenditure PPPs are based on retail prices including trade and transport margins. While these margins can be "peeled off" in theory, this procedure poses many problems in practice. Fourthly, ICP PPPs are based on market prices. For the comparison of production values, relative prices at factor costs are more relevant.

Another method to estimate PPPs is the so called international comparisons of output and productivity (ICOP) approach. The origins of the production approach to international comparison stem from the work of Rostas (1948) and Paige and Bombach (1959). It was further developed by the ICOP team at the University of Groningen under the leadership of Angus Maddison. The first bilateral comparisons for manufacturing were for Brazil/USA and Mexico/USA for 1975 and first published in 1988.

ICOP derives purchasing power parities from values of output and quantities produced by sector of the economy. In combination with data on labour and capital, measures of labour, capital and total factor productivity are compiled. Most ICOP comparisons have been bilateral, with the United States and Germany as the numéraire countries, though multilateral techniques have also been applied to manufacturing and agriculture comparisons. ICOP has focused mainly on agriculture and manufacturing, although recently extensive work has also been done on services (see van Ark and Timmer, 2001, for an overview of the ICOP work).

ICOP aims to develop industry-specific conversion factors using producer output data instead of final expenditure information. This method is fundamentally different from the pricing technique in the ICP expenditure approach. Ideally, one would like to use specific producer prices to develop "industry PPPs". However, no international comparable producer prices for specified products are available. Instead ICOP uses product unit values which are derived from value and quantity information for product groups. Hence each unit value has a quantity counterpart, as quantities times "unit prices" equal the value equivalent. By matching as many products as possible, unit value ratios

are derived which can be weighted up to industry, branch and total manufacturing levels. These can then be used to express output of different countries in a common currency.

One major advantage of the ICOP approach is that in general all necessary information can be derived from a single primary source, which for manufacturing is the census of production or industrial survey. This source contains great detail on the output and input structure by industry and information on the sales values and quantities of most products. For Brazil, the data are derived from the latest census of production for 1985 (*Censos econômicos de 1985 – Censo industrial).* We also used production censuses for Mexico for 1988 (*XIII Censo industrial - Censos económicos 1989*) and the United States for 1987 (*1987 Census of Manufactures*). The benchmark years were not only chosen in relation to the latest production census in Brazil, but also because they are in the middle of the period considered in this paper, i.e. 1970-99.

As the production censuses are not well harmonised across countries, the comparisons are done on a two-country basis Brazil/USA and Mexico/USA. An advantage of comparing Brazil and Mexico *VIA* the USA is that a comparison with the USA provides an indication of the productivity gap between the countries and as such the potential of catch-up.

In the ICOP approach[3], relative prices are referred to as unit value ratios (UVRs) instead of PPPs as they are based on ratios of unit values (UVs) of products. These unit values are derived by dividing ex-factory output values (o) by produced quantities (q) for each product i in each country:

$$UV_i = \frac{o_i}{q_i} \qquad (1)$$

The unit value is a kind of average price at which a similar group of products was sold by all manufacturers in a given year. In each bilateral comparison, products are matched according to more or less detailed product descriptions, e.g. frozen fruits, infants' underwear, aluminium window frames, and car tyres. For each matched product, the ratio of the unit values of both is calculated:

$$UVR_i^{XU} = \frac{UV_i^X}{UV_i^U} \qquad (2)$$

with *x* being Brazil or Mexico and *u* the base country, the United States. The UVR indicates the relative producer price of the matched product in both countries. Product UVRs are used to estimate UVRs at more aggregate levels: industries, branches and total manufacturing. These levels correspond to those distinguished in the 1987 US Standard Industrial Classification (SIC). Manufacturing output is the sum of output of branches, which in turn is the sum of the industries' output value. The value of an industry's output equals the sum of the values of the produced products. Within the comparison of each industry between two countries, only part of products can be matched as quantity information often lacks, it may be difficult to find comparable products, or countries produce unique products. The matched products can be considered as a sampled subset of products within an industry which relative price, under certain conditions, may be considered representative for the non-matched part.

[3] The description of the ICOP methodology is based on Timmer *et al.* (2001).

Aggregation Step One: from Product to Industry Level UVRs

The UVR for an industry is the weighted mean of the product UVRs, using output values of base country (USA) or the other country (Brazil or Mexico) as weights. The UVR for an industry using US weights is estimated as follows:

$$UVR_j^{xu(u)} = \sum_{i=1}^{I_J} \left(\frac{UV_i^{x(x)}}{UV_i^{u(u)}} \times w_{ij}^{u(u)} \right) \text{ with } \qquad w_{ij}^{u(u)} = \frac{o_{ij}^{u(u)}}{\sum_{i=1}^{I_J} o_{ij}^{u(u)}} \tag{3}$$

with i=1,.,I_J the matched products in industry j, w_{ij} the output share of the ith commodity in industry j. $UVR_j^{xu(u)}$ indicates the unit value ratio between country x and the base country (USA) weighted at base country quantities indicated by the u in brackets. This equation can be rewritten to show that the use of base country value weights leads to the Laspeyres index:

$$UVR_j^{xu(u)} = \frac{\sum_{i=1}^{I_J} q_{ij}^u * UV_{ij}^{x(x)}}{\sum_{i=1}^{I_J} q_{ij}^u * UV_{ij}^{u(u)}} \tag{4}$$

Instead of US weights, one can also weight the product UVRs by the quantities of the "other" country (Brazil or Mexico):

$$UVR_j^{xu(x)} = \frac{1}{\sum_{i=1}^{I_J} \left(\frac{UV_i^{x(x)}}{UV_i^{u(u)}} \times w_{ij}^{u(x)} \right)} \text{ with } \qquad w_{ij}^{u(x)} = \frac{o_{ij}^{u(x)}}{\sum_{i=1}^{I_J} o_{ij}^{u(x)}} \tag{5}$$

Again this index can be easily rewritten to show that it is a Paasche index:

$$UVR_j^{xu(x)} = \frac{\sum_{i=1}^{I_J} q_{ij}^x * UV_{ij}^{x(x)}}{\sum_{i=1}^{I_J} q_{ij}^x * UV_{ij}^{u(u)}} \tag{6}$$

Aggregation Step Two: from Industry to Branch Level UVRs

The aggregation to branch UVRs is done by weighting the industry UVRs, by either US quantities:

$$UVR_k^{xu(u)} = \sum_{j=1}^{J_k} \left(\frac{UV_j^{x(x)}}{UV_j^{u(u)}} \times w_{jk}^{u(u)} \right) \tag{7}$$

with j=1,., J_k the number of industries in branch k for which a UVR has been calculated (the sample industries); w_{jk} the output share of the j^{th} industry in branch k. The weight of industries depends not only on the size of their output but also on the reliability of the industry UVR, being lower the lower the reliability, as unreliable UVRs should have a limited influence on the branch UVR. Therefore the set of industries J_k is split into two, J_k(a) and J_k(b) depending on their reliability. UVRs of industries belonging to the first set (J_k(a)) are

weighted with the total industry output at own prices: $o_{jk}^{Tu(u)}$. The UVRs from the other industries (belonging to $J_k(b)$) are weighted only by the output value of the matched products in the industry: $o_{jk}^{Mu(u)} = \sum_{i=1}^{I_j} uv_{ij}^{u} q_{ij}^{u}$. Hence the weights are given by

$$\begin{aligned} w_{jk}^{u(u)} &= o_{jk}^{Tu(u)} / o_{k}^{Mu(u)} \qquad \forall j \in J_k(a) \\ w_{jk}^{u(u)} &= o_{jk}^{Mu(u)} / o_{k}^{Mu(u)} = \sum_{i=1}^{I_j} uv_{ij}^{u} q_{ij}^{u} / o_{k}^{Mu(u)} \qquad \forall j \in J_k(b) \end{aligned} \tag{8}$$

with $o_{k}^{Mu(u)} = \sum_{J_k(a)} o_{jk}^{Tu(u)} + \sum_{J_k(b)} o_{jk}^{Mu(u)}$

