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List of abbreviations

Au	Austria
Be	Belgium
De	Germany
Dk	Denmark
EU	European Union
EU15	The 15 EU member states before May 2004
Fi	Finland
Fr	France
Gr	Greece
Ir	Ireland
It	Italy
LP	Labour productivity
Lu	Luxemburg
Nl	Netherlands
OECD	Organisation for economic co-operation and development
Pt	Portugal
Sp	Spain
Sw	Sweden
TFP	Total factor productivity
UK	United Kingdom
US	United States of America

Annex 07: Development of Productivity in the Transport sector

1 Review of existing transport statistics

1.1 Introduction

The transport sector is an important component of the overall economy. The table below shows the contribution of transport to overall value added.

Table 1-1: Contribution of transport to total value added (2003)

Country	Contribution of transport to total VA
Austria	5.27%
Belgium	5.25%
Denmark	6.00%
Finland	7.22%
France	4.20%
Germany	3.60%
Greece	5.62%
Ireland	2.15%
Italy	5.01%
Luxembourg	5.19%
Netherlands	4.53%
Portugal	3.74%
Spain	5.97%
Sweden	5.31%
UK	4.62%
Czech Republic	4.95%
Hungary	4.81%
Poland	5.50%
EU15	4.32%
US	2.96%

Source: Groningen database

Across EU15 countries, the contribution of the transport sector to overall Value Added is broadly similar with the EU15 being 4.32 per cent. The country where transport contributes most to value added is Finland (7.22 per cent), and the contribution is lowest in Ireland (2.15 per cent). The new member states of the Czech Republic, Hungary and Poland are similar to the EU15 countries in terms of transport's contribution.

In comparison with the EU15, transport's contribution to value added is less in the US: 2.96 per cent compared to 4.32 per cent.

The table below shows the relative sizes of the four transport sub-sectors measured by labour share in 2003.

Table 1-2: Relative size of transport sub-sectors (2003)

Country	Inland	Water	Air	Supporting
Austria	71.28%	0.26%	4.64%	23.82%
Belgium	63.39%	1.08%	4.21%	31.31%
Denmark	45.96%	14.08%	5.46%	34.51%
Finland	50.93%	9.84%	7.10%	32.13%
France	50.53%	1.26%	7.90%	40.30%
Germany	49.12%	3.43%	7.54%	39.91%
Greece	27.50%	51.19%	2.72%	18.58%
Ireland	28.95%	6.29%	33.62%	31.13%
Italy	52.49%	4.55%	4.58%	38.38%
Luxembourg	49.33%	3.76%	33.81%	13.10%
Netherlands	49.90%	6.11%	13.73%	30.26%
Portugal	39.96%	5.29%	18.47%	36.28%
Spain	59.32%	2.59%	9.68%	28.42%
Sweden	56.88%	4.44%	9.15%	29.53%
UK	41.93%	3.77%	14.33%	39.98%
Czech Republic	67.07%	0.54%	1.74%	30.65%
Hungary	72.79%	0.52%	2.36%	24.33%
Poland	78.62%	1.05%	2.62%	17.71%
EU15*	50.99%	5.20%	9.73%	34.08%
US	63.82%	5.16%	20.47%	10.55%

**EU15 figure is for 2002*

The supporting transport sector refers to activities such as travel agents – activities dedicated to servicing the transport sector which would not exist in another part of the economy without it.

From the above table one notes that for nearly all countries, the inland transport sector is the largest of the four transport sub-sectors. The exception is Greece. Poland has the largest labour share for the inland transport sector – 78.62 per cent. For most countries (except Greece), the water sector is the smallest. Austria has the smallest water sector. The size of certain sectors will of course be related to geographical conditions in a particular country.

When the EU15 is compared to the US, one notes that their land sectors are both the largest sectors and water sectors are of comparable size. However, the relative importance of supporting services to transport is greater in the EU15 than the US. This may be explained again by exogenous factors such as population density and geographical conditions.

However, it should be noted that the above table refers to labour shares only – the relative sizes of each sub-sector may differ when capital is taken into account. For instance, the size of the aviation sector may rise relative to other sectors when capital is taken into account because of its comparatively large capital usage.

1.2 Overview of productivity statistics

This section sets out productivity indicators for selected EU countries and the US. The indicators examined are Labour Productivity (LP) and Total Factor Productivity (TFP). LP refers to the change in output over the change in the labour input, whereas TFP refers to the change in output over the change in total inputs (labour and capital).The dataset used is complied by the Groningen Growth and Development Centre at the University of Groningen. The dataset covers all EU15 countries and selected new Member States, as well as other OECD countries. The period covered for the EU15 countries is between 1979 and 2003 and 1993 and 2003 for the new Member States. The analysis is therefore limited to these countries for this time period. A further restriction on the analysis is the lack of complete data on TFP: the Groningen dataset only has TFP data on four EU countries and the US. It is important for future research that data is collected for the missing countries. It should also be noted that for Germany, data prior to unification refers to West Germany only.

Nonetheless, despite the data limitations, it is possible to make some initial observations and inferences based on the existing data which can then be used as the basis for further analysis. However, their validity extends only to the countries in question.

The Groningen dataset divides the economy into 60 industries (the 60 Industry Database); four of these can be classed as being part of the transport sector. These include: inland transport, water transport, air transport and supporting and auxiliary transport categories. Labour productivity is measured both by hour and by person. For our analysis the relevant measure is labour productivity per hour. The data is given in volume indices. While the volumes themselves are interesting, we are more concerned with the changes in labour productivity over the period in question.

Labour productivity can be affected by a number of factors. These include economic cycles (relating to output changes and availability and use of inputs), technological shocks, labour legislation and capital/labour ratios. The purpose of this statistical review is to begin to develop an understanding of past transport productivity trends so that further econometric analysis can be undertaken to identify the importance of different explanatory factors.

1.3 EU 15 countries

The following four tables chart the changes in LP across the transport sub-sectors. It is important to note what these figures do and do not tell us. In the first instance, they chart the changes in LP. They do not tell us the absolute levels of labour productivity. Thus, it is not possible to make comparisons about the overall levels of productivity between countries. Rather what one can say is, for instance, that in 1992 LP in inland transport in Denmark fell by 3.55 per cent whereas in Ireland it grew by over 10 per cent the same year. Growth rates can be compared not levels. Nonetheless, determining why growth rates differ is equally important as determining the absolute levels of LP.

Table 1-3: Hourly labour productivity growth rates for EU15 countries 1981-2003 (inland transport) (in %)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1981	-4.46	2.83	-9.95	-4.64	1.98	0.55	2.25	0.32	0.06	2.16	2.91	-0.40	1.43	-1.13	5.11
1982	4.57	0.44	-3.68	-0.84	4.13	-0.05	0.51	-5.27	1.02	-0.37	-2.19	9.84	-0.22	1.10	1.09
1983	0.69	6.35	-5.27	5.03	-0.14	4.53	13.38	-10.28	0.59	5.81	7.69	6.80	3.52	-4.77	4.15
1984	1.45	7.50	9.17	1.47	1.82	3.34	6.83	19.78	7.53	5.29	5.23	4.99	4.32	4.09	3.22
1985	5.88	1.28	1.25	4.39	2.61	2.79	9.58	-8.48	2.45	2.60	2.66	4.78	4.22	1.03	7.94
1986	3.19	-3.46	-0.51	-0.02	3.97	-3.90	7.10	4.09	1.23	39.83	1.84	7.33	-1.00	0.91	4.60
1987	4.26	4.78	-0.14	0.58	3.80	0.40	-1.54	-18.13	3.32	-1.33	8.01	-0.59	3.45	5.46	8.74
1988	4.52	7.67	8.00	1.13	5.89	4.10	9.19	24.29	4.89	14.73	-1.31	4.13	7.31	1.00	7.57
1989	0.27	3.75	5.69	7.17	3.25	2.37	4.00	2.94	6.22	0.41	1.89	-0.42	8.97	0.47	2.23
1990	3.82	4.37	-5.44	6.20	-0.71	7.70	-3.01	-4.69	3.17	5.98	-0.81	2.34	0.85	6.82	-2.74
1991	5.91	1.62	-0.18	1.56	1.79	5.28	0.25	13.47	1.69	17.48	-0.15	9.62	-1.15	-1.79	-0.07
1992	5.21	1.01	-3.55	1.95	4.13	-1.40	4.90	10.33	3.24	2.40	-4.26	5.37	5.35	10.70	2.14
1993	-1.83	4.69	4.66	7.45	-2.27	2.93	4.63	-19.17	6.21	11.09	-0.08	-0.85	3.10	-3.29	4.03
1994	-1.62	3.02	10.80	0.13	4.76	8.27	2.03	32.91	10.27	17.20	2.27	6.29	10.36	7.56	6.79
1995	-4.36	-1.72	-3.52	1.44	0.38	16.27	10.12	10.51	3.64	17.01	-4.31	0.92	2.38	6.25	3.54
1996	-3.49	-5.38	-7.15	3.63	4.31	5.01	-1.44	-7.04	-3.90	8.84	4.44	-4.79	0.16	4.23	3.51
1997	9.01	-2.01	0.56	0.32	0.49	-1.46	-6.74	10.66	-3.03	-9.61	1.55	-2.50	0.20	7.80	1.00
1998	-2.44	4.04	-3.71	0.23	8.72	-2.42	-4.20	16.86	1.34	14.97	4.58	11.49	0.27	2.84	-2.76
1999	-0.53	-1.77	-1.00	2.43	-4.44	7.94	-10.97	-3.77	2.50	-4.88	0.95	4.29	3.88	0.36	-7.23
2000	2.79	1.86	-1.76	6.54	0.93	-2.47	3.82	-0.66	-4.78	1.48	-2.35	0.87	4.16	1.06	1.41
2001	-2.16	0.21	4.37	0.43	-2.03	-4.27	4.37	-7.42	11.61	3.17	-1.84	-2.79	3.83	1.45	-3.24
2002	5.80	2.49	3.96	-0.62	2.57	-8.84	2.52	-30.15	1.68	5.56	1.04	-0.48	-2.87	1.12	6.03
2003	5.56	3.42	3.12	1.95	-0.70	-0.43	-1.59	3.74	-3.15	3.58	0.85	5.09	0.60	3.35	0.08

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

Table 1-4: Hourly labour productivity growth rates for EU15 countries 1981-2003 (water transport) (in %)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1981	5.99	2.83	21.47	-4.29	6.75	7.37	2.25	0.32	0.06	2.16	15.77	-0.40	1.07	6.82	5.67
1982	6.99	0.44	-4.67	-4.72	-7.06	-0.57	0.51	-5.27	1.02	-0.37	-5.68	9.84	-4.20	-5.64	12.04
1983	8.92	6.35	-1.80	1.80	-15.54	-11.70	13.38	-10.28	0.59	5.81	5.75	6.80	0.12	-18.04	23.12
1984	54.07	7.50	-12.88	-8.44	-5.49	9.57	6.83	-14.65	7.53	5.29	1.81	4.99	-3.44	-11.64	24.86
1985	-9.38	1.28	-30.12	-8.81	11.43	11.30	9.58	14.64	2.45	2.60	5.84	4.78	-34.74	10.47	16.72
1986	39.73	-3.46	10.32	3.09	0.08	-10.00	7.10	33.48	1.23	39.83	-15.18	7.33	5.55	-2.30	12.23
1987	9.26	4.78	76.23	2.60	4.96	-1.52	-1.54	-6.21	3.32	-1.33	-4.57	-0.59	46.29	-6.09	6.09
1988	59.60	7.67	31.43	18.26	2.13	16.40	9.19	1.18	4.89	14.73	7.97	4.13	3.03	47.61	9.43
1989	32.16	3.75	14.33	5.60	8.75	6.35	4.00	51.45	6.22	0.41	12.96	-0.42	-13.79	-8.24	-0.27
1990	-12.80	4.37	60.45	5.59	-17.06	-0.18	-3.01	-9.37	3.17	5.98	7.27	2.34	-1.74	15.86	6.35
1991	-7.63	1.62	6.62	-4.88	7.87	2.77	0.25	20.35	1.69	17.48	5.26	9.62	3.35	-1.82	0.10
1992	-27.19	1.01	29.25	4.57	9.71	11.92	4.90	-7.97	3.24	2.40	10.95	5.37	45.72	-18.06	11.19
1993	-3.89	4.69	-36.38	20.57	17.23	25.15	4.63	-0.28	10.41	11.09	-5.00	-0.85	-5.50	-19.25	66.32
1994	24.17	3.02	14.07	12.50	27.15	17.99	2.03	27.38	5.79	17.20	4.48	6.29	26.15	-7.42	4.78
1995	-6.42	-1.72	65.07	-6.41	-12.75	3.87	10.12	31.04	-1.23	17.01	8.99	0.92	4.05	9.82	-12.31
1996	-1.43	-5.38	30.25	3.95	8.40	23.10	2.57	-15.96	-6.42	-71.63	-4.13	-8.30	-1.33	22.16	12.65
1997	26.08	-25.15	16.64	4.57	17.25	17.32	41.98	-19.57	0.51	68.43	20.39	7.53	5.48	6.57	-12.90
1998	-3.57	-33.74	-20.95	6.65	42.33	12.04	-7.23	19.79	11.45	0.05	10.56	11.00	4.57	-25.06	-6.84
1999	26.18	160.74	47.96	2.36	15.44	26.66	199.49	-5.03	-11.25	-6.61	4.76	-2.36	9.05	26.01	-23.78
2000	-9.97	30.91	27.71	-1.82	-0.37	8.16	42.79	-2.50	46.95	-1.39	9.34	20.97	5.13	-4.54	29.95
2001	70.84	-14.11	9.58	-3.40	10.63	40.18	-5.58	-0.66	2.69	-4.39	9.14	-5.71	0.49	5.58	1.15
2002	1.46	2.49	3.96	0.44	-7.85	24.48	10.06	-11.59	-12.26	6.78	-14.72	3.55	-8.04	22.98	24.98
2003	2.28	3.42	3.12	4.59	-1.81	-0.43	4.26	3.74	-3.15	3.58	9.66	5.09	0.60	-0.75	-17.67

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

Table 1-5: Hourly labour productivity growth rates for EU15 countries 1981-2003 (air transport) (in %)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1981	3.49	2.83	-0.95	7.65	3.54	2.21	2.25	0.32	0.06	2.16	13.87	-0.40	21.90	-2.37	4.41
1982	0.62	0.44	-6.00	5.10	-0.41	0.78	0.51	-5.27	1.02	-0.37	-2.50	9.84	9.60	2.73	5.16
1983	2.88	6.35	3.06	1.23	10.60	2.02	13.38	-10.28	0.59	5.81	7.20	6.80	-10.83	4.61	6.76
1984	16.69	7.50	11.93	4.88	9.32	0.86	6.83	19.09	7.53	5.29	10.13	4.99	20.76	-7.26	4.67
1985	3.71	1.28	-3.28	4.67	0.91	3.24	9.58	-17.85	2.45	2.60	-1.45	4.78	-2.81	14.41	-0.44
1986	-3.60	-3.46	8.67	2.88	-1.71	-4.55	7.10	17.98	1.23	39.83	-10.76	7.33	3.24	40.70	-1.43
1987	5.29	4.78	21.00	16.30	0.96	-0.58	-1.54	-17.97	3.32	-1.33	6.30	-0.59	23.91	7.19	14.27
1988	-3.52	7.67	8.10	5.43	6.76	3.44	9.19	14.78	4.89	14.73	8.57	4.13	11.48	18.42	-8.01
1989	30.98	3.75	-15.98	4.13	-0.99	2.55	4.00	-8.50	6.22	0.41	7.26	-0.42	9.16	-3.57	-0.67
1990	6.80	4.37	-9.52	-5.50	-12.53	6.44	-3.01	14.59	3.17	5.98	10.02	2.34	-19.32	6.99	0.31
1991	0.55	1.62	-42.45	4.31	1.46	6.60	0.25	-0.12	1.69	17.48	6.92	9.62	5.48	-0.50	-9.23
1992	31.53	1.01	30.22	-4.40	2.87	17.34	4.90	-11.79	3.24	2.40	12.41	5.37	20.98	-7.67	16.62
1993	8.71	4.69	-28.10	8.22	2.54	26.86	4.63	12.96	14.30	11.09	8.59	-0.85	15.96	12.97	11.63
1994	23.11	3.02	6.34	11.97	23.95	7.11	2.03	42.75	5.80	17.20	8.67	6.29	-12.46	-14.45	8.12
1995	13.18	-1.72	-13.26	12.65	-9.60	-0.28	10.12	-22.79	1.25	17.01	11.79	0.92	17.20	10.99	10.34
1996	-4.85	-5.38	9.23	0.64	7.79	10.97	10.25	3.83	-5.18	-1.82	-0.35	-3.84	19.79	1.90	-1.11
1997	51.85	2.97	-6.59	4.11	12.32	6.49	-28.70	14.25	22.28	16.07	5.28	6.46	3.90	-0.42	3.26
1998	37.63	6.04	-2.68	3.32	7.82	-0.06	10.82	15.94	58.48	0.85	4.82	13.63	-0.40	-4.50	0.57
1999	-7.49	-7.13	-6.54	-2.80	1.94	-1.28	-32.85	-3.59	-66.31	14.64	-0.54	-15.61	-6.11	-7.86	60.30
2000	-12.20	-24.91	6.94	1.84	-10.40	12.11	16.24	-0.79	2.58	0.29	5.13	8.31	8.21	1.42	-3.62
2001	-50.94	117.55	9.75	5.08	-17.07	-23.98	-13.38	-0.66	36.01	7.39	-3.62	10.98	-5.86	-17.83	0.04
2002	1.96	2.49	3.96	6.40	9.83	-11.03	28.53	-11.59	5.84	5.52	-2.58	9.93	9.37	22.08	-6.87
2003	-7.22	3.42	3.12	3.12	5.11	-0.43	0.37	3.74	-3.15	3.58	0.31	5.09	0.60	6.29	16.10

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

Table 1-6: Hourly labour productivity growth rates for EU15 countries 1981-2003 (supporting activities) (in %)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1981	-3.27	2.83	1.14	1.96	6.88	0.55	2.25	0.32	0.06	2.16	4.07	-0.40	9.43	5.12	5.77
1982	-6.16	0.44	6.18	3.69	4.43	-0.05	0.51	-5.27	1.02	-0.37	-2.66	9.84	0.44	4.47	0.62
1983	22.40	6.35	6.47	3.06	-2.25	4.53	13.38	-10.28	0.59	5.81	-0.34	6.80	3.25	-1.46	3.37
1984	14.73	7.50	7.31	6.44	5.38	3.34	6.83	3.53	7.53	5.29	3.75	4.99	9.72	2.00	2.33
1985	-0.30	1.28	1.20	3.23	6.34	2.79	9.58	1.63	2.45	2.60	-0.03	4.78	21.43	3.08	7.03
1986	-6.46	-3.46	-6.37	2.94	-0.10	-3.90	7.10	10.57	1.23	39.83	-0.98	7.33	-0.77	-1.72	4.41
1987	0.15	4.78	5.11	5.05	2.80	0.40	-1.54	-23.45	3.32	-1.33	-6.18	-0.59	12.59	9.60	8.61
1988	4.86	7.67	-5.52	3.40	6.88	4.10	9.19	10.07	4.89	14.73	0.75	4.13	-10.60	8.00	6.54
1989	-8.49	3.75	25.76	-3.24	10.48	2.37	4.00	-2.10	6.22	0.41	1.30	-0.42	-4.08	0.43	1.67
1990	-0.89	4.37	-0.22	7.91	-4.06	7.70	-3.01	26.06	3.17	5.98	-0.86	2.34	14.75	7.74	-3.33
1991	2.65	1.62	1.49	8.76	-1.26	5.28	0.25	-7.74	1.69	17.48	-1.75	9.62	2.52	-3.44	0.72
1992	11.71	1.01	-5.39	4.81	0.48	2.11	4.90	9.16	3.24	2.40	-2.14%	5.37	-2.92	6.46	2.57
1993	-0.09	4.69	7.59	4.10	-1.66	7.58	4.63	-18.95	14.30	11.09	-0.35	-0.85	-9.05	6.36	3.01
1994	10.38	3.02	8.40	1.20	1.91	9.82	2.03	35.12	5.80	17.20	7.09	6.29	-0.69	0.96	6.37
1995	-23.35	-1.72	-5.59	2.30	-2.29	3.35	10.12	0.87	1.25	17.01	13.58	0.92	-3.08	9.78	2.69
1996	-5.49	-5.38	-4.27	3.90	-5.87	3.70	10.67	-0.22	-5.18	1.23	6.21	2.95	-5.52	-4.00	-0.17
1997	19.24	-5.46	-7.64	0.26	15.14	8.54	26.75	3.42	1.52	2.60	4.88	8.01	-4.07	10.11	7.79
1998	0.64	-0.86	-5.46	3.05	-3.01	5.10	-3.49	5.61	-14.99	-4.01	5.15	6.58	-4.32	1.41	13.07
1999	1.49	-7.02	8.64	2.09	3.85	-5.71	25.25	-3.83	6.96	9.44	0.41	-7.40	5.21	-0.83	-18.85
2000	2.28	8.54	11.62	-0.49	1.40	3.88	25.86	-1.07	6.32	18.19	0.53	16.52	-5.75	-1.01	-8.60
2001	-11.92	3.54	-12.81	0.52	-10.08	4.52	4.47	-0.66	-7.12	2.92	0.56	-0.97	-3.62	6.03	8.00
2002	1.64	2.49	3.96	0.21	1.29	5.81	-1.59	-11.5%	1.25	6.66	-2.94	10.13	-3.33	-2.11	0.87
2003	0.81	3.42	3.12	0.79	1.34	-0.43	0.98	3.74%	-3.15	3.58	2.27	5.09	0.60	7.79	1.31

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

The first point to notice is that across the four sectors there is no consistent picture of LP change. In any given year, in any particular sub-sector, LP growth rates vary considerably. Of course, there is no a priori reason to expect LP growth rates to be consistent, but the range of variations is interesting and may suggest that individual countries' growth rates react differently to different explanatory factors. It is also an indication that different countries' transport sub-sectors may be at different stages of development and have differing structural characteristics. Further, how the transport sector is contextualised within a particular geographical location may influence its growth and limiting size.

Of course, as discussed previously, these tables only allow us to compare LP growth rates across EU15 countries. One cannot make the statement that because LP growth rates were higher on average in one country compared to another, that it is more productive. It may be that the country with the lower growth rates is closer to its production possibility frontier (the maximum level of efficiency) and cannot make easy productivity gains.

If one considers the inland transport sector, one notes that with the exceptions of Ireland and to a lesser extent Luxembourg, the rates of LP growth/decline typically do not exceed 10 per cent in any one year. Ireland may be an exception because of its tremendous rate of economy growth generally during the 1990s. However, one cannot, on this data at least, posit a causal relationship from transport productivity growth to wider economic growth (or even total labour productivity growth). Where negative labour productivity growth rates are recorded this may be a reflection of wider economic shocks or sector specific shocks, such as industrial action. The latter may be used as an explanation as to why negative labour productivity growth rates do not happen simultaneously across the EU15.

LP changes in the water sector, in general, seem to be larger than those of the inland transport sector. Changes of the magnitude of over 30 per cent happen on a number of occasions. Indeed, in the cases of Belgium and Greece in 1999, LP nearly doubles in one year. Such large gains may be the result of major structural changes in the particular sub-sector which remove a labour productivity bottleneck and allow for an instant rise in labour productivity.

The aviation sub-sector is similar to the inland transport sector in that while there are large fluctuations in growth rates, these fluctuations tend to be below the 10 per cent upper bound. There are exceptions of course, such as Belgium in 2001 where productivity doubled. The aviation sector, generally, is more volatile and correlated to economic growth, so one might expect to see labour productivity rising in boom periods. From the data this is not always the case.

The last sub-sector is support transport activities. The picture here is not dissimilar to inland and aviation transport – which of course is what this sub-sector depends on.

The preceding tables set out LP growth rates year on year. What is perhaps more interesting is the average growth rate. In this case, the average growth is not the mean of growth rates in each year between 1981 and 2003, but the average growth that would be required to achieve the final productivity index (similar to a compound growth rate).

