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**A comparison of labour productivity growth
in France, the United Kingdom and the United States
over the past century**

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Abstract

What distinguishes this study from the numerous other analyses of economic growth and productivity is the fact that we conducted a comparison of France, the United Kingdom and the United States both over the very long run (i.e. since 1890) and over the recent period (i.e. the past 25 years). During the past century, the United States has replaced the United Kingdom as the leading world power and during the past 25 years, productivity growth has posted contrasting patterns across the three countries, in particular due to the unequal development of information and communication technologies.

The past 120 years have been characterised by significant economic growth and productivity gains in the three countries under review and the remarkable catching-up of the United States by France. At present, total factor productivity is very close in all three countries, hourly labour productivity is slightly higher in France than in the United States, and significantly lower in the United Kingdom. Productivity per employee is slightly lower in France than in the United States and considerably lower in the United Kingdom. These mixed performances can be attributed to the varying contributions of capital deepening, the downward trend in working hours and other growth factors, depending on the period under review.

Codes JEL : O47, O57, E22, J24, N10

Key words: Growth, productivity, capital, ICT, TFP

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1. Introduction

Productivity is a key determinant of the wealth of nations. Almost all theoretical and empirical studies that set out to explain the extremely large growth and living standard differentials between countries focus on the differences in productivity levels and growth rates. These studies are legion and our study is just one more. Like most other studies, it is simply and directly based on the traditional “growth accounting” framework (outlined in Box 2). Its originality, however, lies in the comparison of French, British and US productivity both over the very long run (i.e. since 1890) and over the medium run (i.e. over the past 25 years). It therefore covers a whole century during which the United States has replaced the United Kingdom as the leading world power, and the past 25 years during which productivity growth has posted contrasting patterns across the three countries, in particular due to the uneven development of information and communication technologies (ICT).

We have sought to make the best use of the estimates of aggregate historical data series which go back to the end of the 19th century in the three countries under review for GDP, employment, working time and investment in physical capital (see Box 1). For the past 25 years, we relied on the national accounts available. Many of the estimates on which our comparison is based may clearly be surrounded by a great deal of uncertainty and inaccuracy, not only for the most distant periods but also to a significant extent for the more recent periods. The orders of magnitude may nevertheless be considered as relatively reliable and the large differentials in productivity levels and growth rates are clearly real. One important reason to be confident is the long tradition of statistics gathering in the three countries. Another is the fact that the comparison is limited to the economies of the three countries as a whole (besides, all three countries kept relatively stable frontiers over the entire period under review). Given the difficulties of assessing physical capital stocks and services as well as the significant differences in assessment methods, we considered that it would be wiser to re-estimate the capital series for the three countries on the basis of the investment series using constant depreciation rates and constant user costs of capital (see Box 1). Similarly, we chose to use the same hedonic price estimates (relative to GDP price indices) for France and the United Kingdom as those in the United States for computer hardware, software and communication equipment.

In short, we examined and compared the levels and growth rates of three categories of productivity: labour productivity, both per employee and per hour, and joint labour and capital productivity (or total factor productivity –TFP). We looked at their trend over given periods for the three countries.

In section 2, we comment on the developments over the very long term (1890-2004), while in section 3, we focus on the past 25 years and the key role played by the spread of ICT.

Box 1

Data sources

The data in this study are used to construct indicators over the very long term or, in the case of ICTs, over the past few decades. In order to prevent any breaks, we backcasted, for each indicator, the growth rates from the series covering the more distant periods onto the series covering the most recent period. In view of this backcasting method, the levels of the variables in the backcasted periods may differ from those used for backcasting. These differences are generally small. GDP, investment and fixed capital are expressed in constant domestic currency terms, based on the year 2000 (euro for France).

Comparisons of productivity levels are measured in 1990 constant dollar terms. In each year for which a comparison is made we used PPP exchange rates derived implicitly from PPP 1990 constant dollar GDP estimates provided by Maddison (2003). The databases used are those of Maury and Pluyaud (2004) if ^a, Cahn and Saint-Guilhem (2006) if ^b and Kocoglu (2001) if ^c.