To arrive at the Paasche index, the US weights are replaced by the Brazilian or Mexican output valued at US prices:

$$UVR_{k}^{xu(x)} = \frac{1}{\sum_{j=1}^{J_k} \left(\frac{UV_{j}^{x(x)}}{UV_{j}^{u(u)}} \times w_{jk}^{u(x)} \right)} \tag{9}$$

with

$$\begin{aligned} w_{jk}^{u(x)} &= o_{jk}^{Tu(x)} / o_{k}^{Mu(x)} \qquad \forall j \in J_k(a) \\ w_{jk}^{u(x)} &= o_{jk}^{Mu(x)} / o_{k}^{Mu(x)} \sum_{i=1}^{I_j} uv_{ij}^{u} q_{ij}^{x} / o_{k}^{Mu(x)} \qquad \forall j \in J_k(b) \end{aligned} \tag{10}$$

with $o_{k}^{Mu(x)} = \sum_{J_k(a)} o_{jk}^{Tu(x)} + \sum_{J_k(a)} o_{jk}^{Mu(x)}$

The split in the industry set is based on an assessment of the reliability of the industry UVRs. Given the homogeneous character of the products belonging to an industry, it is expected that product UVRs in an industry do not differ much. Hence, if the variation of the product UVRs is high, this is an indication of unreliability. Also, reliability increases the higher the percentage of industry output covered by matched products. Therefore the coverage ratio is also taken into account when assessing the industry UVR reliability. The following decision rule is used: when the coefficient of variation is less than 0.1, the industry is assigned to $J_k(a)$, other wise to $J_k(b)$:

$$\begin{aligned} &\text{if} \quad cv\left[UVR_{j}\right] < 0.1 \quad \text{then} \quad j \in J_k(a) \\ &\text{otherwise} \qquad\qquad\qquad\quad j \in J_k(b) \end{aligned} \tag{11}$$

The coefficient of variation of industry j (cv_j) is measured as follows:

$$cv\left[UVR_{j}\right] = \frac{\sqrt{var\left[UVR_{j}\right]}}{UVR_{j}} \tag{12}$$

The variance of the industry UVRs is given by the mean of the weighted deviations of the product UVRs around the industry UVR (see Selvanathan, 1991):

$$Var[UVR_J] = (1 - f_{j)}) \frac{1}{I_j - 1} \sum_{i=1}^{I_j} w_{ij} \left(UVR_{ij} - UVR_j\right)^2 \qquad (13)$$

with *Ij* the number of products matched in industry i and f_j the share of industry output which is covered by the matched products within an industry. (1- f_j) is also referred to as the "finite population correction", and ensures that an increase in the coverage of the sample reduces its variance. This formula can be applied to either the Laspeyres or Paasche UVR using output value weights of the base country for the variance of the Laspeyres, and quantity weights of the other country valued at US prices for the variance of the Paasche. To allocate an industry to one of the two sets, a decision is made on the basis of the (geometric) average variance for the Paasche and Laspeyres.

Aggregation Step Three: From Branch to Total Manufacturing UVRs

The aggregation of branch to total manufacturing UVRs is done in the same way as that from the industry to the branch UVRs. US country output weights are used to arrive at the Laspeyres index, and the Brazilian or Mexican quantities valued at US prices are used to arrive at the Paasche index. The Laspeyres and Paasche indices are combined into a Fisher index when a single currency conversion factor is required. It is defined as the geometric average of the Laspeyres and the Paasche.

There is one important difference between aggregation steps two and three, i.e. the output weights of the branch do not depend on the reliability of their UVRs. Branches always enter the weighting system with their total production. This is because the estimated UVRs are the most "characteristic" for the branch even when their variance is high or their representativeness low. Nevertheless, it should be stressed that the UVRs for this branch have to be interpreted with caution.

At the branch level, we can also estimate the reliability of the UVRs. As indicated by the stratified sampling theory, branch variance is calculated by the quadratic output weighted average of the corresponding industry UVRs:

$$Var[UVR_k] = (1 - f_k) \sum_{j=1}^{J_j} w_{jk}^2 \, \mathrm{var}\left[UVR_{jk}\right] \qquad (14)$$

with f_k the share of branch output covered by the matched products within a branch. Two variances are estimated: one using US and one using "other" country weights, of which a geometric average is taken.

Finally, the sample variance of the UVR for total manufacturing given by the quadratic output weighted average of the corresponding branch UVR variances:

$$Var[UVR] = \sum_{k=1}^{K} w_k^2 \, \mathrm{var}\left[UVR_k\right] \qquad (15)$$

4. The Output and Productivity Comparisons: Matchings and UVRs

The first step in our two bilateral comparisons is the reconciliation of the industry nomenclatures of Brazil and the USA on the one hand and Mexico and the USA on the other. This is done at the most detailed industry level. As each country had its own industry classification in the 1980s which did not correspond to an international classification, this was a difficult task. The most detailed breakdowns of the Brazilian, Mexican and US censuses are in 530, 300, and 460 industries respectively. In the Brazil/USA comparison, 229 common industries could be defined, and in the Mexico/USA

comparison 223 common industries.[4] These industries were regrouped into 19 different branches according to the US Standard Industrial Classification 1987. We excluded branch 29 "Petroleum refining and related industries", as it is strongly linked to the natural resource endowments of the countries.

The second step consisted of matching products within each of the common industries in the bilateral comparisons. An example is provided in Table 1 for branch 27 "Printing and Publishing" in the Mexico/USA comparison. Within this branch, 4 common industries are defined. Within two groups of industries (US 1987 SIC codes 27.41/51/52/53/54/59/61/71/82/89 and 27.91/93/95/96), it was impossible to match any items. In industry group 2711/21, we were able to match one product, and in industry 2731/32, six products were matched.

The UVRs of the product matches were aggregated in three steps, of which the first two are illustrated in Tables 1 and 2 respectively. From the product to the industry level, the product UVRs were weighted by either the US or the Mexican quantities. The second aggregation step from the industry to the branch level is shown in Table 2, which recapitulates the UVRs of the industries of Table 1. As in the industry groups 27.41/51/52/53/54/59/61/71/82/89 and 27.91/93/95/96 no matchings could be made, their weight equals zero. For the common industry 27.11/21 with only one match, no coefficient of variation could be derived. The weight of this industry equals the value of the one matched product. In common industry 2731/32, several product were matched. As the coefficient of variation of the UVRs is below 0.1, they are considered representative for the total industry. Therefore the weight of this industry equals total output instead of the value of matched products (in grey). If the coefficient would have been above 0.1, then only its matched output would have been included in the weighting scheme. The "final" weights are converted to a common currency using the industry UVRs of Table 1. Finally, the branch UVRs are obtained as shown in columns (11) to (13).

[4] The correspondances of the industry nomenclatures are available upon request from the authors.