Table 1-7: Hourly labour productivity EU15 countries 1981-2003 (inland transport): (volume indices, 1995 =100)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1980	76.8	65.2	95.3	72.7	70.7	60.2	51.1	69.3	58.3	27.8	83.3	55.9	59.9	72.1	56.8
1990	97.2	91.9	92.8	88.5	92.5	74.3	80.9	67.3	78.5	54.6	107.0	81.4	82.4	83.2	85.2
2003	114.7	102.5	97.8	115.7	109.7	92.4	85.7	77.1	101.3	123.2	109.4	110.7	110.5	124.2	98.2
Ave. 1980-90	2.4%	3.5%	-0.2%	2.0%	2.7%	2.2%	4.7%	-0.3%	3.0%	7.0%	2.5%	3.8%	3.2%	1.4%	4.1%
Ave. 1990-2003	1.3%	0.8%	0.04%	2.1%	1.3%	1.7%	0.04%	1.1%	2.0%	6.5%	0.02%	2.4%	2.3%	3.1%	1.1%
Ave. 1980-2003	1.7%	1.020 %	0.01%	2.0%	1.8%	1.8%	2.2%	0.04%	2.3%	6.4%	1.1%	2.9%	2.6%	2.3%	2.3%

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

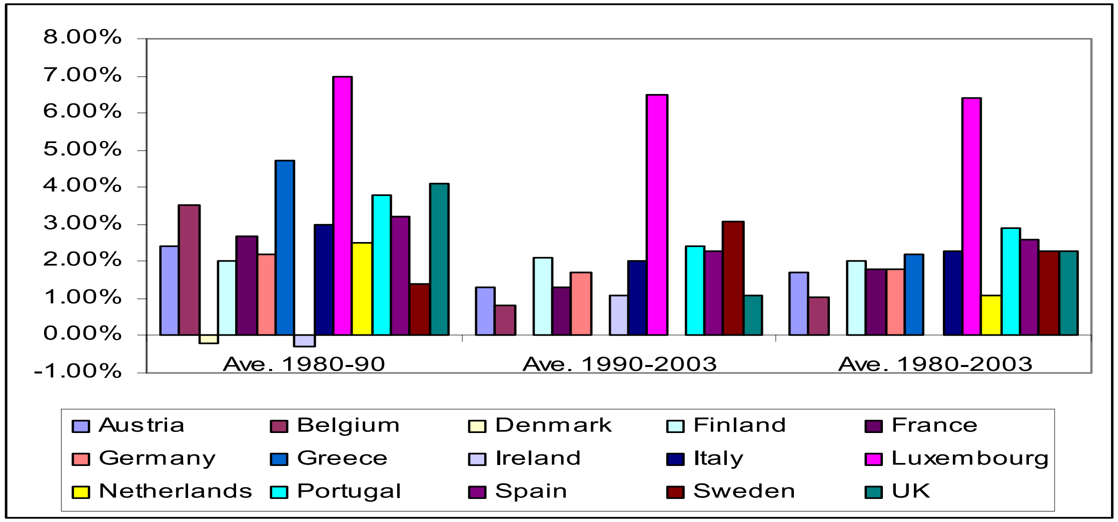


Figure 1-1: Hourly labour productivity EU15 countries 1981-2003 (inland transport):

Table 1-8: Hourly labour productivity EU15 countries 1981-2003 (water transport): (volume indices, 1995 =100)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1980	27.5	65.2	18.7	73.3	76.1	45.0	51.1	37.4	61.3	27.8	60.1	55.9	65.0	130.4	20.0
1990	133.1	91.9	60.6	79.2	65.0	56.7	80.9	54.2	82.6	54.6	79.1	81.4	53.5	151.4	58.8
2003	241.4	145.8	266.6	118.2	208.3	385.1	625.9	68.3	119.3	46.6	149.2	132.7	116.0	151.2	94.2
Ave. 1980-90	17.1%	3.5%	12.5%	0.08%	-2.0%	2.3%	4.7%	3.8%	3.0%	7.0%	2.8%	3.8%	0.981 %	1.5%	11.4%
Ave. 1990-2003	4.7%	3.6%	12.1%	3.1%	9.4%	15.9%	17.0%	1.8%	2.9%	-1.0%	5.0%	3.8%	6.1%	-0.01%	3.7%
Ave. 1980-2003	9.5%	3.4%	11.7%	2.0%	4.3%	9.4%	11.0%	2.5%	2.8%	2.2%	3.9%	3.7%	2.4%	0.06%	6.8%

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

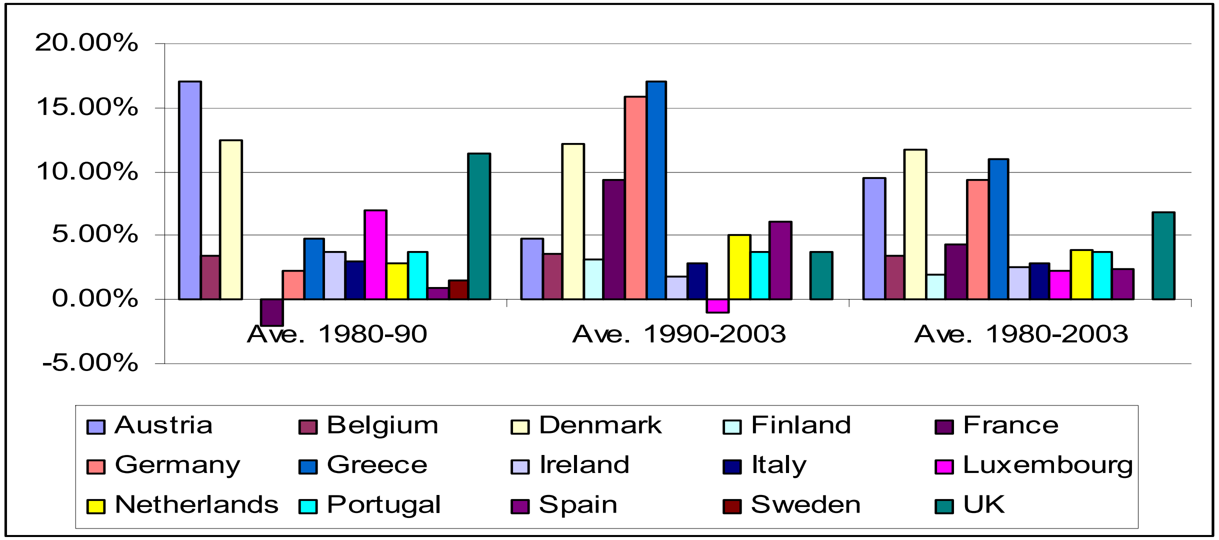


Figure 1-2: Hourly labour productivity EU15 countries 1981-2003 (water transport):

Table 1-9: Hourly labour productivity EU15 countries 1981-2003 (air transport): (volume indices, 1995 =100)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1980	28.1	65.2	179.2	47.1	72.2	50.3	51.1	93.8	57.8	27.8	40.2	55.9	37.5	49.5	56.2
1990	49.9	91.9	201.2	73.5	83.4	59.0	80.9	91.2	77.8	54.6	63.1	81.4	65.9	101.5	70.9
2003	75.0	166.1	116.8	123.6	114.2	88.0	76.0	119.9	88.5	155.1	108.3	136.3	130.5	96.6	171.6
Ave. 1980-90	5.9%	3.5%	1.2%	4.6%	1.5%	1.6%	4.7%	-0.3%	3.0%	7.0%	4.6%	3.8%	5.8%	7.4%	2.4%
Ave. 1990-2003	3.2%	4.6%	-4.1%	4.1%	2.4%	3.1%	-0.5%	2.1%	0.01%	8.4%	4.2%	4.0%	5.4%	-0.4%	7.0%
Ave. 1980-2003	4.2%	4.0%	-1.8%	4.1%	1.9%	2.4%	1.7%	1.0%	1.8%	7.4%	4.2%	3.8%	5.3%	2.8%	4.8%

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

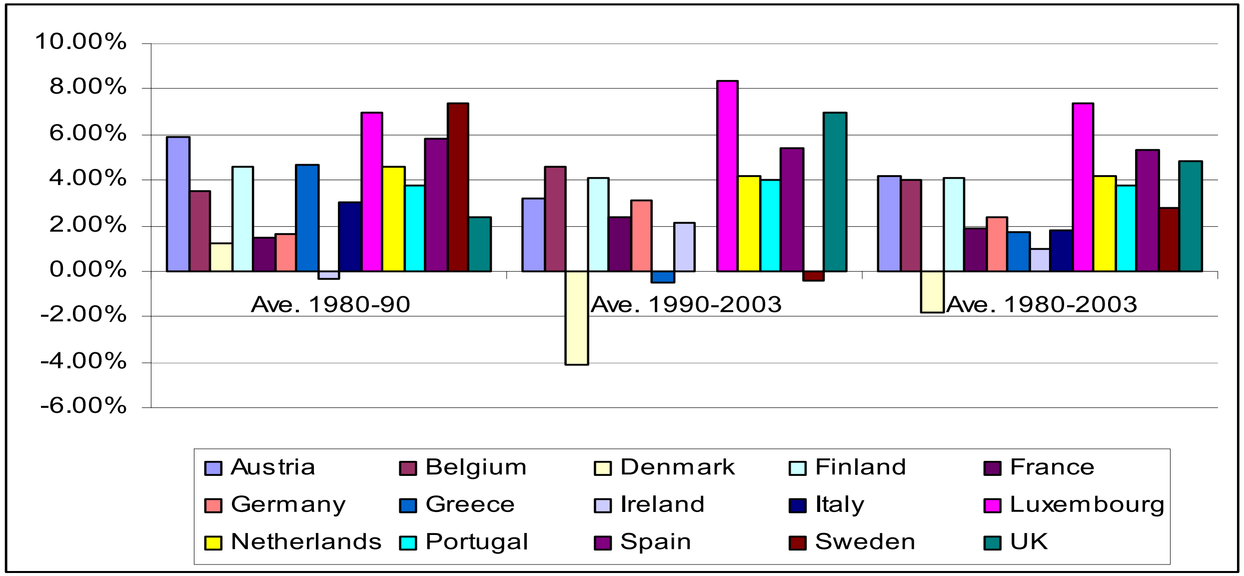


Figure 1-3: Hourly Labour Productivity EU15 countries 1981-2003 (air transport):

Table 1-10: Hourly labour productivity EU15 countries 1981-2003 (supporting activities):(volume indices, 1995 =100)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1980	91.1	65.2	65.3	58.2	72.4	61.6	51.1	87.1	57.8	27.8	87.2	55.9	69.0	57.6	60.1
1990	103.2	91.9	94.6	81.4	102.9	76.2	80.9	89.9	77.8	54.6	85.8	81.4	114.8	82.5	86.0
2003	106.2	98.2	94.7	110.7	102.2	127.6	221.6	94.5	84.8	146.6	118.0	146.6	80.6	117.7	99.6
Ave. 1980-90	1.3%	3.5%	3.8%	3.4%	3.6%	2.1%	4.7%	0.03%	3.0%	7.0%	- 0.02%	3.8%	5.2%	3.7%	3.6%
Ave. 1990-2003	0.02%	0.05%	0.00%	2.4%	- 0.01%	4.0%	8.1%	0.04%	0.07%	7.9%	2.5%	4.6%	-2.3%	2.8%	1.1%
Ave. 1980-2003	0.06%	1.7%	1.6%	2.7%	1.4%	3.1%	6.3%	0.03%	1.6%	7.2%	1.3%	4.1%	0.06%	3.0%	2.1%

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

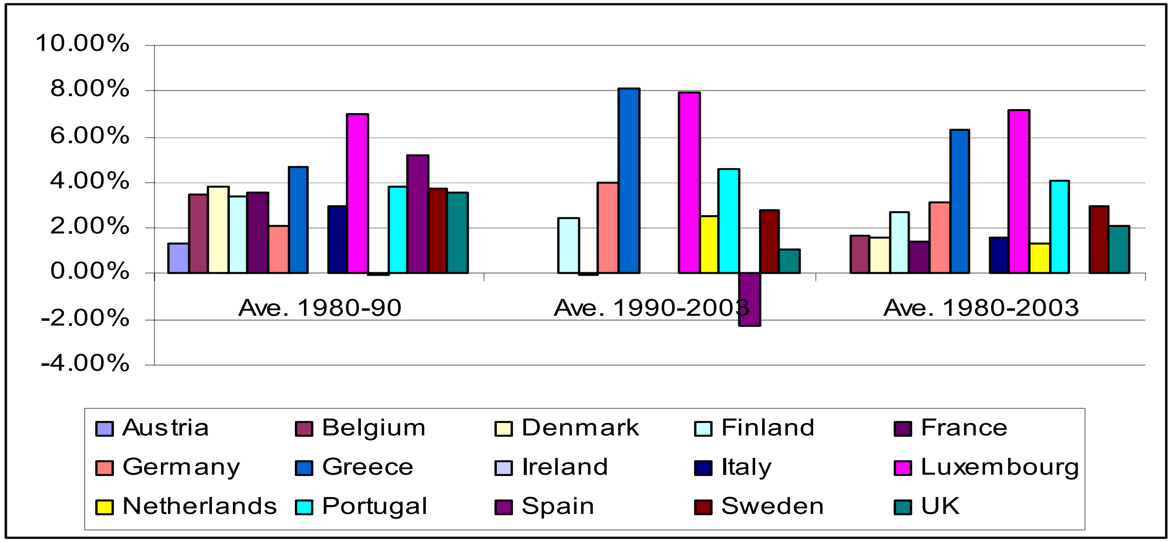


Figure 1-4: Hourly labour productivity EU15 countries 1981-2003 (supporting activities):

Tables Table 1-7to Table 1-10 show the calculated averages rates of LP growth for EU15 member states by transport sub-sector. The averages are split into three categories: 1980-1990, 1990-2003 and 1980-2003. The former two categories allow one to examine if rates of LP are significantly different between the two periods. It should be kept in mind throughout this discussion that this refers just to the labour input into transport output, ignoring capital. Thus, even if a particular sector records low levels of labour productivity growth, it may enjoy much higher levels of total factor productivity growth if capital productivity rises rapidly enough to offset any labour productivity declines.

Let us begin by examining the inland transport sector. For the entire period, average growth rates are positive for all countries. The smallest increase is in the case of Denmark whereas the largest is in Luxembourg. Only four countries experience higher LP growth in the second period compared to the first. These countries are Denmark, Finland, Ireland and Sweden. This in itself is interesting as one might conjecture that Denmark, Finland and Sweden (all Scandinavian countries) were all the receipt of a common factor that helped increase their LP growth. These countries might have common features of their transport sub-sectors which will result in common responses to common shocks. The fact that Ireland reports higher LP growth in the second period may be a reflection of its rapid economic growth in the 1990s. However, one should not lose sight of the actual growth rates: between 1990 and 2003 Ireland averaged 1.1 per cent compared to 6.5 per cent in Luxembourg.

The picture in the water transport sector is more uneven. The overall average growth rates are nearly all higher for water transport than for inland transport. Only Luxembourg, Spain and Sweden have lower overall average growth rates. Reflecting observations made from table 2, there is no clear trend between periods. A number of countries experience an increase in LP growth rates between 1990 and 2003 compared to 1980 and 1990. Indeed, for some countries the increase is very rapid: in the case of Finland growth moved from -2.0 per cent to 9.4 per cent; in Greece from 4.7 per cent to 17.0 per cent; and Germany also shows a large increase. It is interesting to note that Ireland, Denmark and Sweden do not follow the same pattern in water transport as for inland transport. This unevenness between countries' growth rates probably relates back to the fact that the water sectors will be very different between countries. For example, canals may be prevalent in certain countries, or the ports may historically have been more active.

Overall growth rates in the aviation sector are mixed. In the case of Denmark LP actually falls between 1980 and 2003. Luxembourg has the highest rate of overall growth, but the UK also records a rate of 4.8 per cent. The UK figure may related to deregulation of skies during this period. It is not immediately obvious the growth rates are correlated to traffic or passenger numbers – some of the busiest skies in Europe are in France and Germany, and these do not record exceptionally high growth rates. There is also no clear trend between the two periods. A number of countries show a decline in the rate of productivity growth; in three cases this decline becomes negative.

The overall growth rates in support activities to transport are, in general, lower than in other sectors. The clear exceptions are Luxembourg and Greece which record rates of 7.3 per cent and 6.3 per cent respectively.

Across the four sectors, one notes that Luxembourg has experienced the highest growth rates in LP. Most countries have experienced an increase in LP over each of the four sectors: the only exception being Denmark in the case of aviation. There is no clear trend between the two periods in any of the sub-sectors.

1.4 Selected new member states

The table below shows labour factor productivity growth in the four transport sub-sectors for those new Member States for which data has been collected by the University of Groningen. The data set is smaller than for EU15 countries beginning in 1994.

Table 1-11: Hourly labour productivity growth rates for selected new Member States EU15 countries 1981-2003 – inland transport

	Czech Republic	Hungary	Poland
1994	8.88%	3.24%	17.39%
1995	-12.42%	-1.20%	-0.75%
1996	11.15%	-6.25%	-3.63%
1997	-21.62%	12.58%	4.92%
1998	2.04%	8.51%	-8.89%
1999	-1.08%	-5.02%	23.84%
2000	-10.64%	14.46%	12.85%
2001	8.96%	4.81%	5.97%
2002	2.93%	0.95%	12.12%
2003	-8.53%	4.51%	4.15%

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

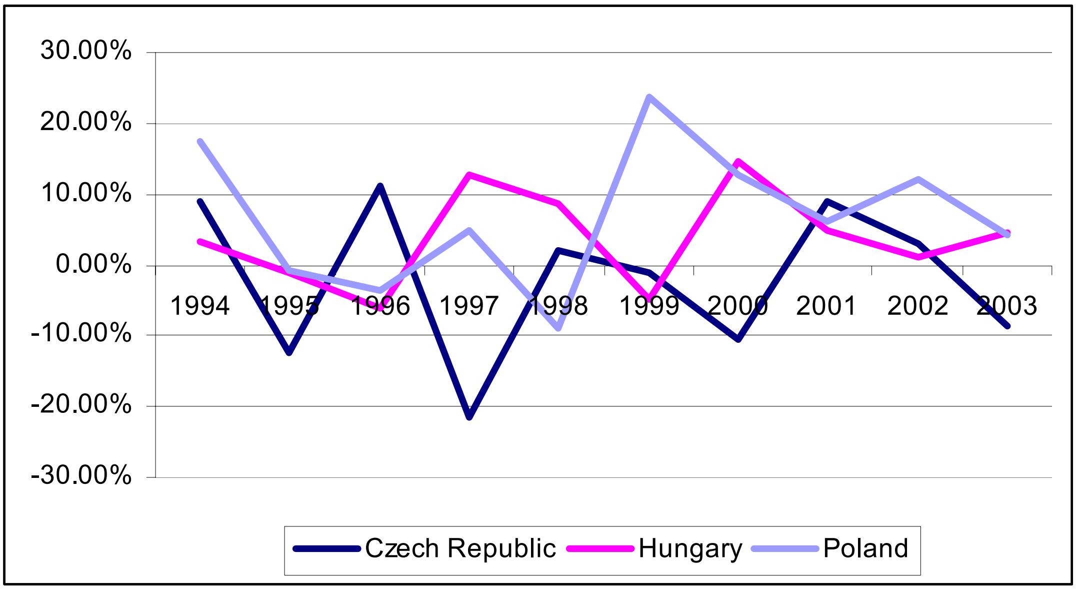
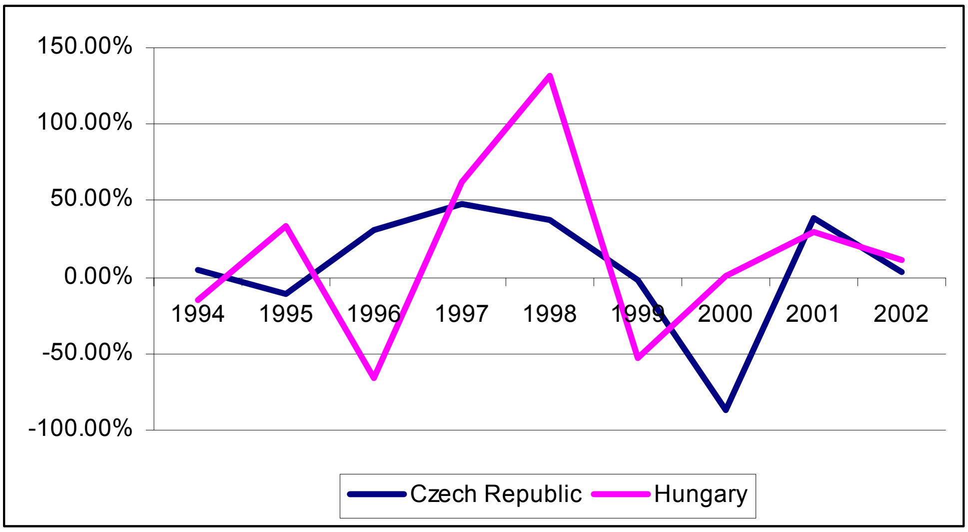


Figure 1-5: Hourly Labour Productivity Growth Rates for selected new Member States EU15 countries 1981-2003 – inland transport

Table 1-12: Hourly labour productivity growth rates for selected new Member States EU15 countries 1981-2003 – water transport

	Czech Republic	Hungary	Poland
1994	4.42%	-14.29%	-25.69%
1995	-11.47%	33.37%	-13.34%
1996	30.24%	-66.45%	-10.23%
1997	48.01%	62.57%	
1998	37.30%	131.36%	
1999	-1.51%	-52.68%	
2000	-86.39%	1.39%	18.26%
2001	38.97%	29.30%	5.97%
2002	2.93%	11.01%	12.12%
2003	-8.53%	11.01%	4.15%

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net



Note: Poland excluded due to missing observations

Figure 1-6: Hourly labour productivity growth rates for selected new Member States EU15 countries 1981-2003 – water transport

Table 1-13: Hourly labour productivity growth rates for selected new Member States EU15 countries 1981-2003 – air transport

	Czech Republic	Hungary	Poland
1994	-38.17%	4.30%	30.41%
1995	169.40%	20.06%	53.64%
1996	-24.10%	-8.70%	-20.10%
1997	13.26%	-3.95%	-8.71%
1998	8.83%	113.62%	10.67%
1999	-9.79%	-42.77%	-10.12%
2000	-37.13%	-4.79%	1.82%
2001	-34.68%	-22.28%	5.97%
2002	2.93%	108.80%	12.12%
2003	-8.53%	8.05%	4.15%

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

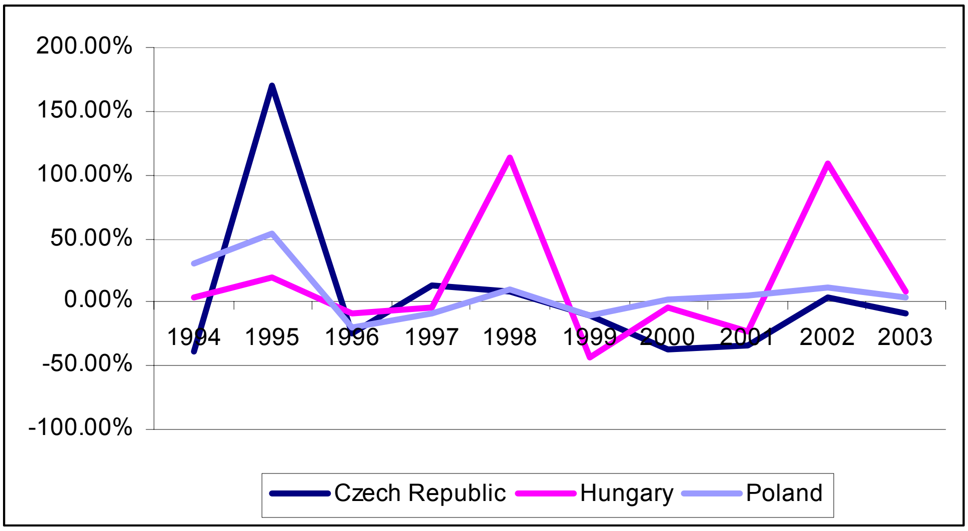


Figure 1-7: Hourly labour productivity growth rates for selected new Member States EU15 countries 1981-2003 – water transport

Table 1-14: Hourly labour productivity growth rates for selected new Member States EU15 countries 1981-2003 – supporting activities

	Czech Republic	Hungary	Poland
1994	-11.53%	65.08%	-4.55%
1995	-13.08%	10.53%	17.86%
1996	1.24%	11.66%	-2.68%
1997	-42.42%	-16.08%	-16.27%
1998	-7.20%	-15.26%	37.81%
1999	8.01%	33.18%	-5.94%
2000	0.62%	-44.27%	11.53%
2001	24.21%	-8.14%	5.97%
2002	2.93%	-2.18%	12.12%
2003	-8.53%	-4.14%	4.15%

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

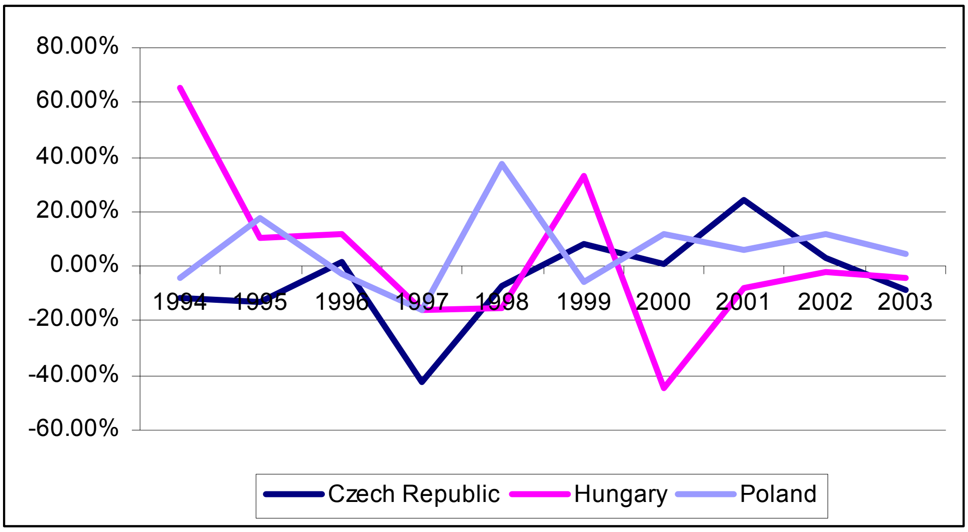


Figure 1-8: Hourly labour productivity growth rates for selected new Member States EU15 countries 1981-2003 – supporting activities

As the tables and figures show there is much more fluctuation in the four transport sub-sectors when compared to the EU15 countries. This is perhaps to be expected given the economic upheavals experienced by these countries during the later 1980s and early 1990s. While the shocks might be common (market liberalisation in a short period), the way each transport sub-sector reacts is different; the reaction being based on each country's context and starting structural point. Given these wider economic trends it may be difficulty to extrapolate specific trends and explanatory factors for productivity changes.

A similar exercise is now carried out to determine the average LP growth rates for the new Member States.

Table 1-15: Hourly labour productivity for selected new member states 1994-2003 (inland transport): (volume indices, 1995 =100)

	Czech Republic	Hungary	Poland
1993	104.9	105.3	92.2
1994	114.2	101.6	101.1
1995	100.0	100.0	100.0
1996	111.2	95.3	99.3
1997	87.1	111.8	110.2
1998	88.9	120.8	100.5
1999	87.9	107.7	117.4
2000	78.6	125.1	132.2
2001	85.6	134.5	141.1
2002	88.1	135.8	160.2
2003	80.6	141.1	166.4
Ave.	-2.37%	2.7%	5.52%

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

Table 1-16: Hourly labour productivity for selected new member states 1994-2003 (water transport): (volume indices, 1995 =100)

	Czech Republic	Hungary	Poland
1993	108.2	93.9	166.7
1994	113.0	75.2	115.8
1995	100.0	100.0	100.0
1996	130.2	34.1	92.5
1997	192.8	57.8	-
1998	264.7	133.1	45.3
1999	260.7	59.1	139.9
2000	35.5	60.9	164.9
2001	49.3	80.7	176.1
2002	50.7	89.6	199.9
2003	46.4	98.6	207.7
Ave.	-7.4%	0.04%	2.02%

Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

Table 1-17: Hourly labour productivity for selected new member states 1994-2003 (air transport): (volume indices, 1995 =100)

	Czech Republic	Hungary	Poland
1993	60.0	85.7	53.6
1994	37.1	83.6	65.3
1995	100.0	100.0	100.0
1996	75.9	92.8	82.3
1997	86.0	92.9	79.5
1998	93.6	197.5	88.0
1999	84.4	106.2	74.7
2000	53.1	102.6	75.8
2001	34.7	81.8	81.0
2002	35.7	1070.8	91.9
2003	32.6	183.5	95.5
Ave.	-5.39%	7.2%	5.39%

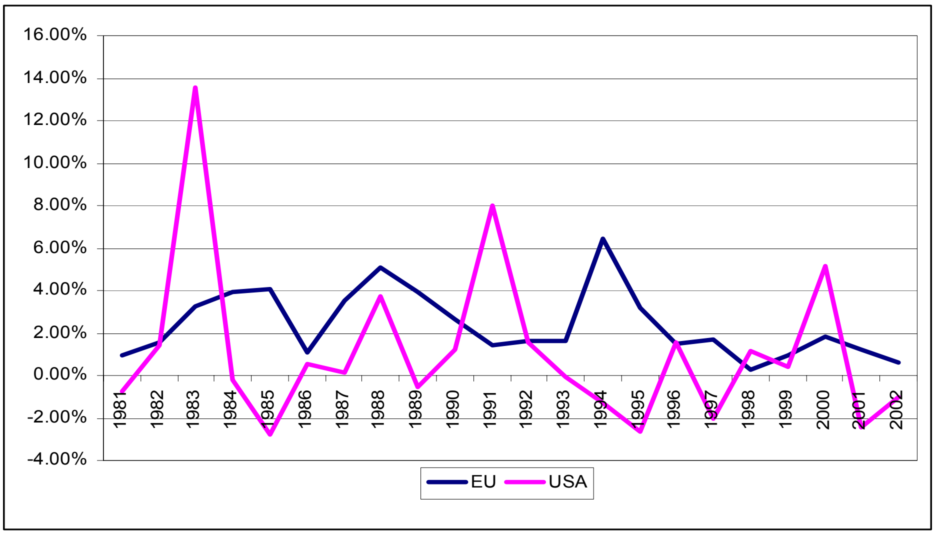
Table 1-18: Hourly labour productivity for selected new member states 1994-2003 (supporting activities): (volume indices, 1995 =100)

	Czech Republic	Hungary	Poland
1993	130.0	58.8	95.4
1994	115.0	90.8	85.1
1995	100.0	100.0	100.0
1996	101.2	113.5	100.3
1997	58.3	99.2	88.8
1998	54.1	83.7	122.5
1999	58.4	104.7	108.7
2000	58.8	59.2	120.9
2001	73.0	55.8	129.1
2002	75.2	54.6	146.6
2003	68.8	52.0	152.3
Ave.	-5.62%	-1.11%	4.34%

It is interesting to note that in all four transport sub-sectors, the Czech Republic is reporting an overall decline in LP. Hungary records positive LP for all sub-sectors except for supporting activities. However, in the case of water transport the increase is marginal. In contrast to both the Czech Republic and Hungary, Poland records positive LP growth across all four sectors.

1.5 A comparison between EU15 and US

We now present some comparisons between the EU15 and the US based on the Groningen database. The graph below compares LP growth in inland transport between the EU15 and US for the period 1981 to 2002.



Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

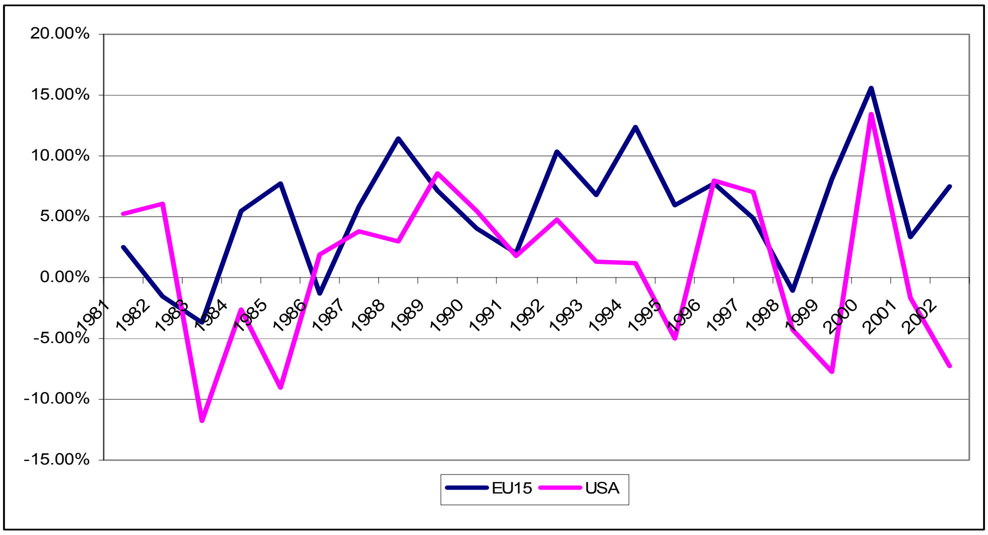
Figure 1-9: Hourly labour productivity growth rates in EU15 and US: 1981–2002 (inland transport)

As tables Table 1-3 and Table 1-6 noted, the overall trend in EU15 countries has been positive, although the growth rates themselves have fluctuated. Since 2000, the EU15 growth rate has declined: 1.25 per cent in 2001 falling to 0.64 per cent in 2002. More time series data would be required to ascertain whether this trend has continued post 2002.

In contrast, the labour factor productivity growth rate in the US has not been uniformly positive and has shown far greater levels of volatility compared to the EU15. One notices that productivity growth spikes periodically in 1983, 1991 and 2000. Each of these spikes is followed by a fall in the rate of productivity growth and subsequently a decline in labour factor productivity. One might speculate that these changes in labour factor productivity growth rates are correlated with economic cycles, much more so than in the EU15. Other explanations might include a more than proportional growth in hours worked in the US than in the EU, but also differences in exogenous variables such as changing population densities and size.

Again, once must recall that one cannot draw the conclusion that the EU15 has greater levels of labour factor productivity than the US from this chart, as volumes and starting points are unknown. However, one can say that the EU15 has demonstrated more consistent growth, which on average has been stronger than the US.

The graph below compares labour factor productivity growth in water transport between the EU15 and US.



Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

Figure 1-10: Hourly labour productivity growth rates in EU15 and US: 1981 – 2002 (water transport)

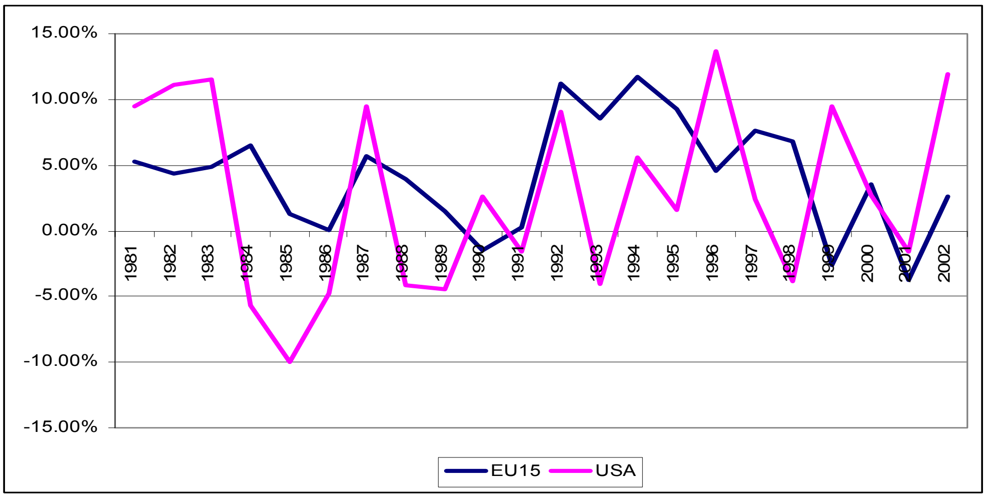
As the above figure illustrates, labour productivity growth in the EU15 countries has exhibited a broad upward trend during the period in question. However, this trend is not consistent, as typically large increases in productivity growth are followed by declines in productivity growth.

The US displays a similar pattern, although its average growth rate during this period is much lower than that of the EU15: 1.0 per cent compared to 5.52 per cent.

Given the usual caveats, one can conclude that the EU15 has demonstrated more consistent growth, which on average has been stronger than the US, although in both cases, growth is highly volatile. Further analysis would be required to determine the variables affecting growth in water transport.

The table below charts LP growth for the aviation sector.

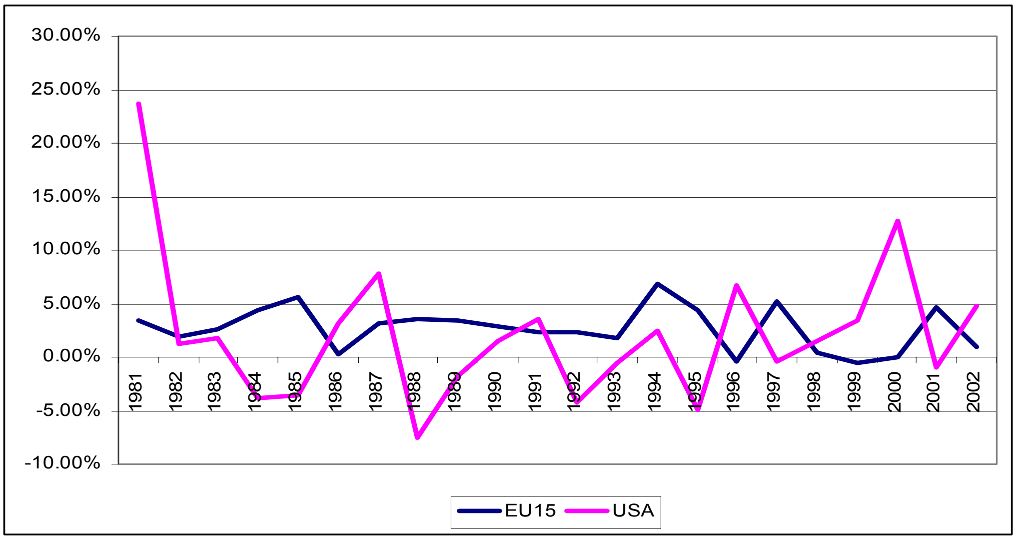
Again, it is not easy to discern a trend from figure 3 regarding LP in the aviation industry. Average growth for the EU15 was 4.16 per cent and 2.74 per cent for the US. One might argue that towards the end of the period there has been a downward shift in EU aviation LP, but without further data one cannot be conclusive. As in the previous two sub-sectors, the US growth rate demonstrates a much higher degree of fluctuation than the EU. This may suggest that US LP in the transport sector as a whole is more sensitive to changes in its explanatory variables, but further econometric work is required to verify such a hypothesis.



Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

Figure 1-11: Hourly labour productivity growth rates in EU15 and US: 1981 – 2002 (air transport)

The final figure shows LP growth rates for support services to transport.



Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

Figure 1-12: Hourly labour productivity growth rates in EU15 and US: 1981 – 2002 (supporting activities)

As has been the case in the previous diagrams, the US exhibits far greater fluctuations with respect to LP than the EU15 countries. Throughout the period, save for 1999, EU15 countries record positive rates of growth. In contrast, the US shows declines in LP in a number of years. There is also a large fall in LP growth rates at the beginning of the period and subsequently growth varies within a 20 per cent band. However, it should also be noted that the peaks of US LP growth exceed those of the EU15.

2 Comparison with other LP studies

The previous section presented LP growth rates from the University of Groningen database. A number of other productivity studies have been carried out in the recent past. These also compare rates between the US and EU. These studies set out to investigate differences in growth rates and the underlying causes of divergent productivity trends. It is useful at this stage to briefly set out the main results of selected comparative studies.

One such comparison is a recent DG Enterprise report entitled EU Productivity and Competitiveness: an industry perspective – can Europe resume the catching-up process by O'Mahoney and Van Ark (eds. 2003). This report calculates LP growth rates for the EU15, US and Japan at both an aggregate economy level and a sectoral level. The report notes that during the latter 1990s, the labour productivity gap between the EU and the US widened and that it is the first time since the Second World War that productivity levels between the two are not converging. The table below compare EU member states, the US and Japan's labour productivity rates across the entire economy.

Table 2-1: Aggregate annual growth rates of labour productivity, 1980-2002

Country	1980-90	1990-95	1995-00	2000-2002
Austria	1.7	1.8	3.2	0.8
Belgium	2.3	2.3	2.8	-0.7
Denmark	1.9	2.4	1.6	1.5
Finland	3.0	2.8	2.9	1.4
France	2.9	1.4	1.3	1.7
Germany	2.5	4.0	2.2	1.3
Greece	1.0	0.6	2.8	4.2
Ireland	4.1	3.6	5.7	3.2
Italy	2.0	2.3	1.0	-0.1
Netherlands	1.9	1.4	0.6	0.3
Portugal	1.7	3.5	3.1	0.1
Spain	3.0	2.3	-0.3	-0.4
Sweden	1.1	2.0	2.2	2.0
UK	2.2	3.0	1.8	1.1
EU	2.3	2.6	1.5	0.8
US	1.4	1.1	2.0	1.7
Japan	3.0	1.8	2.3	0.2

Source: EC/GGDC/The Conference Board in EU Productivity and Competitiveness: an industry perspective – can Europe resume the catching up process (2003). Note 1980-90 refers to West Germany only and EU excludes Luxembourg

The overall picture that emerges is that while for the periods 1980-90 and 1990-95, the EU15 had higher levels of LP growth that the US, in recent years it has fallen behind. The gap actually widened between the latter two periods.

More interesting for our purposes is the sectoral breakdown of labour productivity statistics. The report notes that an industry perspective is useful in that it aids in an understanding of the forces underlying competitiveness and thus identifying the areas of relative weakness vis-à-vis the EU's competitors.

The table below shows the report's estimates of annual LP growth in EU15 countries and the US in the transport sector and sub-sectors.

Table 2-2: Aggregate annual growth rates of labour productivity, 1980-2002

	EU15			US		
	1979-90	1990-95	1995-01	1979-90	1990-95	1995-01
Total economy	2.2	2.6	1.7	1.4	1.1	2.3
Inland transport	2.6	3.0	2.4	1.7	1.0	0.6
Water transport	3.1	5.7	2.6	0.5	0.7	2.2
Air transport	3.4	9.5	3.6	1.0	2.0	3.5
Support activities	3.2	3.7	1.5	-0.9	-0.8	3.6

Source: EU Productivity and Competitiveness: an industry perspective – can Europe resume the catching up process (2003)

While across the economy, the US is experiencing higher rates of LP growth; within the transport sector it is clear that the EU15 countries have experienced higher growth rates in labour productivity. Interestingly, there are hints of convergence for the period 1995-01 in the water and air transport sectors. This also occurred, to a lesser extent, in the Groningen graphs (see figures 2 and 3). However, the Groningen data is extended by one year to 2002, and the growth rates subsequently diverge widely.

A second study that provides a useful comparison is "An analysis of EU and US productivity developments (a total economy and industry level perspective)" by Denis, McMorrow and Röger (2004) for the Directorate General for Economic and Financial Affairs. The report examines empirical evidence to ascertain whether it is possible to predict future productive trends. It also compares the EU15 to the US. The main dataset used is the OECD STAN database and the GGDC dataset.

The table below shows the calculated hourly productivity growth rates for labour factor productivity. The authors calculate the contribution of sub-group industry groups (i.e. the different components of the transport sector) by using the fact that intra-industry effects are dominant, and that, for the period and countries studies, shift and interaction effects are deemed minimal.

Table 2-3: Hourly labour productivity growth rates

	EU15			US		
	1981-1990	1991-95	1996-00	1981-90	1991-95	1996-0
Total economy	2.4	2.3	1.6	1.1	1.1	2.3
Inland transport	2.7	3.1	2.3	1.5	1.0	1.2
Water transport	3.8	5.7	2.4	0.4	0.7	2.9
Air transport	3.7	9	5	1.2	2	4.6
Support activities	3.4	3.6	1.6	-0.9	-0.8	4.6

Source: An analysis of EU and US productivity developments, GGDC

An important point to note is that the authors calculated the contribution to labour productivity per hour from a sub-group of industries using a method compatible to the Tornqvist price index. An implication of this is that the contribution to LPH growth from any sub-group of industries will include reallocation effects amongst industries within that sub-group. The contribution from individual industries will not include any reallocation effects. They are simply the product of that industry's productivity growth rate and of the (nominal) value added share of that industry at the beginning of the period. As a result, the contribution to LPH growth from a sub-group of industries only equals the sum of the contributions of the component industries, if there are no changes in the volume of labour input.

Table 19 shows a similar picture to table 18. Whilst, in aggregate the EU15 have lagged the US in LP growth for the period 1996-2000, in the transport sector LP growth has been, in most cases higher. Although for the period 1996-2000, the US experience higher LP growth rates for water transport and supporting activities, this is an exception from the overall trend. In the case of air transport, the EU15 experience significantly higher levels of growth in the period 1991-95: 9 per cent compared to 2 per cent. One of the caveats we have discussed is that one cannot make inferences about relative productivity levels from observance of growth rates. The DG ECOFIN study calculates relative productivity levels for individual sectors, so one can make a statement about which region is more productive.

Table 2-4: EU15 Labour productivity levels relative to the US

	1980	1990	2000
Inland transport	87.2	98.2	114.9
Water transport	73.2	103.4	129.2
Air transport	88.8	113.7	164.7
Support activities	46.4	71.3	76.8

Source: An analysis of EU and US productivity developments, GGDC

The above table shows the relative levels of productivity in the transport sub-sectors. At the beginning of the period, the US was more productivity in all categories. This lead was especially pronounced in the supporting activities sector. However, this productivity gap was closed during the ensuing decade, and by 1990 the EU had overtaken the US in water and air transport. By the year 2000, the EU15 were more productive than the US in all transport subsectors except supporting activities. This lead was especially large in air transport.

The above table confirms the effect of higher LP growth rates by the EU15 relative to the US.

Table 2-5: Contributions to total VA rate in US and EU15

	EU15			US		
	1981-1990	1991-95	1996-00	1981-90	1991-95	1996-00
Total Economy	2.38	1.51	2.72	2.78	2.07	4.25
Sum of the intra-industry effects	2.38	1.51	2.72	2.78	2.07	4.25
Inland transport	0.07	0.04	0.06	0.04	0.07	0.07
Water transport	0.00	0.01	0.00	0.00	0.00	0.01
Air transport	0.01	0.03	0.04	0.05	0.04	0.05
Support activities	0.04	0.04	0.06	0.01	0.01	0.02

Source: An analysis of EU and US productivity developments, GGDC

The table above shows the contributions of the four transport sub-sectors to total Value Added rate in the EU15 and US economies. What this says is that, for example, during the period 1991-95 in the EU15, value added grew by 1.51 per cent on average, of which 0.04 came from inland transport.

Table 2-6: EU15 VA level relative to US

	1980	1990	2000
Inland transport	132.5	178.0	106.8
Water transport	186.2	183.2	114.0
Air transport	67.1	57.1	49.6
Support activities	627.0	445.0	341.9

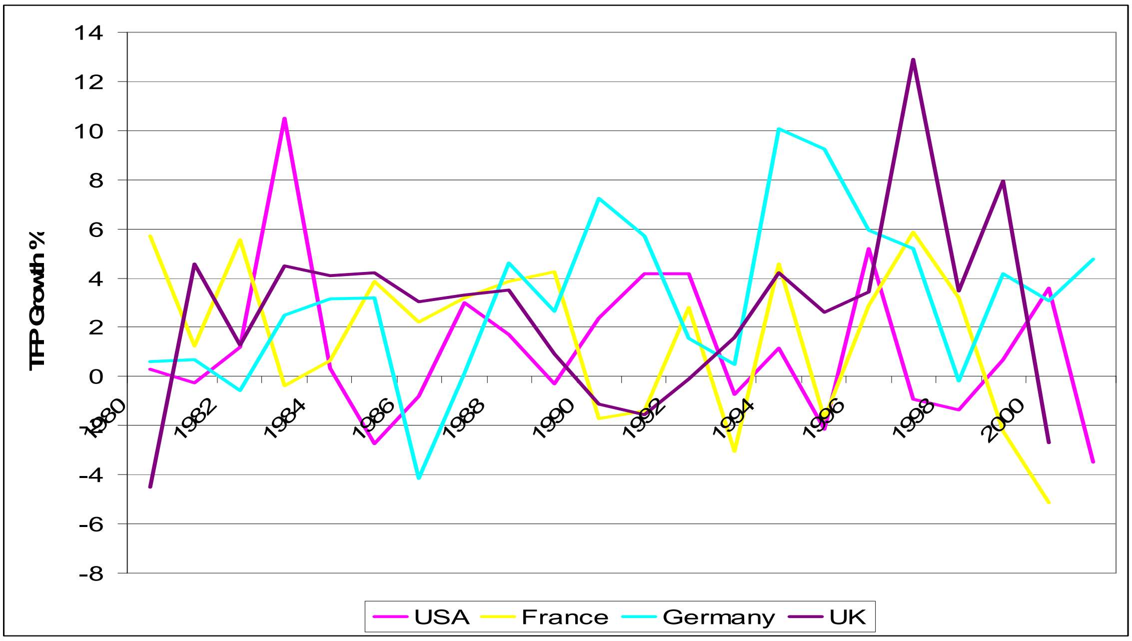
Source: An analysis of EU and US productivity developments, GGDC

The above table compares the value added levels between the EU15 and US. In all sub-sectors, except for air transport, value added is higher than in the EU15 than the US, although the differences have declined since 1980.

3 Total factor productivity

The transport sector has large capital components in the form transport infrastructure. Thus it is important to consider all factors of production: total factor productivity (TFP). This section examines some TFP calculations for the sector.

The table below shows TFP growth rates in selected EU countries and the US for the entire transport sector. These figures come from the University of Groningen database.



Source: Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net

Figure 3-1: Total factor productivity growth rates in selected countries: 1980 – 2001 (complete transport sector)

The table above compares the growth rates of three EU countries and the US for the entire transport sector for the period between 1980 and 2002.[1]

For the period in question, Germany has the highest average growth rate during this period: 3.18 per cent. This may because of greater utilisation of capital goods. Germany is followed by the UK, France and US respectively with rates of 2.64 per cent, 1.63 per cent and 1.16 per cent respectively. This is similar to the situation of labour productivity growth where the US exhibited lower overall growth rates.

It is not easy to discern any trend from the above graph. Each country has experienced years of productivity growth and productivity decline. In addition, there does not seem to be any common movement of trends. During the 1980s, TFP growth ranged between 10 per cent and -5 per cent, but EU countries did not experience growth and declines simultaneously. This is perhaps not surprising due to structural differences in the economies of France, Ger-

[1] The high degree of volatility suggests the use of smoothing – this is done with our estimates in section 4.

many and the UK which led them to being at different stages of the economic cycle at different times.[2] If TFP is correlated with the business cycle, then one might expect to see different rates across the cycle and across different countries. However, the evidence for this is inconclusive, as one might argue the productivity might increase in recessions as more is expected from fewer inputs.

Further, one should not necessarily expect to see convergence in growth rates due to each economy's unique factors and influences. The trend of disparate growth rates continues into the 1990s and beyond.

In section 5.5 we will discuss some empirical evidence on relative TFP level and we will argue that some convergence in TFP levels within the sample (EU15 less Luxemburg plus the US) did indeed took place over the 1979-2002 period.

3.1 Comparison with other TFP studies

Many studies of transport productivity favour the TFP approach. Researchers normally focus on particular transport sub-sectors such as railways or aviation, and these sub-sectors are analysed in isolation making it hard to reach an overall picture for the sector.

Two examples of total transport sector productivity studies are those carried out by Kune and Mulder (2000) and O'Mahoney et al. (1997). Kune and Mulder (2000) carry out a panoramic study of the French transport sector and compare its performance against that of the UK, US and (West) Germany for the period 1970 to 1995.

The transport sector is segmented into several sub-sectors: railways, rail freight, road passengers, inland water, maritime, aviation and transport services.

Each sector TFP is estimated individually and the results are then aggregated for the total transport sector.

It is noted by some authors that, in some sub-sectors, the US can, by virtue of its inherent size, realise much greater scale economies than the comparator European countries and therefore have an inherent productivity advantage. Within certain sub-sectors, such as railways, this has a significant effect.

For example, authorities can load a train in New York which can then travel directly to San Francisco without crossing any national boundaries. In contrast, the railways of each European country operate almost entirely within their own territory; trains must be loaded and unloaded several times to generate the same quantity of ton kilometres as in the US. The same argument can also be applied to the road haulage industry.

The table below summarises Klune and Mulder's results.

2 See, for example, Table 1.2 of "UK membership of the single currency. An assessment of the five economic tests", HM Treasury, 2003.

Table 3-1: Summary of Kune and Mulder results for productivity growth for the overall transport sector in four countries (average annual growth rate)

	Value added				Labour productivity			
	France	Germany	UK	US	France	Germany	UK	US
1973-79	2.9%	2.9%	0.4%	2.5%	3.3%	4.2%	1.0%	1.3%
1979-89	2.7%	2.0%	2.6%	1.8%	3.0%	2.4%	4.1%	0.6%
1989-95	1.4%	4.0%	2.6%	3.7%	0.2%	3.5%	3.6%	1.3%
	Hours worked				Capital productivity			
	France	Germany	UK	US	France	Germany	UK	US
1973-79	-0.3%	-1.2%	-0.6%	1.2%	-0.8%	1.3%	-1.1%	0.7%
1979-89	-0.3%	-0.4%	-1.4%	1.3%	2.0%	1.5%	3.5%	2.7%
1989-95	1.2%	0.5%	-1.0%	2.1%	-1.1%	3.3%	-0.1%	4.6%
	Capital services				Total factor productivity			
	France	Germany	UK	US	France	Germany	UK	US
1973-79	3.8%	1.6%	1.4%	1.8%	1.8%	3.3%	-0.1%	1.1%
1979-89	0.7%	0.5%	-0.9%	-0.8%	2.7%	2.1%	3.6%	1.2%
1989-95	2.5%	0.7%	2.6%	-0.9%	-0.4%	3.4%	1.7%	2.2%

Adapted from Kune and Mulder (2000)

Their results show that the variance of productivity patterns across transport sectors in France resembles those of other countries. Overall productivity gains in Germany and the UK are similar and the same direction to those in France. Perhaps surprisingly, the three European countries all outperform the US. However, one should recall that their results show productivity growth and these cannot (in isolation) be used as the basis of productivity rankings.

There have been a number of TFP studies into individual transport sub-sectors, in particular the railways sector. One such study in the railways sub-sector; Sanchez and Villaroya (2000), uses stochastic frontier analysis (SFA) to estimate TFP and x-inefficiency for European railways over the period 1970 to 1990.[3]

The advantage of this method is that it allows a decomposition of deviations from predicted outcomes into inefficiency and random error. The average median efficiency level for EU15 member states is estimated at 0.8649 (standard deviation being 0.0982).

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[3] Broadly speaking x-inefficiencies are those inefficiencies that explain the differences between the theoretical efficient behaviour of firms and that actually observed. Stochastic frontier analysis is a method of identifying the theoretical efficiency level using actual data.

Positive TFP growth is attributed predominately to technical change (0.45 per cent). Efficiency gains and improvements in economies of scale contribute only 0.19 per cent and 0.16 per cent, respectively. Sanchez and Villaroya further estimate the determinants of TFP in the rail industry.

Table 3-2: Rail Technical Change Indices (TCI) for 10 EU countries 1972 – 1992

Country	TCI	Standard error	95 per cent lognormal interval	
1982				
Belgium	0.867	0.061	0.753	0.993
Denmark	0.222	0.043	0.149	0.318
France	0.646	0.065	0.528	0.781
Germany	1.640	0.417	0.970	2.590
Greece	0.216	0.050	0.134	0.329
Italy	0.613	0.070	0.487	0.761
Luxembourg	0.150	0.016	0.121	0.183
Netherlands	0.386	0.067	0.271	0.533
Portugal	0.109	0.047	0.044	0.226
UK	1.380	0.109	1.180	1.610
1987				
Belgium	0.839	0.060	0.727	0.963
Denmark	0.198	0.039	0.133	0.284
France	0.609	0.063	0.496	0.740
Germany	1.530	0.390	0.909	2.430
Greece	0.210	0.049	0.130	0.320
Italy	0.591	0.069	0.467	0.737
Luxembourg	0.143	0.016	0.115	0.176
Netherlands	0.361	0.063	0.253	0.500
Portugal	0.101	0.044	0.041	0.208
UK	0.143	0.016	0.115	0.176
1992				
Belgium	0.780	0.057	0.675	0.897
Denmark	0.191	0.037	0.129	0.275
France	0.591	0.062	0.478	0.721
Germany	1.480	0.377	0.876	2.340
Greece	0.194	0.046	0.120	0.297
Italy	0.558	0.066	0.440	0.697
Luxembourg	0.136	0.015	0.109	0.168
Netherlands	0.342	0.060	0.239	0.473
Portugal	0.096	0.042	0.039	0.199
UK	1.260	0.099	1.070	1.460

Adapted from Loizides and Tsionas and London Economics

4 Productivity and indirect effects calculations in the transport sector

4.1 Introduction

This section uses the observations made in the previous section and carries out our own productivity and indirect effects computations. In particular, we calculate labour factor productivity (LP) growth rates for EU15 countries, selected new Member States and the US. In addition, we also compute the levels of productivity. This is a contribution to the literature as it is rarely calculated in the transport sector and allows one to identify those countries that have the highest and lowest levels of LP.

While it is relatively simply to calculate the number of people directly employed in the transport sector (i.e. counting the number of people involved in running a bus franchise or laying new railway track), calculating the additional employment caused by the transport sector is less straightforward. We present a methodology for such a calculation and present some results for selected countries.

In this section we also compute TFP growth rates for the EU15 and the US as well as a multilateral index of TFP level that allow us to derive the "frontier countries", i.e. those with the highest levels of TFP.

4.2 Methodology: LP

We broadly follow the same methodology as deployed by O'Mahony and van Ark (2003) in EU Productivity and Competitiveness: an industry perspective – can Europe resume the catching-up process.

As in previous studies, our main dataset has been compiled by the Groningen Growth and Development Centre at the University of Groningen. As noted previously, the dataset covers all EU15 countries and selected new Member States, as well as other OECD countries. The period covered for the EU15 countries is between 1979 and 2003 and 1993 and 2003 for the new Member States. The data is disaggregated according to the standard ISIC rev. 3 classifications.

For our purposes the relevant variables in the dataset include: nominal value added, industry deflators and total number of hours worked in each industry. In order to calculate LP figures the nominal data in the database needs to be converted into real values.

The Groningen database uses 1995 as its base year. Real value added is calculated in two steps. In the first instance, the deflator level in any given year is defined by its own exponential value. Real value added is then given by multiplying the nominal value by 100 and dividing by the previously calculated deflator level as reported in the database. This is done for all years and transport sub-sectors.

