A comparison of structural productivity levels in the major industrialised countries

Bourlès, Renaud and Cette, Gilbert

Université de la Méditerranée and GREQAM, Banque de France and Université de la Méditerranée

2005

OECD Economic Studies No. 41, 2005/2

A COMPARISON OF STRUCTURAL PRODUCTIVITY LEVELS IN THE MAJOR INDUSTRIALISED COUNTRIES

Renaud Bourlès and Gilbert Cette

TABLE OF CONTENTS

Renaud Bourlès, Université de la Méditerranée; Gilbert Cette, Banque de France and Université de la Méditerranée. The views expressed herein are those of the authors but not necessarily their institutions. The authors would like to thank Rémy Lecat, Tristan Maury, Giuseppe Nicoletti, Dirk Pilat, Patrick Sevestre, Paul Schreyer and Paul Swaim for their help and advice. They would also like to thank those who attended the OECD workshop on 27 January 2005 for their useful comments.

Introduction

Hourly labour productivity, along with average hours worked, the employment rate and the working-age population as a share of the total population, is one of the accounting aggregates that determine per capita GDP. Yet according to many analyses, hourly labour productivity in several European countries is much the same as or even higher than in the United States, while per capita GDP is markedly lower (see Cette 2004, 2005 for a summary of this work). In quantitative terms, the difference can be put down to higher average hours worked and/or a higher employment rate in the United States. This suggests that the United States is no longer setting the "technical efficiency frontier"[1] now defined by these European countries. In other words, some of the other industrialised countries have already closed the productivity gap. By "opting" for shorter working hours and/or lower employment rates, the European countries with high hourly productivity would also seem to be promoting more of a leisure society than the United States. The obvious question, addressed in what is becoming a wealth of literature,[2] is whether this greater emphasis on leisure in Europe is the expression of genuine social and collective preferences, or the outcome of the combined effects of regulatory provisions that curb labour-market participation by the working-age population and of tax provisions that act as financial disincentives to such participation.

The above analysis would be valid assuming constant returns to hours worked and the employment rate. Yet recent econometric work (for example by Belorgey, Lecat and Maury, 2004) on panels of countries has shown sharply diminishing returns to both parameters. This would mean that differences in hours worked and/or employment rates in many European countries push up hourly productivity there compared with the United States. The analysis proposed by Cette (2004, 2005) consisted in correcting "observed" hourly productivity by factoring in the differences in average hours worked and/or the employment rate (compared with the United States) stemming from these diminishing returns, in order to obtain "structural" hourly productivity. It then emerged that, with the exception of some highly specific small countries (*e.g.* Norway), structural productivity levels in every country were lower than in the United States, which would in fact still appear to be setting the "technical efficiency frontier".

Taking this analysis further, the present study focuses on refining the measurement of the effects of the employment-rate gap on productivity by breaking down the working-age population by sex and age into six categories (with three age groups: 15-24, 25-54 and 55–64). This is because it is possible that diminishing returns to the employment rate vary across these categories, and it emerges that the gaps with the United States are not evenly spread but concern specific working-age population groups, *i.e.* the young, older workers or women. This empirical analysis is based on a panel of OECD countries from 1992 to 2002. The numerous problems of simultaneity between the variables are addressed by using instrumental variables.

The results should be viewed with the usual caution. They are associated with a large number of simplifying assumptions and should accordingly be viewed as realistic orders of magnitude rather than precise measurements. Of these assumptions, those of uniform returns to employment rates and hours worked are probably very robust. They suggest, for instance, that the returns to the employment rate of all six categories of the working-age population remain unchanged, whether the initial employment rate in that category is 20% or 70%.

We should point out that this study of the effect on productivity of the employment rate by sex and age is not directly comparable with the findings of studies on the productivity effects of the sex and age profile of the working population. Our study looks at the effects on productivity of the gender and age structure of the working-age population broken down into *insiders* and *outsiders* (*i.e.* those in or outside the labour market), rather than the effects on productivity of the age and gender structure of *insiders* alone. Among the recent empirical studies on the effects that the structure of the employed population has on productivity, Hellerstein and Neumark (2004) find that the productivity of women is less than that of men, and an age effect that is ambiguous (possibly quadratic); Aubert and Crépon (2003) find an age effect that is not really significant.[3] We should also point out that one explanation occasionally put forward for the effect of age on productivity is the diffusion and rapid renewal of new technologies, which may reinforce phenomena relating to the erosion of human capital with age (for this, see for instance Aubert, Caroli and Roger, 2004).

This study begins by recalling the insights gleaned from a range of comparative measurements of "observed" hourly productivity, before moving on to estimate the returns to hours worked and the employment rate, this second parameter being considered first at an aggregate level and then by category of the working-age population. The study then measures "structural" hourly productivity, adjusting for the effects of differences in hours worked and the employment rate on "observed" productivity, and ends with some concluding remarks.

Apparent labour productivity in the major industrialised countries

The international comparisons available on labour productivity are contrasting[4] but the evidence they provide appears to be robust to the inevitable statistical uncertainty (Table 1):

Table 1. **Productivity, per hour and per worker, in 2002**

Country	Productivity per hour as a % of the United States level			Productivity per worker as a % of the United States level		
	OECD [a]	Groningen [b]	Eurostat [c]	OECD [d]	Groningen [e]	Eurostat [f]
United States	100	100.0	100.0	100	100.0	100.0
European Union[1]	82		89.5	78		78.5
Euro zone	92		90.9	83		78.5
Japan	71	75.8	69.6	75	71.1	69.9
OECD	76			77		
Germany	93	104.7	92.1	79	81.3	73.6
Australia	78	84		83	79	
Canada	85	86.6	87.4	86	82.1	86.3
Spain	74	73.8	73.9	79	71.3	74.2
Finland	82	90.4	83.3	83	77.3	77.9
France	113	107.1	107.4	95	85.4	89.7
Ireland	105	109.4	104.0	102	97.7	96.5
Italy	94	98.5	91.9	88	84.9	82.7
Norway	125	121.1	124.2	98	87.8	92.8
Netherlands	102	106.3	102.2	80	76.2	75.2
United Kingdom	79	86.2	83.7	78	75.3	79.4
Sweden	86	88.9	85.0	80	75	74.7
Korea	42	36.8		59	54	
Greece	65	61.8	64.5	73	63.5	69.3
Hungary	50	50.6		52	47.8	48.7
Portugal	53	54.1	52.8	53	49.4	50.4
Poland	35	33.2		40	39.8	37.9
Czech Republic	40	43.9	40.7	46	44.9	44.7
Slovak Republic	40	43.5	44.8	46	45	43.5
Austria	88	100.7	89.5	81	80	75.9
Belgium	108	110.8	106.7	98	93.5	92.5
Denmark	94	101	89.4	80	80.4	75.4
Mexico	30	33		33	36.2	

Notes: [a] and [d]: PPP 2002; [b] and [e]: 1999 EKS $.; [c] and [f]: PPS. Explanations regarding country groupings in this table are given in the following section "Labour productivity …".

1. European Union of 15 countries for Eurostat, 19 countries for OECD.

Sources: [a] and [d]: OECD (http://www.oecd.org/dataoecd/30/40/29867116.xls) and Pilat (2004); [b] and [e]: Groningen Growth and Development Centre and The Conference Board, Total Economy Database, February 2004; [c] and [f]: Eurostat - Structural indicators database.

- According to this, the countries with the highest hourly labour productivity levels are in Europe. In Belgium, France, Ireland and Norway, they appear to be particularly high. This suggests it is not the United States that is currently setting the "technical frontier" but rather some European countries.

- Given the comparatively low hourly productivity of some European countries like Spain and more particularly Portugal and Greece, hourly productivity, in the European Union of 15 Member States, would appear to be markedly lower (by some 10 to 20 percentage points) than the United States average. The gap also appears to be large in the United Kingdom (some 15 to 20 points), Canada (some 15 points) and Japan (25 to 30 points).

At the same time, among the countries with hourly labour productivity levels similar to those of the United States (with a difference of less than 10 points), the hours worked and employment rates (except in Norway, the Netherlands and Denmark) are markedly lower than those observed in the United States (Table 2). The gap is particularly large for hours worked in the Netherlands and, to a lesser extent, Germany, Belgium and France; and for the employment rate in Italy, Spain and Belgium and, to a lesser extent, France, Germany and Ireland. We should point out that the lower number of hours worked may stem from shorter full-time working hours or a higher level of part-time work, or even from a combination of the two, as is the case in the Netherlands. The lower employment rate may stem (in quantitative terms) from a lower participation rate or a higher unemployment rate.

Table 2. **Hours worked and employment rates, in 2002**

Country	**Average annual hours worked**	**Part-time employment**[1] as a % of total employment	**Employment rate** as a % of population aged 15 – 64	**Labour force participation** as a % of population aged 15 – 64	**Unemployment rate** as a % of labour force
United States	1 800	13.0	71.9	76.4	5.8
European Union (19)	1 619		62.9	69.1	8.9
Euro zone	1 548				
Japan	1 798	25.1	68.2	72.3	5.6
OECD	1 739		65.1	69.9	6.9
Germany	1 443	18.8	65.3	71.5	8.6
Australia	1 824	27.5	69.2	73.7	6.1
Canada	1 731	18.7	71.5	77.4	7.7
Spain	1 813	7.6	59.5	67.1	11.4
Finland	1 727	11.0	67.7	74.5	9.1
France	1 437	13.7	62.2	68.3	8.9
Ireland	1 666	18.1	65.0	67.9	4.3
Italy	1 599	11.9	55.6	61.2	9.1
Norway	1 342	20.6	77.1	80.3	4.0
Netherlands	1 338	33.9	73.2	75.6	3.1
United Kingdom	1 692	23.0	72.7	76.6	5.1
Sweden	1 581	13.8	74.9	79.0	5.2
Korea	2 410	7.6	63.3	65.4	3.2

Greece	1 928	5.6	56.9	63.1	9.8
Hungary	1 766	2.8	56.2	59.7	5.8
Portugal	1 697	9.6	68.1	72.0	5.4
Poland	1 958	11.7	51.7	64.8	20.3
Czech Republic	1 980	2.9	65.7	70.9	7.3
Slovak Republic	1979	1.6	56.9	69.9	18.6
Austria	1 567	13.5	65.8	68.7	4.2
Belgium	1 547	17.2	59.7	64.1	6.9
Denmark	1 462	16.2	76.4	79.9	4.3
Mexico	1 888	13.5	60.1	84.7	2.4

Note: Explanations as to the country groupings in this table are given in the following section "Labour productivity …".

