The ICOP Manufacturing Database: International Comparisons of Productivity Levels

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International comparisons of productivity levels provide an important complement to the more familiar international comparisons of productivity growth. They place the productivity record of a country in the comparative perspective of its current level of productivity and provide insights into the possible scope for further growth. They serve as a starting point for studying international competitiveness, economic growth and patterns of convergence and divergence in the world economy. Current analytical work in this area is highly dependent on the Penn World Tables (PWT) constructed by Alan Heston and Robert Summers (Summers and Heston 1991). PWT rely on purchasing power parities (PPPs) derived from the UN International Comparisons Program (ICP). PPPs are now provided on a regular basis by Eurostat, the OECD and the World Bank. However, expenditure PPPs raise problems for comparisons by industry (agriculture, industry and services) as, by design, such PPPs are not available on an industry basis.

In 1983, the ICOP (International Comparisons of Output and Productivity) project was set up at the University of Groningen in the Netherlands under the direction of Angus Maddison to pursue research on industry-of-origin comparisons of output and productivity. The ICOP work follows in the tradition of Rostas (1948), Paige and Bombach (1959), West (1971), Frank (1977) and Smith, Hitchens and Davies (1982). ICOP studies for the manufacturing sector, which until now have represented the core of the program, have two distinctive characteristics. Firstly, they make use of industry-specific currency conversion factors, which are called unit value ratios, or UVRs, based on producer output data instead of final expenditure information. These UVRs are used to convert output into a common currency for a benchmark year. A second distinctive characteristic of ICOP studies is that data on production and employment are usually derived from a single primary source, which for manufacturing is the census of production or industrial survey, hence guaranteeing consistency in terms of coverage of the output and input.

Since the first comparison of manufacturing output and productivity for Brazil and Mexico relative to the United States by Maddison and van Ark (1989), comparisons have been made for more than 30 countries through the research input of a dozen scholars, mainly at the University of Groningen, but also at the National Institute for

Economic and Social Research (London), the Centre d'Études Prospectives et d'Informations Internationales (Paris) and the Technical University Eindhoven. The database covers countries at various stages of development, including countries in the OECD area, Eastern Europe, Latin America, Asia and Africa.[1] ICOP data are currently used on a regular basis by various international organizations, including the ILO (2001) and the OECD (Scarpetta et al., 2000), and by business organizations, such as the McKinsey Global Institute (1993) and The Conference Board (1997, 1998).

Manufacturing Unit Value Ratios

The main novelty in ICOP studies is the derivation and use of industry-specific purchasing power parities based on producer output data instead of final expenditure information. The basic data sources for the calculation of these PPPs are the manufacturing censuses or industrial surveys of the different countries. These contain product level data on quantities and output values, allowing for calculation of unit values for each item or group of items. For example, the U.S. Census of Manufactures contains information for more than 10,000 industrial products, but generally less information is available for other countries. On the basis of a binary product matching procedure between each country and the reference country, product level unit value ratios (UVRs) are derived. To give an indication of the level of detail involved in these matches, typical product matches are ladies shoes, rubber automobile tires, cars with a cylindric capacity of a certain size, Portland cement, etc.. These product UVRs are subsequently aggregated into higher level UVRs by a stepwise weighting procedure from product level to industry level, to branch level and finally to the level of total manufacturing. The number of product matches varies substantially between comparisons, i.e., from only 67 product matches in the case of the China/U.S. comparison for 1985 up to 760 product matches in the case of East Germany/West Germany comparison in 1992. On average the binary comparisons include around 180 matches, covering on average 30 per cent of the "own country" output and 20 per cent of the "base country" output. As the procedure to obtain unit value ratios is quite resource intensive, it is usually done for a single benchmark year — at present mostly the year 1987, or a year close to that.[2]

Table 1 provides a comparison of the Fisher UVRs — which is the geometric average of Laspeyres UVRs, using own base weights, and Paasche UVRs, using own country weights — for total manufacturing with ICP PPPs for total GDP and the official exchange rates. It should be emphasized that the methodology and sources used for the ICOP approach has been fundamentally different from those used in the ICP program. Prices in ICOP are essentially unit values, obtained from values and quantities for product groups as given in manufacturing censuses and industrial surveys, whereas ICP PPPs are derived from specified prices which are obtained from a specific survey set up for the purpose.[3] A strong advantange of ICOP UVRs over ICP PPPs, is that the output coverage of matched products is substantially larger than percentage of total expenditure covered by ICP PPPs.

