Productivity in services: an international comparative perspective

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1. Introduction

Relatively little work has been done on international comparisons of service productivity. This is partly because of the complexity of the measurement problems. Also, service productivity is strongly affected by the institutional organization, the legal framework and cultural preferences within each country.

There is a need, however, to get a clearer picture of the comparative productivity performance of service industries. Firstly, services account for an increasing share of economic activity. In 1995, the average output share of services for OECD countries was about 70 per cent of total GDP, though there are substantial differences among countries. The United States (US) had the highest service output share, at over 80 per cent of total GDP in 1994. In Germany the service output share was only 65 per cent in 1995, and it was more highly concentrated in financial and business services.[1]

Secondly, international trade in producer services is rising rapidly. Because of this, the comparative productivity performance of service industries directly affects the trade balance of nations.

A third reason is that services have become increasingly integrated with industrial activity. As a result, even when some particular service is not traded, higher productivity of service producers can play a role in increasing a country's world market share in industrial products. The integration of industrial and service activities is partly caused by the outsourcing choices of industrial enterprises and partly by the rise of new business activities. In practice, a much greater share of the labour force is associated with the production of the final output of industrial products than would appear to be the case from just counting those who are employed by manufacturing establishments.

This paper deals with measurement of productivity differentials in services for five countries: namely Canada, France, Germany,[2] the Netherlands and the US. Estimates of levels of output and productivity relative to the US are obtained for

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transport, communication and distribution. The estimates are based on the industry of origin approach, which has been applied in the International Comparisons of Output and Productivity (ICOP) project. The ICOP method is discussed in more detail in section 2. It makes use of data on industry outputs and inputs from production statistics and from national accounts in combination with estimates of quantity relatives and purchasing power parities by industry.

Sections 3 and 4 present labour productivity results for transport and communication, and for wholesale and retail trade. Overall, we find that the US is the productivity leader. However, there are big differences in relative probability levels between industries. For example, we find that European countries are further behind US productivity in railways than in air transport. In communication, and, in particular, in telecommunication, productivity differences between countries are now quite small. In distribution, the gap in gross margin per hour worked between most countries and the US is bigger for retail than for wholesale trade.

In section 5 of the paper we compare the results for services with those for the commodity sectors, including agriculture and manufacturing. Recent papers have called attention to the convergence in service productivity between countries as a driving factor behind convergence at the aggregate level.[3] Although we do not present time series, it appears from our estimates for 1992 that productivity differences were at least as large for services as for the commodity sectors.

Section 6 briefly considers possible explanations for the observed productivity gaps in services. This evidence remains inconclusive, but suggests directions for further research.

2. Methodology of international comparisons of service productivity

In international comparisons of service productivity, two approaches can be distinguished. The first is a *case study approach*. In this approach, a specific industry is analyzed in detail to determine its output and input variables and the production processes. These case studies often make use of data for individual establishments and benchmarking techniques to compare performance. At present there are only a limited number of such studies. Recent examples include the studies of the McKinsey Global Institute (for example, McKinsey Global Institute 1992; Baily 1993) and studies which measure efficiency frontiers in, for example, air transport, postal services and railways (Good et al. 1993; Perelman and Pestiau 1994).[4]

The second approach, which is characteristic of this paper, is called the *sectoral approach*. It focusses on sectors (e.g. agriculture, industry, market and non-market services), branches (e.g. food products, machinery, transport, finance, etc.) and industries (e.g. dairy products, woodworking machinery, airlines, insurance, etc.) in relation to the performance of the total economy. The aims of the sectoral approach are to stay as close as possible to concepts and definitions of the national accounts, to try to apply uniform methods across sectors, and to try to achieve full coverage of all activities in a particular sector or branch. Hence this method provides a link

between the micro-type case studies and studies of macroeconomic performance.

Most sectoral comparisons have concentrated on commodity sectors of the economy. The problem in services is that one cannot clearly distinguish between prices, quantities and quality. Firstly, the 'quantity' of a service is difficult to capture, as it often represents a process by which a user (consumer) or the user's good is changed (Hill 1977). Secondly, compared to goods, many services are characterized by a greater degree of heterogeneity (perhaps even uniqueness), so that aggregation is difficult. These problems, in combination with the relative scarcity of data on services, makes decomposition of output into price, quantity and quality a complex task (Griliches 1992).

In order to compare output across countries, we constructed sectoral purchasing power parities to convert output value to a common currency, say US dollars.[5] Exchange rates cannot be used for this purpose because these are increasingly affected by capital movements or speculation. Also, exchange rates only pertain to goods and services that are tradeable. Other studies have exclusively relied on 'expenditure-based' purchasing power parities, but these are inappropriate as a conversion factor for industry output which is expressed in terms of producer prices.[6]

Our method derives from earlier ICOP studies by Maddison and Mulder (1993) and Mulder (1994), although we have refined these procedures.[7] For transport and communication we first compared the volume of each service 'i' across countries. In transport, the quantity unit is passengers or passenger kilometres for passenger transport and tons or kilometres for freight transport. In communication the unit is pieces of mail delivered for postal services and telephone access lines or number of calls for telecommunication. Each comparison is made on a bilateral basis with the US as the benchmark country. We obtained unit value ratios from the quantity indicators between each pair of countries X and U (Q_i^X/Q_i^U) and the corresponding value of gross output or revenue (GVO_i) in each country.[8] Hence the average *unit value ratios* for countries X and U in transport and communication are:

$$UVR_{trcom}^{XU(X)} = \frac{\sum_{i=1}^{r}\left[GVO_i^{X(X)} - \frac{Q_i^X}{Q_i^U}\right]}{GVO_{trcom}^{U(U)}}, \tag{1a}$$

applying output weights in the national currency of country X ($GVO^{X(X)}$) for service i, and

$$UVR_{trcom}^{XU(U)} = \frac{GVO_{trcom}^{X(X)}}{\sum_{i=1}^{r}\left[\frac{Q_i^X}{Q_i^U} * GVO_i^{U(U)}\right]} \tag{1b}$$

using country U's output weights ($GVO^{U(U)}$) for service i.[9]

For distribution, our output measure is the gross margin (sales minus purchases of goods destined for resale and changes in inventories). For retail trade we obtained separate purchasing power parities for the sales of retail goods (PPP_i) and for the purchases of these goods (UVR_i). The sales *PPP*s are selected expenditure *PPP*s weighted at the sales value of the particular product groups ($Sales_i$). For purchases we used unit value ratios for manufacturing from earlier ICOP studies weighted by the purchases of these goods ($Purchases_i$). The unit value ratios refer to the producer prices. These were used as proxies for the purchase prices of retailers. The formula for the 'double deflated' PPP values for retail trade evaluated using sales and purchases weights ($Sales^{U(U)}$ and $Purchases^{U(U)}$) is:[10]

$$PPP^{XU(U)}_{Retail} = \frac{\sum_{i=1}^{R}\left(\left[Sales_i^{U(U)} * PPP_i^{XU}\right]\left[Purchases_i^{U(U)} * UVR_i^{XU}\right]\right)}{Gross\ Margin^{U(U)}_{Retail}}. \quad (2a)$$

Evaluated using the sales and purchases weights of country X ($Sales^{X(X)}$ and $Purchases^{X(X)}$), these purchasing power parities are:

$$PPP^{XU(X)}_{Retail} = \frac{Gross\ Margin^{X(X)}_{Retail}}{\sum_{i=1}^{R}\left(\left[Sales_i^{X(X)} / PPP_i^{XU}\right]\left[Purchases_i^{X(X)} / UVR_i^{XU}\right]\right)} \quad (2b)$$

where PPP^{XU} refers to expenditure purchasing power parities for good *i* and UVR^{XU} refers to unit value ratios for good *i*.