GDP

- France: National accounts for the period 1970-2004^b; Groningen Growth and Development Centre (GGDC)¹ for the period 1950-1969^a, Villa (1994)^a for the period prior to 1950;
- United Kingdom: National accounts for the period 1955-2004^b; GGDC and Feinstein (1976) for the period prior to 1955^a;
- United States: National accounts, BEA for the period 1950-2004^b and GGDC for the period 1929-1949^a; Mitchell (1998)^a for the period prior to 1929;

Employment

- France: National accounts for the period 1960-2004^b; Villa (1994)^a for the period prior to 1960;
- United Kingdom: National accounts for the period 1960-2004^b; Feinstein (1976)^a for the period prior to 1960;
- United States: National accounts for the period 1960-2004^b; Mitchell (1998)^a for the period prior to 1960;

Working time

For the three countries: OECD for the period 1970-2004; GGDC for the period 1950-2004; Maddison (2001) for 1870, 1913 and 1950; linear interpolation for the periods 1890-1913, 1913-1950;

Non-ICT investment

- France: National accounts for the period 1993-2004, INSEE for the period 1846-2002^c, Levy-Leboyer (1978)^c for the period 1820-1845. The breakdown of total GFCF between equipment and buildings is taken from INSEE databases for the period 1845-2002 and Villa (1994) for the period 1820-1845;
- United Kingdom: National accounts for the period 1965-2004^b; Maddison (1993)^b for the period prior to 1965;
- United States: National accounts for the period 1929-2004^b; Maddison (1993)^b for the period prior to 1929;

ICT investment

- France: National accounts base 2000 for the period 1978-2004 and base 1995 for the period 1959-1977;
- United Kingdom: GGDC for the period 1980-2004, and French trends for the period 1959-1979;
- United States: GGDC for the period 1980-2004 and BEA for the market economy for the period 1959-1979;

Fixed capital

Fixed capital series are constructed on the assumption that the annual depreciation rates are: 2.5% for buildings, 10% for non-ICT equipment, 15% for communication equipment and 30% for computer hardware and software. The coefficients used to factor in the war effects are taken from Villa (1994)^c and applied;

Prices of ICT products

The relative ICT price indices (compared to GDP prices) for France and the United Kingdom are the same as those taken from the US national accounts.

¹ The June 2005 version of the database may be downloaded from the following address: <http://www.ggdc.net>.

Box 2

The breakdown of the effects of TFP and capital deepening and the growth accounting approach²

Solow (1956, 1957) was one of the first to put forward the breakdown of the effects of TFP and capital deepening on GDP and the growth accounting approach. The following equations concern the breakdown in level and growth rate terms of GDP and productivity, but for reasons of simplicity, the commentary only covers the breakdown of growth. We assume that the production possibilities may be represented using a total production function with a total factor productivity TFP variable (or autonomous technical progress). Production (or output Y) can be written as:

$$Y = \text{TFP} \cdot F(K_j, L_i)$$

where K_j and L_i represent respectively the volume of j-type capital and i-type labour (or inputs). Assuming that the production function is a Cobb-Douglas production function in linear log form and labour is homogeneous (which is the case in the present study), we obtain the following relation:

$$y = \text{tfp} + \sum_j \alpha_j \cdot k_j + \beta \cdot l \quad \text{first difference: } \Delta y = \Delta \text{tfp} + \sum_j \alpha_j \cdot \Delta k_j + \beta \cdot \Delta l$$

where y , k_j , l and tfp represent the logs of the volume of output, j-type capital, labour and TFP, where Δ is the first difference (or annual rate of change) and where α_j and β represent the elasticities of output with respect to the inputs K_j and L . We assume unit (constant) returns to scale: $\sum_j \alpha_j + \beta = 1$.

The growth rate of the economy can be written as the sum of the growth rate of each input weighted according to its production elasticity and the growth rate of TFP (or technical progress). Growth accounting can also be presented identically in terms of labour productivity accounting (assuming constant returns to scale), as follows:

$$(y - l) = \text{tfp} + \sum_j \alpha_j \cdot (k_j - l) \quad \text{first difference: } (\Delta y - \Delta l) = \Delta \text{tfp} + \sum_j \alpha_j \cdot (\Delta k_j - \Delta l)$$

where $\alpha_j (k_j - l)$ represents the contribution of j-type capital deepening to labour productivity.

In order to apply this breakdown, it is necessary to obtain estimates of production and its factors. In macroeconomic analyses, these data are available in national accounts. The sources used in this study are detailed in Box 1. It is also necessary to measure the elasticities of production with respect to inputs. In addition to the hypothesis of constant returns to scale, it is generally admitted that production factors are remunerated at their marginal productivity (at least over the medium to long term), which means that it is possible to estimate the factor elasticities on the basis of the share of their remuneration (cost) in total income (or total cost). Given that labour costs (wages and related social security contributions) represent roughly two thirds of income, it is assumed that $\sum_i \alpha_i = 0,3$ and therefore $\beta = 0,7$.

TFP is measured as a residual: it measures the contribution to labour productivity that is not attributable to factor inputs. These types of breakdown are mainly descriptive. Although they do not provide any causal explanations, they are useful for making comparisons and explaining any differentials in productivity levels and growth rates between periods and countries.