Despite these differences in methodology, two observations can be made when comparing ICOP UVRs and ICP PPPs. First, for developing countries the UVR for total manufacturing is much higher than the GDP PPP. This is because the GDP PPP also includes relative prices of services which are generally much lower in developing countries than in developed countries, the so-called Balassa effect. For example, for India the difference in the GDP PPP and the ICOP manufacturing UVR is more than 150 per cent. This implies that the use of GDP PPP for

Table 1
Comparison of Manufacturing Unit Value Ratios with Exchange Rate and GDP PPP in Benchmark Years

	Fisher Unit Value Ratios (own currency/US$)	Exchange Rate (own currency/US$)	GDP PPP (own currency/US$)	Exchange Rate as % of Fisher UVR	GDP PPP as % of Fisher UVR
base country: United States					
Australia/US (1987)	1.49	1.43	1.28	96	86
Belgium/US (1987)	42.61	37.33	40.5	88	95
Brazil/US (1985)**	4091	6202	2539	152	62
Canada/US (1987)	1.33	1.33	1.31	100	98
China/US (1985)	1.45	2.90	0.79	200	54
Finland/US (1987)	5.62	4.40	6.01	78	107
France/US (1987)	7.22	6.01	6.80	83	94
India/US (1983)	8.08	10.10	3.06	125	38
Indonesia/US (1987)	1200	1644	417	137	35
Japan/US (1987)	174	145	210	83	121
Korea/US (1987)	700	823	474	118	68
Mexico/US (1988)**	1753	2290	869	131	38
Netherlands/US (1987)	2.32	2.03	2.34	88	101
Sweden/US (1987)	8.03	6.34	8.43	79	105
Taiwan/US (1986)	29.60	37.90	23.3	128	79
Tanzania/US (1989)*	117	143	n.a.	122	n.a.
UK/US (1987)	0.71	0.61	0.563	86	79
USSR/US (1987)	0.455	n.a.	n.a.	n.a	n.a
West Germany/US (1987)	2.21	1.80	2.20	81	100
Zambia/US (1990)*	43.79	34.47	19.85	79	45
base country: West Germany					
Czechoslovakia/West Germany (1989)	3.87	8.01	n.a	207	n.a.
Czech Republic/Germany (1996)	9.0	18.0	6.1	200	68
East Germany/West Germany (1987)	1.89	4.52	0.85	239	45
East Germany/West Germany (1992)	0.70	1.00	n.a	143	n.a.
Hungary/West Germany (1987)	13.80	25.80	8.67	187	63
Hungary/Germany (1996)	54.4	101.4	42.2	186	78
Poland/West Germany (1989)	343	765	248	223	72
Poland/Germany (1996)	0.92	1.79	0.82	195	89
base country: France					
Egypt/France (1996)**	0.31	0.58	0.21	187	68
Morocco/France (1997)**	0.86	1.63	0.55	190	64
base country: United Kingdom					
Portugal/UK (1984)	190	195	105	103	55
Spain/UK (1984)	197	214	164	109	83

Note: Only benchmark years and countries which are used for estimates in Table 2; See ICOP website (http://www.eco.rug.nl/ggdc/icop.hmtl) for details on studies for individual binary comparisons. Exchange rates from IMF; GDP PPPs from Eurostat, OECD and Penn World Tables.

* Provided by ICIS Research Group at Technical University Eindhover.

**Provided by CEPII Research Group, Paris.

Source: For full references see ICOP website.

manufacturing productivity comparisons can lead to a large overestimation of relative productivity levels in less advanced countries. Secondly, the exchange rate also differs from the manufacturing UVR but in a less systematic way. It appears that for less developed countries, the exchange rate is generally considerably higher than the manufacturing UVR, whereas in most developed countries, the exchange rate is lower. Price levels range from 35 per cent of the U.S. level in Indonesia to 121 per cent in France. Explanations of these systematic trends can be a fruitful area for further research.