For wholesale trade we used ICOP *UVR*s, but unlike the case of retail trade, we did not apply a double deflation procedure. Rather, we used the *UVR*s directly to convert the gross margin. Hence, the average unit value rates for countries *X* and *U* in retail trade are:

$$UVR^{XU(X)}_{Wholesale} = \frac{Gross\ Margin^{X(X)}_{Wholesale}}{\sum_{i=1}^{R}\left[Sales_i^{X(X)}\ Purchases_i^{X(X)}\right]\_UVR_i^{XU}} \quad (3a)$$

at the gross margin weights of country *X*, and

$$UVR^{XU(U)}_{Wholesale} = \frac{\sum_{i=1}^{R}\left[Sales_i^{U(U)}\ Purchases_i^{U(U)}\right] * UVR_i^{XU}}{Gross\ Margin^{U(U)}_{Wholesale}} \quad (3b)$$

at the gross market weights of country *U*.

Once the currency conversion factors are obtained, the second step in the

procedure is to apply the *UVR*s and *PPP*s to convert output for each industry to a common currency, such as US dollars. One may use the geometric average of the *PPP*s or *UVR*s as the weights for each of the two countries, which yields the Fisher *PPP* and *UVR*. Once output is converted to a common currency, it is related to the corresponding labour input. The latter is either estimated as the number of persons employed or, if the data are available, as the total number of hours worked.

For the detailed estimates of productivity in sections 3 and 4, output and labour input are obtained from primary statistical sources such as transportation statistics and the census of distribution. Primary statistical sources allow the use of more detailed information on the outputs and inputs of individual industries so that the *PPP*s and *UVR*s are reweighted according to output shares. However, primary statistics are often not well harmonized, so certain adjustments need to be made. Thus in section 5 we aggregate the comparisons to the level of national accounts in order to provide a link with the macro statistics.

3. Comparative productivity levels in transport and communication

The transport and communication sector consists of a range of transport services (railways, road passenger and freight transport, water transport, air transport and other transportation services) and two major communication services (postal services and telecommunication). Table 1 shows the distribution of employment for these industries in Canada, France, Germany, Netherlands and US in 1992. Transport makes up about two thirds of the employment of the transport and communication sector, whereas communication accounts for the other third. It is only in the case of the Netherlands that the share of transport is more than three quarters sectoral of employment. For all countries, road freight is the largest transport industry in terms of employment. Air transport has a relatively large employment share in the US.

Table 2 shows the quantities for each transport and communication service expressed per capita and relative to the US. It shows that the distribution of transport services is quite different across countries. For example, in European countries the number of passenger train kilometres per capita is many times higher than in North America. In contrast, freight train kilometres per head of the

TABLE 1
Persons engaged in transport and communication (thousands), and percentage distribution, Canada, France, Germany, Netherlands and the United States, 1992

	Canada	France	Germany	Netherlands	US
Transport by branch (%):	512	854	1,060	307	3,880
Railways	10.4	13.3	23.8	9.4	6.8
Road Passenger Transport	20.1	23.6	19.6	10.9	10.8
Road Freight Transport	35.1	29.5	45.8	33.9	48.5
Water Transport	4.8	2.3	2.8	8.3	4.6
Air Transport	11.0	7.3	8.0	10.9	18.9
Transportation Services	18.5	24.0	(a)	26.6	10.4
Communication	214	450	528	84	1,733
Transport & Communication	726	1,304	1,588	391	5,613

(a) Not available separately, but included in the other branches.
SOURCE: See data appendix.

population in Europe are lower than on the other side of the Atlantic.

One problem in using quantity relatives stems from differences in the share of terminal services in total output. Transport activity includes not only the movement of passengers and freight, but also loading and unloading . The terminal element increases in importance when the average haul distance is shorter. For example, the average passenger trip by train in France (74 kilometres), Germany (42 kilometres) and the Netherlands (47 kilometres) is much shorter than in Canada (339 kilometres) and the US (459 kilometres), as can be seen from table 9. Domestic transport in Europe therefore is characterized by a greater terminals share. Terminal activities require more labour input per unit of output than the movement of passengers and freight.

Shorter travel distances and the greater terminal shares in Europe are partly related to greater population density. We therefore adjusted the quantity relatives for railways by weighting movement and turnover by a factor which takes account of the average distance and population density relative to the US.[11] As table 2 shows, in most cases this adjustment more than doubled the quantity of output per person in European railways relative to the US, but differences still remain.

Table 3 shows unit value ratios and labour productivity by industry in transport and communication. The unit value ratios are implicitly derived from comparisons of passenger kilometres and ton kilometres or the number of persons or tons transported, in combination with corresponding revenues (see formulas 1(a) and 1(b). The UVRs for total transport and communication were above the prevailing exchange rate for France and in particular for Germany. This implies that the price levels of these services were 36 per cent and 68 per cent higher than in the US, respectively. In Canada and the Netherlands price

TABLE 2

Ratios of quantities per head of population for various transport modes and communication, Canada, France, West Germany and the Netherlands relative to the US, 1992

Transport Mode	Unit	Canada (US=1.00)	France (US=1.00)	Germany (US=1.00)	Netherlands (US=1.00)
Passenger Transport:					
- Train					
unadjusted for terminal element	passenger km/person	1.26	28.19	18.55	25.95
adjusted for terminal element	passenger km/person	n.a.	58.63	38.78	41.32
- Urban Transit	passengers/person	1.51	2.04	2.80 }	1.55
- Intercity Bus Carriers	passengers/person (a)	3.23	27.50	}	13.29
- Air	passenger km/person	0.72	0.30	0.43	0.70
Freight Transport:					
- Train					
unadjusted for terminal element	ton km/person	1.44	0.14	0.15	0.03
adjusted for terminal element	ton km/person	n.a.	0.17	0.19	0.03
- Truck	ton km/person	1.80	1.46	0.96	3.05
- Inland Water	ton km/person (b)	1.53	0.05	0.28	1.85
- Maritime	ton/person	11.22	5.53	3.79	62.75
- Air	ton km/person	0.88	1.23	1.39	2.95
Communication:					
- Telecommunication	access lines/person	0.99	0.93	0.97	0.86
	number of calls/person	1.00	0.28	0.36	0.29
- Postal services	pieces of mail/person	0.54	0.60	0.39	0.66

(a) except France/US and Netherlands/US, which is measured in passenger kilometres per person

(b) except Canada/US which is measures in tons per person

NOTE: population figures are 28.4 million for Canada, 57.4 million for France, 64.8 million for West Germany, 15.2 million for the Netherlands and 255.4 million for the US. See OECD, *National Accounts 1960-1995*, vol. I, edition 1997.