In our study, the volume of labour L is written as $L = N \cdot H$ where N is the level of employment and H the average annual working time. The suggested breakdowns of productivity concern alternately productivity per employee or productivity per hour, and are conducted on the basis of the respective relations (where the contribution of TFP is identical):

$$(y - n) = \text{tfp} + \sum_j \alpha_j \cdot (k_j - n) + (1 - \sum_j \alpha_j) \cdot h \quad \text{first difference: } (\Delta y - \Delta n) = \Delta \text{tfp} + \sum_j \alpha_j \cdot (\Delta k_j - \Delta n) + (1 - \sum_j \alpha_j) \cdot \Delta h$$

$$(y - l) = \text{tfp} + \sum_j \alpha_j \cdot (k_j - l) \quad \text{first difference: } (\Delta y - \Delta l) = \Delta \text{tfp} + \sum_j \alpha_j \cdot (\Delta k_j - \Delta l)$$

² For a history of growth accounting and TFP assessment (or “residual”), see Griliches (1996) or Cette, Mairesse and Kocoglu (2005).

2. Long run trends

We first comment on the trends over the entire period (2.1), then by sub-periods (2.2). Given that the other studies on the subject cover a wide range of periods, a comparison with other sources is made at the beginning of Section 2.2.

2.1. Trends over the entire period

Over the entire period from 1890 to 2004, labour productivity posted strong growth in all three countries. The level of productivity per employee and per hour increased by a factor of 10 and 20 in France, 5 and 9 in the United Kingdom and 7 and 12 in the United States (Table 1). The large differentials between the growth rate of productivity per employee and that of hourly productivity can be attributed, in accounting terms, to the decline in average annual working time: between 1890 and 2004, it dropped by roughly 50% in France (sliding from 3,050 hours to 1,520 hours) and roughly 40% in the United Kingdom (2,820 to 1,670 hours) and the United States (2,930 to 1,820). France has posted the highest average annual productivity gains (2.1% per employee and 2.7% per hour) and the United Kingdom the lowest (1.5% and 1.9%); the United States is in an intermediate position (1.8% and 2.2%).

Table 1
Productivity levels and average annual growth, 1890-2004

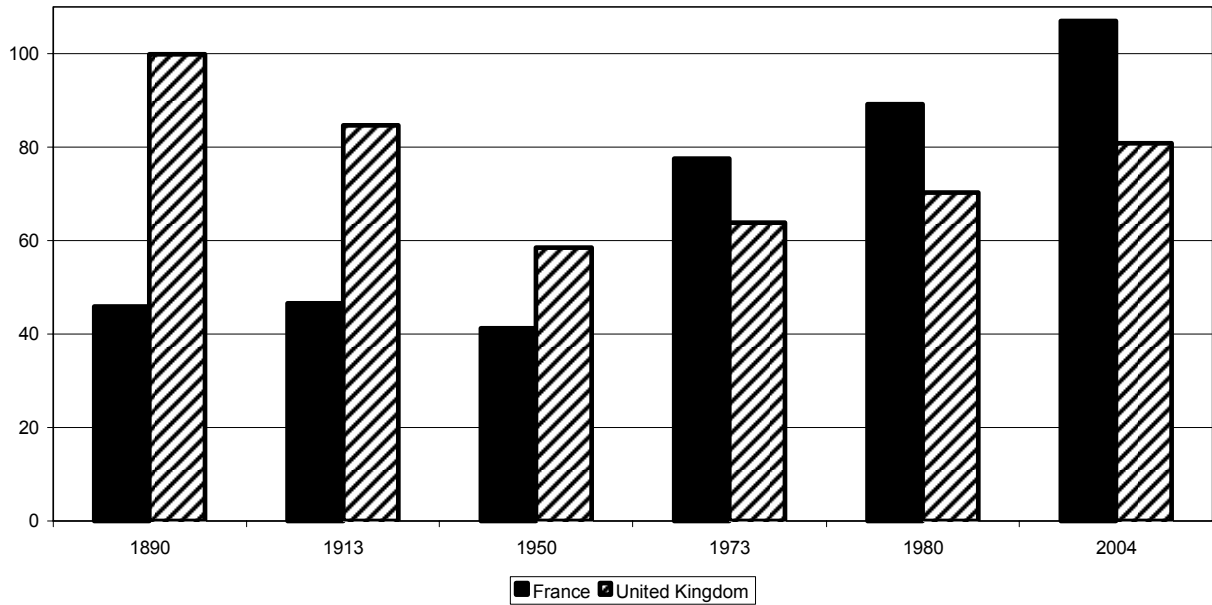
	Average annual growth rates, in %, 1890-2004			Productivity levels, as a % of the US levels			
	France	United Kingdom	United States	1890		2004	
				France	United Kingdom	France	United Kingdom
Labour productivity per employee	2.1	1.5	1.8	48.2	96.1	89.2	73.8
Labour productivity per hour	2.7	1.9	2.2	45.9	99.9	107.1	80.8
Total factor productivity	2.1	1.2	1.7	51.6	161.6	103.1	101.4

Source: Authors' calculations, see Box 2.