For the aggregate transport sector, we follow O'Mahony et van Ark (2003) and build an aggregate transport deflator using the formula below which expresses real value added growth rates as the difference between current prices value added and the aggregate transport deflator growth rate.[4]

$$\Delta \ln V^{t} = \Delta \ln V^{t} P^{V,t} - \Delta \ln P^{V,t}$$

Real aggregate value added growth is given as the growth rate of aggregate current value added minus the growth rate of the deflator. From these equations, LP levels and growth rates are computed using standard techniques.

One further methodology point to note is that for seven countries (Czech Republic, Denmark, Hungary, Poland, Sweden, the US and UK) the figures had to be converted into Euros for purposes of final comparison. Since the base year is 1995, the 1995 conversion rates were used (although in the case of new Member States this data was not available, and so 1996 was used).

In this section we begin by focusing on the total transport sector across the EU15, and then in comparison with the US.

4.3 Results: LP growth rates in transport

The table below shows LP growth rates for EU15 countries for the period 1980 to 2003.

As was the case, in previous sections for the individual sub-sectors, there is no consistent trend in LP growth rates, either between countries or between years. No country has experienced consistently positive LP growth between 1980 and 2003 – but this is perhaps to be expected as all countries experience (negative) shocks from time to time.

It is interesting to note that even within any given year there is no commonality in the way LP rates react. For example, in 2000, at the height of the technology boom one might expect that most countries receive a positive productivity shock. This is indeed the case for some countries such as Denmark and Portugal, which record growth rates of 8.96 per cent and 9.43 per cent respectively. The biggest growth comes in Greece at 20.90 per cent. However, there remain some countries that record negative growth rates, namely: France, Ireland, Sweden and the UK.

A further point to note is that for most countries growth rates in LP do not typically exceed 10 per cent (either positive or negative) in any given year. The new exceptions to this are Greece and Ireland which in a number of years record double digit growth, and in the case of Ireland decline. Luxembourg also records high growth for a number of years. For example, in 1999 Greece recorded LP growth of 35.60 per cent which far exceeded that of any other EU15 country. Similarly, in Ireland in 2002 LP fell by 17.70 per cent. In the case of Ireland, productivity falls are often swiftly followed by large gains, as in the years 1987 and 1988 and 1993 and 1994.

LP growth rates in the other EU15 countries is generally lower, typically not more than 4 per cent in any given year, and often much lower than this. However, the size of fluctuations is also smaller.

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4 For a full exposition of the methodology see EU Productivity and Competitiveness: an industry perspective – can Europe resume the catching-up process by O'Mahony and van Ark (2003).

Table 4-1: LP growth rates for EU15 total transport sector: 1980 – 2003 (in %)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1980	4.03	1.10	-9.69	3.31	7.46	0.90	5.11	6.16	3.33	1.08	2.26	8.96	1.52	3.18	-2.09
1981	-3.29	2.83	8.05	-2.33	3.85	1.08	2.25	0.32	0.06	2.16	6.77	-0.40	4.73	1.43	5.34
1982	3.19	0.44	3.12	-0.02	3.54	-0.14	0.51	-5.27	1.02	-0.37	-2.53	9.84	0.42	0.65	1.80
1983	3.32	6.35	3.57	4.55	-0.37	3.06	13.38	-10.28	0.59	5.81	4.99	6.80	1.67	-5.89	5.15
1984	4.08	6.64	-4.55	1.10	3.47	3.56	6.83	4.36	7.03	5.29	4.98	4.99	6.04	0.75	4.26
1985	4.12	3.19	-17.41	2.43	3.90	3.42	9.58	-1.19	2.26	2.60	1.57	4.78	3.19	3.32	7.71
1986	2.99	-4.35	16.09	0.68	2.35	-4.37	7.10	15.20	1.06	39.13	-3.17	7.33	-0.98	1.85	4.60
1987	4.30	4.90	27.08	2.93	3.52	-0.02	-1.54	-17.33	2.74	1.14	2.37	-0.59	8.17	4.95	8.95
1988	4.51	8.04	11.07	3.95	6.30	4.48	9.19	12.84	4.72	14.55	1.26	4.13	4.28	9.36	6.45
1989	2.84	4.96	7.20	5.54	5.39	2.63	4.00	6.61	5.85	2.51	3.59	-0.42	5.38	-1.24	1.81
1990	5.05	4.09	10.64	6.75	-3.20	7.23	-3.01	7.19	3.42	6.10	1.39	2.34	2.49	8.39	-2.31
1991	5.11	3.45	-2.12	3.19	1.11	5.28	0.25	4.76	1.73	14.10	0.82	9.62	0.09	-2.08	-0.50
1992	9.49	1.51	5.18	3.27	3.18	1.95	4.90	1.55	3.28	5.73	-0.31	5.37	6.82	3.98	3.61
1993	-0.54	2.07	-9.82	7.84	-0.98	7.53	4.63	-10.12	7.08	10.12	0.85	-0.85	0.29	-2.17	5.82
1994	2.95	2.47	12.39	2.75	6.11	9.18	2.03	34.41	9.48	16.86	4.43	6.29	6.37	3.35	6.76
1995	-7.92	-0.27	6.54	1.80	-1.56	10.03	10.12	2.30	3.25	20.58	3.30	0.92	1.43	7.62	3.40
1996	-3.78	-5.61	1.10	3.45	1.24	5.81	2.27	-3.82	-4.50	3.00	3.74	-2.72	0.18	3.68	2.38
1997	13.29	-3.21	1.83	1.21	6.69	4.08	1.94	7.72	-0.20	-0.35	4.62	1.41	-0.40	7.83	2.49
1998	0.37	2.61	-8.45	1.57	4.94	0.69	-3.22	13.25	1.18	7.79	5.02	11.22	-0.60	-1.42	2.85
1999	-0.21	-1.98	7.33	1.86	-0.41	4.64	35.60	-3.59	-3.70	3.03	0.68	-2.11	3.67	0.96	-4.06
2000	1.62	1.83	8.96	3.47	-0.23	2.03	20.90	-0.70	1.49	3.07	0.06	9.43	2.63	-0.15	-1.31
2001	-7.58	4.46	-0.45	0.30	-5.97	-0.58	-1.30	-3.58	6.74	3.36	-0.85	1.21	1.39	1.93	0.60
2002	4.49	2.49	3.96	-0.85	2.54	-2.27	4.99	-17.70	1.04	5.13	-1.13	2.92	-2.29	1.97	3.18
2003	3.80	3.42	3.12	2.08	0.51	-0.43	1.28	3.74%	-3.15%	3.58%	1.50%	5.09%	0.60%	4.42%	1.41%

The next table shows LP growth rates in new Members States for which there is available data.

Table 4-2: LP growth rates in New Member States total transport sector: 1994-2003

	CZE	HUN	POL
1994	1.96%	2.78%	-2.21%
1995	-8.22%	1.94%	3.44%
1996	8.56%	-2.08%	-0.12%
1997	-22.77%	13.97%	4.77%
1998	1.67%	5.47%	7.70%
1999	1.01%	-5.46%	10.20%
2000	-10.16%	-5.05%	11.93%
2001	12.78%	4.73%	6.76%
2002	2.93%	2.68%	13.53%
2003	-8.53%	2.76%	3.89%

The University of Groningen database contains information for the Czech Republic, Hungary and Poland. All three of these countries have experiences of both positive and negative LP growth. In the case of Poland, since 1996 LP has been continuously rising. The rate of growth rose steadily between 1996 and 2000 before falling in 2001. There was a sharp rise in growth the following year, but this was not sustained in 2003. Further time series data is required to determine whether there is a new trend to lower (but positive) growth or more volatile growth. There has been more fluctuation in the cases of the Czech Republic and Hungary. The Czech Republic has experienced large falls in LP, and this was only partially offset by a one-off large increase in LP in 2001. In Hungary, LP growth in the last few years has fallen to similar levels to those of most EU15 countries. The following graph gives a comparison between the EU15 and the US in the transport sector.

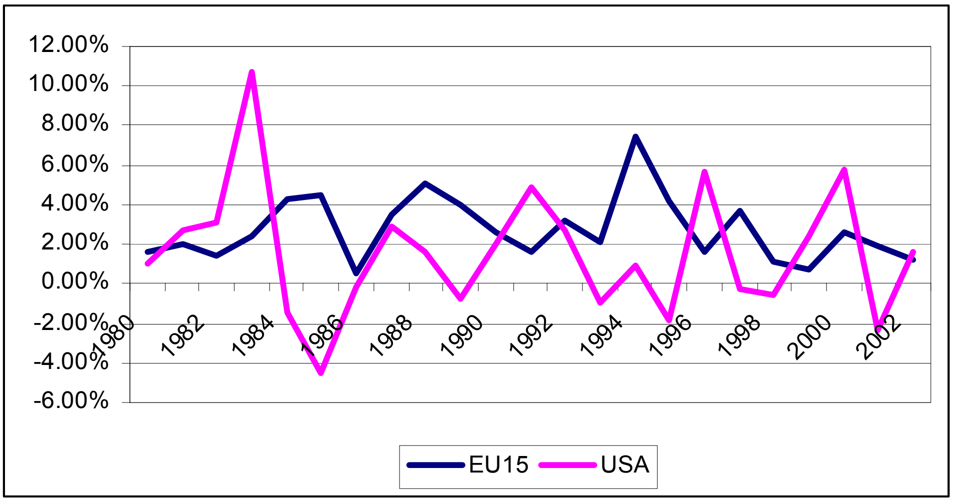

Figure 4-1: LP growth compared in EU15 and US: 1980 – 2003
(complete transport sector)

The table below has the underlying data for the preceding graph.

Table 4-3: LP growth compared in the EU15 and US total transport sector: 1980-2003

	EU15	US
1980	1.64%	1.02%
1981	2.00%	2.73%
1982	1.44%	3.11%
1983	2.42%	10.74%
1984	4.30%	-1.44%
1985	4.53%	-4.49%
1986	0.53%	-0.18%
1987	3.51%	2.90%
1988	5.12%	1.58%
1989	3.98%	-0.71%
1990	2.58%	2.03%
1991	1.61%	4.87%
1992	3.22%	2.73%
1993	2.13%	-0.96%
1994	7.45%	0.97%
1995	4.23%	-1.85%
1996	1.63%	5.64%
1997	3.68%	-0.26%
1998	1.13%	-0.61%
1999	0.68%	2.37%
2000	2.58%	5.78%
2001	1.91%	-2.38%
2002	1.25%	1.64%

What the graph and the table show is that the US has experienced greater LP growth rate fluctuations. Unlike the EU15, in some years, LP actually declines in the US, albeit only slightly in the years 1997 and 1998. In contrast, the EU15 consistently enjoy positive LP growth.

We now move to examine and compare actual levels of LP in the EU15 and US.

4.4 Results – LP levels in transport

The following tables sets out a comparison of transport sector productivity levels. Here it is given in € per hour worked. The exchange rates are taken from the IMF's International Finance Statistics site and are averaged for 1995 – they are no in PPP. Of course, the results exhibit a degree of sensitivity to the exchange rate chosen.

Table 4-4: € per hour for EU15 total transport sector: 1980 – 2003

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1980	18.19	20.60	15.62	18.49	18.87	12.95	3.11	12.13	20.96	9.28	20.57	7.69	12.24	20.06	10.56
1981	17.59	21.18	16.88	18.06	19.60	13.09	3.18	12.17	20.97	9.48	21.96	7.66	12.82	20.34	11.12
1982	18.16	21.27	17.41	18.06	20.29	13.07	3.20	11.53	21.18	9.44	21.41	8.41	12.88	20.47	11.32
1983	18.76	22.62	18.03	18.88	20.22	13.47	3.63	10.34	21.31	9.99	22.47	8.98	13.09	19.27	11.90
1984	19.52	24.12	17.21	19.09	20.92	13.95	3.87	10.79	22.81	10.52	23.59	9.43	13.88	19.41	12.41
1985	20.33	24.89	14.21	19.55	21.73	14.42	4.24	10.66	23.32	10.79	23.96	9.88	14.33	20.06	13.37
1986	20.94	23.81	16.50	19.68	22.24	13.79	4.54	12.28	23.57	15.01	23.20	10.61	14.19	20.43	13.98
1987	21.84	24.98	20.97	20.26	23.02	13.79	4.48	10.16	24.21	15.19	23.75	10.55	15.35	21.44	15.24
1988	22.82	26.99	23.29	21.06	24.47	14.41	4.89	11.46	25.36	17.40	24.05	10.98	16.00	23.44	16.22
1989	23.47	28.33	24.97	22.23	25.79	14.79	5.08	12.22	26.84	17.83	24.91	10.94	16.86	23.15	16.51
1990	24.66	29.49	27.63	23.73	24.97	15.86	4.93	13.10	27.76	18.92	25.26	11.19	17.28	25.10	16.13
1991	25.92	30.50	27.04	24.48	25.25	16.69	4.94	13.72	28.24	21.59	25.47	12.27	17.30	24.57	16.05
1992	28.38	30.96	28.44	25.28	26.05	17.02	5.18	13.93	29.16	22.83	25.39	12.93	18.48	25.55	16.63
1993	28.23	31.60	25.65	27.27	25.80	18.30	5.42	12.52	31.23	25.14	25.61	12.82	18.53	25.00	17.60
1994	29.06	32.39	28.83	28.02	27.37	19.98	5.53	16.83	34.19	29.38	26.74	13.62	19.71	25.84	18.78
1995	26.76	32.30	30.71	28.52	26.94	21.98	6.09	17.22	35.30	35.42	27.63	13.75	20.00	27.80	19.42
1996	25.75	30.49	31.05	29.51	27.28	23.26	6.23	16.56	33.71	36.48	28.66	13.37	20.03	28.83	19.89
1997	29.17	29.51	31.62	29.87	29.10	24.21	6.35	17.84	33.65	36.36	29.98	13.56	19.95	31.09	20.38
1998	29.27	30.28	28.95	30.33	30.54	24.38	6.15	20.20	34.04	39.19	31.49	15.08	19.83	30.64	20.96
1999	29.21	29.68	31.07	30.90	30.42	25.51	8.34	19.48	32.78	40.38	31.70	14.77	20.56	30.94	20.11
2000	29.69	30.22	33.86	31.97	30.34	26.03	10.08	19.34	33.27	41.62	31.72	16.16	21.10	30.89	19.85
2001	27.44	31.57	33.70	32.07	28.53	25.87	9.95	18.65	35.52	43.02	31.45	16.35	21.39	31.49	19.97
2002	28.67	32.35	35.04	31.79	29.26	25.29	10.44	15.35	35.88	45.22	31.09	16.83	20.90	32.11	20.60
2003	29.76	33.46	36.13	32.46	29.41	25.18	10.58	15.92	34.75	46.84	31.56	17.69	21.03	33.53	20.89

If one begins by looking at the end of the period, one can see that there remains a large disparity in the levels of LP in EU15 countries. The highest levels can be found in Luxembourg, Italy, Sweden, Denmark, Finland, the Netherlands and Belgium at over €30 per hour. In contrast, Greece only has € per hour at €10.6.

It is also interesting to note some results which are perhaps surprising. For example, by the end of the period in 2003, Italy records €34.75 per hour compared to only €20.89 in the UK, when one might expect the UK to exhibit higher levels of overall productivity. One possible explanation might be that historically, the UK has experienced under-investment in capital stocks, lowering its labour productivity (indeed we later show the UK to have high TFP growth rates). In contrast, continental transport networks have enjoyed higher, and more consistent, levels of capital investment during this period.

What is equally interesting to investigate are the levels at which each country started. A number of countries that began the period with the highest levels of LP also end the period with high levels of LP. The most conspicuous exception is Luxembourg, which in 1980 had € per hour of 9.3 but by 2003 had reached €46.8 – the highest of any country. This was possible through Luxembourg's high rates of LP growth as evidences in table 24. Greece also exhibited large increases in LP levels, but not to the extent of Luxembourg.

For a number of countries that did not experience high growth rates, the increase in LP levels has been much less dramatic. All countries end the period with a higher level of LP, which for all except France and Ireland is a historical high.

The next table shows LP levels in new Members States for which there is available data.

Table 4-5: LP in € per hour New Member States total transport sector: 1994-2003

	CZE	HUN	POL
1993	4.61	3.19	2.90
1994	4.70	3.28	2.83
1995	4.31	3.34	2.93
1996	4.68	3.27	2.93
1997	3.61	3.73	3.07
1998	3.67	3.93	3.30
1999	3.71	3.72	3.64
2000	3.33	3.53	4.07
2001	3.76	3.70	4.35
2002	3.87	3.80	4.94
2003	3.54	3.90	5.13

As might have been expected, the new Member States have far lower levels of LP when compared to the older EU15 countries. In fact, overall LP levels for the transport sector in these new Member States in 2003 is lower than was the case in old Member States in 1993 (except for Greece).

What is important to acknowledge is that for the Czech Republic and Hungary, the levels of LP in 2003 represent an absolute decline when compared to the level in 1993. This is not surprising given that these two countries experienced negative rates of LP growth in a number of years. Polish LP levels are consistently increasing, but at a declining rate.

The following table gives a comparison between the EU15 and the US in the transport sector.

Table 4-6: LP in € per hour in EU15 and the US: 1979-2003

	EU15	US
1979	16.05	15.96
1980	16.32	16.12
1981	16.64	16.56
1982	16.88	17.08
1983	17.29	18.91
1984	18.04	18.64
1985	18.85	17.80
1986	18.95	17.77
1987	19.62	18.28
1988	20.62	18.57
1989	21.45	18.44
1990	22.00	18.82
1991	22.35	19.73
1992	23.07	20.27
1993	23.56	20.08
1994	25.32	20.27
1995	26.39	19.90
1996	26.82	21.02
1997	27.81	20.96
1998	28.12	20.84
1999	28.31	21.33
2000	29.04	22.56
2001	29.60	22.03
2002	29.97	22.39

At the beginning of the period, LP levels in the EU15 and US are quite similar: €16.0 and €15.9 respectively. During the early 1980s, US LP levels grow faster than those of the EU15, and so by 1984 the US is actually more productive than the EU15.

However, this situation does not last and from the mid-1980s, the EU15 records uniformly positive growth rates translating into a steadily increasing LP level. In contrast, the growth in the US is more variable and actually causes the level to fall from one year to the next in some instances.

The result of these divergent growth paths means that by the end of the period in 2002, despite starting with broadly equal LP levels, the EU15 is more productive in the transport sector than the US: €29.9 per hour compared to €22.4.

This trend is graphed below.

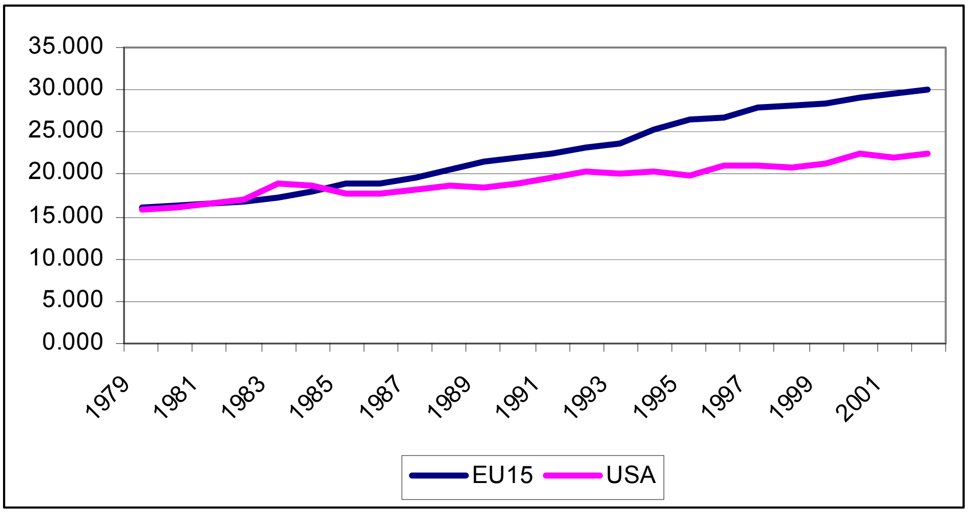

Figure 4-2: LP levels compared in EU15 and US: 1979 – 2002 (complete transport sector)

The next four tables show the levels of labour productivity disaggregated across the four transport sub-sectors in EU15 countries for the period1979-1980.

Table 4-7: € per hour for EU15 land transport sector: 1980 - 2003

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1980	18.87	18.86	25.31	15.83	17.53	11.06	2.99	14.37	17.87	8.05	18.52	5.33	10.37	17.53	8.74
1981	18.03	19.40	22.79	15.09	17.88	11.12	3.06	14.41	17.89	7.96	19.06	5.31	10.52	17.33	9.19
1982	18.86	19.48	21.96	14.97	18.61	11.11	3.08	13.65	18.07	8.22	18.64	5.83	10.50	17.52	9.29
1983	18.99	20.72	20.80	15.72	18.59	11.61	3.49	12.25	18.17	8.90	20.07	6.23	10.87	16.68	9.68
1984	19.26	22.28	22.71	15.95	18.93	12.00	3.72	14.67	19.54	9.50	21.12	6.54	11.34	17.37	9.99
1985	20.40	22.56	22.99	16.65	19.42	12.34	4.08	13.43	20.02	10.91	21.68	6.85	11.82	17.54	10.78
1986	21.05	21.78	22.87	16.65	20.19	11.86	4.37	13.98	20.27	14.41	22.08	7.35	11.70	17.70	11.28
1987	21.94	22.82	22.84	16.75	20.96	11.90	4.30	11.44	20.94	14.22	23.85	7.31	12.10	18.67	12.26
1988	22.93	24.57	24.67	16.94	22.19	12.39	4.70	14.22	21.96	15.67	23.54	7.61	12.99	18.86	13.19
1989	23.00	25.49	26.07	18.15	22.91	12.69	4.89	14.64	23.33	16.26	23.98	7.58	14.15	18.95	13.49
1990	23.88	26.61	24.65	19.28	22.75	13.66	4.74	13.96	24.07	16.95	23.79	7.76	14.27	20.24	13.12
1991	25.29	27.04	24.61	19.58	23.16	14.38	4.75	15.83	24.48	19.78	23.75	8.50	14.11	19.88	13.11
1992	26.61	27.31	23.73	19.96	24.11	14.18	4.98	17.47	25.27	20.36	22.74	8.96	14.86	22.01	13.39
1993	26.12	28.59	24.84	21.45	23.57	14.60	5.21	14.12	26.84	23.39	22.72	8.88	15.32	21.28	13.93
1994	25.69	29.46	27.52	21.47	24.69	15.80	5.32	18.77	29.59	30.28	23.23	9.44	16.91	22.89	14.87
1995	24.57	28.95	26.56	21.78	24.78	18.38	5.86	20.74	30.67	30.22	22.23	9.53	17.31	24.32	15.40
1996	23.72	27.39	24.66	22.57	25.85	19.30	5.78	19.28	29.47	32.15	23.22	9.07	17.34	25.35	15.94
1997	25.85	26.84	24.79	22.64	25.98	19.02	5.39	21.34	28.58	31.01	23.58	8.85	17.38	27.33	16.10
1998	25.22	27.93	23.87	22.70	28.24	18.56	5.16	24.94	28.96	36.20	24.66	9.86	17.42	28.10	15.65
1999	25.09	27.43	23.64	23.25	26.99	20.03	4.59	24.00	29.69	32.94	24.89	10.29	18.10	28.20	14.52
2000	25.79	27.94	23.22	24.77	27.24	19.53	4.77	23.84	28.27	34.51	24.31	10.37	18.85	28.50	14.73
2001	25.23	28.00	24.23	24.88	26.69	18.70	4.98	22.07	31.55	36.36	23.86	10.08	19.58	28.91	14.25
2002	26.69	28.70	25.19	24.72	27.37	17.05	5.10	15.41	32.08	37.95	24.11	10.04	19.01	29.24	15.11
2003	28.18	29.68	25.98	25.20	27.18	16.97	5.02	15.99	31.07	38.18	24.31	10.55	19.13	30.22	15.12

Table 4-8: € per hour for EU15 water transport sector: 1980 - 2003

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1980	7.59	24.41	6.73	17.93	15.45	24.65	5.79	3.92	28.46	11.42	21.67	29.83	15.81	52.37	11.49
1981	8.04	25.10	8.18	17.16	16.50	26.47	5.92	3.93	28.48	11.28	25.08	29.71	15.98	55.94	12.14
1982	8.61	25.21	7.80	16.35	15.33	26.32	5.95	3.72	28.77	11.66	23.66	32.63	15.31	52.79	13.60
1983	9.37	26.81	7.66	16.65	12.95	23.24	6.75	3.34	28.94	12.62	25.02	34.85	15.33	43.27	16.74
1984	14.44	28.83	6.67	15.24	12.24	25.46	7.21	2.85	31.12	13.47	25.47	36.59	14.80	38.23	20.91
1985	13.09	29.20	4.66	13.90	13.64	28.34	7.90	3.27	31.88	15.46	26.96	38.34	9.66	42.23	24.40
1986	18.29	28.19	5.14	14.33	13.65	25.50	8.46	4.36	32.27	20.42	22.87	41.15	10.19	41.26	27.38
1987	19.98	29.53	9.06	14.70	14.33	25.12	8.33	4.09	33.35	20.15	21.82	40.91	14.91	38.75	29.05
1988	31.89	31.80	11.91	17.38	14.63	29.24	9.09	4.14	34.98	22.22	23.56	42.60	15.36	57.20	31.79
1989	42.14	32.99	13.62	18.36	15.91	31.09	9.46	6.27	37.15	23.05	26.61	42.42	13.25	52.49	31.71
1990	36.75	34.43	21.85	19.38	13.20	31.04	9.17	5.68	38.33	24.03	28.55	43.41	13.01	60.81	33.72
1991	33.95	34.99	23.29	18.44	14.24	31.90	9.19	6.84	38.98	28.05	30.05	47.59	13.45	59.70	33.75
1992	24.72	35.34	30.11	19.28	15.62	35.70	9.64	6.29	40.24	28.86	33.34	50.14	19.60	48.92	37.53
1993	23.75	37.00	19.15	23.25	18.31	44.68	10.09	6.27	44.43	33.16	31.67	49.72	18.52	39.51	62.42
1994	29.50	38.12	21.85	26.16	23.28	52.71	10.30	7.99	47.00	42.92	33.09	52.84	23.36	36.58	65.40
1995	27.60	37.46	36.06	24.48	20.31	54.76	11.34	10.47	46.42	42.84	36.07	53.33	24.31	40.17	57.35
1996	27.21	35.45	46.97	25.45	22.02	67.40	11.63	8.80	43.44	11.88	34.58	48.90	23.99	49.07	64.61
1997	34.30	26.53	54.79	26.61	25.81	79.08	16.51	7.08	43.66	21.36	41.63	52.58	25.30	52.29	56.27
1998	33.08	17.58	43.31	28.38	36.74	88.60	15.32	8.48	48.66	21.69	46.03	58.37	26.46	39.19	52.42
1999	41.74	45.84	64.08	29.05	42.41	112.22	45.87	8.05	43.18	19.38	48.22	56.99	28.85	49.38	39.96
2000	37.58	60.01	81.84	28.52	42.26	121.37	65.50	7.85	63.46	19.73	52.72	68.95	30.33	47.14	51.92
2001	64.20	51.54	89.68	27.55	46.75	170.14	61.85	7.80	65.16	19.27	57.54	65.01	30.48	49.77	52.52
2002	65.14	52.82	93.23	27.67	43.08	211.80	68.07	6.90	57.18	20.34	49.07	67.31	28.03	61.21	65.64
2003	66.62	54.63	96.14	28.94	42.30	210.88	70.97	7.15	55.37	20.46	53.81	70.74	28.20	60.75	54.04