Table 1

Example of Aggregation Step 1: Printing and Publishing, Mexico/USA, 1987/88

US SIC		Product matches	USA			Mexico			UVR of product matches		
			Value (million US$)	Quantity (million)	Unit Value	Value (million pesos)	Quantity (million)	Unit Value	At US weights	At Mexican weights	Fisher
27	**Printing, Publishing**	**7**	**8 670**			**476 000**					
27.11/21	**Newspapers & periodicals**	**1**	**5 248**			**153 797**			**1 631**	**1 631**	**1 631**
	Newspapers	1	5 248	104 965	0,05	153 797	1 886	82	1 631	1 631	1 631
27.31/32	**Books and book printing**	**6**	**3 422**			**322 203**			**1 315**	**1 252**	**1 283**
	Paperbound elementary school textbooks		511	116	4	21 400	4	4 933	1 114	1 114	1 114
	Technical and bussiness books		1 272	105	12	85 727	5	17 580	1 450	1 450	1 450
	Paperbound law books		149	6	27	53 750	2	28 342	1 045	1 045	1 045
	Hardbound bibles		62	8	8	59 342	6	9 333	1 211	1 211	1 211
	Other paperbound books		1 292	518	2	92 029	28	3 246	1 302	1 302	1 302
	Pamphlets		135	115	1	9 955	7	1 487	1 271	1 271	1 271
27.41/51/52/53/54/59/61/71/82/89		**0**									
27.91/93/95/96		**0**									

Table 2

Example of Aggregation Step 2: Printing and Publishing, Mexico/USA, 1987/88

SIC	Product matches	Coefficient variation	Matched Output		Industry Output		Final Weights				Final UVRs		
		(geometric average)	USA (million US$)	Mexico (million pesos)	USA (mio. US$)	Mexico (mio. pesos)	USA (million US$)	Mexico (million pesos)	USA (million pesos)	Mexico (million US$)	At US weights	At Mexican weights	Geo-metric average
	(1)	(2)	(3)	(4)	(5)	(6)	(7) (3) or (5))	(8) = (4) or (6))	(9) = (7) * US weights UVR)	(10) = (8) / Mex. weights UVR)	(11) = ((9)/(7))	(12) = ((8)/(10))	(13)
27	**7**	**0.001**	**8 670**	**476 000**	**65 055**	**617 837**	**21 124**	**617 837**	**29 432 162**	**465**	***1 393***	**1 329**	**1 361**
27.11/21	*1*		***5 248***	***153 797***	*49 179*	*1 225 601*	*5 248*	*153 797*	*8 560 729*	*94*	*1 631*	*1 631*	*1 631*
27.31/32	*6*	***0.047***	***3 422***	***322 203***	*15 876*	*464 040*	*15 876*	*464 040*	*20 871 433*	*371*	*1 315*	*1 252*	*1 283*
27.41/51/52/53/54/59/61/71/82/89					*66 984*	*1 408 829*							
27.91/93/95/96					*4 157*	*475 990*							

The main results for the product matches, UVRs and reliability indicators are shown in Tables 3 and 4. Overall it was possible to match more than twice as many products between Mexico and the USA than between Brazil and the USA, i.e. 435 instead of 209. In the Brazil/USA comparison, for 122 common industries it was impossible to match any products, in 56 industries it was possible to match one product, in 27 industries two products, in 10 industries three products, in 10 industries four products and in 4 industries five or more products. In the Mexico/USA comparison, in 61 common industries it was impossible to match any products, in 40 industries it was possible to match one product, in 42 industries two products, in 41 industries three products, in 19 industries four products and in 20 industries five or more products. In both bilateral comparisons, most matches were made in food products and machinery and computers. Other branches with many matchings in the Brazil/USA comparison are furniture and fixtures and primary metals and metal products, and in the Mexico/USA comparison electronic and electrical equipment, and textiles and wearing apparel.

The 1987 US census volumes and unit values were adjusted to make them comparable with those for Brazil (1985) and Mexico (1988). From various issues of the *US Industrial Outlook*, it was possible to derive producer price indices of the gross value of output at the most detailed (4-digit) industry level for 1985 to 1988. From the *Annual Survey of Manufactures*, we obtained the gross value of output and employment at the industry level for 1985 and 1988. With these data, the unit value (p) and volume adjustment (q) factors were estimated. Subsequently, they are applied to the Laspeyres index (see formulae (4)):

$$\frac{\sum_{i=1}^{I_J} q_{ij}^{u,1975} * q * UV_{ij}^{x(x)}}{\sum_{i=1}^{I_J} q_{ij}^{u,1975} * q * UV_{ij}^{u(u),1975} * p} \qquad (16)$$

and the Paasche index (see formulae 6):

$$\frac{\sum_{i=1}^{I_J} q_{ij}^{x} * UV_{ij}^{x(x)}}{\sum_{i=1}^{I_J} q_{ij}^{x} * UV_{ij}^{u(u)} * p} \qquad (17)$$

Columns 2 to 4 show the UVRs at Brazilian or Mexican prices, at US prices and the geometric average. Column 5 presents the price level, i.e. the ratio of the Fisher (geomtric average) UVR to the nominal exchange rate. This ratio indicates whether Brazilian or Mexican products are relatively cheaper or more expensive than those produced in the USA (ratio below or above 100 respectively). On average, Brazilian manufacturing products were less expensive than those of Mexico (66 and 77 per cent of the US price level in 1985 and 1988 respectively). Brazil and Mexico each had price advantages in different branches. In Brazil, the highest relative prices were observed in printing and publishing, rubber and plastics, and electronic and electrical equipment and the lowest in furniture and fixtures, tobacco products, wood, and transport equipment. In the Mexico, the highest relative prices were in professional equipment and primary metals and the lowest in clothing and metal products.

Table 3

Unit Value Ratios and Reliability Indicators by Manufacturing Branch, Brazil/USA, 1985

US SIC 1987		Number Of product matches	Unit value Ratios (cruz./US$)			Price Level (USA =100)	Coefficient of variation		Matched Output as Percentage of Total	
			Brazilian quantity weights	US quantity weights	Geo-metric average		Brazilian Quantity Weights	US quantity weights	USA	Brazil
20	Food Products	49	3 736	2 706	3 180	51	0.041	0.107	41.1	64.8
21	Tobacco Products	1	2 486	2 486	2 486	40	n.a.	n.a.	10.3	40.7
22	Textiles	3	7 239	4 456	5 680	92	n.a	n.a.	2.5	11.2
23	Clothing and Apparel	4	3 293	4 831	3 988	64	0.350	0.001	5.8	23.2
24	Wood Products. Except Furniture	5	2 472	2 932	2 692	43	0.060	0.193	25.1	17.5
25	Furniture and Fixtures	20	1 613	1 959	1 777	29	0.033	0.090	25.5	57.3
26	Paper and Allied Products	14	4 232	5 027	4 613	74	0.043	0.000	49.5	79.5
27	Printing and Publishing	2	9 305	9 809	9 554	154	n.a	n.a.	1.4	12.1
28	Chemicals	15	7 106	5 734	6 383	103	0.068	0.122	12.2	38.0
30	Rubber and Plastics	6	8 872	7 158	7 969	128	0.090	0.137	3.5	19.8
31	Leather and Leather Products	6	3 362	2 549	2 927	47	0.006	0.174	30.9	39.4
32	Non-metallic minerals	10	4 553	3 681	4 094	66	0.078	0.000	10.4	39.6
33&34	Primary Metals & Metal Products	20	5 304	3 852	4 520	73	0.032	0.086	17.5	27.6
35	Machinery and Computers	24	2 378	2 643	2 507	40	0.389	0.157	17.5	17.6
36	Electronic & Electrical Equipment	19	6 213	7 368	6 766	109	0.067	0.070	10.0	37.0
37	Transportation Equipment	7	2 627	2 751	2 689	43	0.010	0.000	25.4	56.3
38	Professional Equipment	2	3 410	3 922	3 657	59	n.a	n.a.	0.1	55.1
39	Other Industries	2	3 272	4 455	3 818	62	n.a	n.a.	5.6	8.1
20-39	Total Manufacturing	209	4 588	3 648	4 091	66	0.029	0.034	19.4	39.1
	Exchange Rate		6 202	6 202	6 202					

Sources: Authors calculations based on Brazilian and US Censuses of Manufactures, see text.