1. Part-time work here means an average of fewer than 30 hours per week.

Source: OECD Labour Market Statistics and Pilat (2004).

Differences in hours worked and employment rates across countries may affect relative productivity levels, as the returns to these two parameters are not constant:

- It is often assumed with regard to hours worked that the effects of fixed costs (which produce increasing returns to hours worked), stemming for instance from the inclusion in hours worked of periods of time that are hard to shorten and not directly productive, are outweighed by the effects of fatigue (which produce diminishing returns). Consequently, returns to hours worked are assumed to be diminishing in the aggregate.[5] The assumption that there are strong fatigue effects may seem surprising given that the working week is at a fairly historic low in many industrialised countries. It should be borne in mind that hours worked are given here as an annual average and that these fatigue effects also include leave and sick-leave effects.

- The assumption of constant returns to the employment rate could be accepted if we assume that employment-rate differentials are identical across all working-age categories. Yet a close look at the employment-rate gap between Western Europe and the United States shows that this assumption should be categorically rejected (see Table 3). Breaking the working-age population down by gender and into three age groups (young, adults and older), we see that the differences in the employment rates are negligible for adult men and women (except for adult women in Italy, Spain, Greece and Ireland) and that they are concentrated in the younger age group (the employment-rate gap with the United States is at least 20 points in France, Italy, Greece and Belgium) and the older age group (the gap is at least 20 points in those same four countries, as well as in Germany, Spain and Austria). The productivity of younger and older people who are not in employment can be considered to be lower than that of adults in employment. In the case of younger people, the differential stems from the fact that the more productive are hired first; as for older people not in employment, it stems from a loss of human capital, since older people who are still in their jobs have probably maintained or even increased their human capital more than those who are no longer in employment. In European countries, the foreseeable increase in the average employment rate will concern mainly these two age groups (younger and older people not in employment), which means that returns to the employment rate will be diminishing.[6] At this point it is important to stress that the analysis of linkages between employment and productivity focuses, in this study, on the productivity of labour-market "*outsiders*" whereas previous work focused on "*insiders*". Use of the existing literature on this subject is accordingly limited (see above).

Table 3. **Employment rates in 2002** (%)

Country	Population aged 15 – 64	Population aged 15 - 24	Population aged 25 - 54			Population aged 55 - 64
	Total	Total	Total	Men	Women	Total
United States	71.9	55.7	79.3	86.6	72.3	59.5
European Union (19)	62.9	37.4	76.2	85.4	67.0	39.2
Japan	68.2	41.0	78.0	92.0	63.9	61.6
OECD	65.1	43.7	75.5	87.0	64.1	49.4
Germany	65.3	44.8	78.8	85.6	71.8	38.6
Australia	69.2	59.6	77.1	85.8	68.4	48.2
Canada	71.5	57.3	80.2	85.3	75.2	50.4
Spain	59.5	36.6	70.1	85.8	54.2	39.7
Finland	67.7	39.4	81.6	84.0	79.1	47.8
France	62.2	24.1	79.4	87.4	71.6	39.3
Ireland	65.0	45.3	76.6	87.6	65.6	48.0
Italy	55.6	26.7	70.1	86.0	54.0	28.9
Norway	77.1	56.9	84.4	88.1	80.6	68.4
Netherlands	73.2	66.9	81.9	91.2	72.5	41.8
United Kingdom	72.7	61.0	80.6	87.2	73.8	53.3
Sweden	74.9	46.5	84.2	85.9	82.4	68.3
Korea	63.3	31.5	73.4	88.7	57.7	59.5
Greece	56.9	27.0	71.5	89.0	54.7	39.2
Hungary	56.2	28.5	73.0	79.7	66.5	25.6
Portugal	68.1	41.9	81.5	89.4	74.0	50.9
Poland	51.7	20.0	67.5	73.1	61.9	27.9
Czech Republic	65.7	33.7	82.5	90.2	74.6	40.8
Slovak Republic	56.9	27.2	75.1	79.5	70.6	22.9
Austria	65.8	48.7	80.1	86.8	73.2	27.6
Belgium	59.7	28.5	76.6	86.2	66.8	25.8
Denmark	76.4	64.0	84.7	88.7	80.8	57.3
Mexico	60.1	46.0	68.4	94.5	45.8	53.1

Note: The country groups in this table are explained in the following section "Labour productivity …".

Source: OECD Labour Market Statistics.

Thus, increasing hours worked and employment rates in continental European countries would lower the comparative level of hourly labour productivity there. In other words, the strong hourly productivity performance of many European countries compared with the United States cannot be attributed solely to good causes: their performance is boosted by the fact that average hours worked are much fewer than in the United States and that employment is heavily concentrated in the most productive segments of the population. The less productive segments (in this case younger and older persons or adult women) are voluntarily or involuntarily excluded from employment.

Labour productivity, employment rates and hours worked: an aggregate approach

The variables are defined in the box below and details of sources are given in the Annex. We shall be looking in turn at the estimated relationship, the results of estimates using the OLS method and those obtained using instrumental variables.

Estimated relationship

An analysis of the impact on labour productivity of changes in the employment rate and hours worked may initially be envisaged using econometric estimates of the following dynamic relationship (1), based in part on estimates by Gust and Marquez (2002, 2004) or Bélorgey, Lecat and

Maury (2004), in which the explained variable (Δph) corresponds to the rate of change in hourly labour productivity (PH):

$$\Delta ph = a_1.\Delta ph_{-1} + a_2.\Delta ER + a_3.\Delta h + a_4.\Delta CUR + \sum_{i \geq 5} a_i.X_i + cte + u \qquad (1)$$

where:

- The estimates are conducted on relationship (1) in its dynamic or static form (by constraining $a_1 = 0$). The expected sign of a_1 is *a priori* uncertain, the sole constraint on this coefficient being $|a_1| < 1$. If $a_1 > 0$, the long-term effect of a change in the other variables is greater (in absolute terms) than the short-term effect. For example, an increase in the employment rate (ER) reduces hourly productivity, but less in the short term than in the long term as firms may temporarily offset the effect of hiring less productive people by increasing rates of work. Conversely, if $a_1 < 0$, the long-term effect of change in the other variables is smaller than the short-term effect. In the same example, this means that an employment-rate increase reduces hourly productivity more sharply in the short term than in the long term as the people concerned gradually close some of their productivity gap, the initial gap being to some extent caused by a loss of human capital, stemming from the fact that they were previously not in employment.

- The coefficients a_2 and a_3 reflect the short-term effects of absolute changes in the employment rate (ΔER) and the rate of change in hours worked (Δh) on hourly productivity. *A priori* we expect: $-1 < a_2, a_3 \leq 0$.

- The coefficient a_4 reflects the effects of the economic cycle on hourly productivity, the position in the cycle being quite simply measured by the capacity utilisation rate (CUR). *A priori* we expect to find: $0 < a_4$.

- There are numerous other variables X_i that may affect labour productivity. Those whose effects have been tested here are investment rates (INVR, with an expected coefficient that is positive), ICT production as a share of GDP (ITPR, positive), ICT spending as a share of GDP (ITSR, positive), the ICT investment rate (ITIR, positive),[7] R&D spending as a share of GDP (R&DSR, positive), internet users as a share of the population (IUR, positive), the change in self-employment as a share of total employment (ΔSER, uncertain), the change in part-time employment as a share of total employment (ΔPTR, uncertain)[8] and the change in public employment as a share of total employment (ΔPER, uncertain). The choice of these variables was to some extent dictated by previous studies, such as those by Gust and Marquez (2002, 2004) and Belorgey, Lecat and Maury (2004) which focus on the impact of ICT on productivity. Both studies show that the acceleration in productivity in the United States in the second half of the 1990s was in part due to the size of the ICT producing sector and to the widespread diffusion of ICTs there. As this is a first-difference study, many of the determinants of productivity that are very stable in every country over the period concerned (*e.g.* human capital) have not been used. For the same reason, the impact of missing level variables has not been captured by the fixed effects tested for, as they are not significant in any of the 14 countries that were eventually selected.

The specification represented by relationship (1) is obviously very simplistic. In particular, the dynamic effects are represented by the mere presence of an autoregressive term and are therefore assumed to be identical for all of the relevant explanatory variables. Furthermore, the effects of each explanatory variable on productivity are assumed to be the same, regardless of the variable's actual level, which is also a powerful simplifying assumption. The assumption regarding non-linear effects is quite plausible as an economic reality. So the results of the estimates set out below should be viewed with the utmost caution: while the direction of the effects addressed here can be viewed as robust, their magnitude is bound to be very imprecise.

The estimates are based on annual data for the period 1992-2002 across a panel of 25 OECD countries, as listed in the box below. We have opted for a short estimation period (11 years) but the information required for our final choice of estimates was not always available over a longer period.

Box: **Variables used in the study**

The definitions and sources of these variables are given in the annex.