SOURCE: See data appendix.

TABLE 3

Unit value ratios and gross value added per person employed for various transport modes and communication, Canada, France, West Germany and the Netherlands relative to the US, 1992

Transport Mode	Canada/US		France/US		West Germany/US		Netherlands/US	
	Unit Value Ratio (Can$/ US$)	Gross Value Added per Person Engaged (US=100)	Unit Value Ratio (FF/ US$)	Gross Value Added per Person Engaged (US=100)	Unit Value Ratio (DM/ US$)	Gross Value Added per Person Engaged (US=100)	Unit Value Ratio (DFL /US$)	Gross Value Added per Person Engaged (US=100)
Railways (a)	1.45	63.8	8.24	59.6	4.24	27.8	1.42	80.7
Road Passenger Transport	1.07	98.5	5.20	100.3	1.17	133.9	1.22	146.4
Road Freight Transport	0.82	118.6	7.23	83.1	3.57	63.8	1.43	141.2
Water Transport	1.33	97.8	10.49	46.4	5.82	58.0	2.65	67.4
Air Transport	1.06	100.4	7.74	88.5	2.98	106.9	2.37	106.5
Transportation Services (c)	1.02	109.1	9.22	79.0	3.07	(b)	1.68	90.1
Total Transport	1.02	107.1	9.16	71.4	3.07	66.3	1.68	111.6
Communication	1.02	97.8	5.27	79.0	2.11	63.1	1.76	88.1
Total Transport & Communication	1.03	101.2	7.21	76.4	2.63	65.8	1.70	97.8
Exchange Rate	1.21		5.29		1.56		1.76	

(a) adjusted for terminal element. See Table 2.

(b) transportation services are included with other transport modes.

(c) the PPP for transportation services was assumed to equal the average PPP for all other industries.

SOURCE: Unit value ratios obtained from gross value of output at factor cost and quantity relatives (see data appendix). Value added and employment, see data appendix.

levels were slightly lower than in the US.[12] For all countries, price levels are relatively high for water transport and (with the exception of the Netherlands) for railways.

The second column of each pair in table 3 shows the relative productivity performance in terms of value added per person employed. The table shows that the productivity performance of the transport sector in Canada and the Netherlands was relatively close to that of the US, whereas French and German levels were substantially lower.

The results for the transport industries suggest a substantial variation in productivity. Productivity relative to the US was lowest in railways, with 64 per cent for Canada/US, 60 per cent for France/US, 81 per cent for Netherlands/US and only 28 per cent for Germany/US. The lower European productivity is partly related to the much greater share of passenger compared to freight transportation in all European countries relative to the US. However, the fact that Canada (with a freight transport share almost as high as in the US) had low productivity in rail transport relative to the US, whereas Dutch railways (with a much lower share of freight transport) had relatively high productivity levels suggests the need to look for other explanations.

Road passenger transport in Europe is relatively more productive than in the US. Road freight transport was less productive in France and Germany, whereas productivity levels were high in Canada and the Netherlands.

Productivity in air transport is relatively similar between countries.

For communication we derived our unit value ratios on the basis of quantities of mail delivered (for postal services) and a weighted average of the ratio of the number of access lines and the number of calls made (for telecommunication) (see table 2). Table 3 shows that labour productivity in communication is quite similar between the US and Canada, and somewhat lower in the Netherlands and in particular in France and Germany.

Within the communication sector, postal services and telecommunication can be examined separately. Table 4 shows that the amount of mail delivered per person employed is relatively low in the European countries. However, much of the mail in the US is commercial. The favourable productivity performance of postal services in the US may be partly because of differences in product mix.[13] For telecommunication we followed the McKinsey Global Institute (1992) by looking at access lines as well as at the number of calls per person employed. Table 4 shows that in terms of access lines, all countries are relatively close. However, in terms of capacity use, characterized by calls per person employed, the European countries come out much lower than the US and Canada.[14]

TABLE 4

Labour productivity in postal services and telecommunications, Canada, France, Germany, Netherlands and the United States, 1992

	Postal Services		Telecommunications		
	Pieces of Mail Delivered per Person Employed (US=100.0)	Employment as % of Employment in Communications	Number of Access Lines per Person Employed (US=100.0)	Number of Calls per Person Employed (US=100.0)	Employment as % of Employment in Communications
France	37.5	65.6	110.2	17.4	34.4
Germany	21.1	62.8	87.9	19.1	37.2
Netherlands	51.5	66.9	135.8	22.3	33.1
Canada	92.4	36.3	95.1	122.6	63.7
United States	100.0	50.0	100.0	100.0	50.0

(a) The number of local calls was estimated implicity by using the 1987 ratio of local to long distance and international calls from Statistics Canada, *Telephone Statistics 1987*.

SOURCE: Telecommunication: OECD (1995), *Communications Outlook 1995*. Number of calls from ITU, *Statistical Yearbook 1994*. Canada: long distance domestic and international calls from Statistics Canada. Postal services: Canada from Canada Post Corporation; France: INSEE, *Annuaire statistique de la France 1997*; Germany: Statistisches Bundesamt, *Statistisches Jahrbuch 1994*; Netherlands from Royal Dutch PTT, *Annual Report 1992*. US: Dept. of Commerce, *Statistical Abstract of the United States*, various issues.

4. Comparative productivity levels in retail and wholesale trade

The distribution sector consists of retail trade and wholesale trade. Table 5 shows that, in 1992, with the exception of the Netherlands, retail trade accounted for more than two thirds of employment in distribution, and wholesale trade for one third. The share of wholesale trade in the Netherlands is relatively large due to the importance of international freight transport. However, the distinction between these two subsectors has become somewhat artificial because over time there has been a substantial backward integration of retailing into wholesaling. This reduced the share of 'stand-alone' wholesale activities in total distribution. In our data, however, wholesale trade only refers to wholesale merchants and excludes the wholesale departments of manufacturing establishments and agents and brokers.

TABLE 5
Employment, employment shares, part-time employment shares and average annual working hours for full-time equivalent employee in retail trade and wholesale trade, 1992

	Canada	France	Germany	Nether-lands	US
Total Employment (1000s)	1,934	3,000	3,445	933	16,871
Retail Trade % breakdown:	69	69	67	60	72
Durable Goods	39	23	27	22	39
Nondurable Goods, excl. Food	15	19	22	15	14
Food	15	27	18	24	19
Part-time Employment as % of Total Employment	n.a.	17	27	52	38
Average Annual Hours Worked	1,611	1,552	1,504	1,225	1,472
Wholesale Trade % breakdown:	31	31	33	40	28
Durable Goods	22	17	19	24	17
Nondurable Goods, excl. Food	5	8	8	10	6
Food	n.a.	6	6	6	5
Average Annual Hours Worked	1,903	1,663	1,627	1,689	1,865

SOURCE: See data appendix, except part-time employment shares which are derived from Eurostat, *Panorama of EU Industry 95/96* and, for the US, estimated on the basis of estimates from *Survey of Current Business* of all persons employed, total hours worked, average hours per full-time employee and assuming that the average hours of a part-time employee are 50% of the average hours of a full-time employee.