Relative Productivity Levels in Manufacturing

The unit value ratios for the benchmark year are used to express output and labour productivity in the same currency units.[4] For level comparisons output and labour input are preferably derived from the same sources, e.g. the manufacturing census or the industrial survey of each country. The data from these sources, which are often not well harmonized internationally, require careful adjustments for the concept of output or value added used, the definition of labour input and the exact classification of activities by industries. The benchmark estimates of output and labour productivity are then extrapolated over time using series on real output and labour input, i.e. persons employed and, where possible, working hours. The latter series are mostly taken from the national accounts and employment statistics as the intertemporal comparability is usually greater for those statistical sources than for the census.

Table 2 provides labour productivity measures for total manufacturing for 29 countries for 1960, 1973, 1987, 1998 and 2000. We provide estimates of value added per person employed and, where possible, of value added per hour worked. The basic comparisons are made for a benchmark year, usually 1987 as indicated in Table 1. For low income countries, the basic comparisons are usually for the larger firms in the industry, as detailed census material for small scale manufacturing firms usually are not available. For example, in Indonesia the annual manufacturing survey excludes establishments with less than 20 employees, and the oil refining and liquid natural gas industry. In India, establishments with less than 20 employees using no power, or establishments with less than 10 employees using power, are not covered by the census. Where possible we made use of secondary sources and national accounts to provide a comparison for the whole of manufacturing as well.[5]

The countries in Table 2 are ranked according to their value added level per person employed in 1987. Here we point out some of the main trends.[6] It is clear that on a per person employed basis, the United States has been the productivity leader over the past 50 years. In 1998 all countries showed levels of manufacturing output per person employed of less than 85 per cent of the U.S. level. Most European countries have shown a strong convergence in manufacturing labour productivity toward the U.S. level since the 1960s, though in a number of countries this process has lost momentum or has even been reversed after 1973 (notably in West Germany, see van Ark and Pilat, 1993). U.K. productivity performance is rather poor and has stagnated around the 50 per cent of the U.S. level since the 1960s. Canada's relative position worsened in the past decades but from a relatively high level in the 1960s, hence its current productivity level is still well above that of the United Kingdom or Australia. Japan showed rapid catch up with the United States during most of the period, but remained below 75 per cent of the value added per person employed in the United States during the 1990s.

On a per hour worked basis, the U.S. leadership in manufacturing has been challenged by sev-

Table 2:
ICOP Estimates of Comparative Levels of Labour Productivity in Manufacturing, 1960-2000
United States=100