The UVRs for total manufacturing of both Brazil/USA and Mexico/USA comparisons turn out to be very reliable, as the coefficients of variations are well below 0.1 (see columns 6 and 7). The variation coefficients of the Brazil/USA comparison are twice as high as those of the Mexico/USA comparison indicating the latter are even more consistent. With regard to individual branches in the Brazil/USA comparison, the UVRs for wood products, rubber and plastics and machinery and computers have to be interpreted with caution as their variation coefficients exceed 0.1. In the Mexico/USA comparison, the reliability of the branch UVRs is questionable only for rubber and plastics and other industries.

Coverage ratios also indicate the reliability of the results, see the final two columns of the two tables by the coverage ratios of output, i.e. the share of total sales included in the matches. The product matches covered a higher share of output in the Mexico/USA comparison compared to the Brazil/USA comparison. Although a relatively similar share of Brazilian and Mexican output was covered (39 and 46 per cent respectively), only 19 per cent of US output was included in the Brazil/USA compared to 33 per cent in the Mexico/USA comparison. The highest coverage ratios in the Brazil/USA comparison were in paper and allied products and food products, and in the Mexico/USA comparison in tobacco products, leather and leather products and textiles

Table 4

Unit Value Ratios and Reliability Indicators by Manufacturing Branch, Mexico/USA, 1988

US SIC 1987		Number of product matches	Unit value Ratios (pesos/US$) Mexican Quantity Weights	US quantity weights	Geo-metric average	Price Level (USA =100	Coefficient of variation Mexican Quantity Weights	US quantity weights	Matched Output as Percentage of Total USA	Mexico
20	Food Products	73	1 841	1 186	1 477	65	0.032	0.035	65.8	59.9
21	Tobacco Products	2	1 218	1 229	1 224	53	n.a.	n.a	97.1	98.0
22	Textiles	30	2 141	1 468	1 773	77	n.a.	0.056	100.0	56.8
23	Clothing and Apparel	32	1 490	1 043	1 247	54	0.046	0.029	41.3	40.5
24	Wood Products. Except Furniture	12	1 960	1 414	1 665	73	0.038	0.021	28.1	40.4
25	Furniture and Fixtures	12	2 244	2 231	2 237	98	0.060	0.024	35.5	57.9
26	Paper and Allied Products	13	2 262	2 023	2 139	93	0.045	0.036	63.2	72.7
27	Printing and Publishing	7	1 317	1 258	1 287	56	0.032	0.037	6.4	13.3
28	Chemicals	41	2 303	1 662	1 956	85	0.035	0.059	23.3	28.2
30	Rubber and Plastics	11	1 067	1 175	1 120	49	0.100	0.103	4.5	21.2
31	Leather and Leather Products	10	1 468	1 511	1 489	65	n.a.	0.038	100.0	61.0
32	Non-metallic minerals	23	2 392	1 590	1 950	85	0.071	0.034	25.9	49.6
33	Primary Metals	26	2 425	2 552	2 488	109	0.030	0.027	67.2	43.7
34	Metal Products	28	1 807	1 077	1 395	61	0.054	0.048	8.7	49.9
35	Machinery and Computers	34	2 052	1 937	1 994	87	0.049	0.050	9.3	35.1
36	Electronic & Electrical Equipment	41	2 373	1 877	2 111	92	0.053	0.065	14.6	22.4
37	Transportation Equipment	21	2 119	1 815	1 961	86	0.029	0.050	34.6	49.8
38	Professional Equipment	8	2 962	3 141	3 050	133	0.031	0.015	22.8	50.5
39	Other Industries	11	1 417	1 813	1 603	70	0.210	0.101	8.5	16.4
20-39	Total Manufacturing	435	2 033	1 511	1 753	77	0.012	0.015	33.3	46.1
	Exchange Rate		2 290	2 290	2 290					

Note: the UVRs for the branch printing and publishing are not the same as those in Table 2. In Table 2, US production is in 1987 prices and volumes and Mexican production in 1988 prices and volumes. In Table 4, US quantities and prices were adjusted to 1988. *Sources* of Tables 3 and 4: censuses of manufacturing as described in the Text.

5. Reconciliation of Industrial Census Data with the National Accounts

Before calculating relative productivity levels, it is important to assess the consistency of the information in the censuses with estimates of output and employment in the national accounts (see Table 5). A major difficulty in reconciling census information with the national accounts is that the value added concepts in the censuses strongly differ from those in the national accounts: in general the former only deduct intermediate goods and industrial services from gross output, while the latter also exclude non-industrial services. Moreover, although the concept of value added in national accounts is similar in the three countries due to the international guidelines of UN/IMF/OECD/Eurostat, the censuses in Brazil, Mexico and the USA each adopted a different value added concept. Van Ark and Maddison (1994) and detailed definitions and data in the production censuses made it possible to harmonise the value added data between the censuses and the national accounts for Brazil and Mexico. For the USA, the census lacks detailed data on inputs and therefore it was not possible to harmonise the value added data between the census and national accounts.

In Brazil, the census value added concept (*valor de transformação industrial*) is larger than the national accounts concept as it includes various non-industrial services. In the census, detailed data are available on these non-industrial services only for the 21 major industry groups. So branch ratios had to be used to derive a rough estimate of these inputs for each industry. After the deduction of

these services[5], value added of the census and national accounts are comparable. Census value added is slightly higher than national accounts value added. It is clear that the national account understate industrial output by relying almost exclusively on activity registered in the census, a result also found by van Ark and Maddison (1994) for 1975 and other authors cited in the latter study. This finding is confirmed by comparing data on employment in the census (5,231 thousand) and the national accounts (8,063 thousand). The national accounts make almost no adjustment for activity of the industrial workers outside the census (referred to as *autonomos* or non-census establishments). This is most obvious in textiles in clothing.

In Mexico, the definitions of value added of the census the national accounts are almost the same. The only two types of intermediate services included in the census definition are the costs of patents, licenses, technical assistance and technology transfers, and rental costs of machinery, equipment and other goods. The 1988 census did not provide data these input categories. However, the subsequent census for 1993 had information on rental costs (*pagos por alquileres)*. We applied the 1993 ratios of rental costs to census value added in order to adjust 1988 census value added to the national accounts concept. Mexican census value added include indirect taxes. The most important cases for which we have made a correction are alcoholic beverages and tobacco and tobacco products, where taxes represented 76 and 69 per cent of census value added respectively.

The Mexican national accounts make substantial adjustments for activity excluded from the census, as the value added estimate is 33 per cent higher than that of the census. The census does not only omit small establishments, as value added per person is lower in the census than in the national accounts figures. This paradoxical result for the informal sector may be due to the fact the national accounts only include paid employees, whereas in the informal sector there is a high proportion of unpaid family employees. Nevertheless, the Mexican national accounts are likely to make too big imputations for informal activity outside the census.