In general the censuses of distribution include information on output and labour input for some 30 to 50 individual industries in the retail and wholesale trade sector. We aggregated these to the level of durable goods, non-durable goods, and food products for retail trade and for wholesale trade. Table 5 shows that the durable

goods retail sector is relatively large in the US. The food retail sector has a relatively large employment share in France.

There are important differences across countries in terms of the share of part-time workers in total employment. Part-time employment in retail trade is much more important in the Netherlands and the US than in France and Germany. These differences affect comparisons of output per person, as average annual working hours per person employed in the former two countries are lower than in the latter two. Our productivity calculations for distribution are therefore adjusted to a 'per hour'-basis.

In this study we used gross margin, which is sales minus purchases of goods destined for resale and changes in inventories, as our main output concept. Gross margins and employment were mostly obtained from the censuses of distribution.[15] This concept comes closest to the actual distribution service which the sector provides.

We applied a double deflation procedure to obtain the purchasing power parities for retail trade. The conversion factors for sales represent selected expenditure PPPs for goods. For purchases we used unit value ratios (UVRs) for manufacturing from earlier ICOP studies. For wholesale trade we applied a single deflation procedure, using ICOP UVRs for the gross margin and value added figures. The first column in the pairs of columns for each binary country comparison in table 6 shows the UVRs that were used to convert the gross margin to US dollars.

Table 6 shows that labour productivity for the distribution sector as a whole is highest in the US. Relative to the US, the gross margin per hour worked is lowest in Canada at only 58 per cent of the US level.

The results from table 6 can be compared with the estimates of the McKinsey Global Institute (1992) for value added per employee in general merchandise retailing in 1987. For Germany/US, our results for retail trade match quite well with those of McKinsey, particularly after adjusting for the somewhat lower number of working hours per person in the US compared to Germany (see table 5). For France/US, our figures are considerably higher than those of McKinsey, which may have been partly caused by the fact that food stores are included in our estimates and not in McKinsey's study.

5. Comparative productivity in services and other sectors of the economy

The estimates for transport, communication and distribution in the previous sections are based on primary statistical sources which are not strictly comparable across sectors. Moreover the output concepts do not match over sectors. We used value added for transport and communication, and gross margin

TABLE 6

Purchasing power parities, unit value ratios and labour productivity in distribution France, Canada, Germany and the Netherlands relative to the US, 1992

Distribution Industry	Canada/US		France/US		Germany/US		Netherlands/US	
	UVR (Can$ /US$)	Gross Margin per Hour Worked (US=100)	UVR (FF /US$)	Gross Margin per Hour Worked (US=100)	UVR (DM /US$)	Gross Margin per Hour Worked (US=100)	UVR (DFL /US$)	Gross Margin per Hour Worked (US=100)
Retail Trade (a)	1.74	50.3	7.16	94.4	2.69	91.6	2.36	74.5
- Durables	1.64	45.0	7.70	82.7	3.07	84.7	2.00	89.6
- Nondurables, excl. Food	1.67	64.2	9.75	67.1	2.27	107.1	3.78	52.9
- Food	2.26	47.0	5.59	143.8	2.11	114.0	1.51	116.4
Wholesale Trade	1.38	66.5	7.54	72.6	1.95	98.3	2.01	103.5
- Durables	1.41	63.4	7.54	62.9	1.82	111.2	2.01	99.2
- Nondurables, excl. Food	1.25	83.5	7.72	91.8	2.26	76.0	1.86	124.4
- Food	1.49	60.3	7.27	110.1	2.13	89.1	2.28	95.8
Total Distribution	1.54	58.0	7.34	84.7	2.39	92.1	2.26	88.6
Exchange Rate	1.21		5.29		1.56		1.76	

(a) in Retail Trade the conversion factor is a combination of PPPs (for sales) and UVRs (for purchases)

NOTES: 'Gross margin' refers to the value of sales minus the value of purchases and inventory adjustment. UVRs are Fisher indexes, i.e. geometric averages of the UVRs at national weights and at weights of the US. UVRs for retail trade are obtained by separate weighting of expenditure PPPs for sales and ICOP UVRs for purchases. The retail sales PPPs are adjusted for Value Added Tax or Sales Tax for all comparisons, except Germany/US. In the latter case, the gross margin in Germany included value added tax, so that US sales were increased by 7.5 per cent to account for sales taxes (O'Mahony, 1996a). European statistics refer to 'enterprises', and the Canadian and US statistics refer to 'establishments'. The US and Canadian wholesale figures relate only to merchant wholesalers, and exclude manufacturing subsidiaries and commission agents.

SOURCE: See data appendix.

for distribution. These differences may obscure the link between the sector and the macro level productivity estimates. We therefore reconstructed the productivity estimates for transport and communication and distribution by applying the UVRs from the previous sections to a single source for GDP and employment, namely the *OECD National Accounts*, (OECD (1), 1997).[16] We then did the same for estimates of agriculture, manufacturing and the economy as a whole, with these being derived from earlier ICOP studies.[17] We also added estimates on Japan/US (from Pilat 1994) and UK/US (O'Mahony, Oulton and Vass 1998) which were based on comparable methods. As the original benchmark years differed for the various studies which were used (1987, 1990, 1992 and 1993), we adjusted all estimates to a 1990-basis. Finally, we adjusted all measures from an 'output per person employed' to an 'output per hour worked'-basis. In general the adjustment for hours leads to higher productivity levels for Canada and the European countries relative to the US, and to lower productivity for Japan.

Table 7 shows that relative to the US, labour productivity in agriculture is much lower than in the other sectors of the economy except the Netherlands. Even for manufacturing, most countries still show a substantial shortfall in labour productivity relative to the US. Only labour productivity in Dutch manufacturing exceeds that of the US. Note that there are no indications that productivity gaps in the two service industries are any smaller than in the commodity industries. This is in contrast to the conclusion of Bernard and Jones (1996) that productivity convergence in services has been much faster than in manufacturing.

For Canada and to a lesser extent for Germany, France and the UK, productivity relative to the US is considerably lower in the manufacturing and in the service sectors than when the performance is examined. It should be noted, however, that productivity estimates for other services (in particular non-market services such as health, education and government) suffer from greater data and methodological problems. Differences in the industry composition of employment between the economies may also partially explain the different relative standings.[18]

6. Towards explanations of cross-country productivity differences

What is still needed are more basic explanations for the observed productivity differentials in transport and communication and in wholesale and retail trade. Of particular interest are the implications of differences in capital intensity, scale of operation, technological innovation capacity, and the degree of deregulation.