	1960		1973		1987		1998		2000	
	Value Added per Person Employed	Value Added per Hour	Value Added per Person Employed	Value Added per Hour	Value Added per Person Employed	Value Added per Hour	Value Added per Person Employed	Value Added per Hour	Value Added per Person Employed	Value Added per Hour
India										
all firms	2.2		2.3		2.2		2.7			
registered firms only (a)	7.9		7.7	6.2	8.8	6.8	11.7	9.3		
China										
all firms	6.8		5.8		4.5		7.6			
large firms only (b)					5.7		8.0			
Indonesia										
all firms	3.3f		2.7	2.4	4.6	4.2	5.4	4.8		
medium & large only (c)			9.5j	7.4j	8.0	6.3	13.0	11.0		
Tanzania	9.0i		11.6		3.9					
Zambia	9.3h		10.7		5.3		3.1			
Egypt (d)			14.3		18.7		16.0k			
Hungary	19.0		17.8		20.1		27.1			
Poland	25.4		26.4		21.2		18.6			
East Germany	25.8		23.8		22.5	23.5	63.5			
Morocco					23.1		27.3			
Czechoslovakia	29.4		25.4		24.0		13.6l			
Portugal	17.1		27.6		24.5	23.2	23.5	25.3		
Taiwan	11.9g	8.7g	18.9	14.6	24.9	20.4	30.5	26.9		
USSR										
all industry (e)	27.2		25.5	26.8	26.1	27.7				
manufacturing only					24.8	26.3				
Korea	11.3g	8.0g	17.1	12.7	26.5	18.4	43.1	35.9		
Mexico	43.5		41.7		28.3		27.2			
Brazil	54.1		56.0		42.5		35.9			
Spain	25.8		43.4	38.0	45.0	49.2	38.4	43.0	33.8	38.2
Australia	45.2	44.5	45.7	46.7	48.4	49.9	42.5	43.3	38.1	39.0
United Kingdom	48.3	44.6	53.4	54.9	53.6	58.0	50.1	57.8	47.9	55.2
Finland	48.8	45.5	55.0	58.7	65.9	74.3	86.4	102.4	88.9	106.6
Sweden	52.0	54.5	74.7	90.1	68.4	87.4	83.9	100.8	79.2	95.1
West Germany	65.6	60.7	78.3	83.1	70.2	82.2	71.3	91.8	67.9m	88.6m
France	50.8	50.2	71.9	76.2	71.2	84.0	79.4	97.5	72.2	92.6
Japan	32.3	24.8	67.4	58.3	76.4	67.5	73.6	73.5	71.6	70.4
Canada	75.8	75.5	83.5	85.1	77.5	79.4	70.9	72.9	64.1	65.7
Belgium	44.9	45.3	61.4	71.6	78.5	99.8	83.9	107.5	75.4	96.0
Netherlands	51.3	47.6	73.3	80.5	83.3	105.4	78.0	103.7	72.3	95.3
United States	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(a) establishments with 20 or more employees and establishment with between10-20 employees using power; (b) enterpises above township level; (c) establishments with 20 or more employees except those in oil and gas refineries; (d) firms with 10 employees or more; (e) including mining and public utilities; (e) 1961; (g) 1963; (h) 1964; (i) 1965; (j) 1975; (k) 1997; (l) Czech Republic; (m) 1999.

eral European countries, such as Belgium and the Netherlands and — more recently — Finland and Sweden, as annual hours worked are much shorter in most European countries. As hours worked in Europe continued to decline rapidly in the 1990s, improvements on a per hour base relative to the United States lasted somewhat longer.

Emerging Southern European economies such as Portugal and Spain showed rapid catch up in the past but still have a long way to go to approach productivity levels of the most advanced countries in the OECD. During the 1990s, the Eastern European countries have hardly recovered from the collapse of the socialist planning system. By the end of the 1990s, productivity was around 20-25 per cent of the U.S. level, which is not too different from their relative performance in the 1960s. The relative productivity performance of the Czech Republic has even considerably worsened. Mexico and Brazil had relatively high productivity levels in the 1960s, i.e. well above those of countries in Asia, and Eastern and Southern Europe. However, the economic crises of the 1980s has slashed their performance to 30-35 per cent of the U.S. level in the 1990s and little improvement can be noticed so far. The growth miracle of the East Asian economies, South Korea and Taiwan is well recorded. But as these countries departed from very low productivity levels in the 1960s, relative levels are still well below that of the United States and other OECD countries. As much of East Asia's productivity advantage over other countries at similar income levels is based on particularly long working hours, value added per hour worked is less impressive. The three large Asian economies, India, China and Indonesia, operate at very low levels of relative labour productivity. Even when considering the large-scale sector only, value added per person employed is not above 13 per cent of the U.S. level, well below that of other countries in our data set. However, some catch up appears to take place in the 1990s. Finally, Zambian and Tanzanian manufacturing are currently at the bottom of relative labour productivity levels. Although in the 1960s its level was higher than in most Asian countries, its decline has been very strong, especially in the crisis years of the 1990s.

Some of the comparative results may cause some surprise for readers used to looking at comparative measures of per capita income. The present figures are comparisons of labour productivity in a sector that makes intensive use of capital. Moderate differences in capital intensity can have a big impact on the comparisons of manufacturing labour productivity. For example, manufacturing in Latin American countries has traditionally been much more capital intensive than in Asia. Differences in industry composition can also have a large impact, as appears from studies using shift-share analysis (Timmer, 2000). An issue of a more statistical nature is that the further the extrapolated time series move away from the benchmark year, the more problematic the measures become. This is so in particular for series of real manufacturing output in formerly planned economies, and for developing countries with sizeable small-scale manufacturing sectors. However, on the whole the measures do not contradict those for the total economy, which include agriculture and services which often have very different comparative productivity levels.