Table 4-9: € per hour for EU15 air transport sector: 1980 - 2003

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1980	14.44	19.22	73.58	28.07	29.43	32.34	6.56	18.98	40.15	16.49	19.87	17.58	12.38	24.79	13.85
1981	14.94	19.77	72.89	30.22	30.47	33.05	6.71	19.05	40.18	16.29	22.63	17.51	15.10	24.20	14.46
1982	15.03	19.85	68.51	31.76	30.35	33.31	6.74	18.04	40.59	16.84	22.06	19.23	16.54	24.86	15.20
1983	15.47	21.11	70.61	32.15	33.56	33.98	7.65	16.19	40.82	18.23	23.65	20.54	14.75	26.01	16.23
1984	18.05	22.70	79.04	33.72	36.69	34.27	8.17	19.28	43.90	19.46	26.05	21.57	17.82	24.12	16.99
1985	18.72	22.99	76.45	35.30	37.02	35.38	8.95	15.84	44.97	22.34	25.67	22.60	17.31	27.60	16.92
1986	18.04	22.19	83.08	36.32	36.39	33.77	9.58	18.68	45.52	29.50	22.90	24.25	17.88	38.83	16.67
1987	19.00	23.25	100.52	42.24	36.74	33.57	9.44	15.33	47.04	29.11	24.35	24.11	22.15	41.62	19.05
1988	18.33	25.04	108.66	44.53	39.22	34.73	10.30	17.59	49.33	32.09	26.43	25.11	24.69	49.29	17.53
1989	24.01	25.98	91.30	46.37	38.84	35.61	10.72	16.10	52.40	33.29	28.35	25.00	26.96	47.53	17.41
1990	25.64	27.11	82.60	43.82	33.97	37.91	10.39	18.45	54.06	34.70	31.20	25.59	21.75	50.85	17.46
1991	25.78	27.55	47.53	45.71	34.47	40.41	10.42	18.42	54.98	40.51	33.35	28.05	22.94	50.60	15.85
1992	33.91	27.83	61.90	43.70	35.46	47.41	10.93	16.25	56.76	41.69	37.49	29.55	27.75	46.72	18.49
1993	36.86	29.13	44.51	47.29	36.36	60.15	11.44	18.36	64.87	47.90	40.72	29.30	32.18	52.78	20.64
1994	45.38	30.01	47.33	52.95	45.06	64.43	11.67	26.20	68.63	62.00	44.25	31.15	28.17	45.15	22.31
1995	51.36	29.50	41.05	59.65	40.74	64.25	12.85	20.23	69.48	61.88	49.46	31.43	33.02	50.11	24.62
1996	48.88	27.91	44.84	60.03	43.91	71.30	14.17	21.01	65.88	59.40	49.29	30.22	39.55	51.06	24.35
1997	74.22	28.74	41.89	62.50	49.32	75.92	10.10	24.00	80.56	73.56	51.89	32.18	41.09	50.84	25.14
1998	102.15	30.48	40.77	64.58	53.18	75.88	11.19	27.83	127.67	75.31	54.39	36.56	40.92	48.56	25.28
1999	94.49	28.30	38.10	62.77	54.21	74.91	7.52	26.83	43.01	82.61	54.10	30.85	38.42	44.74	40.53
2000	82.97	21.25	40.75	63.92	48.57	83.98	8.74	26.62	44.12	85.52	56.88	33.42	41.58	45.38	39.06
2001	40.71	46.24	44.72	67.17	40.28	63.84	7.57	26.44	60.01	93.81	54.82	37.09	39.14	37.29	39.08
2002	41.51	47.39	46.49	71.47	44.24	56.80	9.73	23.38	63.51	97.86	53.40	40.77	42.81	45.52	36.39
2003	38.51	49.01	47.94	73.70	46.50	56.56	9.76	24.25	61.51	98.44	53.57		43.07	48.38	42.25

Table 4-10: € per hour for EU15 supporting activities in the transport sector: 1980 - 2003

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK
1980	29.25	27.79	22.90	27.24	21.10	14.69	2.06	13.03	25.41	8.87	27.80	10.19	18.83	16.61	13.80
1981	28.29	28.58	23.16	27.77	22.55	14.77	2.10	13.07	25.43	8.77	28.93	10.15	20.60	17.46	14.60
1982	26.55	28.71	24.59	28.80	23.55	14.76	2.11	12.38	25.69	9.06	28.16	11.14	20.69	18.24	14.69
1983	32.50	30.53	26.18	29.68	23.02	15.43	2.40	11.11	25.84	9.81	28.07	11.90	21.36	17.97	15.18
1984	37.28	32.82	28.10	31.59	24.26	15.95	2.56	11.50	27.79	10.47	29.12	12.50	23.44	18.33	15.54
1985	37.17	33.24	28.43	32.61	25.80	16.39	2.81	11.69	28.47	12.02	29.11	13.09	28.47	18.90	16.63
1986	34.77	32.09	26.62	33.57	25.77	15.75	3.00	12.93	28.82	15.87	28.82	14.05	28.25	18.57	17.36
1987	34.82	33.62	27.98	35.26	26.49	15.82	2.96	9.90	29.77	15.66	27.04	13.97	31.80	20.35	18.86
1988	36.52	36.20	26.44	36.46	28.31	16.47	3.23	10.89	31.23	17.26	27.24	14.55	28.43	21.98	20.09
1989	33.42	37.56	33.25	35.28	31.28	16.86	3.36	10.66	33.17	17.91	27.60	14.49	27.27	22.08	20.42
1990	33.12	39.20	33.17	38.08	30.01	18.15	3.26	13.44	34.22	18.67	27.36	14.83	31.30	23.78	19.74
1991	34.00	39.84	33.67	41.41	29.63	19.11	3.27	12.40	34.80	21.79	26.88	16.25	32.08	22.97	19.89
1992	37.98	40.24	31.86	43.40	29.77	19.52	3.43	13.54	35.92	22.43	26.31	17.12	31.15	24.45	20.40
1993	37.94	42.13	34.27	45.18	29.28	21.00	3.59	10.97	41.06	25.77	26.21	16.98	28.33	26.01	21.01
1994	41.88	43.40	37.15	45.72	29.84	23.06	3.66	14.82	43.44	33.36	28.07	18.05	28.13	26.26	22.35
1995	32.10	42.65	35.08	46.77	29.15	23.83	4.03	14.95	43.98	33.29	31.88	18.21	27.27	28.82	22.95
1996	30.34	40.36	33.58	48.59	27.44	24.71	4.46	14.92	41.70	32.95	33.86	18.75	25.76	27.67	22.91
1997	36.18	38.16	31.02	48.72	31.60	26.82	5.65	15.43	42.34	36.07	35.52	20.25	24.71	30.47	24.70
1998	36.41	37.83	29.32	50.20	30.65	28.19	5.45	16.30	35.99	35.15	37.35	21.58	23.65	30.90	27.93
1999	36.95	35.17	31.86	51.25	31.83	26.58	6.83	15.67	38.49	36.81	37.50	19.99	24.88	30.64	22.66
2000	37.79	38.18	35.56	51.00	32.27	27.61	8.60	15.51	40.93	44.90	37.70	23.29	23.45	30.33	20.71
2001	33.29	39.53	31.00	51.26	29.02	28.86	8.98	15.40	38.01	47.21	37.91	23.06	22.60	32.16	22.37
2002	33.83	40.51	32.23	51.37	29.39	30.54	8.84	13.62	38.49	49.78	36.79	25.40	21.85	31.48	22.56
2003	34.11	41.90	33.24	51.78	29.79	30.41	8.93	14.13	37.28	50.08	37.63	26.69	21.98	33.94	22.86

Table 4-11: € per hour for EU15 compared to the US: 1980 – 2003

	EU15				US			
Sector	Land	Water	Air	Support	Land	Water	Air	Support
1980	13.25	17.65	20.32	17.86	15.20	20.21	18.01	17.11
1981	13.45	18.92	21.50	18.58	15.09	21.28	19.71	21.15
1982	13.96	18.64	23.06	19.50	15.30	22.56	21.90	21.41
1983	14.44	18.39	24.34	19.99	17.37	19.89	24.43	21.80
1984	15.44	20.53	26.44	21.42	17.33	19.38	23.06	20.97
1985	15.52	20.77	26.29	21.78	16.85	17.62	20.76	20.23
1986	16.66	21.82	27.64	23.22	16.94	17.95	19.76	20.88
1987	16.80	22.22	28.44	23.34	16.97	18.64	21.63	22.52
1988	17.66	25.64	29.79	24.16	17.60	19.20	20.73	20.83
1989	18.51	27.47	31.12	25.18	17.51	20.85	19.80	20.47
1990	18.85	27.80	29.36	25.68	17.73	21.98	20.32	20.78
1991	19.21	31.41	32.26	26.54	19.15	22.37	19.99	21.52
1992	19.64	30.31	34.21	27.02	19.44	23.44	21.80	20.60
1993	20.13	35.04	38.53	28.11	19.43	23.74	20.92	20.49
1994	21.53	39.86	40.46	29.81	19.17	24.01	22.09	20.99
1995	22.46	42.84	45.69	30.77	18.67	22.81	22.44	19.95
1996	22.37	42.70	44.86	31.49	18.96	24.62	25.52	21.28
1997	22.47	46.53	48.83	32.53	18.57	26.34	26.13	21.18
1998	23.10	49.24	55.95	32.58	18.79	25.22	25.11	21.50
1999	23.24	45.41	52.77	32.30	18.87	23.26	27.48	22.22
2000	22.93	55.96	52.22	32.51	19.84	26.40	28.23	25.05
2001	23.77	59.73	52.00	34.43	19.35	25.97	27.77	24.82
2002	24.32	63.93	53.93	35.22	19.14	24.09	31.08	25.99

The final table compares the individual transport sub-sectors between the EU15 and the US. By the end of the period (2003), the EU15 can be said to be more productive in all the sub-sectors: land, water and air. In the case of water transport, the EU15 is significantly more productive than the US.

We now calculate the compound growth rates of LP levels. This is done through a standard procedure of regressing the logarithm of the LP level on the trend – a methodology known as the fitted trend approach. This is written as $\ln(LP_t) = \alpha + \beta Trend_t + u_t$., where β represents the average growth rate over the period. The advantage of the fitted trend approach is that the average growth rate is less subject to extremely high or low labour productivity levels in the first and/or last year of the sample.

Table 4-12: Average growth rates in the transport sector LP levels for EU15 countries and the US: 1979-2003 (in %)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK	EU15	US
Ave. 1979-1980	3.08	3.22	3.40	1.96	3.37	1.34	5.81	-0.02	2.63	7.51	1.20	4.67	3.24	1.54	4.84	2.90	1.46
Ave. 1990-2003	0.89	0.33	0.22	2.40	1.47	4.04	6.70	2.36	1.64	6.82	2.15	3.05	1.55	2.50	2.02	2.74	1.27
Ave. 1979-2003	2.45	2.00	3.76	2.96	2.16	3.58	5.08	2.53	2.67	7.95	1.94	3.51	2.61	2.51	3.07	2.99	1.36

Table 4-13: Average growth rates in the land transport sector LP levels for EU15 countries and the US: 1979-2003 (in %)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK	EU15	US
Ave. 1979-1980	2.67	3.10	-0.02	1.53	3.05	1.44	5.81	-0.18	2.84	8.48	3.03	4.67	3.00	1.03	4.59	3.57	1.82
Ave. 1990-2003	0.49	0.36	-0.01	2.10	1.52	2.29	-0.06	2.00	1.86	5.84	0.45	1.86	2.50	3.41	0.94	2.08	0.03
Ave. 1979-2003	1.75	1.91	0.29	2.42	2.19	2.73	2.37	2.22	2.82	7.70	1.10	3.03	3.03	2.77	2.51	2.88	1.13

Table 4-14: Average growth rates in the water transport sector LP levels for EU15 countries and the US: 1979-2003 (in %)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK	EU15	US
Ave. 1979-1980	17.3	3.10	3.67	-0.05	-0.01	1.79	5.81	2.99	2.84	8.48	2.84	4.67	-2.19	-1.00	12.4	4.12	-1.00
Ave. 1990-2003	6.42	3.45	13.3	3.37	10.5	15.9	19.2	1.27	3.42	-4.03	3.42	3.41	5.91	0.69	2.71	6.56	1.07
Ave. 1979-2003	8.48	2.80	12.9	3.10	5.46	9.25	10.1	4.34	3.37	2.73	3.37	3.62	3.81	0.24	7.22	5.91	1.41

Table 4-15: Average growth rates in the air transport sector LP levels for EU15 countries and the US: 1979-2003 (in %)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK	EU15	US
Ave. 1979-1990	4.02	3.10	0.04	5.06	3.35	0.82	5.81	-1.30	2.84	8.48	3.12	4.67	7.45	7.44	2.71	4.45	0.79
Ave. 1990-2003	5.27	3.49	-2.64	4.13	2.60	3.36	-2.13	3.16	0.17	8.10	4.24	3.13	5.03	-1.11	7.68	5.16	3.54
Ave. 1979-2003	7.36	3.00	-4.11	4.12	2.18	4.14	1.52	1.91	2.43	8.58	5.04	3.52	5.53	3.05	4.51	4.69	1.65

Table 4-16: Average growth rates in the supporting transport sector LP levels for EU15 countries and the US: 1979-2003 (in %)

	Au	Be	Dk	Fi	Fr	De	Gr	Ir	It	Lu	Nl	Pt	Sp	Sw	UK	EU15	US
Ave. 1979-1980	2.56	3.10	3.02	3.27	3.80	1.44	5.81	-1.93	2.84	8.48	-0.10	4.68	5.26	2.95	4.12	3.71	-0.33
Ave. 1990-2003	-0.21	-0.28	-0.40	2.09	0.19	4.09	9.48	1.28	0.33	8.10	3.38	4.08	-3.10	2.79	1.05	2.52	1.75
Ave. 1979-2003	0.67	1.60	1.55	3.10	1.53	3.53	6.39	1.23	2.31	8.58	1.47	3.98	0.40	3.21	2.37	3.68	0.48

The first of the five tables examines the average growth rates in LP levels for the entire transport sector in individual EU15 member states, as well as making a comparison between the EU15 and the US. Typically, growth over the period 1979 to 2003 has been steady for EU15 countries. While Luxembourg enjoyed the faster average growth of 7.95 per cent, all other countries experience growth rates of at least 2 per cent on average per year. The overall EU15 average growth rate in LP levels in the transport sector was just under 3 per cent (2.99 per cent). This compares very favourably to the US, which was only able to record an average growth rate of 1.36 per cent.

The table also breaks down the period into two sub-periods: 1979 to 1990 and 1990 to 2003. In most countries, LP level growth was faster in the first period than the second. Exceptions include Finland, Germany, Greece, Ireland, the Netherlands and Sweden. In the cases of Austria, Belgium and Denmark, the fall in LP level growth in the second period is very marked.

The following four tables disaggregate the transport sector. Table 4-13 looks at LP levels in the land transport sub-sector. As in the aggregated transport sector, all countries record positive growth for the overall period. Luxembourg records the highest growth rate again, with Denmark having the smallest average growth rate in the EU15.5 The combined EU15 LP level growth rate is over double that of the US. In the second period, the rate of growth slows considerably in the US. Indeed, this slowdown in the period 1990-2003 s not confined to the US and is replicated in the majority of EU15 countries.

A number of EU15 countries demonstrate high levels of LP level growth in the water subsector for the period 1979-2003. Denmark is the leader with 12.9 per cent average growth, but Austria, France, Germany Greece and the UK also record average growth rates exceeding 5 per cent. The combination of these countries leads to the overall EU15 average growth rate being 5.91 per cent – considerably higher than that of the US (1.41 per cent). It is interesting to note that compared to the land and overall transport sectors, for a number of countries growth is much stronger in the second period than the first. Especially striking is Greece, which in 1979 to 1990 recorded average growth of 5.81 per cent (which in itself is strong) that accelerated to 19.2 per cent in the following period.

The EU15 continues to maintain a lead of the US in average growth rates of LP levels in the air transport sub-sector. In this case, the EU15 have an average growth rate of 4.69 per cent compared to 1.65 per cent in the US. Within the EU15 countries, growth rates are positive. The exception is Denmark, but this is an outlier due to a large drop at the beginning of the period (see footnote). There is no consistent picture saying which period shows higher growth rates. For some countries, higher growth rates are recorded between 1979 and 1990, e.g. Finland, Greece, Spain and Sweden, whereas for others higher growth rates are experienced in the latter period, e.g. Austria and the UK.

The final table looks at level growth in the supporting sub-sector. In this case, four countries experience negative growth (falls) in the second period. However, despite these falls in the

5 However, it should be noted that from the Groningen database, there is a large fall in LP levels for Denmark at the beginning of the period which may distort results.

second period, overall growth continues to be positive for all EU15 countries and the EU15 as a whole continues to enjoy higher productivity level growth than the US.

These findings corroborate our early results of the actual levels of LP in EU15 countries and the US.

4.5 TFP calculations

Output in the transport sector does not solely depend on labour input; there is a significant capital contribution as well. The transport sector has large capital components in the form transport infrastructure. Thus it is important to consider all factors of production: total factor productivity (TFP).

Due to data constraints (namely missing data on capital stocks in the transport sector) it was only possible to calculate TFP for the combined transport and communication sector. The main data source for capital stocks was the University of Groningen "60 Industry Database" and the OECD STAN database. Our samples include the EU15 countries (less Luxemburg) plus the US. The sample period runs from 1979 to 2002. For some countries we have shorter time series due to data availability problems in the STAN database: this is especially the case for Greece, Portugal, Ireland, Germany and Sweden, for which we have data starting from 1995, 1995, 1987, 1991 and 1993, respectively.

Total factor productivity growth in the transport and communication sector has been computed according to equation 1

1 $$\Delta \ln TFP_{it} = \Delta \ln VA_{it} - \frac{1}{2}(\alpha_{it} + \alpha_{it-1})\Delta \ln H_t - (1 - \frac{1}{2}(\alpha_{it} + \alpha_{it-1}))\Delta \ln K_{it}$$

In equation1, VA stands for value added, H is the total number of hours worked in the sector, K is the stock of capital in the sector and □ is the labour share in value added.

Data on value added comes from the University of Groningen "60 Industry Database": value added for the transport and communication sector was derived aggregating value added for water transport, land transport, air transport, auxiliary transport and post and communication. In the aggregation we used Tornqvist deflators, following a procedure described in O' Mahoney and Van Ark (2003) and Denis, McMorrow and Roger (2004). The values were converted to US dollars using an economy wide PPP exchange rate.

For the labour input, we used information contained in the University of Groningen "60 Industry Database" on the number of hours in the water transport, land transport, air transport, auxiliary transport and post and communication sectors.

Labour share as been computed as the ratio of labour compensation (taken form the STAN database) over value added. The resulting ratio has been corrected to take into account that labour compensation does not include wages, salaries and social contributions of independent workers. We therefore derived a corrected labour share multiplying the ratio between labour compensation and value added by the ratio between the total employment and the total number of employees.[6] The resulting labour share displayed some year-to-year volatility for most of the countries. This is in general considered as a possible consequence of measurement error. We therefore further adjusted the labour share following an econometric procedure suggested by Griffith et al (2004): under the assumption that the technology structure of the firms in the transport and communication sector is translog and under standard market clearing conditions, Harrigan (1997) showed that the labour share can be expressed as the function of the capital labour ratio and a country constant:

(1) $$\alpha_{it} = \varsigma_i + \vartheta \ln(K/H)_{it} + v_{it}\ .$$

Under the assumption that the v_{it} are i.i.d. measurement errors, we can estimate equation xxx by fixed effects and use the fitted values from equation xxx as the labour share in the computation for equation xxx above.

The capital stock variable is the gross fixed capital stock for the transport and communication sector at constant price which was taken from the OECD STAN database and converted to US dollars through an economy-wide PPP exchange rate. The gross capital stock was however available for only eight countries (Belgium, Denmark, France, Germany, Finland, Italy, Spain and UK). For the others the series of gross fixed capital formation was available in the STAN OECD database and a time series of gross capital stock for each of the remaining countries was constructed using a perpetual inventory method described in Scarpetta and Tressel (2002) which in turn follows the OECD ISDB User Guide:

(2) $$GCS_t = GCS_{t-1} + GFCF_t - \frac{1}{2(ASL-5)} \sum_{j=5}^{2ASL-5} GFCF_{t-j}$$

GCS is the gross capital stock, GFCF is the gross fixed capital formation, ASL is the average service life of the asset. The average service lives for the assets used in the transport and communication sector is taken from the OECD ISDB 1998 for the countries for which the information was available, while for these countries for which no information was available an average was used.

Equation 2 requires a beginning of year capital stock and a time series of gross fixed capital formation which goes quite further in the past (depending on the average service life of the assets). To derive figures for the gross fixed capital formation in the years before 1979 we made the assumption that the gross fixed capital formation grew at the average rate of 5 per cent. In second place, the beginning of period gross capital stock (1979 for most of the countries) was computed as GCS=GFCF/s, where s was the average investment to capital ratio for the countries for which we had the relevant information in the period 1978-1980.

The resulting capital stock series will ultimately depend on the estimate of the beginning capital stock (and therefore s) and our assumption of the 5 per cent growth rate of the gross

6 For Spain and Sweden, the OECD STAN database did not contain enough information to adjust the ratio of labour compensation to value added in the early years of the sample. For Spain we did not have information for the early years of the sample and therefore we made the assumption that the ratio between employment and employees was constant at the 1985 level, the first year for which we had information. For Sweden we assumed a value of 1.05 for the ratio.

fixed capital formation in the decades before 1979. In the case of the eight countries for which we had the original OECD series for the gross capital stock, the correlation between the original and the artificial ones created following the procedure outlined above was however very near to one.[7]

The table below sets out calculated TFP growth for selected years in the EU15 (except Luxembourg) and US. The missing observations refer to instances where there is a lack of data.

Table 4-17: TFP growth in EU15 and US (transport and communications sector)

Member State	1980	1984	1988	1992	1996	2000	2003
Austria	7.91%	6.41%	7.55%	10.34%	2.92%	1.05%	6.45%
Belgium	2.79%	8.61%	9.24%	0.06%	-2.89%	5.63%	4.13%
Denmark	-6.02%	1.63%	9.47%	8.15%	7.57%	9.94%	1.63%
Finland	6.49%	3.56%	7.16%	3.06%	5.92%	8.08%	2.85%
France	11.03%	5.10%	8.48%	4.35%	2.99%	2.35%	0.44%
Germany	-	-	-	4.94%	4.16%	2.78%	-0.68%
Greece	-	-	-	-	-2.92%	18.49%	5.97%
Ireland	-	-	13.60%	4.97%	8.63%	16.89%	7.09%
Italy	-	9.68%	6.99%	7.52%	0.54%	5.62%	-
Netherlands	4.41%	5.71%	4.02%	3.27%	5.05%	10.54%	4.35%
Portugal	-	-	-	-	4.03%	10.74%	5.52%
Spain	-	5.32%	6.58%	8.70%	4.58%	8.25%	3.85%
Sweden	-	-	-	-	5.86%	8.02%	5.54%
UK	-1.24%	5.03%	5.84%	2.70%	6.82%	6.73%	4.49%
US	5.78%	-1.86%	3.73%	4.04%	6.20%	9.86%	-

It is interesting that, in contrast to LP growth rates, TFP growth rates in the US compare favourably with a number of EU member states. This is especially pronounced in the later years. For example, in 2000 the US registered faster growth in TFP than the economies of France, Germany, Italy, Spain and the UK. It will be interesting to investigate whether this trend persists post 2003. Of course, it should be stressed that the above figures related to the transport and communications sectors.

The graph below summarises TFP growth for the US and selected EU countries.

7 Also the correlation of the year –to- year changes in the two sets of series was very high.

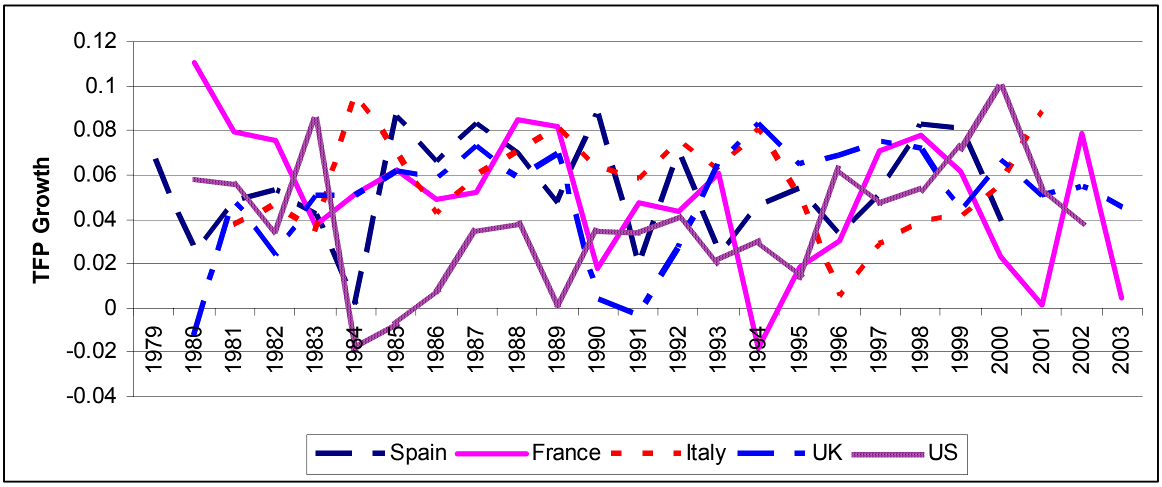

Figure 4-3: TFP growth in the US and selected EU countries (transport and communications)

The overall pattern observed is not too dissimilar from the results of the five countries' TFP in the transport sector only in the University of Groningen database.

We have also calculated TFP frontier levels in the transport and communications sector to identify the most productive countries in the EU15 and the US. Further details of the methodology are given in section 5.5. Here we simply present the results.

Table 4-18: Multilateral TFP transport and communication sector

Dependent variable	$MTFP_{it}$	$MTFP_{it}$	$MTFP_{it}$	$MTFP_{it}$
Year	1980	1990	1995	2000
FIRST COUNTRY	BEL	BEL	ITA	ITA
SECOND COUNTRY	US	US	BEL	US
THIRD COUNTRY	ITA	ITA	US	NET
AVERAGE	0.79	0.76	0.76	0.84
S.D.	0.177	0.153	0.138	0.103
MAX	1	1	1	1
MIN	0.51	0.47	0.51	0.70

Table 4-18 shows that Belgium was the frontier country in the 1980s and early 1990s, and that it was replaced as the frontier country by Italy in the later years of the sample, with the

US always in the first three positions of the ranking. We can also note that the average value increased over time and that the dispersion fell, as can also be seen by the increase in the relative TFP level of the "worse" country, which increased form 0.5 to 0.7.

In conclusion, this section has summarised our results for LP and TFP calculations. In the case of LP we calculated both growth rates and levels. The picture that emerged was similar to that of existing studies, i.e. LP growth in the EU15 has been greater than that of the US. We also calculated LP levels in the transport sector as a whole and in individual sub-sectors. These calculations confirmed that the higher LP growth rates have led to the EU15 enjoying a significant LP advantage of the US.

In contrast, the picture for TFP is not so clear-cut. One must stress here again that the results are based on calculated capital stocks for the transport and communications sector. On the basis of such calculations, it is difficult to discern a trend for the US and EU countries. A point of interest is that towards the end of the period, TFP growth in the US exceeds that of a number of European countries.

4.6 Indirect employment effects

While it is relatively simply to calculate the number of people directly employed in the transport sector (i.e. counting the number of people involved in running a bus franchise or laying new railway track), calculating the additional employment caused by the transport sector is less straightforward.

Two types of employment effects arise from direct employment: linkage effects and induced effects. Linkage effects refer to the jobs created in the supply or distribution chain. An example would be jobs in a catering firm which had a contract to supply train buffets. The jobs of those employed in the catering company will be directly affected if there is a change in demand from the train companies. So for example, if the train operator began offering new routes, then the number of jobs in the catering company might increase due to increased orders. The second effect is the induced employment or the income multiplier effect that arises due to expenditure of the incomes that employees in the transport sector earn. This additional expenditure creates further jobs as the money is spent on goods and services – a ripple effect.

In this section we calculate indirect employment caused by the transport sector.