6.1. Capital Intensity

A higher amount of capital per person employed in the US may account for its relatively high level of labour productivity. If so, then correction for capital

TABLE 7

Comparative levels of labour productivity by sector in 1990 according to national accounts sources and ICOP PPPs and UVRs

	Agriculture, incl. Forestry and Fisheries		Manufacturing		Transport and Communication		Retail Trade and Wholesale Trade		Total Economy	
	Gross Value Added per Person Engaged	Gross Value Added per Hour Worked	Gross Value Added per Person Engaged	Gross Value Added per Hour Worked	Gross Value Added per Person Engaged	Gross Value Added per Hour Worked	Gross Value Added per Person Engaged	Gross Value Added per Hour Worked	Gross Value Added per Person Engaged	Gross Value Added per Hour Worked
Canada	n.a.	n.a.	73.6	75.4	76.7	74.1	57.4	51.1	93.7	89.9
France	60.0	72.7	80.9	95.5	64.7	73.2	104.2	101.6	95.4	98.8
Germany	34.1	31.7	75.9	89.4	59.7	64.0	74.0	70.1	90.8	92.4
Japan	8.1	10.2	86.4	78.3	44.6	31.3	72.6	55.1	75.4	61.6
Netherlands	80.4	89.2	83.8	111.6	97.1	112.5	72.9	69.6	83.5	98.8
United Kingdom	55.7	n.a.	53.1	60.4	72.7	74.1	70.2	71.5	73.4	76.2
United States	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

General method: Estimates of UVRs and PPPs for various years are adjusted to 1990 with national accounts deflators and applied to national accounts data for GDP at factor cost and labour input from OECD, *OECD National Accounts, Volume II, 1983-1995*, 1997.

SOURCE: See data appendix.

intensity might be expected to lead to total factor productivity (TFP) estimates which exhibit smaller gaps between each country and the US than for labour productivity. At this point, however, sectoral estimates of the stock of physical capital (i.e. machinery and equipment and non-residential structures) which are consistent across countries are scarce. For three of the core countries in our sample (France, Germany and the US), we compare sectoral stock estimates from O'Mahony (1996b) which are based on a standardized PIM method, applying US asset lives for the stock estimates of all countries. Table 8 shows the estimates of the nonresidential capital stock per person-hour worked in France and Germany relative to the US for transport and communication, wholesale and retail trade, and for the total economy. The second column for each pairwise comparison shows the relative level, defined as the value added per combined unit of labour and capital input.

TFP is measured by subtracting the logarithm of the relative capital intensity multiplied by the share of capital income in total factor income from the logarithm of the relative labour productivity level:

$$\ln \frac{A^X}{A^U} = \ln \frac{Y^X / L^X}{Y^U / L^U} (1-\alpha) \ln \frac{K^X / L^X}{K^U / L^X} \tag{4}$$

with *X* and *U* denoting the two countries, *A* denoting joint factor productivity, *Y* denoting the value added, *L* for total hours worked, *K* for the nonresidential capital stock and α representing the unweighted average of the share of labour compensation in gross domestic product in country *X* and country *U*.

Table 8 shows that, as measured here, differences in capital intensity between France, Germany and the US are rather small. For France, the slightly lower level of capital intensity accounts for part of the labour productivity gap. For Germany, capital intensity in distribution is bigger than in the US, so that the TFP gap between these two countries is larger than the difference in labour productivity. Other explanations are needed to understand the remaining inter-country productivity differences in the service sectors.[19]

6.2 Scale and Scope

Productivity in services is strongly affected by the size of the market and the scale at which services can be produced and sold. Direct interaction between the producer and customers is an important characteristic of many services (Hill 1977). Because of this, service production is more constrained by the size of the domestic market. This aspect may be important in accounting for the higher levels of productivity in services in the US relative to Canada and the European countries.

TABLE 8

Comparative levels of equipment and structures per person employed (1989) and joint

factor productivity (1990)

	Transport and Communication		Retail Trade and Wholesale Trade		Total Economy	
	Equipment and Non-Residential Structures per Hour Worked (1989)	Joint Factor Productivity (1990) (a)	Equipment and Non-Residential Structures per Hour Worked (1989)	Joint Factor Productivity (1990) (a)	Equipment and Non-Residential Structures per Hour Worked (1989)	Joint Factor Productivity (1990) (a)
France	94.6	74.5	91.7	104.3	96.5	99.9
Germany	93.3	65.4	106.1	69.1	113.5	89.1
United States	100.0	100.0	100.0	100.0	100.0	100.0

(a) using 1989 estimates of capital intensity

General method: machinery and equipment and nonresidential structures were estimated on the basis of the perpetual inventory method using the standardised US asset lives for all countries. The capital stock is converted to US dollars at expenditure PPPs for capital formation. Joint factor productivity is obtained as the logarithm of value added per hour worked minus the logarithm of the capital intensity (adjusted for hours) times the share of capital in value added (which is 1 minus the labour share).

SOURCE: Capital stock in US dollars from O'Mahony (1996c). Employment and factor shares from van Ark (1996a). GDP, hours and labour productivity from Table 7.

As discussed above, average distances for domestic transport services in Europe are much shorter than in North America. This is to a large extent related to the greater population density of European countries. Table 9 shows the shorter distances in Europe, particularly in rail transport, in inland water transport and in trucking. As a result, European transport industries are characterized by a greater terminal element which explains a good deal of the lower productivity levels in rail and water transport since terminals are characterized by lower labour productivity than the movement of passengers and goods.

In road passenger transport, productivity in France, Germany and the Netherlands is higher than in the US despite shorter distances for interurban transport in Europe (see table 3). This can be explained by the product mix. Passenger road transport in the US has to do almost entirely with urban transportation, and intercity traffic is mainly by private transport and air travel.

Average distances in air transport are considerably higher in Europe than in the US because of the greater share of intercontinental flights by European airlines, particularly in Germany and the Netherlands. This may have contributed to the relatively high productivity levels in Dutch and German air transport.[20]

TABLE 9
Average distance of passenger and freight transport (km per passenger trip or freight trip) and population density (numbers per km2), Canada, France, Germany, the Netherlands and the US, 1992

Transport Mode	Canada	France	Germany (West)	Nether-lands	US
Passenger Transport:					
- Train	339	74	42	47	459
- Bus carriers (excluding urban)	n.a.	n.a.	n.a.	12	112
- Air	1,916	1,694	1,984	3,482	1,621
Freight Transport					
- Train	947	367	223	569	849
- Truck	488	87	71	133	727
- Inland Water	n.a.	148	313	255	689
- Air	2,202	n.a.	4,098	6,071	2,238
Population Density					
- persons/km2	2.7	105.5	223.4	360.2	27.2

SOURCE: See data appendix.

Concerning the distribution sector, the literature suggests that a major explanation for superior productivity performance in the US relates to the larger size of operations.[21] Table 10 shows values for three indicators of size. The US has fewer retail shops per 10,000 inhabitants than any of the other four countries, particularly in the case of food retail shops (panel A). Panel B shows that the sales value per establishment is much bigger in the US than in the other countries, particularly in food retailing. Wholesale establishments are of a much bigger size than retail establishments. Panel C of table 10 compares the number of employees per establishment, which confirms the estimates from panels A and B.