- PH: Hourly labour productivity;
- N: Total employment;
- POP: Working-age population;
- ER: Employment rate;
- ERC_j: Employment-rate contribution of category j. $ERC_j = N_j / POP$;
- $\overline{ERC_j}$: Employment-rate contribution of categories other than category j. $\overline{ERC_j} = ER - ERC_j$;
- SER: Self-employment as a share of total employment;
- PER: Public employment as a share of total employment;
- H: Average annual hours worked;
- PTR: Part-time employment as a share of total employment;
- CUR: Capacity utilisation rate, a variable centred and normed for each country using the average and standard deviation observed in France;
- INVR: Investment spending as a share of GDP (investment rate);
- ITPR: ICT production as a share of GDP;
- ITSR: ICT spending as a share of GDP;
- ITIR: ICT investment as a share of GDP (ICT investment rate);
- R&DSR: R&D spending as a share of GDP;
- IUR: Internet users as a share of the population;
- Q: Volume GDP;
- P: Consumer price index;
- Subscript $_{-1}$ indicates that the variable is lagged by one period;
- Subscript j indicates that the variable refers to category j;
- Δ before a variable means a difference of the first order;

- o above a variable gives its year-on-year growth rate;
- ^ above a coefficient gives its estimated value;
- Variables in lower case correspond to their logs.

List of the 25 OECD countries serving as a basis for this empirical study:

Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Mexico, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, United Kingdom and United States

List of 21 countries:

The previous list of 25 countries, excluding Austria, Belgium, Denmark and Mexico.

List of 14 countries:

The previous list of 21 countries, excluding the Czech Republic, Greece, Hungary, Korea, Poland, Portugal and the Slovak Republic.

Estimation results using the OLS method

The estimates of dynamic relationship (1) ($a_1 \neq 0$) or static relationship (1) ($a_1 = 0$) obtained using the ordinary least squares method (OLS) produce the following results (see Table 4):

Table 4. **Estimation results for relationship (1)**

OLS – Estimation period: 1992-2001

A. Estimate of static relationship 1 ($a_1 = 0$)

Explanatory variables	25 countries [1]	21 countries [2]	14 countries [3]	14 countries [4]	14 countries [5]	14 countries [6]	14 countries [7]	14 countries [8]	14 countries [9]	14 countries [10]
ΔER	-0.212 (0.044)	-0.196 (0.043)	-0.203 (0.039)	-0.191 (0.039)	-0.203 (0.039)	-0.196 (0.040)	-0.219 (0.040)	-0.219 (0.044)	-0.204 (0.040)	-0.200 (0.048)
Δh	-0.721 (0.085)	-0.551 (0.095)	-0.583 (0.118)	-0.645 (0.119)	-0.559 (0.118)	-0.578 (0.119)	-0.572 (0.118)	-0.573 (0.119)	-0.587 (0.123)	-0.581 (0.119)
ΔCUR	0.150 (0.025)	0.114 (0.027)	0.086 (0.024)	0.079 (0.023)	0.083 (0.024)	0.081 (0.024)	0.080 (0.024)	0.089 (0.024)	0.086 (0.024)	0.086 (0.024)
INVR				-0.038 (0.015)						
ITPR	0.100 (0.030)	0.079 (0.029)	0.166 (0.029)	0.160 (0.029)	0.185 (0.030)	0.171 (0.030)	0.178 (0.030)	0.165 (0.029)	0.166 (0.029)	0.166 (0.029)
ITSR					-0.059 (0.030)					
IUR						-0.003 (0.003)				
R&DSR							-0.136 (0.064)			
ΔSER								-0.094 (0.124)		
ΔPTR									-0.012 (0.078)	
ΔPER										0.015 (0.128)

Cte	0.005	0.006	ε	0.008	0.003	ε	0.002	ε	ε	ε
	(0.005)	(0.002)	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Adjusted R²	0.308	0.214	0.341	0.366	0.355	0.340	0.351	0.339	0.336	0.336

B. Estimate of dynamic relationship 1 ($a_1 \neq 0$)

Explanatory variables	25 countries [1]	21 countries [2]	14 countries [3]	14 countries [4]	14 countries [5]	14 countries [6]	14 countries [7]	14 countries [8]	14 countries [9]	14 countries [10]
Δph_{-1}	0.181	0.234	0.116	0.086	0.095	0.110	0.108	0.116	0.117	0.116
	(0.053)	(0.058)	(0.074)	(0.074)	(0.074)	(0.074)	(0.075)	(0.074)	(0.074)	(0.074)
ΔER	-0.185	-0.169	-0.198	-0.188	-0.199	-0.192	-0.212	-0.214	-0.200	-0.193
	(0.044)	(0.042)	(0.039)	(0.039)	(0.039)	(0.040)	(0.040)	(0.044)	(0.040)	(0.048)
Δh	-0.745	-0.563	-0.567	-0.628	-0.548	-0.564	-0.556	-0.557	-0.574	-0.566
	(0.084)	(0.092)	(0.118)	(0.119)	(0.118)	(0.118)	(0.118)	(0.119)	(0.122)	(0.119)
ΔCUR	0.158	0.115	0.085	0.079	0.082	0.080	0.079	0.087	0.085	0.085
	(0.025)	(0.026)	(0.024)	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
INVR				-0.034						
				(0.015)						
ITPR	0.079	0.064	0.147		0.169	0.155	0.161	0.148	0.150	0.149
	(0.031)	(0.029)	(0.032)		(0.033)	(0.032)	(0.032)	(0.031)	(0.031)	(0.031)
ITSR					-0.053					
					(0.030)					
IUR						-0.002				
						(0.003)				
R&DSR							-0.126			
							(0.064)			
ΔSER								-0.094		
								(0.123)		
ΔPTR									-0.019	
									(0.078)	
ΔPER										0.025
										(0.128)
Cte	0.004	0.004	ε	0.007	0.002	ε	0.002	-ε	ε	ε
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Adjusted R²	0.339	0.272	0.348	0.368	0.358	0.346	0.356	0.346	0.343	0.343

Notes: The numbers in brackets below the coefficients are standard deviations. For details of the lists of 25, 21 and 14 countries, see box.

- The estimated values of some coefficients are not stable to the list of countries. For instance, *i)* the coefficient for the rate of change in hours worked (Δh) is strongly impacted by the inclusion of Austria, Belgium, Denmark and Mexico on the list of countries (differences between columns [1] and [2] in Tables 4A and B); *ii)* the coefficients for changes in the capacity utilisation rate (Δ CUR), ICT production as a share of GDP (ITPR) and the autoregressive term (Δph_{-1}) are strongly impacted by the inclusion of the same four countries (differences between columns [1] and [2] in Tables 4A and B) plus the Czech Republic, Greece, Hungary, Korea, Poland, Portugal and the Slovak Republic on the list (differences between columns [2] and [3] Tables 4A and B). Both of these country groups are fairly specific: the first group of four countries comprises three small European countries for which some of the data used have occasionally had to be reconstituted, plus another country, Mexico, for which the available data are still somewhat imprecise; the second group comprises countries in Asia and Southern or Eastern Europe which are still trying to catch up with the more advanced industrialised countries. As these estimated coefficients are unstable to the list of countries, the emphasis is placed on analysing the results for the 14 most industrialised countries, none of which are shown by the estimates to have a marked impact on the results. Moreover, for this same group of 14 countries, the estimates also appear to be robust when one or two years of observation are withdrawn.

- The coefficients of the variables for investment rates (INVR), ICT spending as a share of GDP (ITSR), the internet user ratio (IUR) and R&D spending as a share of GDP (R&DSR) carry the opposite sign to the one expected and are usually not significantly different from zero. Furthermore, the coefficients of the variables for changes in the rate of self-employment (ΔSER), part-time employment (ΔPTR) and public employment (ΔPER) are not significant in any of the estimates. Consequently, these variables will not feature on the list of explanatory variables. The study therefore focuses on the estimates whose results are set out in column [3] of Tables 4A and B.

- The estimation results of the static and dynamic relationships are consistent with regard to long-term effects. According to the dynamic formulation (Table 4B, column [3]), it emerges that *i)* a one-point change in the employment rate has an inverse effect on hourly productivity of 0.20% in the short term (the same year) and 0.22% in the long term; *ii)* a 1% change in hours worked has an inverse effect on hourly productivity of 0.57% in the short term and 0.64% in the long term; *iii)* a one-point change in the utilisation rate has a parallel effect on hourly productivity of 0.09% in the short term and 0.10% in the long term; *iv)* a one-point change in ICT production as a share of GDP has a parallel effect on growth in hourly productivity of 0.15% in the short term and 0.17% in the long term.

The results obtained can be compared with the only two previous studies proposing estimates of identical or similar relationships:

- Gust and Marquez (2002, 2004), using OLS or GLS on the private sector alone over the period 1993-2000, have estimated a relationship very similar to static relationship (1) on a panel of 13 countries (plus Ireland in our own panel of 14 countries) over the 1990s.[9] They do not take into account the effect of change in hours worked, and the measurement of the position in the cycle is an OECD estimation of the GDP differential, where the coefficient is not significant. ICT production as a share of GDP and ICT spending as a share of GDP are, along with changes in the employment rate, explanatory variables whose coefficients are significant and have the expected signs. The effect of a change in the employment rate, measured by the employed share of the 15-and-over age group, is 3.5 to 4 times stronger than the one estimated here for the change in the employment rate measured by the employed share of the 15-64 age group. There are many possible reasons for the differential, including a difference in coverage (private economy or economy as a whole), a difference in the definition of the relevant variable (employment rate in the 15-and-over age group or the 15-64 age group), or a difference in the panel (presence or absence of Ireland, period covered).[10]

- Bélorgey, Lecat and Maury (2004) also propose an estimate of a very similar relationship, using the GMM (Generalised Method of Moments) or OLS techniques, on a panel of 25 countries or the same 13 countries as in the previous study, over the period 1992-2000.[11] The explanatory variables for changes in productivity are variations in the employment rate, hours worked, the capacity utilisation rate and the level of ICT production and spending as a share of GDP. Changes in the utilisation rate always affect changes in productivity, with a coefficient very similar to the one estimated here (0.1% of productivity for a one-point variation in the utilisation rate). ICT production and spending as shares of GDP have a joint effect on changes in productivity, but the production effect alone is specifically significant, as in our measurement. Finally, a 1% increase in hours worked or in the employment rate reduces hourly productivity by some 0.65% and 0.3%, respectively, for the 25-country panel and by 0.8% and 0.4% for the 13-country panel. These results are similar to ours, given the differences in the samples.