For the USA, a consistent comparison between value added of the census and the national accounts is not possible as the census provides no detailed information on inputs of non-industrial services. On average census value added is 31 per cent higher than national accounts value added, with the largest differences in food products and chemicals. The two sources almost give the same estimates of employment in manufacturing, despite the fact that the census excludes firms without employees. However, van Ark and Maddison (1994) estimated that they accounted for only 0.5 per cent of total manufacturing output in 1977.

In principle, one would prefer to use national accounts instead of censuses to assess the performance of the entire manufacturing sector, including establishments omitted by the census. However, with the likely underestimation of value added in the Brazilian national accounts and the overestimation of value added in the Mexican national accounts, the use of these sources produce odd results. For this reason, we decided to stick to the census for Brazil and Mexico, as all data on output,

[5] Rents (alugueis condominios e arrendamentos de imoveis), other rents and leasing (alugueis e "leasing" de maquinas e equipamentos e veiculos), freight and carriage (fretes e carretos), excise duties and other indirect taxes (impostos e taxas), insurance premiums (premios de seguro), repair and maintenance (serviços de reparação et manutençãco da maquinas), and other costs (outros despesas e costos).

input and employment come from one single source. For the USA, however, it was not possible to use the census, as it was not possible to adjust census value added. Instead we relied on the national accounts.

Table 5
Comparison of Census and National Accounts Estimates of Value Added and Employment, Brazil (1985), Mexico (1988) and the USA (1987)

US Industrial Classification, 1987	Industry	Value Added (national accounts concept), million national currency units			Employment (000s)		
		Census	National Accounts	Ratio	Census	National Accounts	Ratio
	BRAZIL, 1985						
20+21	Food, Beverages and Tobacco	54 820	45 146	1.21	828	1 217	0.68
22+23+31	Textiles and Clothing	48 851	47 375	1.03	1 009	2 283	0.44
24+25+26+27	Wood, Paper and Publishing	31 539	33 852	0.93	671	1 218	0.55
28+30+32	Chemicals	85 377	65 046	1.31	894	1 066	0.84
33+34	Basic Metal and Metal Products	53 410	45 554	1.17	584	844	0.69
35+36+38	Machinery & Eq. Except Transport	66 361	57 795	1.15	771	820	0.94
37	Transport Equipment	24 285	26 621	0.91	308	367	0.84
39	Other manufacturing	10 538	8 888	1.19	165	247	0.67
20-39	**Total Manufacturing**	**375 182**	**330 277**	**1.14**	**5 231**	**8 063**	**0.65**
	MEXICO, 1988[a]						
20+21	Food, Beverages and Tobacco	11 194 [b]	19 964 [b]	0.56	544	610	0.89
22+23+31	Textiles and Clothing	5 358	9 334	0.57	424	522	0.81
24+25+26+27	Wood, Paper and Publishing	4 720	8 752	0.54	293	337	0.87
28+30+32	Chemicals	13 884	21 232	0.65	426	474	0.90
33+34	Basic Metal and Metal Products	7 053	10 775	0.65	265	270	0.98
35+36+38	Machinery & Eq. Except Transport	8 032	8 385	0.96	426	430	0.99
37	Transport Equipment	8 688	7 618	1.14	156	268	0.58
39	Other manufacturing	519	2 155	0.24	43	70	0.61
20-39	**Total Manufacturing**	**59 450**	**88 215**	**0.67**	**2 576**	**2 981**	**0.86**
	USA, 1987 [c]						
20+21	Food, Beverages and Tobacco	132 035	89 451	1.48	1 575	1 720	0.92
22+23+31	Textiles and Clothing	61 683	47 107	1.31	1 949	2 019	0.97
24+25+26+27	Wood, Paper and Publishing	185 359	146 515	1.27	3 468	3 637	0.95
28+30+32	Chemicals	198 571	136 695	1.45	2 446	2 464	0.99
33+34	Basic Metal and Metal Products	121 094	97 135	1.25	2 230	2 168	1.03
35+36+38	Machinery & Eq. Except Transport	287 474	220 150	1.31	4 806	4 849	0.99
37	Transport Equipment	137 076	113 715	1.21	1 957	2 034	0.96
39	Other manufacturing	14 913	15 773	0.95	321	427	0.75
20-39	**Total Manufacturing**	**1 138 204**	**866 541**	**1.31**	**18 751**	**19 318**	**0.97**

[b] Employment figures of the national accounts refer to paid employees only; [b] excludes indirect taxes and subsidies, as taken from the national accounts (*Sistema de cuentas nacionales de México)*: 546,310 million for alcoholic beverages and 1,130,942 million for tobacco and tobacco products; [c] census value added corresponds to the census concept of value added, which is larger than the national accounts concept. The census provides no detailed data on inputs to make both concepts comparable.
Sources: national accounts: see Figure 1. Censuses as described in text.

6. Labour Productivity Levels, Brazil/USA and Mexico/USA

Labour productivity is estimated by value added per person engaged. The UVRs estimated previously are used to express value added in a common currency. The main results for our benchmark years are shown in Table 6. In 1985, Brazilian output was 11 per cent of that of the USA, whereas Mexican output was only 4 per cent of the US level in 1988. Employment levels in the same years were 27 and 13 per cent of the US level.

Brazilian relative labour productivity was about 15 percentage points higher than that in Mexico. Brazil was more productive than Mexico in all branches except for tobacco products, printing and publishing, rubber and plastics, non-metallic minerals. Both countries had similar productivity levels in non-metallic minerals and transport equipment. Brazil's highest relative productivity levels were, surprisingly, in machinery and computers, professional equipment, and furniture and fixtures, and its lowest were in tobacco products, rubber and plastics and non-metallic minerals. Mexico's highest relative productivity levels were in rubber and plastics and in transport equipment and the lowest in wood and wood products and in furniture and fixtures.

Table 5

Brazilian and Mexican Relative Output, Employment and Productivity, USA=100

		Brazil as a Percent of the USA (US=100).1985			Mexico as a Percent of the USA (US=100). 1988		
		Value Added	Employment	Labour productivity	Value Added	Employment	Labour Productivity
20	Food Products	22.7	48.8	46.5	8.6	32.3	26.5
21	Tobacco Products	11.6	56.6	20.5	3.7	13.7	26.7
22	Textiles	24.4	44.8	54.4	9.2	25.8	35.8
23	Clothing and Apparel	17.2	32.4	53.2	3.8	12.8	29.4
24	Wood Products. Except Furniture	9.6	26.3	36.5	1.1	8.1	14.0
25	Furniture and Fixtures	25.4	35.2	72.0	2.1	15.0	14.0
26	Paper and Allied Products	8.1	18.9	42.6	2.0	7.8	26.3
27	Printing and Publishing	1.4	10.3	13.5	1.7	5.2	32.9
28	Chemicals	11.8	31.6	37.3	4.0	14.2	28.1
30	Rubber and Plastics	8.1	25.9	31.2	7.8	14.2	54.7
31	Leather and Leather Products	90.2	182.4	49.4	12.9	59.1	21.9
32	Non-metallic minerals	18.2	58.6	31.0	8.2	25.5	32.0
33	Primary Metals	12.9	25.3	50.8	3.8	13.2	29.1
34	Metal Products				3.1	11.3	27.8
35	Machinery and Computers	17.2	22.7	75.8	1.2	5.7	20.6
36	Electronic & Electrical Equipment	4.4	12.0	36.4	2.5	15.8	15.8
37	Transportation Equipment	8.6	15.4	55.9	3.9	7.6	50.8
38	Professional Equipment	4.3	5.8	75.1	0.3	2.1	12.5
39	Other Industries	12.0	29.1	41.3	1.8	9.5	18.9
20-39	Total Manufacturing	11.4	26.7	42.5	3.6	13.1	27.4

Sources: value added and employment in Brazil and Mexico from the censuses of production (see Text), and in the USA from the national accounts (see Figure 1). Value added was converted to a common currency using UVRs of Tables 3 and 4.