We also attempted to measure the productivity performance of retail establishments by employment size category. Unfortunately, the distributional information in the censuses only allows us to consider three size categories: 0-9, 10-99 and 100 and more employees. This is too few to assess the effect of differences in size distribution on comparative productivity performance.[22] The employment shares by size category confirm the view from table 10 that in retailing the European countries (particularly France and the Netherlands) have relatively more persons employed in small establishments. However, we also find that France and the Netherlands have a greater employment share than the US in large retail shops (100 and more employees). There appears to be a greater polarization in establishment size for retailing in Europe than in the US. The size distribution in the wholesale sector is much more equal across countries.

TABLE 10
Indicators of differences in size distribution in wholesale and retail trade, 1992

	Canada	France	Germany	Netherlands	US
	Panel A - Number of establishments per 10,000 inhabitants				
Retail Trade	64.4	70.6	62.8	83.9	27.8
Durable Goods	34.5	29.6	29.6	28.2	17.2
Nondurable Goods, excl. Food	16.5	15.0	15.0	26.2	8.7
Food	13.4	26.0	18.2	29.5	1.9
Wholesale Trade	21.2	15.1	16.3	52.5	15.3
Durable Goods	16.0	8.9	9.6	31.9	11.2
Nondurable Goods, excl. Food	3.1	3.9	4.0	6.7	2.8
Food	2.0	2.3	2.7	13.8	1.3
	Panel B - Sales per Establishment (1000 US$)				
Retail Trade	559	583	542	403	2,471
Durable Goods	631	403	445	306	1,605
Nondurable Goods, excl. Food	427	190	656	186	2,908
Food	537	1015	604	688	8,407
Wholesale Trade	2,816	3,255	3,805	1,869	4,731
Durable Goods	2,373	2,879	3,776	1,754	3,176
Nondurable Goods, excl. Food	3,760	3,296	3,335	3,466	8,537
Food	4,835	4,641	4,602	1,361	9,921
	Panel C - Number of Employees per Establishment				
Retail Trade	7.3	4.5	4.6	4.4	13.6
Durable Goods	7.7	4.1	4.0	3.4	11.7
Nondurable Goods, excl. Food	6.0	3.0	6.4	4.3	6.8
Food	7.8	5.7	4.2	5.3	62.6
Wholesale Trade	10.0	13.9	8.6	4.8	11.2
Durable Goods	9.6	17.2	8.5	5.2	10.8
Nondurable Goods, excl. Food	10.4	8.0	8.6	6.9	10.2
Food	12.6	11.2	9.4	2.6	17.4

SOURCE: Data appendix; France, Germany and Netherlands adjusted from enterprise to establishment basis on the basis of the following sources: France: INSEE, SIRENE data base (see also Mulder 1994); Germany: Statistisches Bundesamt, *Unternehmen und Arbeitsstätten*, 1994; Netherlands CBS, *Statistiek van het Ondernemingenbestand*.

6.3 Innovation

In recent decades, technological innovations appear to have increased in importance in the service industries. Advances in information technology have been expected to contribute to greater efficiency and a rise in service quality.

In transport and communication, technological innovation leads to a faster delivery of the service, improved access to the transport and communication system and an increase in safety of transportation services. We have examined a range of

indicators that reflect innovation in transport and communication, and provide information on vintages and quality as well. Concerning access to rail services, we found that Canada, France and the US had the most kilometres of rail track per head of the population. However, long tracks often characterize long distances between populated areas, as is the case in the US and Canada.

France and Germany are the only two countries examined which offered high speed rail transport, accounting for 30 per cent and 10 per cent of total passenger kilometres respectively in 1992. The average age of passenger coaches in the Netherlands was less than half that of the French and German coaches. The final two indicators we examined for rail transport provide an indication of safety of rail travel: the number of crossings per 10 kilometres of track, and the number of accidents per billion passenger kilometres.

In road transport, capacity use of the road network appears to be much higher in Germany and the Netherlands than in France and the US. However, we found no indications of a direct relation between capacity use and productivity.

For air transport, delivery speed is measured by the percentage of on-time arrivals and departures. Only two-thirds of flights in the Netherlands arrive or depart within 15 minutes of scheduled time. These measures are somewhat better for France and Germany. In the US, 85 per cent of departures and arrivals are on 'time'. The age of the aircraft fleet is lower in Europe than in North America. In Germany and the Netherlands, planes were only 5 to 6 years old compared to more than 11 years in North America. Except for the more modern fleet in Europe, we do not find great differences in innovation capacity for air transport. However, data for a number of countries are still missing, and other important variables, like flight frequency, were not yet available.

A number of innovation measures for communication services were available from OECD (1995) sources and the Universal Postal Union. These include the number of letter boxes and post offices per capita, the share of digitalization in telecommunication, the number of mobile phones and fax machines per 100 people, and the faults incidence within 24 hours. On the basis of these various measures we may conclude that no one of the countries examined has a clear-cut innovation advantage in transport and communication.

The distribution sector has also been characterized by advances in information technology. Increased delivery speed, a greater diversity of assortment and a larger customization of services are major outcomes of this. In this respect important advances have been made in European countries relative to the US. For example, in 1987/88, 10 to 30 per cent of retail sales in European countries were made in establishments with scanning cash registers compared to 50 per cent in the US (EIM 1989). However, between 1987 and 1992, stores with scanning registers increased fivefold in the Netherlands, sixfold in France and tenfold in Germany (Eurostat 1995).

At this point, we are not able to establish any sort of compelling evidence of a link between innovation and higher productivity.

6.4 Deregulation

It has been suggested that barriers to competition caused by regulations and restrictions in service industries hampered productivity and efficiency in Europe relative to the US (Baily 1993). For example, in Germany, the railway sector is moving only slowly towards privatization and restructuring of the network.

In air transport and telecommunication in Europe, regulations and restrictions have been slimmed down quite substantially since the late 1980s. A comparison of our estimates with those for the late 1980s suggests that the productivity differentials in airlines and telecommunication are now considerably smaller than some years ago.[23] Increased liberalization of airline routes appears to have contributed to greater capacity use. It appears that greater international competition in telecommunication also positively affected productivity performance.[24]

Baily (1993) suggests that regulation of retail trade plays a major role in explaining the productivity shortfall in retailing for Europe relative to the US.[25] This includes rigid zoning laws which hampered the creation of superstores and shopping malls. Another important restriction on retail activity concerns laws on shop opening hours (Pilat 1997).

The relatively high price levels of distribution which we observed in section 4 may indicate high distribution margins. This may be due to a lack of price competition in Europe, although earlier studies do not find evidence of excessively high retail margins in Europe.[26] Alternatively, these high price levels may be a sign of the inefficiency of the European distribution sector. Finally, it also needs to be emphasized that non-price competition has become increasingly important in the distribution sector (i.e., this is competition involving things such as accessibility of location, product assortment, and ambiance).[27]

7. Conclusion

The estimates of productivity in transport and communication and distribution from this study suggest that productivity differentials between Canada, France, Germany and the Netherlands on the one hand and the US on the other are at least as large as for the commodity sectors (including manufacturing). However, we find substantial differences in productivity across industries within the main service sectors. At an aggregate level, therefore, it seems important to take account of differences between countries in industry composition within the service sectors. Our search for reasons to explain the observed productivity differentials is in its infancy.