Estimation results using the instrumental-variables method

The estimation results presented above may be subject to simultaneity bias. To correct for this, the study continues using instrumental variables. Bélorgey, Lecat and Maury (2004) used GMM, but their estimates were based on 25 countries, including those that have just been shown to have a strong impact on estimation outcomes. The focus of this study is confined to 14 countries, a sample too small to envisage using GMM.

Three tests are used to assess adjustment quality: the Nelson and Startz test (1990a and 1990b) and the Sargan test (1958), which tell us about the overall quality of the adjustment and the overall relevance of the instruments, and the Durbin-Wu-Hausman test (Durbin, 1954; Wu, 1973; Hausman, 1978) to ensure that the instruments are exogenous.

As with estimates using the OLS method, the variable coefficients for investment rates (INVR), ICT spending rate (ITSR), R&D spending (R&DSR), changes in the rate of self-employment (ΔSER), part-time employment (ΔPTR) and public employment (ΔPER) always showed an implausible order of magnitude, and all of these variables were eventually removed from the list of explanatory variables. We also conducted a more in-depth analysis of the impact of ICT investment as a share of GDP (ITIR) and its findings are set out and discussed below. The instrumentation of explanatory variables is aimed at correcting for two types of specification bias in the estimates: bias stemming from certain errors of measurement that are inevitable with the variables used and bias caused by simultaneity between those same variables. Many ranges of instruments were tested for relevance. The most satisfactory (column [8] in Table 5), namely the one that produces plausible results and is validated by all three tests, is obtained for relationship (1) estimated as dynamic ($a_1 \neq 0$), does not instrument the autoregressive term $(\Delta ph)_{-1}$, change in hours worked (Δh) or change in the capacity utilisation rate (Δ CUR) and opts to use as instruments for the other variables the second difference of the explained variable (Δ2(Δph)), present (Δq) and lagged variations (Δq_{-1}) in output, the lagged variation in the employment rate (ΔER_{-2}) and the investment rate (INVR). This is because there is evidence that using variations in hours worked or the capacity utilisation rate, in a static ($a_1 = 0$) or dynamic ($a_1 \neq 0$) form of relationship (1), always produces less satisfactory results (columns [1] to [7] of Table 5).

Table 5. **Estimation result for relationship (1)**

Instrumental variables method – period: 1992-2001

Explanatory variables	14 countries							
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Δph_{-1}		-0.379		-0.530		-0.296		-0.393
		(0.280)		(0.320)		(0.184)		(0.210)
ΔER	-0.583	-0.653	-0.701	-0.844	-0.675	-0.538	-0.789	-0.635
	(0.177)	(0.239)	(0.216)	(0.289)	(0.194)	(0.150)	(0.234)	(0.170)
Δh	-0.465	-0.209	0.419	0.655	-0.685	-0.726	-0.463	-0.531
	(0.583)	(0.738)	(0.687)	(0.893)	(0.260)	(0.221)	(0.281)	(0.239)
ΔCUR	0.225	0.203	0.065	0.065	-0.261	0.249	0.114	0.113
	(0.086)	(0.105)	(0.061)	(0.077)	(0.082)	(0.070)	(0.056)	(0.048)
ITPR	0.606	0.769	0.793	1.049	0.697	0.611	0.844	0.758
	(0.192)	(0.301)	(0.227)	(0.350)	(0.194)	(0.175)	(0.231)	(0.192)
Cste	-0.022	-0.027	0.030	-0.038	-0.027	-0.020	-0.034	-0.026
	(0.009)	(0.013)	(0.011)	(0.015)	(0.010)	(0.008)	(0.012)	(0.008)
Sargan test								
Statistic	3.556	2.734	6.175	2.137	0.958	4.760	4.176	7.921
P-value	0.314	0.434	0.103	0.544	0.811	0.190	0.243	0.047
Durbin-Wu-Hausman test								
Statistic	73.141	73.019	52.358	66.844	80.704	70.092	1.150	51.975
P-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nelson & Startz test								
$R^2 \cdot n$	44.744	11.2312	11.9957	105.737	18.543	51.291	23.199	21.406
Threshold: 2								

Notes: The numbers in brackets beneath the coefficients are their standard deviation. Lists of the 25, 21 and 14 countries are given in the box.

List of instruments:

[1]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; Δh_{-1}; ΔCUR_{-1}; INVR;
[2]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; Δh_{-1}; ΔCUR_{-1}; INVR; $(\Delta ph)_{-1}$;
[3]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; Δh_{-1}; INVR; ΔCUR;
[4]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; Δh_{-1}; INVR; ΔCUR; $(\Delta ph)_{-1}$;
[5]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; ΔCUR_{-1}; INVR; Δh;
[6]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; ΔCUR_{-1}; INVR; Δh; $(\Delta ph)_{-1}$;
[7]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; INVR; Δh; ΔCUR;
[8]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; INVR; Δh; ΔCUR; $(\Delta ph)_{-1}$.

The use of instrument $\Delta 2(\Delta ph)$ was questionable on the grounds of simultaneity. It was therefore replaced in supplementary estimates by the same variable lagged by one period. However, this change of instrument reduces the Durbin-Wu-Hausman statistic and produces long-term coefficients that are very similar to those given above. The results of these alternative estimates can be obtained from the authors on request.

The results thus obtained tell us that (column [8] of Table 5):

1. The use of instrumental variables substantially alters the impact of the autoregressive term. This is because, owing to the autoregressive nature of relationship (1), the OLS estimator is theoretically non-convergent (if the residuals do not all have the right homoscedasticity), unlike the instrumental variables estimator. Moreover, as the autoregressive term, by construction, has the most simultaneity with the other variables concerned, it is the most sensitive to the corrections for bias made by instrumental variables.

2. The long-term coefficients here would be smaller than the short-term ones, as the autoregressive term has a negative sign. Again, in the case of change in the employment rate

or hours worked, this means that there is a learning effect. This is particularly satisfying with regard to the effects of changes in the employment rate. For instance, while people who are of working age but not in work are markedly less productive than those in work, the transition to employment enables them gradually to increase their human capital and approach (but not attain) the productivity level of people in employment.

3. It emerges that in the long term, *i)* a one-point variation in the employment rate changes hourly productivity by -0.46% (compared with a short-term effect of -0.64%); *ii)* a 1% variation in hours worked changes hourly productivity by -0.38% (-0.53%); *iii)* a one-point change in the utilisation rate raises hourly productivity by 0.08% (0.11%); *iv)* a one-point change in ICT production as a share of GDP raises the growth in hourly productivity by 0.54% (0.76%). These long-term effects differ fairly markedly from those estimated using the OLS method, as described above. However, they are very similar to those estimated by Belorgey, Lecat and Maury (2004) using GMM on a panel of 25 countries, which indicate that in the long term: *i)* a one-point variation in the employment rate changes hourly productivity by –0.50% and *ii)* a 1% variation in hours worked changes hourly productivity by –0.36%.[12] But there is quite a difference in the short-term effects of both these variables and in short and long-term effects of changes in the utilisation rate or ICT production as a share of GDP, which are not used in the remainder of this study.

Some studies, such as that of Gust and Marquez (2002, 2004), have managed to identify an impact on productivity from ICT production but also an (only just significant) impact from ICT spending. Yet the influence of ICT spending as a share of GDP is not significant in the estimates described above. An interesting way of refining the analysis is to test the hypothesis of an impact of ICT investment spending alone as a share of GDP (ITIR). The results of the estimates are given in Table 6.

Table 6. **Estimation results for relationship (1)**

Impact of the ICT investment rate on productivity

Using the instrumental-variables method - Period: 1992-2001

Explanatory variables	14 countries	13 countries (list of 14 minus Norway)			
	[1]	[2]	[3]	[4]	[5]
Δph_{-1}	-0.393	-0.411	0.235	-0.402	-0.385
	(0.210)	(0.161)	(0.107)	(0.146)	(0.189)
ΔER	-0.635	-0.556	-0.164	-0.492	-0.583
	(0.170)	(0.117)	(0.089)	(0.097)	(0.139)
Δh	-0.531	-0.526	-0.879	-0.377	-0.654
	(0.239)	(0.175)	(0.249)	(0.162)	(0.279)
ΔCUR	0.113	0.108	0.130	0.082	0.127
	(0.048)	(0.036)	(0.046)	(0.032)	(0.051)
ITPR	0.758	0.620		0.604	0.599
	(0.192)	(0.122)		(0.110)	(0.143)
ITIR			0.007	-0.003	0.003
			(0.004)	(0.001)	(0.004)
Cste	-0.026	-0.020	-0.012	-0.011	-0.027
	(0.008)	(0.005)	(0.010)	(0.004)	(0.012)
Sargan test					
Statistic	7.921	17.703	37.177	25.641	13.145
P-value	0.047	0.001	0.000	0.000	0.001
Durbin-Wu-Hausman test					

Statistic	51.975	33.807	15.918	26.481	33.605
P-Value	0.000	0.000	0.000	0.000	0.000
Nelson & Startz test					
R^2*n	21.406	71.659	67.067	84.108	54.180
Threshold: 2					

Notes: The numbers in brackets beneath the coefficients are standard deviations. The lists of the 25, 21 and 14 countries are given in the box.

List of instruments:

[1]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; INVR; Δh; ΔCUR; $(\Delta ph)_{-1}$.;
[2]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; INVR; Δh; ΔCUR; $(\Delta ph)_{-1}$;
[3]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; INVR; Δh; ΔCUR; $(\Delta ph)_{-1}$;
[4]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; INVR; Δh; ΔCUR; $(\Delta ph)_{-1;}$ ITIR;
[5]: $\Delta 2(\Delta ph)$; Δq; Δq_{-1}; ΔER_{-2}; INVR; Δh; ΔCUR; $(\Delta ph)_{-1}$.