4.6.1 Methodology

There are a number of methods that can be used to calculate indirect employment numbers. These methods give us rough estimates of the employment created by a specific increase in output, i.e. the effect of a marginal change, but are not suitable for estimating the effects of the transport sector as a whole. We summarise the various techniques available to the researcher below, and use the one we consider most suitable to estimate the effects of changes in the transport sector rather than those of the transport sector as a whole.

One method to calculate economy wide impacts of changes in a sector is to use a computable general equilibrium model. These model specify a system of equations that link the various sectors of the economy together. Typically they will specify interactions via prices between factor markets as well between the markets for good and services.

Another method to calculate employment due to linkage effects is to use detailed data on procurement firms and budgets i.e. to work directly from existing supplier links and quantities. This method is the most reliable because it involves the fewest assumptions. However, this approach is also the most data intensive. It requires detailed information on supplier company employment and turnovers, and on the exact amount of business given to each supplier. By working out the proportion of total business and therefore total employment that the supply contract represents for each supplier, this approach allows the researcher to calculate how much of the supplying firm’s employment is attributable to the business given by the firm in question. This is challenging even for single private sector firms, but to replicate this exercise for the whole of the transport sector would be unrealistic.

Standard cost-benefit approaches that look at additionality could also be used for calculating changes to the transport infrastructure i.e. marginal effects. However such approaches would not be suitable for the objective at hand. The existence of a transport sector is deeply entrenched in so many parts of productive and consumption activity that an economy wide cost-benefit analysis of the sector as a whole would be not just difficult but also meaningless.

Without access to a computable general equilibrium model (CGE) or a fully specified economic model (econometric or system dynamics), the method that we consider to be the most suitable for assessing sector level change is to use multipliers derived from Input-Output tables. Input-Output tables provide a complete picture of the flows of products and services within an economy for all sectors in an economy. Specifically, the tables detail the flows between various industries and also between industries and the final demand sector. Such linkages can then be used to estimate the extent to which any given industry contributes to the various final demand sectors.

The main concept behind the multiplier is the recognition that the various sectors that make up an economy are interdependent. One can manipulate the Input-Output table to estimate different types of multipliers depending on whether there is an interest in output, employment or income effects. The constituent component of the multipliers is the Leontief Inverse matrix. This is derived from the symmetric industry-by-industry use matrix and shows how much of each industry’s output is required, in terms of direct and indirect requirements, to produce one unit of a given industry’s output. We derive output effects from the Leontief inverse tables, and then use industry level output-employment ratios to determine employment effects.

The estimates of employment thus derived are for gross employment rather than net new employment i.e. the estimate of the number of jobs includes those employees who have been displaced from other productive uses. The last data we have available to us to provide a possible adjustment to gross employment is a set of four case-studies conducted by the DfEE (now known as the DfES)[8]. This study estimated how many employees were re-absorbed into the economy 23 months after plant closures in 4 case studies in the UK. An average re-

8 See Moore and O’Neill (1996).

absorption rate of 52% was found, but with some geographical variation. In the absence of better data, we use the figure of 52% as a bench mark, and present both gross and net estimates.

A second important caveat to repeat here is that the use of Leontief multipliers in the I-O tables is intended for marginal changes in the output of a particular sector. We calculate the effects of changes over the nine year period for which we have reliable data. The implied multiplier can be used to estimate the effects of other potential changes in the transport sector, for example, an increase in output in the rail transport sector of £10m. We would suggest caution in extending these results to very large changes[9]: the effect of transport on the economy is likely to be non-linear and therefore it is not generally acceptable to apply marginal results to the entire sector, or to changes that are very large as compared to the sector as a whole.

Finally, the model does not give general equilibrium effects, i.e. it does not take into account possible changes in other industries and the resultant shifts in employment that would arise as the transport sector expands or contracts. The model also does not take account of movements in unemployment in entirely unrelated industries, and so did not involve any prediction about aggregate employment or unemployment levels.

The techniques used to estimate the induced employment that arises from the expenditure of income created by an injection to the economy is more straightforward. A national income multiplier of 1.1 is widely used and accepted.[10] This multiplier suggests that 10 direct jobs in the transport sector lead to an additional one job in the wider economy.

4.6.2 Empirical results

In this section we present some estimates of employment effects from the transport sector. We have developed detailed spreadsheets that calculate the employment and output effects for a highly disaggregated level for the UK, Finland, Germany and the US. The spreadsheets are based on the most recent Leontief inverse calculations and employment and output data available.[11] Using the spreadsheets, we are able to calculate the employment effects of changes in the changes in air transport, water transport, railways, other land and ancillary transport sectors.

We are not able to replicate the analysis for the remaining EU countries as the Leontief inverse has not, to our knowledge, been calculated for them.

9 The size of the change can be judged in proportion to the size of the sector. Clearly a change which would double the size of the sector, for example, would not be considered marginal.

10 For example, in the English Partnerships (September 2004) "Additionality Guide: A Standard Approach for Assessing the Additional Impact of Projects"

11 For the UK and Finland, we use a Leontief inverse calculated in 1995, and output and employment figures from 2003. For Germany, the Leontief inverse was calculated in 2000, and the last set of consistent output and employment figures were for 2002. For the US, the Leontief inverse was last calcuted in 1997, and the latest output and employment figures are from 2004.

Table 4-19 below presents the employment effects of the change in the output of the transport sub-sectors between 1996 and 2003 for the UK. Water transport has seen an overall reduction in output over this period and therefore the change in employment is negative.

Table 4-19: Gross employment effects of changes in the UK transport sector between 1996 and 2003

Sector	Output change 1996-2003	Employment Effects			
		Direct	Indirect	Total	Implied multiplier
Transport via railways	2,616	23,085	52,435	29,349	2.27
Other land transport	6,930	92,710	142,789	50,079	1.54
Water transport	-273	-1,102	-3,328	-2,225	3.02
Air transport	3,798	15,338	46,293	30,955	3.02
Supporting and auxiliary transport activities;	33,702	171,455	572,209	400,754	3.34
Total	46,773	301,486	810,398	508,912	2.69

The interpretation of the multipliers is as follows: For the air transport sector (for example), each direct job leads to a total of 3.02 jobs (which includes the 1 direct plus 2.02 indirect jobs). It is evident that there is considerable variation between the various sub-sectors, with a weighted average multiplier of 2.69 for the transport sector as a whole.

The estimates of gross employment are naturally very high. The estimates assume that these are jobs that would not otherwise have been created elsewhere, which over-estimates job creation. A possible way to adjust the job figures is to use data on re-absorption rates after loss of employment. We use an estimate derived from the case studies described in DfEE study.[12] The calculations of net employment assume that 52% of the direct and indirect employees would be adjusted back into the economy within 23 months. While this rate is the best we had available to us, it is a compromise as it is not geared to the transport sector. There have also been changes in the economy in the last 10 years that could influence the speed with which people can move between jobs. The table can be adjusted for alternative assumptions regarding the re-absorption rate. Keeping these caveats in mind, we present the adjusted employment figures below in Table 4-20.

12 See Moore and O'Neill (1996).

Table 4-20: Net employment effects of changes in the UK transport sector between 1996 and 2003

Sector	Output change 1996-2003 (£m)	Employment Effects			
		Direct	Total (gross)	Total (net)	Implied multiplier
Transport via railways	2,616	23,085	29,349	25,169	1.09
Other land transport	6,930	92,710	50,079	68,539	0.74
Water transport	-273	-1,102	-2,225	-1,597	1.45
Air transport	3,798	15,338	30,955	22,221	1.45
Supporting and auxiliary transport activities;	33,702	171,455	400,754	274,660	1.60
Total	46,773	301,486	508,912	388,991	1.29

The implied multiplier based on the adjusted job figures averages out to be 1.29 for the transport sector as whole. This means that 100 direct job in the transport sector leads to an additional 29 indirect jobs in other sectors in the economy, even after adjusting for re-absorption.[13]

We now present similar tables for Finland, Germany and USA. Table 4-21 and Table 4-22 set out the gross and net employment effects for Finland, Table 4-23 and Table 4-24 present the effects for Germany, and Table 4-25 and Table 4-26 present the effects for USA. A comparison of the multipliers calculated indicates that for the European countries, the air transport sectors consistently have the highest additional employment effects, with land transport having the lowest. For the US, water transport and freight transportation seems to generate the highest multipliers. The main factor behind this is likely to be a higher dependence on other industries for a given unit of output in the air transport industry. The tables above indicate also that there are substantial additional employment effects arising from the transport sectors. If an income multiplier effect of 1.1 is added to get the composite multipliers, the following gross effects are attained.

13 Note that the net mutliplier can be less than 1, as in the "other land transport category". The net mutliplier of 0.74 implies that if 100 direct jobs were lost in the "other land transport" sector, approximately 74 employees would not have been re-adjusted into the economy, even after 2 years. Alternatively, this can be interpreted to mean that for every 100 direct jobs created, a total of 74 new jobs are created in the economy, rather than being displaced from other productive uses.

The model also does not take into account movements in the employment of unrelated industries, so does not involve predictions of aggregate total employement or unemployment.

Table 4-21: Gross employment effects of changes in the Finnish transport sector between 1996 and 2003

Sector	Output change 1996-2003 (mil €)	Employment Effects			
		Direct	Indirect	Total	Implied multiplier
Land transport	2,100	19,006	5,278	24,284	1.28
Water transport	440	2,559	4,132	1,573	1.61
Air transport	424	1,454	1,572	3,026	2.08
Supporting and auxiliary transport activities;	1808	8,326	7,630	15,956	1.92
Total	4,772	31,345	16,053	47,398	1.52

Table 4-22: Net employment effects of changes in the Finnish transport sector between 1996 and 2003

Sector	Output change 1996-2003 (mil €)	Employment Effects			
		Direct	Total (gross)	Total (net)	Implied multiplier
Land Transport	2,100	19,006	24,284	11,656	0.61
Water transport	440	2,559	1,573	1,983	0.78
Air transport	424	1,454	3,026	1,452	1.00
Supporting and auxiliary transport activities;	1808	8,326	15,956	7,659	0.92
Total	4,772	31,345	47,398	22,751	0.73

Table 4-23: Gross employment effects of changes in the German transport sector between 1996 and 2002

Sector	Output change 1996-2002 (mil €)	Employment Effects			
		Direct	Indirect	Total	Implied multiplier
Land transport	6,950	101,267	35,190	136,457	1.35
Water transport	4,800	7,519	9,638	17,157	2.28
Air transport	5,270	14,039	30,883	44,922	3.20
Supporting and auxiliary transport activities;	14,230	105,684	132,705	238,389	2.26
Total	31,250	228,509	208,416	436,925	1.91

Table 4-24: Net employment effects of changes in the German transport sector between 1996 and 2002

Sector	Output change 1996-2002 (mil €)	Employment Effects			
		Direct	Total (gross)	Total (net)	Implied multiplier
Land Transport	6,950	101,267	136,457	65,499	0.65
Water transport	4,800	7,519	17,157	8,235	1.10
Air transport	5,270	14,039	44,922	21,563	1.54
Supporting and auxiliary transport activities;	14,230	105,684	238,389	114,427	1.08
Total	31,250	228,509	436,925	209,724	0.92

Table 4-25:Gross employment effects of changes in the American transport sector between 1999 and 2004

Sector	Output change 1999-2004 (bil $)	Employment Effects			
		Direct	Indirect	Total	Implied multiplier
Railways and passenger ground transportation	8.3	31,556	49,376	80,932	2.56
Motor freight transportation and warehousing	26.4	193,241	149,495	342,736	1.77
Water transport	5.1	9,056	33,237	42,293	4.67
Air transport	10.8	43,316	59,640	104,956	2.32
Pipelines, freight forwarders, and related services	4.0	4,735	18,307	23,042	4.87
Supporting and auxiliary transport activities; other transport	17.5	193,358	38,836	234,194	1.20
Total	72.1	479,262	348,891	828,891	1.73

Table 4-26: Net employment effects of changes in the American transport sector between 1999 and 2004

Sector	Output change 1999-2004 (bil $)	Employment Effects			
		Direct	Total (gross)	Total (net)	Implied multiplier
Railways and passenger ground transportation	8.3	31,556	80,932	38,847	1.23
Motor freight transportation and warehousing	26.4	193,241	342,736	164,513	0.85
Water transport	5.1	9,056	42,293	20,301	2.24
Air transport	10.8	43,316	104,956	50,379	1.11
Pipelines, freight forwarders, and related services	4.0	4,735	23,042	11,060	2.34
Supporting and auxiliary transport activities; other transport	17.5	193,358	234,194	112,413	0.58
Total	72.1	479,262	828,891	397,513	0.83

Table 4-27: Composite multipliers

	Gross linkage effect (a)	Income multiplier effect (b)	Composite multiplier (a) X (b)
UK	2.69	1.1	2.96
Finland	1.52	1.1	1.67
Germany	1.91	1.1	2.10
USA	1.73	1.1	1.90

This suggests that in the UK, an additional 196 jobs are created for ever 100 direct jobs in the transport sector, while for Finland an additional 67 jobs are created for every 100 direct jobs. The variation is substantial and could reflect differences in the way that the supply chains are structured. However, there is also a possibility that there are differences in the way that the data are complied, so we would not read too much into the differences across countries.

Summarising, this section calculates the additional employment effects that arise due to employment in the transport sector for a sample of EU countries. We find substantial indirect effects, with variation both across sub-sectors and countries. The air and water transport sectors appear to have the strongest external effects while land transport seems to have the lowest. These effects are likely to be key in conducting cost-benefit analysis of additional transport investment as it gives a more accurate picture of employment created than direct effects alone.

5 Empirical analysis of productivity developments in the transport sector and impact of transport productivity on transport-related sectors

5.1 Introduction

The previous sections of the report have discussed the productivity developments in the transport sectors. In this section our aim is twofold.

The first is to provide to provide econometric evidence on the effects that some policies might have had on the dynamics of productivity growth in the transport sector.

There are potentially many policies and variables that might have had an impact on productivity growth in the transport sector, such as expenditure on infrastructure, liberalisation policies, measures aimed to alleviate congestion problems, and so forth.

For instance, liberalisation policies might foster productivity growth in the transport sector because they might provide managers the right incentives to cut slacks and inefficiency and to introduce both product and process innovations[14]. In turn, new and improved transport infrastructure as well as policies aimed to alleviate congestion could reduce transportation costs and allow for inter-modal competition which in turn could lead to faster productivity growth.

While, in principle, it would have been desirable to include in the empirical analysis as many variables as possible that could proxy for the main policies introduced by EU countries over the last twenty years or so, data constraints for most of the countries on one side, and the necessity to include as many countries as possible into the analysis on the other –to give an as broad as possible overview of the EU- have forced us to mainly focus on two sets of policies, namely infrastructure and liberalisation.

Although it might have been preferable to be able to include other variables into the analysis, especially these proxing for the levels of congestion, indicators related to the expansion of infrastructure and the degree of liberalisation are perhaps the two most important and that they might therefore provide at least some useful insights in our attempt to explain productivity growth developments in the EU transport sector.

The second object is to assess econometrically the impact that productivity growth developments in the transport sectors have had on some transport user sectors: in particular, we have considered the motor industry, the financial intermediation sector, the chemical industry, the food sector and retailing.

The remainder of this Annex is organised as follows. Section 5.2 will describe the data issues and the samples used in the econometric analysis of the effects of transport policies on productivity growth developments in the transport sector. In 5.3 we will describe the results of the econometric analysis of the impact of transport policies on productivity growth in the transport sector. Section 5.4 will describe the empirical analysis we have carried out to inves-

[14] See, for a review of these issues, Griffith et al (2006).

tigate the impact that productivity growth in the transport sector had in five selected non-transport sectors. Section 5.5 will contain a data appendix.

5.2 Data issues

As we have commented elsewhere in the report, the BEST measure of productivity growth from a theoretical perspective is total factor productivity growth (TFPG). Under some assumptions (such as constant returns to scale and perfect competition), TFPG can be consistently measured by the Solow residual, i.e. as the fraction of the rate of growth of output which is not explained by input growth. TFPG is preferable to labour productivity growth because the latter can be simply driven by capital accumulation, rather than by technological innovations.

We measured TFPG as the Solow residual using a Tonqvist index approximation as shown in equation 1 :

$$\Delta \ln TFP_{it} = \Delta \ln VA_{it} - \frac{1}{2}(\alpha_{it} + \alpha_{it-1})\Delta \ln H_{t} - (1 - \frac{1}{2}(\alpha_{it} + \alpha_{it-1}))\Delta \ln K_{it} \quad (1)$$

In equation (1) VA stands for value added[15], H for the total number of hours worked in the sector, K for the total gross capital stock in the sector and □ is the labour share in value added in the sector. Referring to the Data Appendix for a more exhaustive treatment of data issues, we might recall in this place that the labour share was quite volatile, which is usually regarded as indicative of measurement error: we have therefore followed a quite common practice in the literature (see Griffith et al, 2004) and smoothed the labour share in value added using econometric analysis (see the Data appendix for an explanation of the exact procedure we followed).

Notwithstanding our theoretical preference of TFPG as an indicator of productivity developments in a sector, data on the capital stock or the gross fixed capital formation[16] in the transport sector are simply not available for most EU countries in the OECD STAN database, which is by far, together with the Groningen productivity databases, the main source of data for cross country-sectoral type of analysis.

However, figures for the gross capital stock, or time series for the gross fixed capital formation are indeed available for the Transport and Communication (TC) sector.

Given that, in terms of value added, the EU Communication sector accounts for about 40 per cent of the whole TC sector, the use of the Transport sector alone would be more preferable, both theoretically, but also empirically: in fact it is likely to be more difficult to “identify” the impact of a transport policy on the productivity growth of a wider sector like the TC one; furthermore, the reconstruction of the capital stock of some countries required a number of assumptions that are likely to have generated substantial measurement error in our depend-

15 We used value added rather than gross output because of data availability problems which would have forced us to drop many countries from the analysis should have we used the gross output measure.

16 The data on gross fixed capital formation can be used to build a time series of capital stocks, under some assumptions. See the data appendix for a detailed explanation of the methodology we followed to build gross capital stock series for the countries for which the STAN database does not report the relevant information.

ent variable, which in turn will be likely to inflate standard errors, making it difficult more difficult to measure accurately the impact of the regressors on the dependent variable.

However, the TC sector is the only one which allows us to use our preferred productivity growth indicator (TFPG) and therefore we decided to conduct the econometric analysis using data related to the wide TC sector, rather than to the transport sector.

However, as a robustness check, we have decided to also run regressions using data related to the transport sector only: in order to do that, we had to rely on labour productivity growth as a proxy for productivity developments in the transport sector.

As mentioned above, due to data constraints, we focused on two set of variables related to infrastructure and liberalisation.

As for the infrastructure variables, in the literature we find different proxies for the stock of infrastructure capital which is relevant for the transport sector (e.g. roads, motorways, railways, etc.). Ideally, our preferred theoretical measure would be a monetary value for the stock of transport capital, ideally split according to transport mode. However, these data are not available for most of the countries and, when they are, the time series are too short to be of some practical use.

An alternative would be to use physical indicators for the relevant transport infrastructure, e.g. length of roads, length of motorways or railways which are available from Eurostat. The main drawback of these data is that they are affected by large measurement errors and, for some countries in some years, significant and difficult to explain volatility.

Furthermore, there is not, a priori, a strong reason to prefer one indicator (e.g. motorways length) over another (e.g. railways length), and using all of them in the regressions might create strong multicollinearity problems. Moreover, these indicators are in general characterised by small year on year variations: this can make difficult the identification of the relevant parameters in the econometric analysis, taking into account that the within estimator that we have used relies on within country year to year variations to identify the parameters.

Finally, while for the motorways length the time series published in Eurostat is fairly complete, for other indicators the data availability is much poorer: in particular, there are no data for some countries in the 1980s: while this does not preclude the use of these indicators in the regression analysis it reduces the sample size significantly.

A further alternative would be to use the monetary value of the public capital stock in the economy as a whole: this is of course a rather imperfect proxy for the stock of transport infrastructure as it considers other public capital stock items such as hospitals, schools, etc. However, as we discussed elsewhere in the Report, it has been widely used in the economic literature; furthermore there is some evidence that narrower public infrastructure measures, such as core infrastructure (which is more closely related to transport infrastructure than the total public capital stock) tend to have a somewhat larger effect on economic and productivity growth: therefore it could be argued, in our analysis, that our results could provide a conscious underestimate for the effects that transport infrastructure might have on productivity growth in the transport sector.

Given these considerations, we have decided to use the public capital stock in the economy as a proxy for the transport infrastructure stock. We have however also checked the impact on our results of using the physical indicators described above.

The second group of variables that we have used in our analysis consists of a set of liberalisation indices for the transport and communication sectors developed by the OECD.

The OECD has in fact developed, for seven non-manufacturing sectors (post, telecoms, gas, electricity, air passenger transport, road transport, railways) a series of indices aimed to capture the degree of liberalisation in these sectors. There are aggregate sector indices for each of the seven sectors and sub-indices for most of the sectors (for instance, there is an indicator of barriers to entry for the railways sector or an indicator of public ownership for the airlines sector, and so forth). Each index has been constructed such that a value of zero stands for a fully liberalised market, while a value of six stands for a fully regulated market. In our empirical analysis four of the seven sectors are relevant: telecom, airlines, railways and road, therefore we have used in our empirical analysis the aggregate indicators as well as an aggregate transport indicator which was computed as the average of the indices for airlines, railways and road transport.[17]

Table 5-6 in section 5.5 summarises the values of the transport indices for the EU15 plus US, Hungary, Poland and Czech Republic. We can note that the degree of liberalisation has increased in all the three sectors, and that the railways is still, on average, the least liberalised of the three. We can also note that while the road sector started experiencing significant liberalisations already in the 1980s, that was not the case (on average) for the airlines and railways sectors, where most of the liberalisations took place over the 1990s. In 2002 we can note that, on average, Greece and Hungary used to have the least liberalised transport sectors in our sample, while the UK had the most liberalised.

If we look at the dispersion (as measured by the standard deviation) in the liberalisation levels, we might note that, between 1980 and 1990, it increased for the airlines and the road sector, while it remained roughly constant for the railways, probably because most of the countries did not liberalise it until the 1990s. If we look at the situation in 2002, there was a further increase in dispersion in the airlines sector (even if the increase should be attributed to the inclusion of Poland, Czech Republic and Hungary) and the railways, while in the road sector the dispersion decreased, as most of the countries undertook substantial liberalisation programmes in the sector.

Some fairly recent studies have made use of these indicators. Nicoletti and Scarpetta (2003) have used a panel of OECD industries to assess the impact that product market regulation had on total factor productivity growth and find that, in general, liberalisation tends to increase productivity growth, especially fostering the pace of productivity catch-up for countries that lag behind the industries' technological frontiers.

Alesina et al (2005) analysed the impact that regulation had on investment in the transport, communication and utility sectors, using OECD panel data. Their main results were that liber-

17 A full description of the construction of these indices can be found in the OECD website, in Convey et al (2005) and in Alesina et al (2005).

alisation -and, in particular, entry liberalisation- had a positive impact on private investment and that the marginal effect of liberalisation tends to be higher when the policy reform is "large", when the change in the policy took place at an already high level of liberalisation and especially for these countries that were early liberalisers.

Griffith et al (2006) in a report for DG Economic and Financial Affairs examined the impact of competition (measured by the mark-up) and liberalisation had in labour and total factor productivity growth in a panel of EU countries.[18] For the service sector, which includes transport, they found that higher mark-ups –taken as a proxy for the degree of competition- tends to reduce total factor productivity growth, even their failure to control for its possible endogeneity, does not allow the authors to interpret their finding as a causation rather than simple correlation.

Finally, Griffith and Harrison (2004) were not able to identify any positive effect of the degree of liberalisation on TFP growth on OECD data for the Water, gas and electricity sectors.

Before turning to the description of the econometric model and to econometric issues that arise we should discuss briefly the sample of countries we have used in the estimations.

As in the case of the choice of the main variables to use in the regression, data constraints have led us to a selection of countries to use in the regression which includes only the EU15 - with the exception of Luxembourg- plus the US.

Unfortunately we have been unable to include Luxembourg or any New Member State in the sample for lack of data on some of the key variables: in fact, we have been not able to find any data on the stock of public capital for the New Member States and Luxembourg. Furthermore, the OECD reports information on the liberalisation indices for all the three transport sectors only in 2003 for the four member states included in their database (i.e. Hungary, Slovakia, Czech Republic and Poland).

Therefore, to sum up, our dataset covers the EU15 countries (less Luxembourg) plus the US over the 1979-2002 period. However, our sample is not balanced because for some countries we have been not able to construct the capital stock for the whole 1979-2002 period because of lack of data in the OECD STAN database. The Data Appendix will explain in detail these and other data-related issues.

5.3 Productivity growth in the transport sector: an econometric analysis

5.3.1 The econometric model

We have estimated different econometric models, depending on the actual variables that we included into the regression. Our baseline specification is an equation of the following type:

(1) $$\Delta \ln TFP_{i,t} = \alpha_0 + \alpha_1 Gap_{i,t-1} + \alpha_2 \Delta \ln Kg_{i,t} + \alpha_4 \Delta Transp_{i,t} + \alpha_5 \Delta Tel_{i.t} + Outgap_{it} + v_{it}$$

(2) $$v_{it} = e_i + \lambda_t + u_{i.t}$$

18 They also looked at the determinants of investments, employment and R&D.

$\Delta \ln TFP_{i,t}$ is the rate of growth of total factor productivity for the transport and communication sector of country i at time t, computed according to equation (1) in section 5.2 $\Delta \ln kg_{i,t}$ is the rate of growth of the public capital stock in the economy as a whole of country i at time t. $\Delta \ln Kg_{i,t}$ will have two kinds of effect on $\Delta \ln TFP_{i,t}$. First, because of the definition of $\Delta \ln TFP_{i,t}$, there is a purely mathematical effect (which we might term, a "bias")[19]. Second, there is the economic effect – which is what we are interested in. To isolate the economic effect, which we called α_2^*, we adjust α_2 by "adding back" the mathematical effect (correcting for the bias). This correction is country-specific, but the average bias is about 0.06, i.e. $\alpha_2^* = \alpha_2 + 0.06$.

$\Delta Transp_{i,t}$ is the change in the liberalisation index in the transport sector of country i between the years t and t-1 and it was computed as the average of the OECD indices for the road, airlines and railways sector; $\Delta Tel_{i,t}$ is the change in the liberalisation index for the communication sector between years t and and t-1, $GAP_{i,t-1}$ is the distance from the technological frontier of country i in time t-1 (Nicoletti and Scarpetta, 2003 and Griffith et al, 2004) and $Outgap_{it}$ is the output gap in the economy as a whole of country i at time t which is aimed to proxy for the impact of country-specific business cycles on TFPG.

It might be worth spending a few words on some of the variables included into the analysis.

$GAP_{i,t-1}$ has been included to control for the fact that countries that lag further behind from the industry technological frontier might experience faster TFP growth: indeed, some evidence of this effect has been identified by Nicoletti and Scarpetta (2003) and Griffith et al (2004) which used a panel of manufacturing and non-manufacturing sectors for a panel of OECD industries.

The technological frontier has been identified using the multilateral total factor productivity index of Caves et al (1982) and the distance from the frontier for each country i has been computed as the difference between the total factor productivity level of the frontier country and the total factor productivity level of country i. Given the way the $GAP_{i,t-1}$ variable has been built, a negative value for its coefficient α_1 would imply that, in our samples, the countries whose transport and communication sector lags further behind the industry frontier have experienced higher total factor productivity growth in the transport and communication sector. For the details on the computation of $GAP_{i,t-1}$ we refer to the Data Appendix.

19 Referring to the data aappendix for a more exhaustive explanation, the bias stems from the fact that the capital stock we have used to compute TFP growth in the transport sector is the sum of private capital stock (e.g. vehicles, buildings, software) and the public infrastructure capital (e.g. roads). In this case, the effect of the public capital stock (as a proxy for transport infrastructure) is likely to provide a downwards biased estimate of the effect of its true effect on "private sector" TFP growth (i.e. computed using only the private capital stock as the capital input).