7. Trends in Price and Labour Productivity Levels, 1970-99

Relative Price Levels

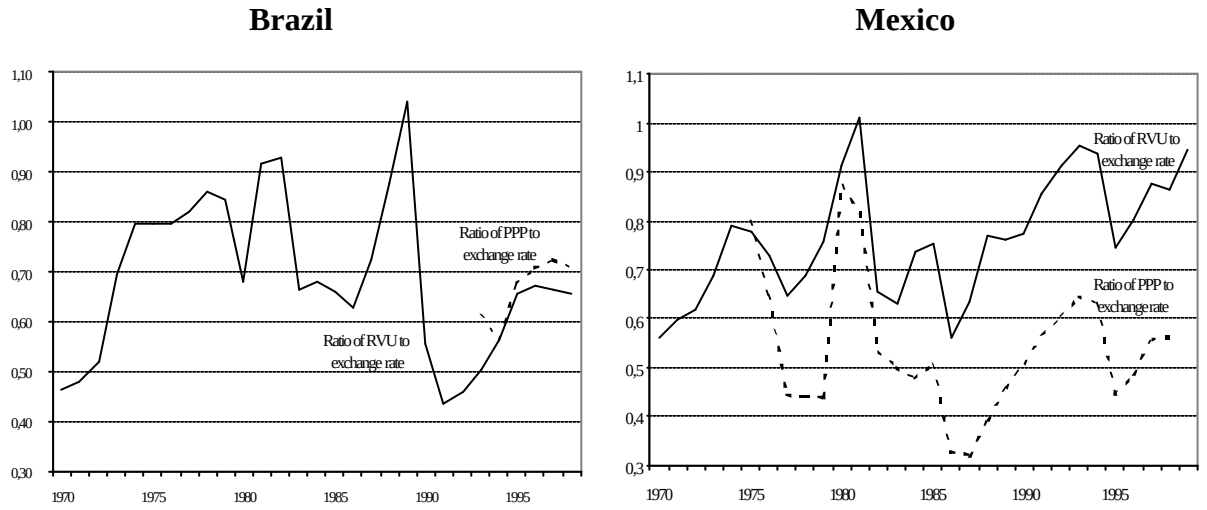
The ratio of the UVR to the exchange rate indicates whether the prices of Brazil and Mexico were above or under those of the USA. The 1985 and 1988 price levels were extrapolated with trends in manufacturing prices and nominal exchange rates, see Figure 3. It turns out that Brazilian and Mexican relative price levels were rather similar between 1970 and 1990. The trends reflects major changes in exchange rate regimes, such as the decline of the Mexican relative price level after it dropped its parity with the Dollar in 1976 and depreciated its currency. The trends for Mexico also show the major devaluations following economic crises such as the debt crisis in 1982 and the peso crisis at the end of 1994.

As Mexico, Brazil tried to maintain a constant exchange rate in the 1970s (it only adopted mini-devaluations), which together with a relatively high rate of inflation led to an increase of the price level. A major devaluation (by 30 per cent) did not occur until the end of 1979 explaining the fall in the relative price level. The contagion of the debt crisis in 1982 led to a major depreciation and fall in price level. From 1985 onwards, the government maintained the nominal exchange rate while inflation accelerated, causing a steep rise in the price level. This policy changed in 1989, with a range of stop-and-go policies, fixing the exchange rate for some months and introducing subsequently major devaluations. This led to a sharp drop in the price level between 1989 and 1991. In the subsequent years, the exchange rate was stabilised using massive market interventions, until the introduction of the Real in July 1994.

Figure 3 also shows the price level of the total economy. In Mexico, the overall price level was below that of manufacturing during the entire period, as expected by the Balassa Hypothesis. The trends for manufacturing and the total economy were almost the same. The few years for which PPPs are available for Brazil show the contrary. This is explained by the introduction of the Real in 1993-94, which led to a strong increase in the relative price level. Internationally exposed sectors, such as manufacturing, limited much more than the other sectors the price increases to reduce the loss of market shares on their home and foreign markets.

Figure 3

Trends in Brazilian and Relative Mexican Price Levels in Manufacturing and the Total economy, USA =1,00



Sources: benchmark UVRs from Tables 3 and 4, extrapolated with time series of manufacturing deflators derived by dividing current value added by constant value added from the national accounts as described in Figure 1. PPPs are from World Bank, World Development Indicators 2001. The price levels of the total economy is measured by the ratio of the PPP to exchange rate; that of manufacturing is measured by the ratio of the RVU to exchange rate. Series of nominal exchange rates from CEPII, the CHELEM database.