Notes

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1 See van Ark (1996a).

2 All estimates in this paper refer to West Germany only.
3 See, for example, Bernard and Jones (1996) and Gouyette and Perelman (1997).
4 See Pilat (1996) for an overview.
5 See Paige and Bombach (1959) and Maddison (1970) for early studies of international comparisons of productivity by sector. For services these studies strongly relied on assumptions concerning 'equal productivity' across two countries or on an assumed correspondence between relative productivity in commodity output and service output.
6 See, for example, Dollar and Wolff (1993), Bernard and Jones (1996) and Gouyette and Perelman (1997) who provide comparative level estimates of service productivity which are based on the OECD Intersectoral Data Base (ISDB). ISDB makes use of a single PPP for total GDP for each sector thereby ignoring price differences between sectors. A somewhat more sophisticated use of expenditure PPPs for service sector comparisons is applied in studies by the National Institute of Economic and Social Research (NIESR), which for service industries mainly relied on selected expenditure PPPs for individual services (Smith, Hitchens and Davies 1982; Smith and Hitchens 1985; O'Mahony, Oulton and Vass 1998). Presently, the NIESR is developing more detailed studies of individual services industries for Germany and the US relative to the UK (O'Mahony 1996a; Vass 1996; O'Mahony, Oulton and Vass 1997) along similar lines as in this study.
7 An earlier ICOP study which also included services was carried out by Pilat (1994) for Japan and Korea in comparison to the US. See also Mulder (1998) on comparisons of labour productivity in service industries in Brazil and Mexico relative to the US.
8 Unit value ratios (UVRs) are conceptually equivalent to purchasing power parities (PPPs), but as the UVRs are implicitly derived from the relative quantities, they represent ratios of unit values rather than prices.
9 As the unit value ratios will be used to compare the value added (which is gross output minus intermediate inputs in transport and communication, one ideally needs not only a UVR for gross output but also one for intermediate inputs. Unfortunately, in practice it was not possible to obtain separate input PPPs for transport and communication.
10 Purchases are adjusted for changes in inventories.
11 See Appendix B for an exposition on the terminal adjustment. We did not make terminal adjustments for roads, water and air transport. Roads, ports and airports are used not only by national transporters but also by foreign transport industries. See Smith, Hitchens and Davies (1982) for an adjustment of the composition effect in comparisons of transport between Germany, UK and US using revenue shares as weights for movement and terminal handling.
12 These UVRs are based on unit values at factor cost level; i.e. these exclude indirect taxes and include subsidies, and should therefore not be interpreted as expenditure PPPs, which represent market prices. Such differences are especially big for industries that are heavily subsidized in Europe, including railways and urban and regional passenger transport.
13 We are grateful to one of our anonymous referees for pointing out this difference in product mix in mail distribution.
14 At this stage our measures are not adjusted for differences in various types of new products, which determine the quality of telecommunication services, such as mobiles, and voice mail (McKinsey Global Institute 1992; Baily 1993). See also Section 6.
15 See the data appendix.
16 All national accounts estimates were adjusted to factor cost level, i.e. excluding indirect taxes and including subsidies. In the case of wholesale and retail trade, value added tax

and sales taxes are still included.

17 For agriculture and manufacturing (with the exception of Canada and Japan), the productivity estimates were already adjusted to national accounts level in earlier studies. See Maddison and van Ark (1994) and van Ark (1996a).

18 See van Ark (1996a, 1996b) for a discussion.

19 O'Mahony's estimates of capital stock in combination with van Ark's sectoral employment estimates suggest bigger differences in capital intensity in the case of Japan and the UK vis-à-vis the US. See O'Mahony (1996b) and van Ark (1996a).

20 On the basis of regression analysis in a study of the airline industry in France, Germany, the UK and the US, Vass (1996) suggests that a 1% increase in stage length in air transport would cause a productivity advantage of between 0.37 and 0.43 percentage points.

21 See Baily (1993), Betancourt (1993), Lachner, Täger and Weitzel (1993) and Messerlin (1993)

22 Furthermore, our estimates of purchasing power parities cannot be diversified across size categories, so that such comparisons would assume the same basket of commodities and the same price levels across categories, which would be unrealistic.

23 Vass (1996) shows that private as opposed to public ownership in airlines, other things being equal, raises productivity by as much as 32 per cent.

24 See, for example, OECD (1995).

25 See Pilat (1997) for an extensive review of the evidence on the relation between regulation and performance.

26 See Betancourt and Gautschi (1996).

27 See Nooteboom, Thurik and Vollebregt (1988) and Betancourt (1993).

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Appendix A
Data Appendix

A detailed account of data and results is given in an underlying research paper (van Ark, Monnikhof and Mulder 1998).

UVRs for transport and communication

The unit value ratios for transport and communication were implicitly derived from combining quantity relatives and the gross value of output in national currencies in transport and communication. Quantity relatives and gross value of output were obtained from the following sources:
Canada: Statistics Canada: *Rail in Canada; Passenger Bus and Urban Transit Statistics; Trucking in Canada; Shipping in Canada*; and *Canadian Civil Aviation*, various issues.
France: Ministère des transports et de la mer, Observatoire économique et statistique des transports (OEST), *Mémento de statistiques des transports*, various issues. OEST (1993), *Enquête annuelle d'entreprise: les entreprises de transport, année 1992*. INSEE, *Annuaire statistique de la France*, various issues.
Germany: DIW, *Verkehr in Zahlen 1994*.
Netherlands: Statistics Netherlands, *Statistisch jaarboek*, various issues; value of output from Statistics Netherlands, *Produktiestatistieken transport-, opslag- en communicatiebedrijven*, various issues. Urban and intercity passenger transport from Koninklijk Nederlands Vervoer en Ministerie van Verkeer en Waterstaat: unpublished worksheets.
United States: train, urban, intercity passenger transport from Dept. of Commerce, *Statistical Abstract of the United States 1995*; trucking, inland water transport, and domestic air freight transport from Department of Transportation, *National Transportation Statistics 1995*; liner vessels from unpublished worksheets of Dept. of Transportation, Maritime Administration (MARAD).
Communication: access lines from OECD (1995), *Communications Outlook*; Germany from Bundespost and Bundespost Telecom. Calls from ITU, *Statistical Yearbook 1994*; Canada was estimated using the ratio of local to long distance (incl. international calls) from Statistics Canada, *Telephone Statistics 1987*.