The ICT investment rate variable (ITIR) is only available for 13 of the 14 countries on the above list of countries, as the information is not available for Norway. To obtain a basis for comparison, therefore, we decided to repeat the most relevant of the previous estimates (column [8] of Table 5 repeated in column [1] of Table 6) using the smaller panel (column [2] of Table 6), leaving the remaining list of instruments unchanged. The outcome shows that the results with this smaller list of 13 countries do not differ markedly from those obtained earlier with the 14-country list (comparison of columns [1] and [2] of Table 6). The replacement, in the list of variables, of the ICT production rate (ITPR) by the ICT investment variable (ITIR) then destabilises all of the estimation results (column [3] of Table 6). In particular, the long-term elasticity of hourly productivity to hours worked falls to below -1, which is not economically plausible. Furthermore, while the sign is indeed positive as expected, the ICT investment rate coefficient is not significant. If the variables for the ICT production rate (ITPR) and the ICT investment rate (ITIR) are both present simultaneously, the coefficients for all of the variables other than the ICT investment rate (ITIR) are very similar to those estimated without the ICT investment rate variable (comparison of columns [4] and [5] with column [2] of Table 6). Furthermore, these two regressions prompt acceptance of the significant impact of ICT production and rejection of that of ICT investment. Thus, when ITIR is not instrumented (column [4] of Table 6), the sign for the coefficient of this variable appears to be implausible, which may stem from errors of measurement or simultaneity bias. Once this specification bias has been corrected by instrumenting the ICT investment rate (ITIR), the coefficient estimated for this variable is not significant (column [5] of Table 6).

These results confirm that the impact of ICT on productivity is clearer on our panel of countries with the presence of an explanatory variable giving the ICT production rate than with variables giving the ICT spending rate, even if that spending is for investment purposes.

Approach based on a breakdown of the working-age population

The results set out in Table 5 above confirm the idea that differences in employment rates and hours worked across the more advanced industrialised countries influence their comparative productivity. The effects of the employment rate on productivity have up to this point been addressed in the aggregate. It has been demonstrated above, however, that differences in employment rates concern different population groups, depending on the country. We should therefore look at the impact of an increase in the employment rate for each segment of the working-age population and each gender.

Methodology

Here we have opted to break the working-age population down into six separate categories by gender and age group (15-24, 25-54 and 55-64 years). The aim is to analyse the effect of a change in the aggregate employment rate caused by a change in the employment rate of each of these categories. Consequently the explanatory variables used here are the contributions of each category to the aggregate employment rate (rather than the employment rates of each category). These contributions, represented as ERC_j, are equal to N_j/POP where N_j is the number of employees in category j and POP the working-age population. This breakdown facilitates the interpretation of the estimated coefficients, with the coefficient of ΔERC_j corresponding to the effect on productivity of a one-point change in the aggregate employment rate stemming from a change in the employment rate of working-age category j. It also provides some interesting additivity, since the effect of an increase in the aggregate employment rate can be approximated by calculating the weighted sum of the coefficients for each contribution.[13] This additivity makes it possible to check the model's specification by looking at whether this weighted sum is equal to the short-term coefficient attached to the aggregate employment rate, *i.e.* -0.635 (see Table 5, column [8]).

Estimating the model described in the first section but distinguishing the six contributions to changes in the aggregate employment rate produces implausible results, as some coefficients do not have the expected sign or are of an implausible order of magnitude. It therefore proved necessary to constrain the coefficients of the other variables in the estimate of relationship (1) to their previously estimated values (Table 5, column [8]). Estimates were thus carried out on each category of the working-age population based on the relationship:

$$\Delta ph - \hat{a}_1.\Delta ph_{-1} - \hat{a}_3.\Delta h - \hat{a}_4.\Delta CUR - \sum_{i \geq 5} \hat{a}_i.X_i = b_{1,j}.\Delta ERC_j + b_{2,j}.\Delta \overline{ERC}_j + cte + v \qquad (2)$$

where:

ERC_j is the contribution of category j to the employment rate and $\overline{ERC_j}$ is the sum of the contributions to the employment rate of all the other categories combined. Coefficients $\hat{a}_i$ are the estimated values of the coefficients corresponding to relationship (1), set out in Table 5, column [8].

Relationship (2) was estimated using the instrumental-variables method, so as to correct for simultaneity effects. Three considerations guided the search for the right specification:

1. Regarding the estimate for each category j, the recalculated aggregate coefficient had to be consistent with the one estimated directly at the aggregate level in the previous section (-0.635).

2. Regarding the six estimates combined, the recalculated aggregate coefficient had to be consistent with the one estimated directly at the aggregate level in the previous section (-0.635).

3. The range of instruments used for each of the six estimates had to be relatively stable. We therefore began by using the same instruments as for the aggregate estimate. Subsequently, the only variables added to the initial range were those relating to employment.

The methodology used here is a simple quantitative breakdown of the short-term effect on productivity of changes in the aggregate employment rate estimated above (-0.635). This is why it is crucial that the estimates relating to each of the six relevant categories be consistent with the aggregate estimate.

Employment-rate effects by age group and gender

Estimating relationship (2) on the basis of the three considerations above produces the results set out in Table 7.

For the estimate regarding women aged 55 to 64, a dummy variable had to be added for Spain. There, that particular category of the working-age population is characterised by an atypically low employment rate (20.1% in 2000) compared with other countries (37.1% across the OECD area).

Table 7. **Estimation results for relationship (2)**

Instrumental variables method – Period: 1992-2001

Explanatory variables	Men aged 15-24	Women aged 15-24	Men aged 24-55	Women aged 25-54	Men aged 55-64	Women aged 55-64
	[1]	[2]	[3]	[4]	[5]	[6]
ΔERj	-0.893	-0.898	-0.488	-0.486	-0.889	-0.920
$\Delta \overline{ER_j}$	-0.550	-0.575	-0.679	-0.706	-0.621	-0.622
DSpain						0.008
Constant	-0.027	-0.027	-0.026	-0.027	-0.026	-0.027
Effect of recalculated ΔTE on the regression	-0.609	-0.602	-0.615	-0.635	-0.636	-0.630
Non-centred R^2	0.882	0.881	0.882	0.879	0.880	0.885
Durbin-Wu-Hausman test						
Statistic	19.412	21.686	19.753	25.609	18.130	17.208
P-Value	0.000	0.000	0.000	0.000	0.000	0.000
Nelson & Startz test						
$R^2 * n$	122.542	122.445	122.570	122.250	122.376	123.071
Threshold: 2						

Notes: List of instruments:

[1]: $\Delta2(\Delta ph)$; $(\Delta ph)_{-1}$; Δq; Δq_{-1}; INVR; Δh; ΔCUR; $(\Delta ERC_j)_{-2}$; $(\Delta ERC_{sex})_{-2}$; $(\Delta ERC_{âge})_{-2}$; ΔPTR; ΔPTR_{-1}; ΔSER; ΔSER_{-1};
[2]: $\Delta2(\Delta ph)$; Δq; Δq_{-1}; INVR; Δh; ΔCUR; $(\Delta ERC_j)_{-1}$; $(\Delta ERC_{sex})_{-1}$; $(\Delta ERC_{âge})_{-1}$; ΔPTR_{-1}; ΔSER_{-1};

[3]: $\Delta2(\Delta ph)$; $(\Delta ph)_{-1}$; Δq; Δq_{-1}; INVR; Δh; ΔCUR; $(\Delta ERC_j)_{-1}$; $(\Delta \overline{ER_j})_{-1}$; ΔPTR_{-1}; ΔPTR;

[4]: $\Delta2(\Delta ph)$; $(\Delta ph)_{-1}$; Δq; Δq_{-1}; INVR; Δh; ΔCUR; $(\Delta ERC_j)_{-2}$; $(\Delta ERC_{sex})_{-1}$; $(\Delta ERC_{âge})_{-1}$; ΔPTR; ΔPTR_{-1}.;
[5]: $\Delta2(\Delta ph)$; Δq; Δq_{-1}; INVR; $(\Delta ERC_j)_{-1}$; $(\Delta ERC_{sex})_{-2}$; $\Delta ERC_{âge}$; ΔPTR; ΔPTR_{-1}; ΔSER_{-1};
[6]: $\Delta2(\Delta ph)$; Δq; Δq_{-1}; INVR; ΔCUR; $(\Delta ERC_j)_{-1}$; $(\Delta ERC_{sex})_{-2}$; $\Delta ERC_{âge}$; ΔPTR_{-1}; ΔSER_{-1}; dSpain;

where: ERC_{sex} is the employment-rate contribution of people of the same gender as those in the relevant category, and $ERC_{âge}$ the employment-rate contribution of those of the same age as those in the relevant category.

Each of these six estimates produces a recalculated aggregate employment-rate effect that is very similar to the one estimated previously from relationship (1). Furthermore, the Nelson and Startz and Durbin-Wu-Hausman tests indicate that for each estimate, the instruments used appear to be exogenous and to correct the simultaneity bias appropriately.

Comparative effects on productivity of employment-rate changes in each category

The short-term effects on labour productivity of a one-point variation in the aggregate employment rate caused by a change in the employment rate in one of the six categories of persons concerned are obtained directly from the estimates of relationship (2) set out in Table 7. From these coefficients we can calculate, as described above, the same short-term effects on aggregates by gender or age or on all those of working age. Finally, we can associate with each of these short-term effects a long-term effect based on an estimate of the autoregressive term in dynamic relationship (1).[14] All of these effects are set out in Table 8. The method used to calculate the aggregate effect on several categories is not strictly speaking an arithmetical average (see note 13). So the value of the semi-elasticity recalculated for aggregate categories is not necessarily included in the interval defined by the semi-elasticities of the various categories concerned.