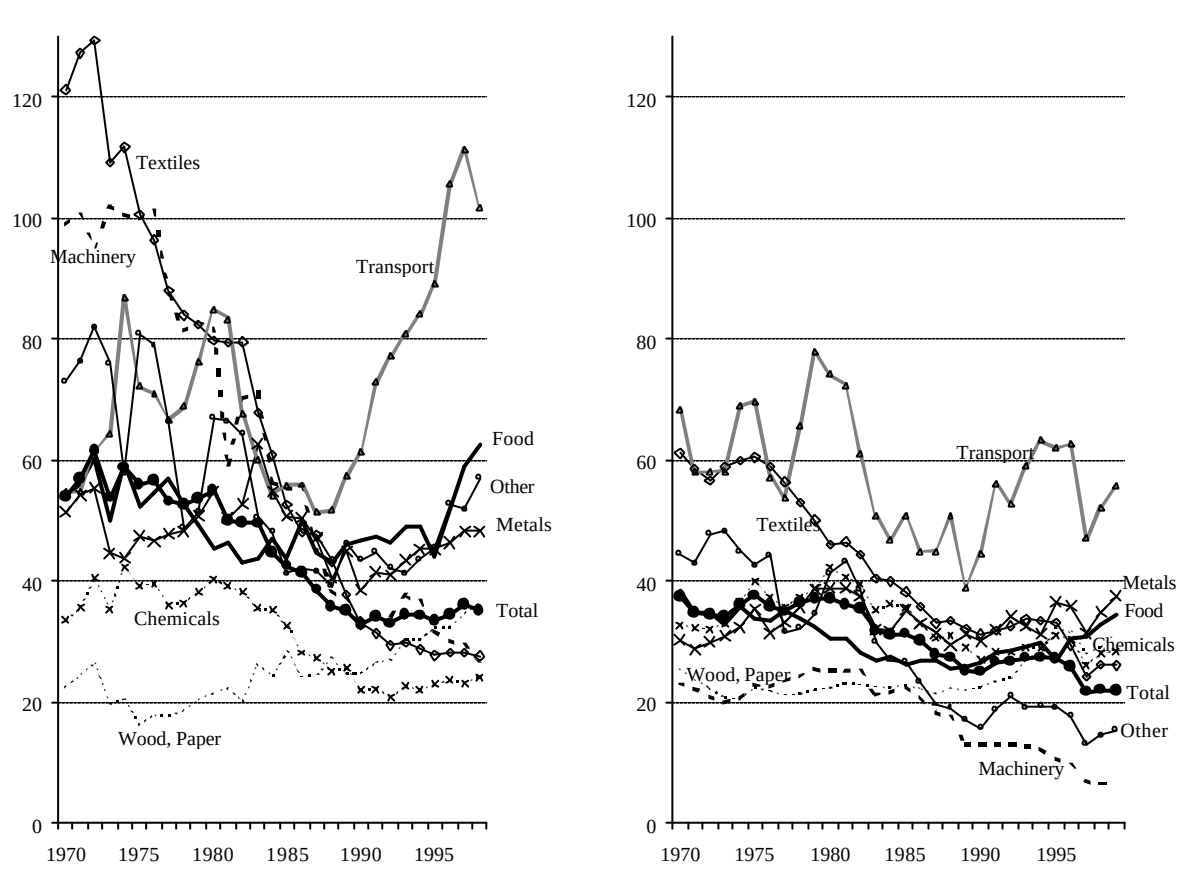
Productivity Levels

The benchmark estimates for 1985 and 1988 can be extrapolated with time series for value added at constant prices and employment for the 1970-99 period, see Figure 3. As shown in Figure 2, productivity growth has been faster in the USA than in Brazil and Mexico. As a consequence, the productivity gaps between Brazil and Mexico on the one hand and the USA on the other widened over time. The largest drop in overall relative productivity of the Latin countries occurred in particular

during the "lost decade" of the 1980s. In the 1990s, Brazil managed to stabilise the productivity gap, whereas Mexico's position further eroded after the peso crisis at the end of 1994. As productivity growth in the USA accelerated in the 1990s, the performance of Mexico until 1995 and that of Brazil throughout the decade are rather remarkable.

Figure 4

Trends in Labour Productivity Levels,
Brazil/USA and Mexico/USA, 1970-1998 (USA=100)



Sources: benchmark productivity levels from Tables 3 and 4, extrapolated with time series of value added and employment as described in Figure 1.

The overall trends hide large differences in gains and losses across the different sectors. In Brazil, most industries lost ground vis-a-vis the USA, except for transport equipment, wood and paper and to a lesser extent food, beverages and tobacco. For Brazil, consistent series of value added and employment only exist for the 1990s. These had to be combined with two other series for the 1980s and the 1970s. In particular for textiles and clothing, machinery and equipment, and transport equipment, the final series produce odd results in terms of trends in relative productivity levels[6]

In Mexico, the only branches that did NOT loose ground relative to their counterparts in the USA are basic metals and metal products and wood and wood products. As in Brazil, the largest relative

[6] For textiles, the Brazilian series show a fall in absolute productivity levels between 1970s and the 1990s, whereas in according to the US series important productivity gains were achieved in this sector. The combination of the two trends results in relative productive levels above 100 per cent in the early 1970s. Another explanation for the high relative level of Brazil in textiles is that the 1985 relative productivity level is probably overestimated due to the exclusion of non-census establishments, which had much lower productivity. For transport equipment, the Brazilian series show a substantial cut in employment with continuous positive output growth resulting in a very high rate of productivity growth in the 1990s. Combined with a moderate rate of productivity growth in the USA, the relative productivity level of Brazil exceeded 100 per cent after 1995.

productivity decline was observed in textiles and clothing. The Mexican time series produce more plausible results than those of Mexico, partly because of the availability of long run time series of the national accounts for value added and employment.

An important question is whether the differences in growth rates between Brazil and the USA in textiles and clothing, machinery and transport equipment are real or due to inconsistencies in the time series. For this purpose it is useful to check the plausibility of the time series by using them to backdate our 1985 benchmark estimates to 1975, which is the year for which the first benchmark comparison was made between Brazil and the USA by van Ark and Maddison (1994).[7] The extrapolated productivity result from 1985 to 1975 was 56 per cent of the US level, which was 7.5 percentage points higher than the result of Maddison and van Ark. Although the results for food products and basic metals and metal products were close, those for the other branches show major discrepancies. This seriously questions the validity of the Brazilian time series.

Table 6
Extrapolation of Relative Productivity Levels to 1975 and Comparison with Results of van Ark and Maddison (USA=100)

	Brazil			Mexico		
	1985	1975		1988	1975	
		Extrapolated	van Ark and Maddison		Extrapolated	van Ark and Maddison
Food, Beverages and Tobacco	43.9	52.5	56.6	25.5	33.9	36.1
Textiles and Clothing	52.7	100.6	52.5	33.4	60.5	38.2
Wood, Paper and Publishing	28.3	16.2	28.6	22.3	22.5	22.3
Chemicals	32.6	39.2	66.6	31.0	40.0	39.3
Basic Metal and Metal Products	50.8	47.5	42.4	29.4	35.4	42.8
Machinery, Equipment (except Transport)	55.3	99.8	51.6	17.5	22.8	31.3
Transport Equipment	55.9	72.2		50.8	69.8	
Other manufacturing	41.3	80.8	39.0	18.9	42.6	29.2
Total Manufacturing	42.5	56.0	48.5	27.4	37.6	37.1

Sources: benchmark results from Table 6, extrapolations based on time series as described in Figure 1.
The same exercise was carried out for the Mexico/USA comparison, see the right hand side of the table. In contrast to the Brazil/USA comparison, the extrapolated results for Mexico from 1988 to 1975 are very close to those of van Ark and Maddison. This finding holds for total manufacturing, as well as most branches except textiles and clothing and other manufacturing.

8. Unit Labour costs

Relative productivity levels are an important determinant of international competitiveness. However, some countries may not be handicapped by low productivity if at the same time labour compensation is also low. The net result of relative productivity and relative remuneration is expressed by the concept of unit labour costs. It divides the labour compensation in Brazil or Mexico relative to the USA by the labour productivity in Brazil or Mexico relative to the USA:

$$ULC^{xu} = \frac{\left(\frac{(W/N)^{x}_{P}}{NER_{P/\$}}\right)}{\frac{(W/N)^{USA}_{\$}}{RLPE}} \qquad (18)$$

[7] It should be stressed that even with exactly the same sources, extrapolated estimates will never exactly compare with benchmark results for the corresponding year, because of inconsistencies in index numbers.

where ULC are unit labour costs, W/N compensation per employee, NER nominal exchange rate, RLPE relative level of labour productivity, subscripts and superscripts represent *x* Brazil of Mexico, *P* currency of Brazil or Mexico, *USA* United States and *$* dollar. Labour costs of Brazil of Mexico are expressed in US$ using the exchange rate, as this is the rate used in international transactions. Labour productivity of the Latin countries, however, is converted into US$ by the UVR as this is the conversion factor applied to produced output.

Table 7 shows the results for both bilateral comparisons. In Brazil and Mexico, the relatively low productivity levels are largely compensated by even lower levels of labour compensation: in Brazil unit labour costs were only 23 per cent of the US level in 1985 and in Mexico only 37 per cent of the US level. The lowest unit labour costs in Brazil are in furniture and fixtures and food products, and in Mexico in rubber and plastics and fabricated metal products.