In 1890, the level of US labour productivity, per employee or per hour, was twice as high as that in France but equal to that in the United Kingdom (see Table 1 and Graphs 1 and 2).³ At the time, France recorded a large proportion of labour in agriculture, compared with the other two countries. Given the changes in labour productivity over the period, the ranking of countries in terms of labour productivity levels is very different in 2004 to what it was in 1890. In 2004, the level of labour productivity in the United Kingdom was lower by roughly 25% per employee and 20% per hour than that in the United States, while in France it was lower by around 10% per employee but higher by 7% per hour. Bourlès and Cette (2005, 2006) have shown that France's strong productivity performance compared to the United States at the end of the period can partly be explained by shorter working hours and a lower employment rate on account of strongly diminishing returns for both variables. After adjusting for the effect of the differentials in these two variables on productivity, it appears that in 2004 hourly labour productivity in France is roughly 5% lower than in the United States.

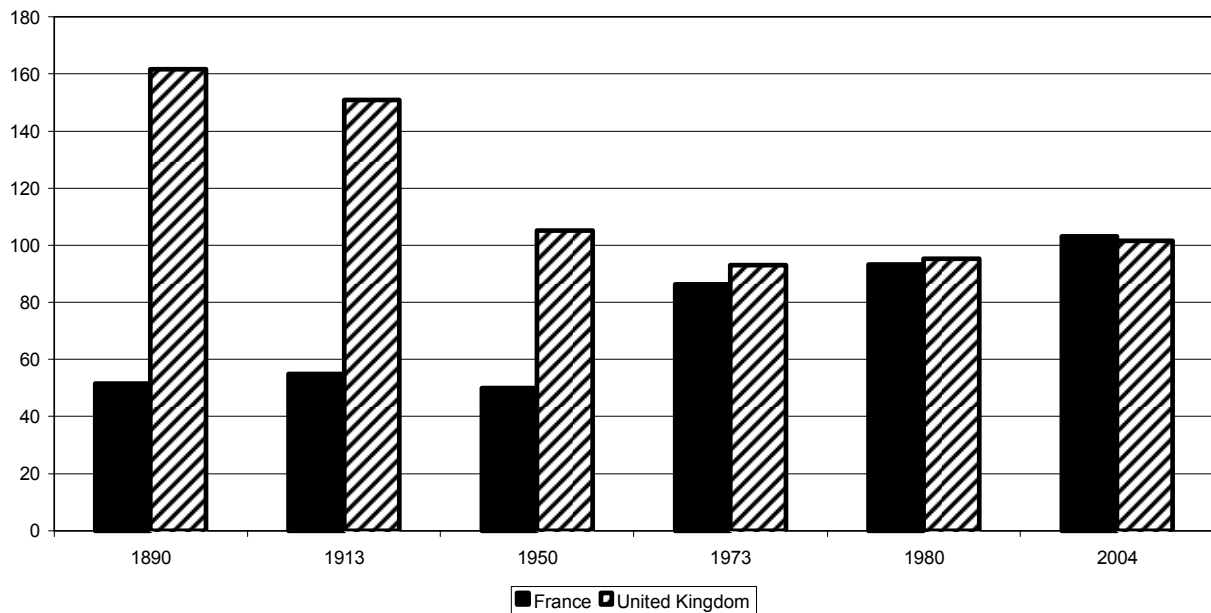
³ For the most remote periods, the productivity levels for France and the United Kingdom obtained in this study differ from those mentioned in Cette (2004). These results do not alter the commented stylised facts. The largest differential is observed for France in 1890 (approximately 8 points). The causes of these differences are two-fold. First, in order to ensure the continuity of historical series, we chose a backcasting method which resulted in differences in the backcasted series and data used for backcasting (see Box 1). Second, the data sources are different (those used in the present study are detailed in Box 1; those used in Cette (2004) are Maddison, 1994, 2001).

Graph 1
Labour productivity per hour, as a % of the US level
 Scope: Economy as a whole – PPP dollar 1990



Source : Authors' calculations, see Box 2.