Table 8. **Effects on labour productivity of a one-point change in the employment rate induced by a change in the employment rates of various working-age categories**

For each category of the working-age population, the first line gives the short-term effect and the second line the long-term effect.

	15 to 24	25 to 54	55 to 64	Aggregate
Women	-0.898	-0.486	-0.920	-0.790
	-0.645	-0.349	-0.660	-0.567
Men	-0.893	-0.488	-0.889	-0.683
	-0.641	-0.350	-0.638	-0.490
Aggregate	-0.895	-0.487	-0.900	-0.626
	-0.642	-0.350	-0.646	-0.449

Notes: For the reason given in the study, the value of the semi-elasticity recalculated for aggregate categories is not necessarily included in the interval defined by the semi-elasticities of the various categories concerned.

Interpretation: A one-point increase in the aggregate employment rate induced by an increase in the employment rate of women aged 15 to 24 would bring down hourly labour productivity by 0.898% in the short term (the same year) and 0.645% in the long term.

For the reasons described above, the effects set out in Table 8 for one category of the working-age population cannot be directly interpreted as information on the productivity of that particular category, in respect of either those in the category who are employed or all those of working age. Regarding such effects, the differences between categories should not be directly interpreted as productivity gaps between the two categories but rather as productivity gaps between people in each category who are currently not employed but would be the first to move into employment. Such comparisons require caution since the effects are an average for all 14 countries and may mask differences between countries that stem from salient features such as the employment rates in each category. This is because the actual impact of a change in a particular category's contribution to the aggregate employment rate is likely to vary from one country to another, depending on the initial level of the employment rate in that category.

The productivity effects of a variation in the aggregate employment rate stemming from a variation in the employment rate of working-age people in the younger age group (15 to 24) and older age group (55 to 64) are markedly greater than for those in the middle age group (25 to 54). Yet we saw above that employment-rate differentials between the larger industrialised countries and in particular *vis-à-vis* the United States concern mainly younger and older members of the working-age population. This means that differences in employment rates can heavily impact on relative levels of hourly productivity. In particular, they can contribute to a marked increase in the hourly productivity of many countries *vis-à-vis* the United States. Furthermore, owing to structure effects (as the semi-elasticities are similar for men and women in each of the three age groups), the productivity effects of a variation in the aggregate employment rate stemming from a change in the employment rate of women are slightly greater than for men.

The effects of an increase in the employment rate in the 15-24 age group may look substantial: a one-point rise in the employment rate stemming from an increase in the employment rate of younger people would bring about a long-term decrease of 0.64% in hourly labour productivity. This calls for two comments: *i)* first, some of the young people concerned may be underachievers and their productivity may actually be markedly lower than average for those in employment; *ii)* any person in this category eventually moves into the higher age group (25 to 54) where productivity is similar or identical to that of the average person in employment. This individual dynamic dimension certainly puts into perspective the scope of any estimated effects on productivity that may be produced by an increase in the employment rate of the younger age group. The effects of an increase in the employment rate in the 55-64 age group may also look substantial. Again, this calls for three comments, which may help to explain the importance of this effect: *i)* some members of this age group have worked little if at all and so have little work experience; *ii)* others have failed to maintain their human capital and may have accordingly lost their jobs; *iii)* some of those aged 55 to 64 who enter employment (or re-enter after a period of non-employment) are not going to make a genuine effort to develop their human capital, given their fast-approaching retirement.

From observed productivity to structural productivity

To calculate "structural" productivity compared with the United States, the long-term coefficients of hours worked and the employment rate were applied to the differences (*vis-à-vis* the United States) "observed" for both of these variables. In this approach, it is assumed that the effects estimated above of annual changes in each variable in each country can be transposed so as to gauge the effects of what may be large differences for the same variables across countries, which is again a highly simplifying assumption. The following calculations should therefore be viewed with the utmost caution.

An initial measurement of the effects of employment-rate differences can be obtained from estimates at the aggregate level (see Table 5, column 8). A second measurement is based on estimates for each of the six categories of the working-age population (Table 7). This disaggregate measurement also produces a structure effect for the working-age population.[15]

The results obtained using these different approaches are set out in Table 9.

Table 9. **Effects of employment-rate differences with the United States on the relative level of hourly labour productivity in 2002**

In % points of hourly productivity in the United States

	Aggregate approach	Approach based on categories of the working-age population								
		Men aged 15-24	Women aged 15-24	Men aged 24-55	Women age 25-54	Men aged 55-64	Women aged 55-64	Total employ-ment rate effects	Structure effect	Total
	[a]	[b]	[c]	[d]	[e]	[f]	[g]	[h]	[i]	[j]
Germany	-3.0	-1.1	-1.1	-0.2	-0.6	0.0	-0.7	-3.6	0.7	-2.9
Australia	-1.2	0.5	0.5	-0.2	-0.7	-0.1	-0.8	-1.0	0.4	-0.6
Canada	-0.2	0.1	0.2	-0.0	0.2	-0.2	-0.6	-0.4	0.0	-0.4
Spain	-5.7	-1.0	-1.6	0.2	-2.3	-0.2	-1.5	-6.3	-0.1	-6.4

United States	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Finland	-1.9	-1.2	-1.0	-0.4	0.1	-0.2	0.2	-2.5	0.8	-1.7
France	-4.5	-1.8	-2.1	-0.1	-0.4	-0.8	-0.8	-5.9	0.5	-5.4
Ireland	-3.2	0.4	0.0	-0.5	-1.5	-0.2	-1.3	-2.9	1.2	-1.7
Italy	-7.4	-1.8	-2.2	0.1	-2.4	-0.7	-1.6	-8.6	0.2	-8.3
Japan	-1.7	-1.1	-1.0	0.3	-1.6	1.7	0.5	-1.3	1.0	-0.3
Norway	2.4	-0.4	-0.3	0.5	0.7	1.0	0.9	2.4	0.0	2.4
Netherlands	0.6	0.3	0.3	1.0	-0.1	-0.2	-1.2	0.1	-0.3	-0.2
United Kingdom	0.3	0.0	-0.2	0.3	-0.1	0.4	-0.1	0.3	0.1	0.4
Sweden	1.4	-1.1	-0.9	-0.1	0.5	1.5	1.6	1.6	0.6	2.2

Notes: [h] = [b] + [c] + [d] + [e] + [f] + [g] and [j] = [h] + [i]. Details of how these effects were calculated are given in the study.

Interpretation: If France had the same employment rates as the United States, hourly labour productivity would be 4.5% lower using the aggregate approach and 5.3% lower using the approach based on working-age categories, as the effect is broken down into a negative effect of 5.9% for employment-rate effects alone and a positive effect of 0.5% for the structure effect.

The effects obtained here using the aggregate approach are often smaller than those measured by Cette (2004, 2005), owing to the semi-elasticity of productivity to the lowest employment rate in absolute terms. Again, the elasticity selected here appears more robust to the list of countries in the sample.

In four countries the employment-rate difference with the United States is found to lower hourly productivity, namely the Netherlands using the aggregate approach and Norway, Sweden and the United Kingdom using both approaches. In these four countries, the aggregate employment rate is higher than in the United States. Everywhere else, employment-rate gaps increase hourly productivity, sometimes substantially (over 5%) as in France, Italy and Spain. The approach based on disaggregation into working-age categories produces effects that are in some cases markedly different to those produced using the aggregate approach. This is particularly the case in Ireland and Japan (where the difference between the two approaches exceeds one point). For countries where the differences in the employment rate with the United States are particularly concentrated on the young and old, which display the lowest estimated semi-elasticities of productivity to the employment rate, the disaggregate approach gives rise to a greater productivity effect for this difference than the aggregate approach. Examples include France, Italy, the Netherlands and Spain.

With this full set of estimation results, we can roughly measure the "structural" level of hourly productivity for each country compared with the United States. This is the relative level of "structural" hourly productivity that would be observed, given the assumptions made, if each country's hours worked and employment rates (for each working-age category) were the same as in the United States. This calculation, the results of which are set out in Table 10, takes into account the diminishing return effects of hours worked and employment rates, based on the elasticities mentioned above, selecting the measurements obtained with the disaggregate approach for the employment-rate effect. The insight gained from this is similar to that derived from the previous, less detailed study by Cette (2004, 2005).

Table 10. **"Observed" and "structural" hourly productivity in 2002**

As% of United States

	"Observed" hourly productivity			Effect of differences…		"Structural" hourly productivity		
	OECD	Groningen	Eurostat	… in hours worked	… in the employ-ment rate	OECD	Groningen	Eurostat

	[a]	[b]	[c]	[d]	[e]	[f] = [a]+[d]+[e]	[g] = [b]+[d]+[e]	[h] = [c]+[d]+[e]
Germany	93	104.7	92.1	-9.4	-2.9	80.7	92.4	79.8
Australia	78	84		0.5	-0.6	77.9	83.9	-0.1
Canada	85	86.6	87.4	-1.5	-0.4	83.1	84.7	85.5
Spain	74	73.8	73.9	0.3	-6.4	67.9	67.7	67.8
United States	100	100	100	0.0	0.0	100.0	100.0	100.0
Finland	82	90.4	83.3	-1.6	-1.7	78.7	87.1	80.0
France	113	107.1	107.4	-9.6	-5.4	98.0	92.1	92.4
Ireland	105	109.4	104	-3.1	-1.7	100.2	104.6	99.2
Italy	94	98.5	91.9	-4.8	-8.3	80.9	85.4	78.8
Japan	71	75.8	69.6	0.0	-0.3	70.7	75.5	69.3
Norway	125	121.1	124.2	-13.0	2.4	114.4	110.5	113.6
Netherlands	102	106.3	102.2	-13.2	-0.2	88.6	92.9	88.8
United Kingdom	79	86.2	83.7	-2.4	0.4	77.0	84.2	81.7
Sweden	86	88.9	85	-5.3	2.2	82.9	85.8	81.9

Notes: [a]: ppp 2002; [b]: 1999 EKS $.; [c]: pps.