Table 7
Relative levels of unit labour costs
Brazil/United States (1985) et Mexico/USA (1988)

SIC		Brazil/USA. 1985			Mexico/USA. 1988		
		Units labour costs	Compensation per employee (USA=100)	Labour Productivity	Units labour costs	Compensation per employee (USA=100)	Labour Productivity
20	Food products	16.8	7.8	46.5	35.4	9.4	26.5
21	Tobacco Products	41.8	8.6	20.5	35.0	9.3	26.7
22	Textile Mill Products	20.8	11.3	54.4	42.1	15.1	35.8
23	Clothing and apparel	18.0	9.6	53.2	34.7	10.2	29.4
24	Lumber and Wood Products	17.6	6.4	36.5	46.4	6.5	14.0
25	Furniture and Fixtures	11.4	8.2	72.0	53.2	7.5	14.0
26	Paper and Allied Products	24.7	10.5	42.6	48.2	12.7	26.3
27	Printing and Publishing	84.4	11.4	13.5	28.3	9.3	32.9
28	Chemicals and Allied Products	32.6	12.2	37.3	48.3	13.6	28.1
30	Rubber and Plastic Products	38.0	11.8	31.2	11.4	6.2	54.7
31	Leather and Leather Products	18.9	9.3	49.4	31.2	6.8	21.9
32	Stone. Clay. Glass and Concrete Products	21.0	6.5	31.0	55.5	17.8	32.0
33	Primary Metal Industries	22.0	11.2	50.8	61.0	17.8	29.1
34	Fabricated Metal Products				23.8	6.6	27.8
35	Machinery and Computer equipment	17.4	13.2	75.8	56.4	11.6	20.6
36	Electronic and Other Electrical Equipment	34.4	12.5	36.4	59.6	9.4	15.8
37	Transportation Equipment	19.7	11.0	55.9	32.5	16.5	50.8
38	Medical. precision and Optical equipment	13.4	10.1	75.1	73.1	9.2	12.5
39	Miscellaneous Manufacturing Industries	25.1	10.4	41.3	36.1	6.8	18.9
20-39	Total Manufacturing	22.7	9.6	42.5	36.7	10.1	27.4

Sources: relative productivity levels from Table 5, labour compensation from censuses of manufacturing as described in Text.

9. Conclusion

International comparisons of productivity levels by industry of origin are a key measure of economic performance next to comparisons of per capita income and other aggregates measures at the economy-wide level. This study assesses the labour productivity gap between Brazil and Mexico on the one hand and the USA on the other in the mid-1980s. It is an update of Maddison and van Ark (1994), who assessed the relative performances of these countries in 1975. The paper adopts the ICOP industry-of-origin methodology developed by the University of Groningen and refined in collaboration with CEPII. This method uses relative producer prices, also referred to as unit value ratios (UVRs) instead of exchange rates or proxy PPPs to express the output of different countries in a common currency (here US$). The paper introduced reliability tests for the UVRs using coefficient of variation. It turned out that both the UVRs of both Brazil/USA and Mexico/USA are well within the confidence intervals, although the variation of the former are higher than that of the latter bilateral comparison. Moreover, the representativeness of the Mexico/USA comparison is far greater than that of the Brazil/USA comparisons, as the relative price estimates are based on a substantially larger part of output in the latter comparison.

Brazilian productivity in 1985 was 42.5 per cent of the US level and that of Mexico in 1988 27.4 per cent. Large variations across sectors exist with regard to relative productivity levels. The reliability tests of the UVRs indicate that in some branches our measures need to be improved, either with new product matches or quality adjustments. However, the most problematic issue, which falls outside the immediate scope of the ICOP methodology, concerns the Brazilian time series of value added and employment used to extrapolate our benchmark results for the 1970-99 period. In particular

the time series for textiles and clothing, and machinery and transport equipment seem very implausible. An alternative and probably more reliable method is to redo a full benchmark comparison each decade. As such the ICOP estimates of comparative labour productivity in textiles and clothing, wood, paper and publishing, machinery and transport equipment and other manufacturing between the 1975 and the 1985 benchmark estimates seem much more plausible than the huge relative productivity changes suggested by the backward extrapolation procedure (see Table 8). To obtain reliable results the 1990s, the way forward therefore also seems to carry out a new set of bilateral comparisons instead of relying on the extrapolated results from 1985 and 1988.

Another area which requires further investigation is the reliability of the national accounts of Brazil and Mexico, and in particular the practice of both countries in estimating value added of informal activity. The Mexican accounts add more than a third to the census estimate of value added, whereas the Brazilians do not seem to make any imputation, in spite of evidence from employment statistics that informal activity is proportionally comparable between the two countries. Van Ark and Maddison (1994) already observed this for 1975, and it would be interesting to check this with the new evidence for the 1990s.

In order to understand the differences in economics performances between Brazil and Mexico, the analysis can be extended with new variables. In particular, it would be interesting to compare the investment behaviour between the two countries, and as such the contribution of capital to labour productivity differences. Hofman and Mulder (1998) presented some rough comparative estimates of labour, capital and multi-factor productivity in manufacturing in Brazil and Mexico. These results could be refined, although sectoral investment data, necessary to build capital stocks, in Brazil and Mexico have to be used with great care. Other variables that would greatly contribute to the understanding of manufacturing performance include human capital, and institutional factors that account for differences in the pace of economic and international trade reforms in both countries in the 1980s and 1990s.

References

Ark, B. van and A Maddison (1994), "An International Comparison of Real Output, Purchasing Power and Labour Productivity in Manufacturing Industries: Brazil, Mexico and the USA in 1975", *Research Memorandum*, No. 567 (GD-6), Groningen Growth and Development Centre.

Ark, B. van , R. Inklaar and M. Timmer (2000), "The Canada-US Manufacturing of Productivity Gap revisited: new ICOP Results", paper presented at the CSLS Conference on the Canada-US Manufacturing Productivity Gap, January 21-22

Ark. B. van and M. Timmer (2001) "PPPs and International Productivity Comparisons: Bottlenecks and New Directions", paper presented Joint World Bank/OECD seminar on purchasing power parities, 30 January – 2 February, Washington DC.

Chevallier, A. and D. Unal-Kesenci (2001), "La productivité des industries méditerranéennes", *Working Paper*, CEPII, Paris, forthcoming.

Cottenet H. & N. Mulder (2001), "The Competitiveness of Egyptian Manufacturing: An International Perspective", *Working Paper*, CEPII, Paris, forthcoming.

Freudenberg, M. and D. Unal-Kesenci, 1994. "French and German Productivity Levels in Manufacturing", *Working Paper*, No. 94-10, CEPII, Paris.

Hofman, A. and N. Mulder (1998), "The Comparative Productivity Performance of Brazil and Mexico, 1950-94", with in J. Coatsworth and A. Taylor (eds.*), Latin America and the World Economy in the Nineteenth and Twentieth Centuries: Explorations in Quantitative Economic History*, Harvard University Press.

Kravis, I.B., A. Heston and R. Summers (1982), *World Product and Income: International Comparisons of Real Gross Product*, Johns Hopkins University Press, Baltimore.

Mulder, N., L. Peres and S. Montout (2001), "Brazil and Mexico's Comparative Manufacturing Performance in the 1980s", Working Paper, CEPII, Paris, forthcoming.

Nayman L. & D. Ünal-Kesenci (2001), "The France-Germany Manufacturing Productivity Comparison: Ten Years After the German Reunification", *Working Paper*, CEPII, Paris, forthcoming.

Paige, D. and G. Bombach (1959), A Comparison of National Output and Productivity of the United Kingdom and the United States, OEEC and the University of Cambridge, Paris.

Rostas, L. (1948), *Comparative Productivity in British and American Industries*, NIESR, Occasional Papers, No. 13, Cambridge University Press, Cambridge.

Selvanathan (1991),

Timmer, M., B. van Ark, N. Mulder, L. Nayman and D.Ünal-Kesenci (2001), "Formalization of the ICOP methodology for binary manufacturing comparisons", mimeo, University of Groningen and CEPII, Groningen and Paris.

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