Graph 2
Total factor productivity, as a % of the US level
 Scope: Economy as a whole – PPP dollar 1990



Source: Authors' calculations, see Box 2.

Growth in total factor productivity accounts for a large share of hourly labour productivity gains over the entire period: roughly 60% in the United Kingdom and 80% in the other two countries; the contribution of capital deepening is much smaller (see Table 2). It therefore appears that, overall, the factors underpinning TFP (in particular, a higher skilled workforce and organisational changes) make a greater contribution to observed productivity gains than capital deepening over the period under review. In 1890, the level of TFP was roughly 60% higher in the United Kingdom than in the United States, while in France it was roughly 50% lower. Given that TFP growth was relatively slow in the United Kingdom and fast in France, the level of TFP in both countries was close to that in the United States in 2004.

2.2. Trends by sub-periods

The 1890-2004 period is broken down into five sub-periods in order to conduct a comparative analysis of productivity growth and its main determinants in France, the United Kingdom and the United States:

- From 1890 to 1913, just before the First World War;
- From 1913 to 1950; including the few years following the Second World War enables us to take into account the reconstruction and recovery of the European economies and to smooth out the most significant effects of the conflict on production capacities and economic structures;
- From 1950 to 1973, just before the first oil shock;
- From 1973 to 1980 i.e. the period between the two oil shocks;
- From 1980 to 2004; this period is broken down into smaller sub-periods in order to analyse the contribution of the spread of ICT.

The results are presented in Table 2 and Graph 3.

Very few analyses make it possible to draw comparisons between several industrialised countries over such a long period. As expected, our results are very close to those of Maury and Pluyaud (2004), as we used their data on real GDP and employment to construct the productivity per employee indicator for each country. They are consistent with those of Gordon (2003), Cette (2004) and van Ark, Frankema and Duteweerd (2004) who measure labour productivity growth over different sub-periods using the real GDP and employment estimates calculated by Maddison (2001).

As regards France more specifically, the assessment by Dubois (1985), which builds on that of Carré, Dubois and Malinvaud (1972), only covers the market economy. Certain differences with our assessment could be attributed to the scope of the analysis (we looked at the economy as a whole). According to Dubois (1985, see Table 6), growth in productivity per employee stood at 5.0% between 1951 and 1973 and 2.4% between 1973 and 1984, while the contribution of TFP to growth of productivity per employee amounted to 1.4% over the sub-period 1896-1913, 1.4% over the sub-period 1913-1951 and 4.2% over the sub-period 1951-1973 (see Table 8). The disparities with our assessment are negligible and could be due to differences in scope and methodology.

As far as the United Kingdom is concerned, our estimates appear to be consistent with those of Crafts (2004a, b and c), although he obtains slightly higher hourly productivity gains (roughly 0.2 of a point per year) over the 1950-1973 period due to a higher TFP contribution.

As regards the United States, Ferguson and Wascher (2004) apply a similar type of breakdown to hourly productivity growth in the US non-agricultural market sector, although the sub-periods used are slightly different to the ones in this study. The results are presented in Table 3. The disparities are not significant and can also be attributed to differences in scope and methodology.

Table 2
**Average annual labour productivity growth (in %) and contributions (in percentage points),
in France, the United Kingdom and the United States**
Scope: Economy as a whole

A – France

	1890- 1913	1913- 1950	1950- 1973	1973- 1980	1980- 2004
GDP	1.9	0.9	5.0	2.7	2.0
Productivity per employee [a]	1.6	1.1	4.6	2.3	1.5
Productivity per hour [b]	1.9	1.9	5.1	3.1	2.3
Contributions :					
Capital intensity, per employee [c]	0.4	0.1	0.7	1.1	0.7
Capital intensity, per hour [d]	0.5	0.4	0.8	1.4	1.0
Working time [e]	-0.2	-0.6	-0.3	-0.6	-0.5
Total factor productivity [f]	1.4	1.6	4.3	1.7	1.3

B – United Kingdom

	1890- 1913	1913- 1950	1950- 1973	1973- 1980	1980- 2004
GDP	1.9	1.2	3.0	1.0	2.5
Productivity per employee [a]	0.9	0.7	2.7	1.1	2.1
Productivity per hour [b]	1.2	1.5	2.7	2.3	2.3
Contributions :					
Capital intensity, per employee [c]	0.2	0.2	1.3	1.2	1.0
Capital intensity, per hour [d]	0.3	0.5	1.8	1.6	1.1
Working time [e]	-0.2	-0.6	-0.1	-0.8	-0.2
Total factor productivity [f]	0.9	1.1	1.4	0.7	1.2