Interpretation: If France had the same number of hours worked as the United States, its hourly productivity would be 9.6% lower. If it had the same employment rates, its hourly productivity would be 5.4% lower. According to the OECD, “observed” hourly productivity is 113% of that of the United States. Corrected for differences in hours worked and employment rates, the “structural” hourly productivity consistent with this “observed” level would in France be 98% of that of the United States.

Sources: [a]: OECD (http://www.oecd.org/dataoecd/30/40/29867116.xls) and Pilat (2004); [b]: Groningen Growth and Development Centre and The Conference Board, Total Economy Database, February 2004; [c]: Eurostat, Structural Indicators database; [d]: Elasticity of hourly productivity to hours worked x difference in hours worked *vis-à-vis* the United States; [e]: column [j] of Table 9.

In every country, the “structural” level of hourly productivity (compared with the United States) is lower than the “observed” level. The fewer hours worked (except in Australia, Japan and Spain) and the lower employment rates (except in Australia, Canada, Japan, the Netherlands, Norway, Sweden and the United Kingdom) produce a significant rise (of over one point) in the comparative level of “observed” hourly productivity. The gap between “observed” and “structural” productivity is often wide: in the case of France, for instance, it is around 15 points (9.5 points and 5.5 points). It exceeds 10 points in the three largest continental European countries only (France, Germany and Italy) as well as in the Netherlands and Norway, and 5 points in Spain. Conversely, it is insignificant (less than 1 point) in only two countries, Australia and Japan, where hours worked and employment rates are both very similar to the levels observed in the United States.

Of the four countries where “observed” levels of hourly productivity are higher than in the United States (France, Ireland, the Netherlands and Norway), only two also have higher “structural” levels of hourly productivity than the United States. They are Ireland and Norway, both small countries where the observed productivity levels are “artificially” raised by salient features, namely the impact of profit transfers stemming from very atypical corporate tax incentives in the case of Ireland,[16] and a highly capital-intensive structure with the focus on three industries -- oil, timber and fisheries -- in the case of Norway. Apart from those two special cases, the fact that “structural” hourly productivity levels are higher in the United States than elsewhere shows that the US is indeed setting the “technical frontier” in terms of productive efficiency and that other countries are lagging behind to varying degrees.

Leaving aside the two small countries (Ireland and Norway) with their special profiles as described above, there is evidence that the gaps between “structural” and “observed” relative hourly productivity levels are all the greater (in absolute terms) when the “observed” relative hourly productivity levels are also high (see figure). It is even clearer if we exclude Spain, which is still catching up in terms of productivity. This confirms that the high levels of “observed” hourly productivity in some European countries are largely attributable to their fairly low hours worked and/or employment rates, compared with the United States, and the diminishing returns to both parameters.

Figure. **"Observed" relative hourly productivity level (%) and gap between "structural" and "observed" relative hourly productivity level (in points)**

Relative levels are defined *vis-à-vis* the United States

"Observed" relative level of hourly productivity

France Netherlands ItalyGermany Spain Finland Sweden Canada

United Kingdom Australia Japan

R^2 = 0.740

R^2 = 0.827 excluding Spain

Gap between "structural" productivity – "observed" productivity

Source: "observed" relative hourly productivity: OECD (http://www.oecd.org/dataoecd/30/40/29867116.xls) and Pilat (2004); gap between "structural" and "observed" relative hourly productivity: authors' calculations, see text.

Concluding remarks

This study confirms the diminishing returns to hours worked and the employment rate. With regard to the employment rate, this diminishing-returns effect is particularly marked in the younger age group (15 to 24) and the older age group (55 to 64) within the working-age population. On that basis, the study shows that the productivity performance of some European countries compared with the United States is largely attributable to the lower levels of hours worked and employment, both of which display sharply diminishing returns. These, in turn, are attributable to the effects of fatigue in the case of hours worked, and to the concentration of employment among adults (aged 25–54) in the case of the employment rate.

Leaving aside some smaller countries whose apparent productivity performance is largely attributable to salient features (Ireland and Norway), the United States is the country with the highest "structural" level of hourly productivity and is therefore setting the "technical efficiency frontier» for industrialised countries. The US lead in terms of ICT dissemination and production goes some way towards explaining its higher "structural" level of hourly productivity, a result that is consistent with previous studies (including Gust and Marquez 2002, 2004).

This analysis suggests that the difference in per capita GDP between European countries and the United States is attributable not only to these lower levels of hours worked and employment but also to lower "structural" productivity. In other words, the lower level of per capita GDP can certainly not be interpreted solely as the expression of a social or "lifestyle" choice combining superior productivity with a stronger preference for more leisure time. It also stems from a productivity gap with the United States. This calls for two economic policy recommendations:

- The first policy recommendation is to look into ways of enabling all of the industrialised countries to close their productivity gap with the United States. This gap, widely analysed by the OECD (2003a, 2003b), is due to many possible causes, including lower average educational attainment in the working-age population, less ICT production and diffusion, regulatory rigidities on goods and labour markets -- rigidities that lessen competitive pressure, eventually constitute rent and hamper certain flexibilities in the mobilisation of factors of production, lowering overall factor productivity. These numerous potential causes are interdependent. For instance, because rigidities on goods- and labour-markets may affect prices and hamper flexibilities, they may be one of the reasons for the delay in ICT diffusion. Furthermore, ICT use requires more highly skilled labour than other techniques, and a less skilled labour force may also mean less ICT diffusion.

- The second policy recommendation is to look into the real nature of the social choice discussed here, which may to some extent be prompted by various tax measures (see Cette and Strauss-Kahn, 2003). With regard to the employment-rate and working-hour differential between many European countries and the United States, for instance, Prescott (2003) holds institutions largely responsible while Blanchard (2004) attributes even greater responsibility, especially regarding working hour differentials, to the expression of preferences, in other words social choices. Prescott's analysis (2003) assumes strong labour-supply elasticities to income from work, elasticities which are currently the focus of major debate in the literature (see for instance Alesina, Glaeser and Sacerdote, 2005). The work by Prescott (2003) and Blanchard (2004) suggests that regulatory arrangements and more broadly institutions should avoid incentives for lesser use of available labour resources and shift towards greater neutrality. This option, which applies more specifically to the younger, older and female members of the working-age population, with differentials that vary across the relevant European countries, would result in greater labour resource utilisation and hence higher per capita GDP. Even taking into account the ensuing decline in labour productivity, better labour resource utilisation would make it possible to close the gap in per capita GDP between European countries and the United States.

These findings should of course be viewed with the usual caution, given the weakness of both the data used and the econometric investigations. They should be backed up with more robust analysis, taking into account for instance differences in employment rates in the working-age population depending on educational achievement. The insight they provide, however, constitutes a valuable springboard for reflection.

NOTES

BIBLIOGRAPHY

Alesina, A., E. Glaeser and B. Sacerdote (2005), "Work and Leisure in the US and Europe: Why So Different?", NBER, Working Paper 11278, April.

Aubert, P., E. Caroli and M. Roger (2004), "New Technologies, Workplace Organisation and the Age Structure of the Workforce: Firm-Level Evidence", INSEE, Working paper, G 2004/07.

Aubert, P. and B. Crépon (2003), "La productivité des salariés âgés: une tentative d'estimation", *Économie et Statistique*, No. 368.

Belorgey, N., R. Lecat and T. Maury (2004), "Déterminants de la productivité apparente du travail", *Bulletin de la Banque de France*, January.

Blanchard, O. (2004), "The Economic Future of Europe", *Journal of Economic Perspectives*, Vol. 18, No. 4, Autumn.

Cette, G. (2004), "Diagnostic macro-économique et lecture historique", in P. Artus and G. Cette: "Productivité et croissance", CAE report, No. 48.

Cette, G. (2005), "Are Productivity Levels Higher in Some European Countries than in the United States?", *International Productivity Monitor*, No. 10, Spring.

Cette, G. and A. Gubian (1997), "La réduction de la durée du travail: les évaluations convergent-elles?", in P. Cahuc and P. Granier (eds.), "La réduction du temps de travail: une solution pour l'emploi?", *Economica*.

Cette, G. and M.-O. Strauss-Kahn (2003), "Productivité horaire et PIB par tête aux États-Unis et en France: Comparaisons et recommandations", *Bulletin de la Banque de France*, December.

Durbin, J. (1954), "Errors in Variables", *Review of the Internationnal Statistical Institute*, 22, pp. 23-32.

Gautié, J. (2003), "Les travailleurs âgés face à l'emploi", *Économie et Statistique*, No. 368.

Giuliani, C.-A. (2003), "D'où viennent les écarts de richesse par habitant entre les États-Unis, la zone Euro, la France et le Japon?", French Ministry of Economic Affairs and Finance, Forecasting Directorate, *Analyses Économiques*, No. 9, September.

Greenan, N. and Y. L'Horty (2004), "La nouvelle économie irlandaise", *Revue Française d'Économie*, Vol. XIX, October.

Gust, C. and J. Marquez (2002), "International Comparisons of Productivity Growth: The Role of Information Technology and Regulation Practices", mimeo, Board of Governors of the Federal Reserve System, International Finance Discussion Papers, No. 727, May.

Gust, C. and J. Marquez (2004), “International Comparisons of Productivity Growth: The Role of Information Technology and Regulatory Practices”, *Labour Economics*, Vol. 11.

Hausman, J. (1978), “Specification Tests in Econometrics”, *Econometrica* 46 (3), pp. 262-280.

Hellerstein, J. and D. Neumark (2004), “Production Function and Wage Equation Estimation with Heterogeneous Labor: Evidence from a New Matched Employer-Employee Data Set”, NBER, Working Paper 10325, February.

Malinvaud, E. (1973), “Une explication de la productivité horaire du travail”, *Économie et Statistique*, No. 48, September.