Gross value added and employment in transport and communication

Value added and employment in transport and communication were obtained from the following sources:
Canada: Value added from Statistics Canada: *System of National Accounts*, various issues. Employment from Statistics Canada, *Survey of Employment, Payrolls and Hours*, various issues;
France: transport from INSEE/SES (1992), *Les Comptes en 1995*; communication from OECD (1996), National Accounts 1982-1994.
Germany: DIW, *Verkehr in Zahlen*, 1994.
Netherlands: CBS, *Produktiestatistieken van transport-, opslag- en*

communicatiebedrijven, various issues.
USA: value added from Dept. of Commerce, *Survey of Current Business*, August 1996. Taxes and subsidies from Dept. of Commerce, unpublished worksheets. TV and Broadcasting was excluded from Communication and postal services GDP was added as the sum of labour compensation and capital depreciation. The latter was estimated by applying the 1994 ratio of depreciation to total expenditure (2.7 per cent) to the total expenditures in 1992, from US Postal Service, *Annual Report of the Postmaster General*, various issues. Employment from Dept. of Commerce, *Survey of Current Business*, July 1994. Postal Services: Dept. of Commerce, *Statistical Abstract of the United States*.

PPPs and UVRs for Retail Trade and Wholesale Trade

The industry PPPs for retail trade were obtained from separate expenditure purchasing power parities for sales of retail goods and 'industry of origin' unit value ratios for purchases of retail goods. On average we have made use of approximately 50 individual expenditure PPPs for sales in retail trade and 30 to 45 UVRs for purchases in retail trade. For wholesale trade we applied a single deflation procedure, using between 33 and 55 ICOP UVRs for manufacturing products.

The expenditure PPPs are Fisher PPPs for 1990 which were kindly provided by Eurostat. These PPPs were adjusted for the effect of differences in Value Added Tax or Sales Tax, which were obtained from Coopers and Lybrand, *1991 International Tax Summaries*, John Wiley & sons, 1991. PPPs were updated 1990 to 1992 with retail price indexes for the US from 1994 Dept. of Commerce, *Statistical Abstract of the United States*, for Canada from Statistics Canada, *Consumer Prices and Price Indexes*; for Germany from Statistisches Bundesamt, *Preise und Preisindizes fuer die Lebenshaltung, Index der Einzelhandelspreise*; and for the Netherlands from Centraal Bureau voor de Statistiek, *Maandstatistiek van de Prijzen (bijvoegsel*), various issues.

The ICOP unit value ratios for manufacturing are obtained from de Jong (1997) for Canada/US and from van Ark and Kouwenhoven (1994) for France/US, both for 1987. They are updated to 1992 with national producer indices. The Germany/US and Netherlands/US UVRs are from unpublished estimates from ICOP/LCRA, which can be obtained from the authors on request.

Gross margin and employment in retail trade and wholesale trade

'Gross margin' refers to the value of sales minus the value of purchases destined for resale and inventory adjustment. European statistics refer to 'enterprises', and the Canadian and US statistics refer to 'establishments'. The US and Canadian wholesale figures relate only to merchant wholesalers, and exclude manufacturing subsidiaries and commission agents.
France: INSEE (1994), *Les Entreprises du Commerce en 1992. Résultats de l'enquête Annuelle d'Entreprise*.
USA: Bureau of the Census, *1992 Census of Wholesale Trade*, vol. *Establishment and Firm Size* and vol. *Measures of Value Produced*; and Bureau of the Census, *1992 Census of Retail Trade*, vol. *Establishment and Firm Size* and vol. *Measures of Value Produced*.
Canada: Statistics Canada, *1992 Wholesale Trade Statistics, Wholesale Merchants, Agents and Brokers* and *1992 Annual Retail Trade*. Employment in Canada derived from Statistics Canada, *The Survey of Employment, Payroll and Hours* (3 digit level), split into 4-digit level using employee compensation figures from the wholesale and retail trade statistics.
Germany: Statistisches Bundesamt, *1992 Beschäftigung, Umsatz und Wareneingang, Lagerbestand und Investitionen im Grosshandel* and *Beschäftigung, Umsatz und Wareneingang, Lagerbestand und Investitionen im Einzelhandel*, Handel, Gastgewerbe,

Reiseverkehr, Fachserie 6.
Netherlands: Centraal Bureau voor de Statistiek, *Produktiestatistieken voor de binnenlandse handel 1992*.
Annual hours from national accounts sources: see below.

Sources on national accounts extrapolation
UVRs and PPPs: The UVRs for agriculture and manufacturing for France/US, Germany/US, Netherlands/US and UK/US are obtained from van Ark (1996a). The UVR for manufacturing for Canada/US (1987) is obtained from de Jong (1997). For Japan/US the UVRs for agriculture (1985) and manufacturing (1987) are derived from Pilat (1994). UVRs for transport and communication and wholesale and retail trade for Canada/US, France/US, Germany/US and UK/US are from Tables 3 and 6 in this paper; for Japan/US (1985) from Pilat (1994) adjusted to factor cost level; and for UK/US (1993) from O'Mahony, Oulton and Vass (1996) also adjusted to factor cost level. For total economy, PPPs are bilateral (Fisher-based) expenditure PPPs between each country and the US for 1990, kindly provided by Eurostat.
National accounts deflators to extrapolate the UVRs to 1990 are derived from OECD (1997), *National Accounts, Volume II, 1983-1995*, except for the UK, which is derived from CSO, *United Kingdom National Accounts*.
GDP in 1990 at current prices from OECD (1997). For each country GDP is expressed at factor cost, i.e. excluding indirect taxes and including subsidies. However, in the case of France/US, Germany/US and Netherlands/US, value added tax could not be excluded. Sales tax for the US were therefore added back in and estimated at 7.5% for retail sales of durable and non-durable goods, excluding food.
Employment in 1990 is also from OECD (1997), with adjustments in the case of distribution to exclude hotels and restaurants.
Annual Hours for Canada are from input-output tables kindly provided by Statistics Canada, for France from INSEE, *Rapport sur les Comptes de la Nation*; for Germany from Institut fuer Arbeitsmarktforschung der Bundesanstalt für Arbeit, *Arbeitszeit und Arbeitsvolumen in der Bundesrepublik Deutschland* (updated); for Japan from Pilat (1994); for the Netherlands from CBS (1992), *Arbeidsrekeningen 1990*; for US calculated on the basis of paid hours from BLS, *Monthly Labor Review* (various issues) and BLS, 'Ratio of hours at work to hours paid for production and nonsupervisory workers by industry' (updated); for UK we used the 1993 UK/US hours ratio from O'Mahony, Oulton and Vass (1998).

Appendix B
Terminal Adjustment for Railways

The comparative measures of passenger and ton kilometres for railways (Q^X/Q^{USA}) were adjusted for the share of terminals in total output by combining it with an estimate of the total number of passengers or tons transported (T^X/T^{USA}):

$$\frac{Q^{X^*}}{Q^{USA^*}} = \left[(1S)\frac{Q^X}{Q^{USA}} + S\frac{T^X}{T^{USA}} \right]. \qquad \text{(A.1)}$$

The weighting factor S was obtained from the ratio of the average distance of a passenger

or freight trip (H^X/H^{USA}) including a correction for the ratio of the population density in both countries (D^{USA}/D^X):

$$S = \left(1 \frac{H^X}{H^{USA}} \right) * \frac{D^{USA}}{D^X}. \quad \text{(A.2)}$$

We did not make this adjustment for the case of Canada, as the distribution of the railway network across the country is very uneven, so that this adjustment method would lead to implausible results.