C – Etats-Unis

	1890- 1913	1913- 1950	1950- 1973	1973- 1980	1980- 2004
GDP	4.1	3.2	4.0	2.5	3.1
Productivity per employee [a]	1.6	1.9	2.2	0.3	1.7
Productivity per hour [b]	2.0	2.8	2.3	0.8	1.7
Contributions :					
Capital intensity, per employee [c]	0.6	0.2	0.5	0.5	0.8
Capital intensity, per hour [d]	0.7	0.5	0.5	0.7	0.8
Working time [e]	-0.2	-0.6	-0.1	-0.4	-0.1
Total factor productivity [f]	1.2	2.3	1.8	0.1	0.9

[f] = [a] – [c] – [e] = [b] – [d]

Source: Authors' calculations, see Boxes 1 and 2.

Table 3
Breakdown of US hourly productivity growth
scope: Non-agricultural market sector – yearly %

	1890- 1917	1917- 1927	1927- 1948	1948- 1973	1973- 1995	1995- 2003
Productivity per hour [b]	1.5	3.8	1.8	2.9	1.4	3.0
Contributions :						
Capital intensity, per hour [d]	0.7	1.0	0.1	1.0	1.0	1.6
TFP [f]	0.8	2.8	1.7	1.9	0.4	1.4

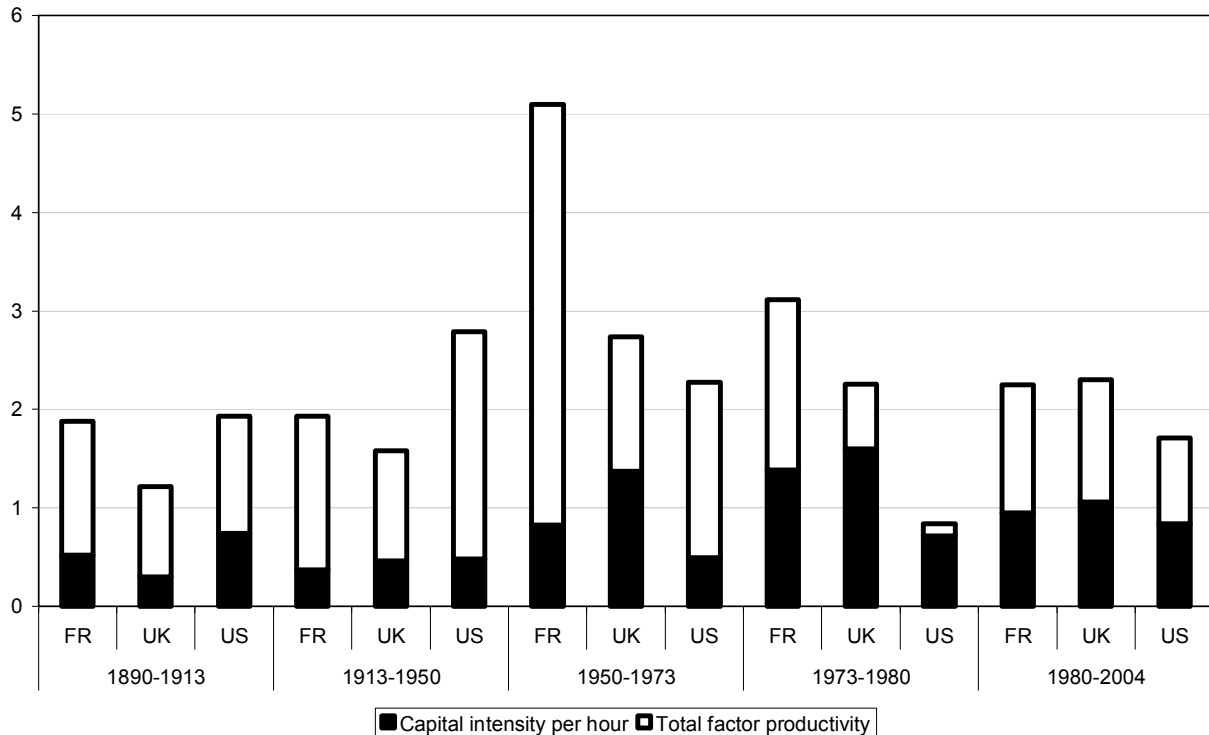
[b] = [d] + [f].

Source: Ferguson and Wascher (2004, p. 6).

Graph 3

Average annual hourly labour productivity growth (in %) and contributions (in percentage points), in France, the United Kingdom and the United States – 1890-2004

Scope: Economy as a whole



Source: Authors' calculations, see Boxes 1 and 2.