Pilat, D. (2004), “International Comparisons of Labour Productivity Levels: The OECD Approach to Estimation”, mimeo, 6 December.

Nelson, C.R. and R. Startz (1990a), “Some Further Results on the Exact Small Sample Properties of the Instrumental Variables Estimator”, *Econometrica* 58, pp. 967-976.

Nelson, C.R. and R. Startz (1990b), “The Distribution of the Instrumental Variables Estimator and its T-Ratio when the Instrument is a Poor One”, *Journal of Business*, 63, pp. 5125-5140.

OECD (2003a), *The Sources of Economic Growth in OECD Countries*; a partial presentation and overview of this publication can be found in Chapter V entitled “Structural Policies and Growth” of the *Economic Outlook* No. 73, June.

OECD (2003b), *Information and Communications Technologies. ICT and Economic Growth: Evidence from OECD Countries, Industries and Firms.*

Prescott, E. (2003), “Why Do Americans Work So Much More Than Europeans?”, Federal Reserve Bank of Minneapolis Research Department Staff Report, No. 321, November.

Sargan, J. (1958), “The Estimation of Economic Relationships Using Instrumental Variables”, *Econometrica*, 26 (3), pp. 393-415.

Wasmer, E. (1999), “Changements de composition de la force de travail. Implications pour les salaires et le chômage”, *Économie et Prévisions*, No. 138-139, 1999/2-3.

Wu, D.M. (1973), “Alternative Tests of Independence between Stochastic Regressors and Disturbance”, *Econometrica*, 42 (3), pp. 529-546.

ANNEX: VARIABLES USED

Table A1. **Sources and definition of variables used**

Variable	Description	Sources	Average 21 countries	Standard deviation 21 countries	Average 14 countries	Standard deviation 14 countries
PH	GDP per hour worked (index)	OECD: Productivity Database				
H	Average annual hours worked per employee (in hours)	1 – OECD Labour Market Statistics 2 – Groningen: Total Economy Database	1 775	239	1 674	162
ER	Employment rate	OECD Labour Market Statistics	0.636	0.073	0.652	0.076
CUR	Capacity utilisation rate	OECD: Main Economic Indicators standardised by the authors)	0.831	0.019	0.831	0.019
ITPR	ICT production (% of GDP)	OECD: STAN database	0.050	0.018	0.054	0.017
ITIR	ICT investment (% of GDP)	OECD: Productivity Database			13 pays 2.680	13 pays 0.892
INVR	Investment rate	OECD Economic Outlook	0.220	0.050	0.201	0.032
IUR	Internet user ratio (per 1 000 inhabitants)	World Bank	114	140	141	151
Q	Volume GDP in PPP and in 1995 $US	OECD Economic Outlook	9.7E+11	1.7E+12	1.3E+12	2.0E+12
P	Consumer price index	OECD: Main Economic Indicators				
PER	Public employment rate (% of total employment)	OECD Economic Outlook	0.178	0.066	0.187	0.073
SER	Self-employment rate (% of total employment)	OECD Economic Outlook	0.183	0.104	0.147	0.068
PTR	Part-time employment rate (% of total employment)	OECD Labour Market Statistics	0.139	0.078	0.172	0.063
ITSR	ICT spending rate (% of GDP)	World Bank	0.062	0.018	0.067	0.016
R&DSR	Research and Development (% of GDP)	OECD Economic Outlook	0.017	0.008	0.020	0.007

Table A2. **Selected descriptive statistics on the variables used**

Variable	Average 21 countries	Standard deviation 21 countries	Average 14 countries	Standard deviation 14 countries
Δph	0.011	0.008	0.009	0.007
Δh	-0.001	0.005	-0.001	0.004
ΔER	0.001	0.012	0.003	0.012
ΔCUR	0.001	0.019	0.0005	0.020
Δp_{-1}	0.020	0.021	0.010	0.006
ER_m1524	0.046	0.012	0.048	0.012
ER _m2554	0.276	0.019	0.280	0.017
ER _m5564	0.039	0.012	0.041	0.011
ER _w1524	0.039	0.012	0.042	0.013
ER_w2554	0.211	0.037	0.214	0.040
ER_w5564	0.025	0.011	0.027	0.012
ER_1524	0.085	0.024	0.089	0.025
ER_2554	0.487	0.049	0.494	0.053
ER_5564	0.064	0.022	0.068	0.022
ER_M	0.361	0.031	0.370	0.029
ER_W	0.275	0.049	0.283	0.054

Note: The country groupings in this table are explained in the section on "Labour productivity …".

1 . This concept of a "technical frontier" is better suited to a more refined sectoral approach, or even to the production of a single good. It is used here for convenience to cover the whole of a country's economy.

2 . See for instance Prescott (2003), Blanchard (2004) or Alesina, Glaeser and Sacerdote (2005).

3 . Both studies also provide a broad review of the literature on these issues.

4 . These three measurements are all initially based on national accounting data drawing on conventional options which may differ across countries. The differences may relate, for instance, to the treatment of the production of financial services, military spending or software spending. Furthermore, the differences observed in these measurements within a single country may have many different causes, including the source of employment data selected (Labour Force Survey or National Accounts), more or less recent revisions of GDP measurements or the conventions used to work out purchasing power parities (see Pilat, 2004; Cette, 2004, 2005 also gives an overview of various sources of statistical uncertainty).

5 . Based on a study conducted by INSEE on microeconomic data, Malinvaud (1973) states that since there are no better indicators than those of the type mentioned above, a coefficient of ½ should be applied to measure the impact that a reduction in hours worked has on hourly productivity. In view of the lesser effects of fatigue due to the decrease in average hours worked over recent decades, more recent research now applies a coefficient of ⅓ or ¼ (see Cette and Gubian, 1997).

6 . This is also the analysis given by Giuliani (2003). While not set out in detail, Wasmer (1999) supposes that the labour force composition affects productivity.

7 . As this variable is available on a smaller sample than for the other variables, its introduction as an explanatory variable has been treated separately.

8 . The effect on hourly productivity of a variation in the ratio of part-time jobs to total employment (ΔPTR) is in theory uncertain, owing to the presence of the variable for the rate of change in average hours worked (Δh) on the list of explanatory variables. The variable ΔPTR, for instance, is aimed at distinguishing between the special effect on productivity of a change in the share of part-time work and that of a change in full-time working hours.

9 . The results referred to here are from Tables 2, 5 and 6 of Gust and Marquez (2002, 2004).

10 . However, we have checked that this difference in the sample (presence or not of Ireland and period of estimation) has, in itself, little impact on the estimation results.

11 . The results referred to here are from the table on page 108 of Bélorgey, Lecat and Maury (2004).

12 The results referred to here are from the table on page 106 of Bélorgey, Lecat and Maury (2004).

13 . Given relationship (1), then: $\Delta ER = \frac{N}{P} . (\overset{o}{N} - \overset{o}{P})$. Similarly, given relationship (2), then:

$$\sum_j \left(\hat{b}_{1,j} . \Delta(\frac{N_j}{P}) \right) = \frac{N}{P} . (\overset{o}{N} - \overset{o}{P}) . \sum_j \hat{b}_{1,j} . \frac{N_j}{N} . \frac{(\overset{o}{N}_j - \overset{o}{P})}{(\overset{o}{N} - \overset{o}{P})} = \tilde{a}_{2,i,t} . \Delta ER \text{ with } \tilde{a}_{2,i,t} = \sum_j \hat{b}_{1,j} . \frac{N_j}{N} . \frac{(\overset{o}{N}_j - \overset{o}{P})}{(\overset{o}{N} - \overset{o}{P})} .$$

Recalculated in this way, coefficient $\tilde{a}_{2,i,t}$ takes on a specific value for each country i and each year t. The recalculated effect $\tilde{a}_2$ of an increase in the aggregate employment rate is therefore obtained using the mean M(i,t) of $\tilde{a}_{2,i,t}$ for all countries i and the whole of period t. The same method is used to calculate an aggregate effect on a group of categories (*e.g.* women, or young people).

14 . The long-term effect is the short-term effect divided by 1.393, the estimated value $\hat{a}_1$ of the coefficient of the autoregressive term Δph_{-1} of relationship (1) being equal to -0.393 (see Table 5, column [8]).

15 . Thus the effects (ERPE) on hourly productivity of differences in the employment rate, of each working-age category j, of country i compared with the United States are calculated as follows:

$$ERPE = \sum_j \hat{b}_{1,j} . (ERC_{i,j} - ERC_{USA,j}) = \sum_j \hat{b}_{1,j} . \left[\frac{POP_{i,j}}{POP_i} . \left(\frac{N_{i,j}}{POP_{i,j}} - \frac{N_{USA,j}}{POP_{USA,j}} \right) + \frac{N_{USA,j}}{POP_{USA,j}} . \left(\frac{POP_{i,j}}{POP_i} - \frac{POP_{USA,j}}{POP_{USA}} \right) \right]$$

Here, the term $\sum_j \hat{b}_{1,j} \cdot \left[\frac{POP_{i,j}}{POP_i} \cdot \left(\frac{N_{i,j}}{POP_{i,j}} - \frac{N_{USA,j}}{POP_{USA,j}} \right) \right]$ corresponds to the effect of differences in the employment rate *vis-à-vis* the United States, while the term $\sum_j \hat{b}_{1,j} \cdot \left[\frac{N_{USA,j}}{POP_{USA,j}} \cdot \left(\frac{POP_{i,j}}{POP_i} - \frac{POP_{USA,j}}{POP_{USA}} \right) \right]$ corresponds to the effect of differences in the structure of the working-age population. The effects of these differences in structure are always small in scale, which is why this second term is not broken down into its six component parts here.

16 . Greenan and L'Horty (2004), for instance, show that GDP is some 20% higher than GNP in Ireland, partly due to tax incentives resulting in the location of the profits of multinational companies in this country.