The liberalisation indices $\Delta Transp_{i,t}$ and $\Delta Tel_{i.t}$ have been included in difference form rather than in levels form. The assumption here is that it is not the level of liberalisation per se, but the changes in liberalisation to drive changes in the rate of growth of total factor productivity. However, we have also run some regressions in which the liberalisation indices have been inserted into equation (1) linearly rather than in difference form.

We have also run some versions of equation (1) using liberalisation indices for the airlines (Air), railways (Rail) and road (Road) sector rather than the more aggregate Transport sector, both in linear and difference form.

The error term v_{it} has been decomposed as specified in equation (2).

In particular, λ_t is a time fixed effect which controls for macro shocks (e.g. technology or business cycles shocks) to TFP growth which are common to all transport and communication sectors included into the analysis; e_i are country specific fixed effects which can be freely correlated with the regressors and that controls for country specific heterogeneity (like country specific managerial efficiencies, country specific measurement errors and, in general, any country specific time invariant effect, like country specific measurement error); finally, $u_{i.t}$ is the usual error term which represents measurement errors and omitted variables.

The model in equation 1 above will be estimated using the within estimator.[20]. The within estimator provides consistent estimates only when all regressors can be considered strictly exogenous.[21] In the case of equation (1), there can be some concerns that some of the regressors–namely the rate of change in the public capital stock and the change in the two liberalisation indices- are not strictly exogenous.

However, we believe that it might be reasonable to assume that these three regressors, though not strictly exogenous, are weakly exogenous: this would be the case if, in the case of the public capital stock, a macro economic shock to TFP growth which resulted also in a higher than average TFP growth in the transport sector allowed the government to spend more resources (given the resulting increase in output) to rise the rate of growth of government investment expenditure the following year: in this case, the disturbance term $u_{i.t}$ will be correlated with future values of the rate of change of the public capital stock, but not with its current and past values.

A similar "story" could be used to argue that also the liberalisation indices are weakly exogenous: if the government observes today a negative shock to productivity, it could well decide tomorrow to react by implementing some liberalisation policy: also in this case, the disturbance term $u_{i.t}$ will be correlated with future values of the change of the liberalisation indi-

20 We have computed standard errors that are robust to both heterosckedasticity and serial correlation. Given the relatively small sample size of our estimates, we have used standard errors corrected for the small sample size. Failure to do so would result in quite smaller standard errors.

21 A regressor is considered strictly exogenous when it is uncorrelated with past, present and future values of the error term ($u_{i.t}$ in our case).

ces, but not with their current and past values.[22] If some regressors are weakly exogenous it is well known that the within estimator is not consistent (Wooldrige, 2002) in small samples.

However, it has been shown (Nickell, 1981) that the bias tends to fade away when the number of years in the panel is sufficiently large. In our case, for most of the countries the number of years is as high as 23, which should ensure that the bias of the within estimator would be reasonably low. Therefore, in this Report, all the regressions have been carried out using the within estimator.[23][24]

5.3.2 The main results: transport and communication

Table 5-1[25] reports the results of our regression analysis. The specification in column 1 reports our baseline specification of equation (1)[26].

As we can see, the coefficient of $GAP_{i,t-1}$ is, as expected, negative (and significant at the 5 per cent level), suggesting that countries that lagged further behind the industry technological frontier experienced faster TFP growth (see Griffith et al 2004, and Nicoletti and Scarpetta, 2003).

The rate of growth of the public capital stock in the economy as a whole appears to have a positive effect on the growth rate of total factor productivity in the transport and communication sector. However, it is only marginally significant at the 10 per cent level, as the p value is 0.105. If we take the point estimate at face value, an increase of the rate of growth of the public capital stock in the economy as a whole of one percentage points (e.g. from two per cent to three per cent) would appear to add about 0.34 percentage points to the rate of growth of total factor productivity in the transport and communication sector. . Recalling that 0.34 is likely to provide a downwards biased estimate of α_2^*, we might say that α_2^* is approximately equal to 0.40.

The change in the transport liberalisation index ($\Delta Transp_{i,t}$) appears to have a negative effect in TFP growth, suggesting that increases in the degree of liberalisation would tend to

22 The weak exogeneity hypothesis would be violated if firms would predict future shoks: in this case the failure of the weak exogeneity shock would be reflected in the existence of serial correlation in the u_{it} error term. In our regressions, we used the Arellano and Bond test for serial correlation and we did not find evidence of it.

23 An alternative would be to first difference the data and then search for suitable instruments.

24 Another possible endogeneity problem might exist if the capital stock were measured with significant error: in this case, given the use of relative TFP as a regressor, a correlation between the error term and the GAP variable could arise, biasing the coefficient. However, the use of lagged GAP should alleviate the possibility of endogeneity and, furthermore, the main results do not change if we drop the GAP variable from the analysis.

25 In each table reporting econometric results, we show the coefficient point estimate and, in parenthesis, the p value.

26 In all specifications in Table 5-1 we have controlled for the output gap in the economy as a whole, although we have not reported the coefficient estimate; similarly, we have not reported the estimates for the individual and time fixed effects.

increase the rate of growth of TFP in the transport and communication sector[27]. However, the coefficient is not significantly different from zero at the usual levels of confidence, and therefore we can not reject the null hypothesis that changes in the degree of liberalisation do not affect the rate of growth of TFP in the transport and communication sector.

In the next columns we have run some sensitivity analysis to our baseline specification.

In column 2 we have substituted $\Delta Transp_{i,t}$ for the changes in the degree of liberalisation of the railways, road and airlines sectors. As we can see, all the three regressors have negative signs. However, the three coefficients appear to be highly insignificant.

We can also note that the effect of the rate of growth of the public capital stock is virtually unaltered from that reported in column 2, but that the level of significance falls slightly (the p value is 0.12).

In column 3 we have inserted the liberalisation indices in the transport and communication sectors in levels rather than in difference form. We can note that the transport index has a negative sign, but that it is largely insignificant. The coefficient of the rate of growth of the public capital stock is remarkably stable, and it is still marginally significant.

In column 4 we repeated a similar exercise with the levels of the liberalisation indices in the road, railways and airlines transport. We can see that, in this case, the coefficients for the degree of liberalisation in the railways and roads are negative, suggesting that higher liberalisation levels tend to increase the rate of growth of TFP in the transport and communication sector, while in the airlines we have the opposite result that higher liberalisation would appear to be associated with lower, rather than faster productivity growth. In particular, we can note that the coefficient for the road liberalisation is largely insignificant, while that for the railways is marginally significant (the p value is 0.12), providing some, admittedly weak, evidence that the level of liberalisation in the railways tends to increase the TFP growth in the transport and communication sector. However, the most striking result is that the index for the degree of liberalisation in the airlines is actually positive, suggesting that a more regulated airlines market would tend to increase TFP growth in the transport and communication sector. A possible rationalisation of this effect could be that increasing liberalisation in the airlines could have created congestion problems in the road network which had a negative impact on TFP growth in the transport and communication sector. Alternatively, the liberalisation might have spurred investment growth in the sector not matched by enough output growth which might have therefore tended to depress TFP growth.

This last result should be however taken with extreme caution, because of the small share of the airlines industry in the total value added of the transport and communication sector. In second place, the presence of four liberalisation indices might create strong multicollinearity problems. [28]

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27 We should recall that higher values of the liberalisation index stand for a more regulated, less liberalised sector.

28 However we run a regression including only the index Airl and the coefficient was still positive and significant.

Furthermore, in this specification the coefficient of $\Delta \ln kg_{i,t}$ falls slightly and the statistical significance deteriorates.

The results so far provide some (weak) evidence that higher rates of growth of the public capital stock in the economy as a whole tend to have a positive impact on the rate of growth of total factor productivity in the transport and communication sector. In the first three columns of Table (1), $\Delta \ln kg_{i,t}$ is in fact significant at the 10, 11 and 12 per cent level. The inclusion of the individual sub-transport indices tends however to reduce both the coefficient and the significance level. However, if we are ready to accept the result of the first three columns, we could go on and investigate the economic "plausibility" of the point estimate (remembering that the coefficient is only "marginally" significant).

We can say that, on average, □2, the coefficient of $\Delta \ln kg_{i,t}$ is about 0.34. . Recalling that 0.34 is likely to provide a downwards biased estimate of α_2^* , we might say that α_2^* is approximately equal to 0.40: this would mean that an additional percentage point to the growth rate of the public capital stock in the economy as a whole would tend to add 0.4 percentage points to the rate of growth of total factor productivity in the transport and communication sector. If we assume that an additional percentage point in the growth rate of TFP translates one to one to the growth rate of value added, we might also say that an additional percentage point to the growth rate of the public capital stock in the economy adds 0.4 percentage points to the growth rate of value added in the transport and communication sector.

However, we should also take into account that our measure of the public infrastructure capital includes other public capital items that are not related to the transport and communication sectors, like hospitals and schools. In this case, a one per cent increases in the total economy public capital amounts to less than one percent increase in the stock of public capital in the transport and communication sector. In particular, we have assumed that the ratio between transport and communication public infrastructure and total public infrastructure is about 0.5-.0.6[29] the overall effect of a one per cent increase in the stock of transport and communication public infrastructure should be approximately an additional 0.67-0.80 (0.40/0.6; 0.40/0.5) percentage points to the TFP growth rate in the transport and communication sector.

How does this result compare with the results that have been surveyed in other annexes and with our own growth model? One of the main conclusions from the literature review on the effects of infrastructure on the level of output in the economy as a whole was that the elasticity of output with respect to the public capital stock was of the order of 0.10-0.20. Our own growth model suggested a somewhat smaller value of about 0.06-0.10.

29 Picci (1999) has reported data for Italy which show that core infrastructure (defined as roads, airports, railroads, subways, ports, telecommunication infrastructure, electrical lines and water) amount to about 60 per cent of total government infrastructure. We therefore have assumed that a range of 50 per cent to 60 per cent for the ratio between transport and communication public infrastructure stock and total public infrastructure stock could provide a reasonable approximation.

In order to translate our result for the transport and communication sector to the total economy, we make the assumption that the effect on the rate of growth of the public capital stock on the rate of growth of the total economy value added is about 0.07xα_2^*, where 0.07 is the relative weight of the EU15 transport and communication value added in the total economy EU15 value added.[30] With α_2^* equal to 0.67-0.80, we might derive an approximate effect –for the economy as a whole- of an increase of the rate of growth of the stock of public capital on the rate of growth of value added, of about 0.05-0.06. We have then to remember that equation (1) is the first difference of an equation which is linear in logs, and that the coefficients of the log-linear equation on which our equation in first (log) difference is based are the same. Therefore, we can consider our □2 in our equation, as the elasticity of output with respect to the public capital stock. This would amount to point out that our results for the transport and communication sector might suggest a value of the elasticity of output with respect to the public capital stock, in the economy as a whole, of about 0.05-0.06 – somewhat smaller than either the empirical literature or our growth model would suggest. But this is a marginal effect, not a level effect.

The fact that the results for the transport and communication sector lead to results for the economy as a whole that are broadly comparable with the main findings of the economic literature, adds some robustness to our findings in the transport and communication sector.

We said in the previous sections that the public capital stock can be an imperfect proxy for the stock of transport infrastructure. We also noted that, however, it was perhaps the best among the alternatives we had at hand. We however tried to re-run some of the regressions above using alternative proxies for the stock of public infrastructure, namely the km of roads, the km of railways and the km of motorways (either independently or together) but we were unable to find any significant effect on the TFP growth rate. However, there might be some reasons for our failure to identify any significant effect: first of all, the data are affected by large measurement errors; in second place, especially for the length of the road network, we have substantially lower degrees of freedom; last but not least, the variation in these infrastructure data is minimal, which makes it more difficult to identify their effect on the TFP growth rate.

[30] We have used 2003 data for the EU15 from the University and Groningen growth accounting database.

Table 5-1: TFP growth regression. Transp&Comm. sector

Dependent variable: $\Delta \ln TFP$	1	2	3	4
Indep. variable				
$GAP_{i,t-1}$	-0.047 (0.03)	-0.047 (0.03)	-0.048 (0.02)	-0.054 (0.01)
$\Delta \ln kg_{i,t}$	0.345 (0.10)	0.339 (0.12)	0.347 (0.11)	0.204 (0.36)
$\Delta Transp_{i,t}$	-0.007 (0.38)			
$\Delta Tel_{i.t}$	0.005 (0.44)	0.005 (0.48)		
$\Delta Road_{i.t}$		-0.003 (0.39)		
$\Delta Rail_{i.t}$		-0.002 (0.67)		
$\Delta Airl_{i.t}$		-0.001 (0.87)		
$Transp_{i,t}$			-0.0014 (0.78)	
$Tel_{i.t}$			0.0007 (0.85)	-0.002 (0.71)
$Road_{i.t}$				-0.004 (0.24)
$Rail_{i.t}$				-0.004 (0.12)
$Airl_{i.t}$				0.009 (0.02)
Time eff	Yes	Yes	Yes	Yes
Fix eff	Yes	Yes	Yes	Yes
F test (pvalue)	0.0000	0.0003	0.0001	0.0002
R^2	0.17	0.15	0.15	0.17

In terms of the effects of liberalisation on TFP growth in the transport and communication sector, we have not been able to identify many robust results. Our regression results do not offer a clear cut picture of the Effect of liberalisation on the TFP growth rate in the transport and communication sector: when we include an aggregate index for the overall transport sector we find that a more liberalised transport sector or an increase in liberalisation tend to increase the TFP growth rate in the transport and communication sector, but also that the result is never significant. However, when we include three indices separately for the road, airlines and railways sector, we find some weak evidence of a positive (and marginally significantly) effect of liberalisation in the railways but a negative effect in the case of the airlines.

In Table 5-2 we tried to verify whether liberalisation might have an indirect effect on TFP growth rather than a direct one. The main hypothesis that we tested has been whether in more liberalised transport sectors the effects of changes in the rate of growth of public capital are larger than in less liberalised ones.

In order to do that we created four dummies variables, Tr1, Tr2, Tr3 and Tr4. Tr1 has been set equal to one when $Transp_{i,t}$ is equal or lower than 2 (which would correspond to a very liberalised sector) and zero otherwise; Tr2 has been set equal to one when $Transp_{i,t}$ is equal or lower than 4 but higher than 2 and zero otherwise; Tr3 has been set equal to one for values of $Transp_{i,t}$ between 4 and 5 and, finally, Tr4 has been set equal to one for values of $Transp_{i,t}$ between 5 and 6.

We have then interacted $\Delta \ln kg_{i,t}$ with the four dummy variables Tr1, Tr2, Tr3 and Tr4 to assess the impact of $\Delta \ln kg_{i,t}$ on the rate of growth of TFP at different degrees of liberalisation.[31]

The results in column 1 show that only $\Delta \ln kg_{i,t}$ *Tr1 is significant at the usual conventional levels.[32] We can note that transport sectors with a high degree of liberalisation (these for which $Transp_{i,t}$ is lower than 2), the effect of the rate of change of the economy wide public capital stock on the rate of growth of the transport and communication sector TFP is substantially higher than in the case of less liberalised transport sectors. As we can see, there seems to be some non-linearities, as the effects of $\Delta \ln kg_{i,t}$ on the rate of growth of TFP seems stronger for sectors where the degree of liberalisation of the transport sector is between 4 and 5 than for these with a degree of liberalisation in the transport sector between 2 and 4.

We have therefore some evidence that seems to suggest that liberalisation (or changes in the degrees of liberalisation), rather than affecting directly the rate of growth of TFP in the transport and communication sector, might affect it indirectly through the rate of growth of the public capital stock, which would be therefore more effective in stimulating productivity growth in more liberalised transport sectors as opposed to more regulated ones.

31 We might have interacted $\Delta \ln kg_{i,t}$ with $Transp_{i,t}$ but that would not have allowed us to capture any non-linearities which might exist between the degree of liberalisation and the impact of the rate of growth of the public capital stock on the rate of growth of TFP in the transport and communication sector.

32 This conclusion is robust to a number of robustness check, such as including into the regression $Transp_{i,t}$, rather than $\Delta Transp_{i,t}$ which is however highly insignificant.

Table 5-2: TFP growth regression. Transp&Comm. sector

Dependent variable: $\Delta \ln TFP$	1	2
Indep. variable		
$GAP_{i,t-1}$	-0.045 (0.05)	-0.057 (0.02)
$\Delta Transp_{i,t}$	-0.007 (0.43)	
$\Delta Tel_{i.t}$	0.004 (0.47)	
$Tel_{i.t}$		-0.001 (0.75)
$Road_{i.t}$		-0.004 (0.27)
$Rail_{i.t}$		-0.004 (0.12)
$Airl_{i.t}$		0.009 (0.03)
$\Delta \ln kg_{i,t}$ *Tr 1	0.70 (0.09)	-0.20 (0.77)
$\Delta \ln kg_{i,t}$ *Tr 2	0.414 (0.21)	0.211 (0.54)
$\Delta \ln kg_{i,t}$ *Tr 3	0.441 (0.19)	0.288 (0.42)
$\Delta \ln kg_{i,t}$ *Tr 4	0.284 (0.26)	0.23 (0.36)
Time eff	Yes	Yes
Fix eff	Yes	Yes
F test (pvalue)	0.0000	0.0000
R^2	0.15	0.17

In column 2 we tested whether the inclusion of the liberalisation indices for the road, airlines and railways affects in any way this result. Column 2 shows that this is indeed the case: the four interaction variables are all highly insignificantly different from zero. We already mentioned above our concerns on the reliability of the results based on the sub-sector indices. We also tried to run a regression without the airlines index and we found that the coefficient of $\Delta \ln kg_{i,t}$ *Tr1 was positive although not significant (the p value is 0.19). It is thus possible that it is the inclusion of the airlines liberalisation index that drives down the effect of $\Delta \ln kg_{i,t}$ *Tr1 on the rate of TFP growth. The economic intuition for this effect is not clear.

If we take the view that the results based on the aggregate transport index should be preferred, an interesting exercise would be to compare the gain that less liberalised countries could gain, in terms of higher effect of the rate of growth of their public capital stock on TFP growth, from an increase in liberalisation. The data shown in Table 5-6 in section 5.5 suggest that no country in our sample has an overall degree of liberalisation higher than 5 for its transport sector, and not even between 4 and 5, in 2002, the last year in our sample.[33] We could however compare the gain that a country with a degree of liberalisation greater than 2 would have by “increasing” its liberalisation index to the 0-2 band.

For instance, in a country like Italy, that in 2002 had a degree of liberalisation of about 3.5 in its transport sector, and after adjusting the relevant coefficient of the public capital stock as we did it above, the effect of one additional percentage point in the rate of growth of its public capital stock would add about 1.2-1.5 percentage points to the TFP growth rate of its transport and communication sector, while we could not reject the possibility that, with the current degree of liberalisation the effect would be nihil.

5.3.3 The main results: transport sector

We explained in some detail above the reasons that led us to analyse the transport and communication sector rather than the more appropriate transport sector. The main reason was that only for the transport and communication sector we had been able to build a sample of countries which included the EU 15 (less Luxemburg) and the US.

In this section we run a regression similar to the equation (1) of section 5.3.1, using the rate of growth of labour productivity in the transport sector as the dependent variable. The main advantage of considering labour productivity growth in the transport sector rather than TFP growth in the transport and communication sector is that the former should allow us to better identify the impact of transport policies because of the focus on the transport sector only; in second place the dependent variable, labour productivity growth, is not subject to the assumption surrounding the construction of the capital stock and, therefore, it should be less subject to measurement error.

The other side of the coin is that labour productivity growth is not an as good indicator as total factor productivity growth. Furthermore, even if in our case TFP growth has been measured with error due to the assumptions which were necessary to build the capital stock series for some countries, we argue that the use of fixed effects in the regression analysis should have “purged” the data at least of the fraction of measurement error that was time-invariant and country-specific.

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33 Hungary, not included in the sample, would have a value of 4.

The main results of the transport sector labour productivity growth regressions are shown in Table 5-3.[34]

The first result which is apparent from all specifications in Table 5-3 is that the rate of growth of the public capital stock is positive, as expected, but never significant. As a sensitivity analysis, we re-run the regression in Table 5-3 using kms of railways and km of motorways instead of the public capital stock but the results were always largely insignificant. We also tried to interact the rate of growth of the public capital stock with dummy variables accounting for different degrees of liberalisation, as we did above, but the variables were always insignificant.

As far as the degree of liberalisation is concerned, we followed a procedure similar to that we used in the case of the TFP growth regressions. We first included the transport index liberalisation in difference form: as we can see in column 1, the coefficient is negative, suggesting a beneficial effect of liberalisation on labour productivity growth in the transport sector. However, the coefficient is poorly determined (the p value is 13 per cent).

In column 2 we included the liberalisation indices for railways, roads and airlines directly into the regression equation. They all have negative sign, but they are all not significantly different from zero at the conventional levels of confidence.

In column 3 we included the transport index in level, rather than in difference form. The results are however quite similar, as its coefficient has a negative sign but is not significantly different from zero.

In column 4 we have included the levels of the liberalisation indices in the road, railways and airlines sector. In this case, the airline liberalisation index is positive, but highly insignificant, while the road and the railways indices are negative, with the railways index which is significant at the 10 per cent level of confidence. The results appear in this case to be quite similar to these we have identified in the case of the TFP growth regression in the transport and communication sector, with the difference that, in this case, the airline liberalisation, though positive, is not significant and the railways sector index is significantly different at the 10 per cent level.

We also ran some additional regressions (not shown) using some finer disaggregation indices which measure, for the railways, road and airlines sectors, the degree of barriers to entry. In this case, we found that the levels of barriers to entry in the railways sector tends to decrease labour productivity growth, with a coefficient which is significant at a confidence level of 11 per cent.

Summing up, while there is some evidence that liberalisation in the transport sector tends to increase labour productivity growth in the transport sector, the evidence, as in the case of total factor productivity growth in the transport and communication sector, is weak, as it relies on coefficients that are significant, in the best of the cases, at the very upper bound of the usual confidence levels (i.e. 10 per cent).

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34 In all the regressions we used standard errors robust to heterosckedasticity of unknown form and serial correlation. Furthermore, in all regressions we controlled for the economy-wide output gap.

Table 5-3: LP growth regression. Transport sector

Dependent variable: $\Delta \ln LP$	1	2	3	4	5
Indep. variable					
$GAP_{i,t-1}$	-0.144 (0.002)	-0.143 (0.002)	-0.144 (0.002)	-0.149 (0.001)	
$\Delta \ln kg_{i,t}$	0.126 (0.61)	0.112 (0.63)	0.130 (0.58)	0.100 (0.69)	0.132 (0.61)
$\Delta Transp_{i,t}$	-0.017 (0.13)				-0.009 (0.34)
$\Delta Road_{i.t}$		-0.006 (0.16)			
$\Delta Rail_{i.t}$		-0.010 (0.25)			
$\Delta Airl_{i.t}$		-0.002 (0.83)			
$Transp_{i,t}$			-0.006 (0.33)		
$Road_{i.t}$				-0.0036 (0.22)	
$Rail_{i.t}$				-0.007 (0.095)	
$Airl_{i.t}$				0.001 (0.68)	
$GAP_{i,t-1}$ *Tr1					-0.274 (0.000)
$GAP_{i,t-1}$ *Tr2					-0.249 (0.000)-
$GAP_{i,t-1}$ *Tr3					-0.221 (0.000)
$GAP_{i,t-1}$ *Tr4					-0.164 (0.000)
Time eff	Yes	Yes	Yes	Yes	Yes
Fix eff	Yes	Yes	Yes	Yes	Yes
F test (pvalue)	0.000	0.0000	0.0000	0.0000	0.000
R^2	0.16	0.16	0.16	0.16	0.21

Another result it is worth signalling is that the technology gap variable is always negative and highly significant, suggesting that countries that have a lower labour productivity level tend to have faster labour productivity growth: we should however be careful in interpreting this variable as a proxy for the technology level, as we did in the case of the TFP growth regression above.

A perhaps better interpretation would be a sort of "convergence" result, i.e. countries with a lower level of labour productivity might also have lower capital stocks: in this case, as a conventional growth model a la Solow would predict, the capital stock would command higher rates of return precisely in the countries with a lower level of labour productivity, ceteris paribus: this in turn would lead to faster capital accumulation and higher growth of labour productivity.

We explored possible interactions between liberalisation and labour productivity growth convergence, by interacting the $GAP_{i,t-1}$ variable with four dummies to proxy for different degrees of liberalisation in the transport sector. In particular, we created a dummy variable Tr1 which has been set equal to one when $Transp_{i,t}$ is equal or lower than 2 (which would correspond to a very liberalised sector) and zero otherwise; a dummy variable Tr2 which has been set equal to one when $Transp_{i,t}$ is equal or lower than 4 but higher than 2 and zero otherwise; a dummy variable Tr3 which has been set equal to one for values of $Transp_{i,t}$ between 4 and 5 and, finally, a dummy variable Tr4 which has been set equal to one for values of $Transp_{i,t}$ between 5 and 6. We then interacted each dummy variable with $GAP_{i,t-1}$.

The results in column 5 show that the four interaction terms are always negative and significantly so at the 1 per cent confidence level[35], suggesting that there is "convergence" in labour productivity independently on the degree of liberalisation in the transport sector.[36] However, the coefficients of the 4 interaction variables increase in absolute level with the degree of liberalisation, suggesting that in more liberalised transport sectors the convergence process in labour productivity is stronger. We can also note that the coefficient for the $GAP_{i,t-1}$*Tr1, $GAP_{i,t-1}$*Tr2 and $GAP_{i,t-1}$*Tr3 variables are quite similar to each other, with only the coefficient of $GAP_{i,t-1}$*Tr4 that is substantially smaller than the previous three. This would suggest that only very low degrees of liberalisation have an impact on the convergence process of labour productivity in the transport sector. In particular, simple t tests show that the coefficients for $GAP_{i,t-1}$*Tr1, $GAP_{i,t-1}$*Tr2 and $GAP_{i,t-1}$*Tr3 are not significantly different from each other, but they are all significantly different from $GAP_{i,t-1}$*Tr4 at the 1 or 5 per cent level.

As a final attempt to further explore the link between liberalisation, infrastructure and transport productivity, we run similar regressions to these reported in Table 5-3 for the land transport sector and, separately, for the air transport sector. We were not able to find any signifi-

35 The 4 coefficients are also jointly significant at the 1 per cent confidence level.

36 The result is robust to different specification of the regression equation, such as including $Transp_{i,t}$ rather than $\Delta Transp_{i,t}$.

cant effect of sector –specific liberalisation indices and, in the land sector, of the rate of change of the public capital stock.

5.3.4 The main results: conclusions

The aim of this section is to briefly summarise the main results of the econometric analysis discussed in the previous two sections.

As we repeatedly argued in the previous section, we tend to prefer the analysis that we carried out on the total factor productivity growth in the transport and communication sector. The reason is that, notwithstanding the use of a wide sector which includes non transport activities, the TFP growth is a more preferable indicator of productivity developments in a sector than the simple labour productivity growth; furthermore, possible country –specific measurement error in the TFP growth series possibly induced by some of the assumption we used in building the capital stock series for some countries should be controlled for by the country fixed effects included in the regression –at least the country specific-time invariant component of measurement error.

Having said that, we can note that both the two sets of results do not provide convincing evidence that liberalisation (or changes in the degree of liberalisation) tends to increase productivity growth in the transport sector. There is in fact, if any, some evidence that increases in the degree of liberalisation increase labour productivity growth, but the coefficients are poorly determined, and the significance level is never lower than 0.10-0.12 (with the exception of the railways-specific index, which is significant at the 10 per cent level and which could therefore suggest that liberalisation in the railways might have had a positive impact on LP growth in the transport sector)

In the case of the TFP growth regression in the transport and communication sector, the inclusion of an aggregate transport sector liberalisation index suggests that liberalisation is beneficial to TFP growth, but the coefficient is never nearly significant; furthermore, the inclusion of individual sub-sector indices provides some evidence that railways liberalisation tends to increase TFP growth while airlines liberalisation tends to decrease it.