If the two sub-periods following the first oil shock are grouped together, our analysis upholds the “Big Wave” description offered by Gordon (1999, 2003) as regards hourly productivity in the United States: productivity growth increases after 1913 relative to the previous period, then slows after 1950 and again after 1973. It is worth noting that these movements are governed by TFP growth, as the contribution of capital deepening is almost unchanged. As regards productivity per employee, the Big Wave is apparent. However, the sub-period with the strongest productivity growth is no longer 1913-1950, but 1950-1973 (but only just). In France and the United Kingdom, a Big Wave is also apparent, but the sub-period with the strongest hourly productivity growth is 1950-1973 and not 1913-1950. This pattern is more pronounced in France than in the United Kingdom. The lag between Europe and the United States, reflected in the temporal shift of the Big Wave, can usually be attributed to several factors, among which the later diffusion of electric energy, the later improvement in the average skill level of the workforce (and their level of education)⁴ and a higher degree of protectionism (see Gordon (2003) for a review of the literature). As in the United States, TFP is the main factor underpinning productivity growth in Europe. However, capital deepening also plays a role in the United Kingdom. In addition, it is worth pointing out another difference between the United States and the other two countries: in the United States, hourly productivity growth has been considerably lower since 1973 than prior to 1913, while in France and the United Kingdom, it has on average been higher since 1973 than before 1950.

The growth rates of productivity and its underlying factors vary depending on the sub-period:

- From 1890 to 1913, France and the United States recorded similar annual growth rates of productivity per employee (roughly 1.6%) and per hour (roughly 2%), and very similar contributions of capital deepening (1/4 to 1/3) and TFP (2/3 to 3/4). Annual productivity growth was

⁴ See van Ark, Frankema and Duteweerd (2004).

lower by $\frac{3}{4}$ of a point in the United Kingdom, mainly on account of a smaller TFP contribution and, to a lesser extent, a smaller rise in capital deepening. Compared with that of the United States, the level of hourly productivity in France thus remained unchanged at roughly 45-50%, while that in the United Kingdom dropped from around 100% to 85%;

- From 1913 to 1950, annual productivity growth (per employee and per hour) was much faster in the United States (where it stood at 1.9% and 2.8% respectively) than in France (1.1% and 1.9%) and, in particular, the United Kingdom (0.7% and 1.5%). These discrepancies can only be attributed to different TFP contributions, as the contribution of capital deepening was identical in all three countries (0.1% to 0.2% for productivity per employee and 0.4% to 0.5% for productivity per hour) and almost identical to that in the previous sub-period. Consequently, compared to that in the United States, the level of hourly productivity dropped by a few points in France to stand at roughly 40% in 1950, and more significantly in the United Kingdom to roughly 60%;
- From 1950 to 1973, annual productivity growth (per employee and per hour) was very strong in France (4.6% and 5.1% respectively), firm in the United Kingdom (2.7% and 2.7%) and slower in the United States (2.2% and 2.3%). Productivity growth in France can be attributed almost entirely to TFP growth, while the rise in capital deepening accounts for about 50% of productivity growth in the United Kingdom. In the United States, the contribution of capital deepening remains unchanged. France thus appears to be rapidly catching up with the other two countries, more via TFP growth than by the spread of more capital intensive production techniques. The productivity gap between the three countries can also be explained by changes in the countries' economic structure. It is mainly during this period that the share of agriculture in French GDP declined significantly, more in line with that in the other two countries. Card and Freeman (2002) estimated that between 1960 and 1979, the impact on labour productivity of a change in the weight of employment in the agricultural sector amounted to roughly 0.5 point each year in France, against 0.1 point in the United Kingdom and the United States. Consequently, relative to that in the United States, the level of hourly productivity in France improved markedly to stand at 80% in 1973, above the level recorded in the United Kingdom (65%), which had posted slower productivity growth;
- During the short period between the two oil shocks (1973-1980), annual productivity growth (per employee and per hour) slowed significantly in the three countries. It was the highest in France (2.3% and 3.1% respectively), intermediate in the United Kingdom (1.1% and 2.2%) and very low in the United States (0.3% and 0.8%). Cetté and Bourles (2006) have shown that the slowdown in US productivity growth over this sub-period can largely (for two thirds) be explained by a rise in the employment rate and a smaller decline in working hours, both variables showing strongly diminishing returns. In the United Kingdom and France, the slowdown in productivity growth is linked to the slowdown in TFP growth, the contribution of capital deepening being almost unchanged compared with the previous sub-period. In France, given that capital deepening actually increased, the slowdown in productivity was less pronounced than the slowdown in TFP. Nevertheless, France, once again, showed the highest TFP gains. Consequently, relative to that in the United States, the level of hourly productivity in France improved markedly to stand at around 90% in 1980 and more slightly in the United Kingdom to roughly 70%;
- Lastly, during the last sub-period 1980-2004, productivity slowed down again in France but accelerated in the United States. In the United Kingdom, only productivity per employee increased, hourly productivity remaining unchanged. The ranking of countries according to average productivity gains varies depending on the indicator used: if one considers productivity per employee, productivity gains are the highest in the United Kingdom (2.1%), followed by the United States (1.7%) and France (1.5%), while in terms of hourly productivity, they are equivalent in France and the United Kingdom (2.3%) and smaller in the United States (1.7%). The slowdown in productivity in France can be attributed to the slowdown in capital deepening