Concluding Remarks

The ICOP manufacturing database provides international comparisons of productivity levels in manufacturing for the period from 1950 onwards. It is based on information from manufacturing censuses and makes use of industry-specific purchasing power parities. The underlying country studies also provide similar data for about thirteen 2- and 3-digit manufacturing

industries. The basic database is continuously being extended in several directions. First, this database is based on binary comparisons, but multilateral aggregation methods have also been applied, which allow comparisons with countries other than the U.S. without violating consistency between the comparisons (Pilat and Rao, 1996; Rao and Timmer, 2000). Second, for a number of countries, capital stock estimates are also available to provide international comparisons of manufacturing multi factor productivity levels (van Ark and Pilat, 1993; Timmer, 2000). Third, the ICOP industry-of-origin approach has also been applied to other sectors in the economy. Pilat (1994) provides comparisons of Japan and South Korea for all sectors, and Mulder (1999) does the same for Brazil and Mexico. Maddison and Rao (1996) provide comparisons of prices and productivity in agriculture based on FAO-data. Van Ark, Monnikhof and Mulder (1999) present measures on the transport and communication, and the wholesale and retail service sectors for a number of OECD countries. More recently, measures of the latter two service sectors have been extended to 18 countries and are included in the current round of ILO Key Indicators on the Labour Market (ILO, 2001).

The ICOP project is an on-going research project and will be annually updated. Currently, a new round of benchmark comparisons is being prepared, being a 1997 benchmark rather than 1987.[7] In this new round, several methodological improvements are being introduced. Most importantly the problems concerning heterogeneity of products in the product matches and differences in quality of products are tackled in various ways. These problems are becoming increasingly serious as manufacturing production becomes increasingly customized and dominated by specialized high-tech products. One approach is to make better use of alternative harmonized data sources across countries (such as the PRODCOM database of the European Union member states). A second approach is to make better use of hedonic techniques to compare products (and their prices), such as automobiles and computers, on the basis of their quality characteristics. A third attempt is to combine industry-of-origin UVRs to a greater extent with selected proxy PPPs, adjusting the latter for transport and distribution margins and export versus import prices. Also, the feasibility of double deflation techniques is being further considered. With the use of input-output tables it is possible to derive input UVRs alongside output UVRs. Van Ark and Timmer (2001) provide a more elaborate discussion of the current and future directions of the ICOP-work. Finally, a broader coverage of countries is desirable and researchers are strongly encouraged to participate in the ICOP research programme in order to increase its country coverage.

Notes

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1 See the ICOP page (http://www.eco.rug.nl/GGDC/icop.html) at the website of the Groningen Growth and Development Centre for a full review.

2 See the ICOP website for recent ICOP studies with a new benchmark for 1997 or thereabout.

3 The "unit value" nature of the ICOP prices raises problems concerning heterogeneity of products within each product group and quality differences. On the whole, ICOP takes a fairly conservative approach by matching only those products for which quality differences can be assumed absent or for which quality adjustments can be made by using information from secondary sources (e.g. for cars and computers). Moreover, statistical procedures are applied to remove outliers from the selection. See Van Ark and Timmer (2001) for a review of these problems and how these are tackled in various ICOP studies.

4 Alternatively, one can apply the UVRs to national accounts data if a clear link with national accounts data is desired. See Szirmai and Pilat (1990) for an early attempt. More recently ICOP UVRs are applied to GDP from national accounts in the ILO *Key Indicators of the Labour Market* (ILO, 2001).

5 The full database, including annual time series on value added, employment and hours worked for the period 1950-2000 is available from the website of the Groningen Growth and Development Centre.

6 For full discussions, the reader is refered to the underlying studies for the various benchmark comparisons, which are reported (and are partly downloadable) from the ICOP website (http:/www.eco.rug.nl/ GGDC/icop.hmtl).

7 Such comparisons are already available for Canada, France, Germany, Japan and the Netherlands relative to the United States. See the ICOP website for references to those studies.

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