A possible explanation for these findings could be that liberalisation does not play a major role in driving productivity growth in the transport sector, and that other variables, like R&D expenditure, or the degree of congestion, which we have not controlled for in the analysis, play a far larger role: if that were indeed the case, the error term would capture the effect of these omitted variables and the standard error would tend to be larger, making it difficult to precisely measure the effect of the included variables.[37] Furthermore, the fact that our TFP growth measure is based on the composite Transport and Communication sector might have included some noise in the estimations and, therefore, standard errors might have been inflated. Finally, it is possible that the effects of liberalisation needs more time to materialise, for instance because of the existence of adjustment costs.

37 Furthermore, if some of these variables, like the congestion levels were in fact correlated with the degree of liberalisation, we might expect some bias in the liberalisation coefficients.

We have however seen that liberalisation might be likely to operate through other indirect channels. For instance, we saw in the regressions in section 5.3.2 that in more liberalised sectors the impact of increases of the rate of changes of the public capital stock (which we used as a proxy for the transport infrastructure capital) was magnified (after allowing for the adjustments described above, an additional one percentage point to the rate of growth of the public capital stock might lead to about 1.2-1.5 additional percentage points to TFP growth in the transport and communication sector), although this effect was not confirmed in the labour productivity analysis in the transport sector. In second place, we have seen that in more liberalised sectors, the convergence towards the industry frontier (measured as the country with the highest transport labour productivity level) tends to be slightly faster than in the most intensively regulated countries.

The evidence regarding the impact of infrastructure is mixed. We discussed at length in the previous sections the drawbacks of our proxy for the stock of transport infrastructure, the most important being that it is only loosely imperfectly connected with the stock of transport infrastructure, as it accounts for also of such items as hospitals, schools, etc. However it has been widely used in the literature on the macroeconomic effects of infrastructure on economic growth and, above all, there is some evidence that it tends to provide somewhat smaller effects than core infrastructure capital, which is more closely associated with transport infrastructure: therefore it should be possible to argue that our result should provide a sort of lower bound for the “true” effect of transport infrastructure. Furthermore, alternative variables[38] like km of roads, motorways or railway tracks are measured with substantial error and they do not provide year on year variation, within each country, sufficiently large to allow the researcher to identify the parameter of interest.

Having said that, our results do not show strong evidence that the rate of growth of the public capital stock has a positive impact on the rate of growth of TFP in the transport and communication sector, as the coefficient of $\Delta \ln kg_{i,t}$ is indeed positive but poorly determined (it is significant, in the best of the case, in the TFP growth regressions at 10 per cent). However, this result is not confirmed when we focus the analysis on the labour productivity growth in the transport sector: in this case, although the coefficient for the rate of growth of the public capital stock is positive, it is never significantly different form zero at the usual levels of confidence.

Which of the two sets of results is more “reliable” as an indicator of the likely effects of infrastructure expenditure programs on productivity growth in the transport sector is not immediately clear. For instance, we are not in a position to argue that the failure of the labour productivity model to show a significant positive effect of the public capital stock on labour productivity growth is due to the fact that the latter is the wrong indicator to consider or that, instead, the positive effect in the TFP model is due to the inclusion of the communication sector activities.

38 Which we used in the regressions but that always turned out to be highly insignificant, with t values close to zero.

What would be required to provide more robust result would be the expansion of databases like the Groningen Growth Accounting Database or the STAN database and, above all, the estimation of sufficiently long time series of the infrastructure capital for as many as possible EU countries.

We have also seen that there is some evidence that the growth in the public capital stock tends to be stronger in more liberalised industries, even if these results is confirmed only for some specification of the TFP growth regressions.

Finally, we have found that countries that lag further behind the industry technological frontier experience faster TFP growth, which results in a convergence process of the level of TFP in the transport and communication sector. The coefficient is remarkably stable and highly significant across all the specification in Table 5-1 and Table 5-3. This result confirms, for the transport and communication sector, the findings of Griffith et al (2004) and Nicoletti and Scarpetta (2003) who also find broadly similar results for a panel of OECD manufacturing and manufacturing and services sectors, respectively.

A similar result is also obtained in the case of the labour productivity growth regressions, where we found that countries with lower levels of LP tend to have faster LP growth and that this “convergence” effect is somewhat stronger in more liberalised countries.

5.4 The impact of transport productivity growth on some transport-related sectors

5.4.1 Introduction

Developments in transport productivity growth in the transport sectors are important because the sector produces intermediate inputs that will be then purchased by other sectors (transport user sectors): high rates of growth of labour or total factor productivity might have important implications for the economic development of some sectors that make an intensive use of transport. The sectors that we have considered in this report are financial intermediation; transport equipment; chemicals, rubber and plastics; food, drinks and tobacco and retail and wholesale.

The data we have used for the analysis mainly came from the Stan database supplemented, for the number of hours worked, by the University of Groningen database. The data cover the EU 15 countries plus the US (with the exception of Luxemburg) over the period 1979-2003.[39]

The main goal of the analysis has been to explore whether and to what extent productivity growth in the transport sector might have led to productivity growth in transport user sectors.

In principle, there can be different channels through which productivity growth, as measured by the Solow residual, could grow in a particular sector.

[39] For some countries we do not have the full time series of data.

The first is what we might call "true productivity change", i.e. technological change, the shift in the industry production (or cost) function due to technological advancements. However, it is unlikely that productivity changes in the transport sector lead to technological changes in transport user sectors. This could happen, for instance, if the transport sector became more productive by, say, increasing its performance in terms of time to delivery, reliability, etc, which in turn might allow for changes in management and organisational practices and techniques in the transport user sectors, for instance increasing just in time production and so forth. This in turn could enable transport user firms to reduce costs over and above the savings in intermediate inputs brought about by a more productive transport sector, resulting in higher productivity growth.

A second source of productivity growth is economies of scale: if a sector is producing with a technology that exhibits increasing returns to scale, then an increase in production would be associated with a less than proportional increase in inputs and with an increase in productivity growth (as measured by the Solow residual).

In our case, an increase in productivity growth in the transport sector might lead to higher production in the non-transport user sectors as long as the non transport user sectors are operating at increasing returns to scale and the higher transport productivity is passed on to them in the form of lower input prices (so that the transport user sectors can expand production and enjoy the benefits of scale economies).

This condition brings us to the last source of productivity growth, namely the existence of mark up: it is in fact well known that the Solow residual can be decomposed into a technological change component, a component due to scale economies and into a mark up component (see, for instance, Hall, 1988). The existence of a mark-up component is important because the impact of productivity growth in the transport sector on the productivity growth in transport user sectors is likely to happen through that channel. In fact, it is unlikely that year on year productivity growth in the transport sector will be sufficiently important to induce technological changes in the transport user sectors. Furthermore, if the transport user sectors were perfectly competitive, the higher productivity in the transport sector would be passed on to the transport user sectors that would pay lower prices for some of their inputs, which, in turn, would be passed to the final consumers: given the degree of scale economies, that should not affect the rate of growth of the transport users' Solow residual. However, when output prices depart significantly from marginal costs (i.e. in the presence of substantial positive mark-ups) the lower input prices would not be entirely passed on to consumers, and, as a result, we could expect a higher Solow residual.

To distinguish all these effects, the technological change , the scale component and the mark up effect would require a detailed modelling of the transport user sectors (e.g. econometric estimation of production or cost function), which in turn would require accurate information of inputs, outputs, input and output prices and, perhaps, firm level data. Then, a model should be derived to analyse how productivity developments in the transport sector impact on the three channels of productivity growth in the transport user sectors, the extent of mark-ups and the relationship between input prices, scale economies and technical change..

A possible short-cut would be to simply see whether TFP growth in the transport sector is related to TFP growth in the transport user sectors. This strategy would not of course tell us where the impact of transport productivity growth on the transport user sectors productivity growth comes from: we however have to point out that the finding of a positive correlation between the rate of growth of productivity of the transport sector and that of transport user sectors is unlikely to be due to technological change/management reorganisations. We would believe that if improvements in productivity in the transport sector had an impact on the productivity of transport user sectors (as measured by the Solow residual) the economies of scale and mark up component would be more likely candidate channels.

5.4.2 The econometric model and the main results

The main econometric model we have estimated has been the following:

(1) $\Delta \ln TFP_{ijt} = \alpha_0 + \alpha_j \Delta \ln TP_{it} + Outgap_{it} + v_{it}$

where $v_{it} = e_i + \lambda_t + u_{i.t}$

$\Delta \ln TFP_{ijt}$ is the rate of growth of total factor productivity in country i, sector j at time t; $\Delta \ln TP_{it}$ is the productivity growth in the transport sector in country i at time t, which could be either the rate of growth of total factor productivity in the transport and communication sector or the rate of growth of labour productivity in the transport sector. The coefficient of $\Delta \ln TP_{it}$ has been allowed to vary over the sectors, so that we are able to estimate the impact of transport productivity growth in each of the five transport user sectors.[40]

The results have been reported in Table 5-4. As we can see, the impact of TFP growth in the transport sector is never significant. The results are confirmed by the results in column 2, where we have used labour productivity growth in the transport sector rather than TFP growth in the transport and communication sectors.[41][42]

The results in Table 5-4, taken at face value, suggest that productivity growth in the transport sector does not have any impact on TFP growth in the five transport user sectors used in this empirical exercise. An interpretation of this result could be based on the brief analysis we have developed in the previous section on the sources of growth in the Solow residual, i.e. technological change, output growth coupled with scale economies and positive mark up. If it is reasonable to assume that productivity growth in the transport sector is unlikely to generate substantial technical and organisational change in these five transport user sectors, the scale economies and mark-up components would be the channels through which higher productivity growth in the transport sector could lead to growth in the Solow residual of the five transport user sectors.

The fact that we do not find any significant effects can be explained (a part with the very stylised nature of the model which might be unable to capture the linkages we are analysing) arguing that either there are not substantial mark-ups in the transport user sectors (i.e. that these sectors are reasonably competitive) used in the sample or to the fact that scale economies are approximately constant. Which of the two explanations are important would require

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40 FI stands for financial intermediation, RW stands for the retail and wholesale sector, CRP stands for chemicals, rubber and plastics, TE stands for transport equipment (such as motor vehicles, etc) and FBT stands for food, beverages and tobacco.

41 The results are very similar if we run separate regressions for each of the five transport user sectors.

42 The F test for the overall significance of the regression suggests that we can not reject the null hypothesis that the regressors are all jointly insignificant in the case of column 2.

us to build econometric models of producer behaviour (like cost or production functions) in these five transport user sectors which appears to be outside the scope of the current research project.

Furthermore, it might be the case that productivity gains in the transport sector could lead to higher productivity in the transport user sectors but not to higher growth rates.

Moreover, our TFP growth refers to the Transport and Communication sector, and therefore we have to acknowledge that our findings might have been driven by productivity developments in the Communication rather than in the Transport sector.

Finally, it is possible that in these sectors -although they have been selected because, a priori, it was considered reasonable to assume that they might be more affected than others from productivity developments in the transport sector - transport costs represent a small share of costs. This, in turn, could make it difficult to identify the effects that productivity developments in the transport sector might have had on the productivity growth of these transport user sectors.

Table 5-4: TFP growth regression. 5 non transport sectors

Dependent variable: $\Delta \ln TFP_{ijt}$	1	2
Indep. Variable:		
$\Delta \ln TFP_{it}$ *FBT	-0.112 (0.20)	
$\Delta \ln TFP_{it}$ *CRP	0.116 (0.20)	
$\Delta \ln TFP_{it}$ *FI	-0.02 (0.70)	
$\Delta \ln TFP_{it}$ *TE	-0.416 (0.14)	
$\Delta \ln TFP_{it}$ RW	-0.014 (0.85)	
$\Delta \ln LFP_{it}$ *FBT		-0.06 (0.37)
$\Delta \ln LFP_{it}$ *CRP		0.07 (0.36)
$\Delta \ln LFP_{it}$ *TE		-0.004 (0.93)
$\Delta \ln LFP_{it}$ *FI		-0.249 (0.28)
$\Delta \ln LFP_{it}$ RW		0.034 (0.51)
Time eff	Yes	Yes
Fix eff	Yes	Yes
Ftest (p value)	0.012	0.30
R^2	0.07	0.07

5.5 Data appendix[43]

The main sources of data are the University of Groningen "60 Industry Database" and the OECD STAN database. Our samples include the EU15 countries (less Luxemburg) plus the US. The sample period runs from 1979 to 2003. For some countries we have shorter time series due to data availability problems in the STAN database: this is especially the case for Greece, Portugal, Ireland, Germany and Sweden, for which we have data starting from 1995, 1995, 1987, 1991 and 1993, respectively.

Total factor productivity growth in the transport and communication sector has been computed according to equation 1:

$$\Delta \ln TFP_{it} = \Delta \ln VA_{it} - \frac{1}{2}(\alpha_{it} + \alpha_{it-1})\Delta \ln H_t - (1 - \frac{1}{2}(\alpha_{it} + \alpha_{it-1}))\Delta \ln K_{it} \quad (1)$$

In equation 1, VA stands for value added, H is the total number of hours worked in the sector, K is the stock of capital in the sector and □ is the labour share in value added.

Data on value added comes from the University of Groningen "60 Industry Database": value added for the transport and communication sector was derived aggregating value added for water transport, land transport, air transport, auxiliary transport and post and communication. In the aggregation we used Tornqvist deflators, following a procedure described in O' Mahoney and Van Ark (2003) and Denis, McMorrow and Roger (2004). The values were converted to US dollars using an economy wide PPP exchange rate.

For the labour input, we used information contained in the University of Groningen "60 Industry Database" on the number of hours in the water transport, land transport, air transport, auxiliary transport and post and communication sectors.

Labour share has been computed as the ratio of labour compensation (taken form the STAN database) over value added. The resulting ratio has been corrected to take into account that labour compensation does not include wages, salaries and social contributions of independent workers. We therefore derived a corrected labour share multiplying the ratio between labour compensation and value added by the ratio between the total employment and the total number of employees.[44] The resulting labour share displayed some year-to-year volatility for most of the countries. This is in general considered as a possible consequence of measurement error. We therefore further adjusted the labour share following an econometric procedure suggested by Griffith et al (2004): under the assumption that the technology structure of the firms in the transport and communication sector is translog and under standard mar-

43 In this data appendix we describe the data we have used in this project. We will base our description on the data we have used to build the models in section 5.3 (for the other models a similar description would apply).

44 For Spain and Sweden, the OECD STAN database did not contain enough information to adjust the ratio of labour compensation to value added. For Spain we did not have information for the early years of the sample and therefore we made the assumption that the ratio between employment and employees was constant at the 1985 level, the first year for which we had information. For Sweden we assumed a value of 1.05 for the ratio.

ket clearing conditions, Harrigan (1997) showed that the labour share can be expressed as the function of the capital labour ratio and a country constant:

(2) $$\alpha_{it} = \varsigma_i + \vartheta \ln(K/H)_{it} + v_{it} \; .$$

Under the assumption that the v_{it} are i.i.d. measurement errors, we can estimate equation 2 by fixed effects and use the fitted values from equation 2 as the labour share in the computation for equation 1 above.

The capital stock variable is the gross fixed capital stock for the transport and communication sector at constant price which was taken from the OECD STAN database and converted to US dollars through an economy-wide PPP exchange rate. The gross capital stock was however available for only eight countries (Belgium, Denmark, France, Germany, Finland, Italy, Spain and UK). For the other countries the series of gross fixed capital formation was available in the STAN OECD database and a time series of gross capital stock for each of the remaining countries was constructed using a perpetual inventory method described in Scarpetta and Tressel (2002), which in turn follows the OECD ISDB User Guide:

(3) $$GCS_t = GCS_{t-1} + GFCF_t - \frac{1}{2(ASL-5)} \sum_{j=5}^{2ASL-5} GFCF_{t-j}$$

GCS is the gross capital stock, GFCF is the gross fixed capital formation, ASL is the average service life of the asset. The average service lives for the assets used in the transport and communication sector is taken from the OECD ISDB 1998 for the countries for which the information was available, while for these countries for which no information was available the average for the other countries was used.

Equation 3 requires a beginning of year capital stock and a time series of gross fixed capital formation which goes quite further in the past (depending on the average service life of the assets). To derive figures for the gross fixed capital formation in the years before 1979 we made the assumption that the gross fixed capital formation grew at the average rate of 5 per cent. In second place, the beginning of period gross capital stock (1979 for most of the countries) was computed as GCS=GFCF/s, where s was the average investment to capital ratio for the countries for which we had the relevant information in the period 1978-1980.

The resulting capital stock series will ultimately depend on the estimate of the beginning capital stock (and therefore s) and our assumption of the 5 per cent growth rate of the gross fixed capital formation in the decades before 1979. In the case of the eight countries for which we had the original OECD series for the gross capital stock, the correlation between the original and the artificial ones created following the procedure outlined above was however very near to one.[45] We also hope that at least the fraction of the country-time invariant measurement error will be controlled for in the econometric analysis by the country specific fixed effects.

To proxy for the infrastructure capital stock, we used different variables. Our preferred one, the stock of public capital in the economy as a whole, has been taken from Kamps (2004)

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45 Also the correlation of the year –to- year changes in the two sets of series was very high.

and converted to US dollars using a PPP exchange rate. The other variables, length of motorways, length of roads and railways have been taken form the Eurostat CRONOS database.

Our TPF growth computations have therefore made use of PPP exchange rates rather than market exchange rates. Even if they are theoretically superior to market exchange rates, it is worth mentioning that TFP growth calculations might be affected by the use of PPP rather than market exchange rates. However, in our case, when we compare the TFP growth rates and the multilateral TFP levels computed with market exchange rates and PPP exchange rates, they display very similar patterns , which suggests that our main findings should not have been seriously affected by the choice of PPP rather than market exchange rates.

We have argued in section 5.3 that our point estimate for the effect of a higher rate of growth of the public infrastructure capital stock on TFP growth is a downwards biased estimate of the "true" economic effect on TFP growth. The reason for the bias stems from our definition of TFP growth.

To explain in some more detail how this arises, let us consider the production function in equation 4:

(4) $$Y = AF(L, KP)$$

L is labour input, KP is the private capital stock and A is Hicks neutral technical change. Under profit maximising behaviour and perfect competition, the Solow Residual (SR, ie TFP growth) can be used to compute the Hicks neutral technical change index A:

(5) $$\dot{A} = \dot{SR} = \dot{Y} - S^L \dot{L} - (1 - S^L)\dot{KP}$$

Here a dot over a variable indicates a rate of change and S^L stands for the labour share.

The effects of public infrastructure could be incorporated in the model assuming that public infrastructure affects A by raising the productivity of the private inputs (as an externality effect) or directly into the production function as an unpaid input into the production process.

In this case, as shown in La Ferrara and Marcellino (2000), the rate of growth of the Solow Residual, computed according to equation 5, is a function of the rate of growth of the public infrastructure stock KG[46].

However, in our model, we were unable to distinguish between the private and the public capital stock employed in the transport sector. What we have instead is an aggregate measure of the total capital stock employed in the sector, which is the sum of the private and public capital stock. In this case, simply regressing TFP growth, computed according to equation 1 rather than as in equation 5, on the rate of growth of the public infrastructure stock (and assuming that the latter can be approximated, as we did, by the public capital stock in the economy as a whole rather than by the public infrastructure capital employed in the transport and communication sector as it would be more appropriate) is likely to provide a downwards estimate of the true effect of higher growth rates of public infrastructure capital on

46 Private inputs such as private capital and labour would not affect the rate of growth of the Solow Residual under conditions of perfect competition and constant returns to scale.

the rate of growth of the transport and communication "private sector" Solow Residual. In other words, if TFP growth is computed according to equation 1, an increase in the rate of growth of the stock of public infrastructure would tend to increase the rate of growth of TFP, but at the same time, there would be a corresponding proportional increase in the capital stock, which would tend to depress TFP growth. To derive an estimate of the likely extent of the bias, let us consider the following production function, which has been implicitly used to derive our TFP growth estimates:

(6) $$Y = A(KP + KG)^{\gamma} L^{1-\gamma}$$

Here KG represents the stock of public capital and □ the elasticity of output with respect to capital that, under perfect competition and constant returns to scale can be approximated by the capital share in value added.

From 6, A (which represents TFP in the case of profit maximising behaviour and perfect competition), can be expressed as:

(7) $$A = \frac{Y}{(KG + KP)^{\gamma} L^{1-\gamma}}$$

We can use equation 7 to compute the bias affecting the coefficient α_2 in equation 1 of section 5.3.1 above by noting that:

(8) $$\frac{\partial A}{\partial KG} = \frac{Y}{L^{1-\gamma}}(-\gamma) * (KG + KP)^{-\gamma-1} = -\gamma \frac{A}{KG + KP}.$$

Turning the former expression into elasticity form, we can note that:

(9) $$\frac{\partial A / A}{\partial KG / KG} = -\gamma \frac{KG}{KG + KP}$$

Equation 9 represents the bias of the coefficient α_2 in equation 1 of section 5.3.1. It depends on □ and the relative importance of the stock of public infrastructure in the total capital stock of the transport sector. The $\frac{KG}{KG + KP}$ ratio is bounded between zero and one. It tends to zero when the stock of public infrastructure is small, relative to the stock of private capital, while it tends to one when the reverse is true. The size of the bias is country- specific as it depends on the share of capital in value added and on the $\frac{KG}{KG + KP}$ ratio. However, if we plug into equation 9 country-specific estimates for both the capital share and the $\frac{KG}{KG + KP}$ ratio, we get values for the bias ranging from about 0.04 to about 0.07, with a mean value of about 0.06, that it to say about 17 per cent of our preferred estimate of 0.34 for α_2, a relatively small bias.

Thus our point estimate of the (true) α_2 is 0.34+0.06=0.4. To this we should add the correction that takes into account the fact that the transport and communication public capital stock is only about 0.5/0.6 of the total government public capital stock, which lead us to a final estimate of about 0.67/0.80.

Turning to the other variables used in the econometric analysis, the output gap for the economy as a whole has been taken from the AMECO database.

Finally, the technology gap variable has been constructed using the multilateral total factor productivity index of Caves et al (1982). We followed Griffith et al (2004) computing the level of TFP in the transport and communication sector for each country relative to a common reference point (the geometric mean of all countries): this measure of multilateral TFP is given by equation 4:

(4)
$$MTFP_{it} = \ln\frac{VA_{it}}{\overline{VA_{it}}} - \sigma_{it}\ln\frac{H_{it}}{\overline{H_{it}}} - (1-\sigma_{it})\ln\frac{K_{it}}{\overline{K_{it}}}$$

Where $\overline{VA_{it}}$, $\overline{H_{it}}$ and $\overline{K_{it}}$ are the geometric averages of value added, number of hours and gross capital stock, respectively and $\sigma_{it} = \frac{1}{2}(\alpha_{it} + \overline{\alpha_{it}})$ is the average between the labour share and the geometric mean of the labour shares. The frontier country is defined as the country with the highest MTFP. The distance from the frontier, which can be considered as a superlative index number measure of relative TFP, is defined as $GAP_{it} = MTFP_{Ft} - MTFP_{it}$, where $MTFP_{Ft}$ is the multilateral TFP of the frontier country. GAP_{it}, or relative $MTFP_{it}$, is negative, because country i lies below the TFP level of the frontier country: the smaller GAP_{it} is, the further country i is from the industry frontier and the greater the potential for technology transfer (Griffith et al, 2004): therefore, the sign of GAP_{it} should be negative in equation 1 in section 5.3.1.

Table 5-5 shows that Belgium was the frontier country in the 1980s and early 1990s, and that it was replaced as the frontier country by Italy in the later years of the sample, with the US always in the first three positions of the ranking. We can also note that the average value increased over time and that the dispersion fell, as can also be seen by the increase in the relative TFP level of the "worse" country, which increased form 0.5 to 0.7.

The liberalisation indices in the transport and communication sectors are taken form the OECD International Regulation database. The overall transport index, Transp, has been computed by us as the mean of the indices for airlines, road transport and the railways. The sub-sector indices are computed aggregating different types of liberalisation related indices. For instance, the liberalisation index for the railways is obtained through aggregating the results of an airlines entry barrier index and an airlines public ownership index. The exact process followed by the OECD to build these liberalisation indices is discussed at length in Convey et al (2005) to which we refer.

Table 5-5: Multilateral TFP transport and communication sector

Dependent variable	$MTFP_{it}$	$MTFP_{it}$	$MTFP_{it}$	$MTFP_{it}$
Year	1980	1990	1995	2000
FIRST COUNTRY	BEL	BEL	ITA	ITA
SECOND COUNTRY	US	US	BEL	US
THIRD COUNTRY	ITA	ITA	US	NET
AVERAGE	0.79	0.76	0.76	0.84
S.D.	0.177	0.153	0.138	0.103
MAX	1	1	1	1
MIN	0.51	0.47	0.51	0.70

The value of the indices for some selected years (1980, 1990 and 2002) are reported in the Table below.

Table 5-6: Liberalisation indices

Country	Airlines	Railways	Road
1980			
Austria	5.97	6.00	4.50
Belgium	6.00	6.00	6.00
Denmark	5.73	6.00	6.00
Finland	5.28	6.00	6.00
France	6.00	6.00	6.00
Germany	6.00	6.00	6.00
Greece	6.00	6.00	6.00
Italy	5.58	6.00	6.00
Ireland	5.96	6.00	6.00
Luxembourg	-	-	-
Netherlands	6.00	6.00	6.00
Portugal	6.00	6.00	6.00
Spain	6.00	6.00	6.00
Sweden	6.00	6.00	1.48
UK	4.35	6.00	0.49
US	1.72	3.00	5.02
Hungary	-	-	-
Czech Republic	-	-	-
Poland	-	-	-
Slovak Republic	-	-	-
Max	6.00	6.00	6.00
Min	1.72	3.00	0.49
S.D.	1.10	0.75	1.70
1990			
Austria	4.52	6.00	1.75
Belgium	6.00	6.00	5.02
Denmark	5.73	6.00	0.49
Finland	4.48	6.00	2.24
France	6.00	6.00	1.75
Germany	4.63	6.00	5.24
Greece	6.00	6.00	6.00
Italy	5.58	6.00	6.00
Ireland	5.96	6.00	0.98
Luxembourg	-	-	-
Netherlands	6.00	6.00	6.00
Portugal	6.00	6.00	2.24
Spain	4.91	6.00	5.59
Sweden	6.00	5.25	0.98

UK	2.85	6.00	0.49
US	0.42	3.00	2.98
Hungary	-	-	-
Czech Republic	-	-	-
Poland	-	-	-
Slovak Republic	-	-	-
Max	6.00	6.00	6.00
Min	0.42	3.00	0.49
S.D.	1.50	0.76	2.12
2002			
Austria	1.19	5.33	1.75
Belgium	0.20	4.88	1.75
Denmark	0.43	3.00	0.49
Finland	1.75	5.25	0.49
France	1.65	5.25	1.75
Germany	0.00	3.90	1.45
Greece	4.36	5.70	6.00
Italy	1.87	2.93	5.61
Ireland	4.37	5.70	0.49
Luxembourg	-	-	-
Netherlands	0.49	2.81	1.25
Portugal	3.35	4.05	0.64
Spain	1.12	4.88	1.90
Sweden	0.81	3.75	0.98
UK	1.43	0.38	0.49
US	0.00	3.00	0.49
Hungary	5.64 (2003)	3.75 (2003)	2.51
Czech republic	4.43 (2003)	2.25 (2003)	3.00
Poland	3.51(2003)	1.69 (2003)	1.75 (2003)
Slovak Republic	4.20 (2003)	1.88 (2003)	1.48 (2003)
Max	5.64	5.70	6.00
Min	0.00	0.38	0.00
S.D.	1.75	1.47	1.54

OECD indicators of sectoral regulation

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