and TFP growth, while the acceleration in US productivity is linked to reverse movements in these two variables. In the United Kingdom, the contribution of TFP increased, while that of capital deepening decreased. France continued to post the highest TFP gains, in the wake of the trend apparent since World War II. Consequently, the level of hourly productivity relative to that in the United States increased markedly in France to exceed (at roughly 105%) that in the United States, and to a lesser extent in the United Kingdom to roughly 80%.

We will now look at the 1980-2004 period in greater detail.

3. Trends over the 1980-2004 period

In this section, we first focus on the changes in productivity over the past 25 years (3.1) then on the more specific impact of the spread of information and communication technologies (ICT) on these developments (3.2).

3.1. Changes in productivity over the past 25 years

The main findings are the following (Table 4, Graph 4):

- Over the sub-period 1980-1990, both France and the United Kingdom posted a growth rate of productivity per employee close to 2%, above the US rate of 1.4%, although productivity growth in the United States had risen sharply compared with the previous period 1973-1980 (0.3%). As regards hourly productivity, productivity growth was much higher in France (2.8%) than in the United Kingdom (1.9%) and the United States (1.3%), where it had also substantially increased on the previous sub-period (0.8%). The growth differential in productivity per employee between France and the other two countries over this sub-period can largely be explained by a higher average annual TFP contribution (1.7% against 1.1% in the United Kingdom and 0.7% in the United States), as the contribution of capital deepening was almost identical in all three countries (0.7% to 0.9%). However, compared with the previous sub-period (1973-1980), the contribution of TFP remained unchanged in France, whereas it rose significantly in the two other countries, in particular the United States;
- Over the sub-period 1990-1995, productivity growth rates differed widely across countries. In the United States, it was identical to that of the previous sub-period (1980-1990); the contributions of capital deepening and TFP were also identical. In the United Kingdom, productivity growth per employee and per hour increased sharply, by 1 and 1.3 points respectively. Approximately half of this acceleration is due to a higher TFP contribution and the second half to a higher contribution of capital deepening. In France, productivity growth per employee and per hour slowed considerably, shedding roughly 1 point in both cases. This slowdown results almost entirely from the slowdown in TFP growth (which declined by 0.8 point), and probably contains a strong cyclical component given the decrease in GDP growth. Thus, the feature that used to distinguish France from the other two countries i.e. strong TFP growth disappeared from the early 1990s;

Table 4
Average annual labour productivity growth (in %) and contributions (in percentage points),
in France, the United Kingdom and the United States
Scope: Economy as a whole

A - France

	1980- 2004	1980- 1990	1990- 1995	1995- 2000	2000- 2004
GDP	2.0	3.3	1.2	2.8	1.6
Productivity per employee [a]	1.5	2.0	1.2	1.2	1.0
Productivity per hour [b]	2.3	2.8	1.9	1.9	1.8
Contributions :					
Capital intensity per employee [c]	0.7	0.9	0.8	0.4	0.6
<i>Non-ICT capital intensity per employee</i>	0.4	0.6	0.6	0.0	0.3
<i>ICT capital intensity per employee</i>	0.3	0.2	0.2	0.4	0.3
Capital intensity per hour [d]	1.0	1.1	1.0	0.6	0.8
<i>Non-ICT capital intensity per hour</i>	0.7	0.9	0.8	0.2	0.5
<i>ICT capital intensity per hour</i>	0.3	0.2	0.2	0.4	0.3
Working time [e]	-0.5	-0.6	-0.4	-0.5	-0.6
TFP [f]	1.3	1.7	0.9	1.3	0.9

B - United-Kingdom

	1980- 2004	1980- 1990	1990- 1995	1995- 2000	2000- 2004
GDP	2.5	2.6	1.7	3.2	2.9
Productivity per employee [a]	2.1	1.9	2.9	2.0	1.6
Productivity per hour [b]	2.3	1.9	3.3	2.4	2.1
Contributions :					
Capital intensity per employee [c]	1.0	0.8	1.4	1.1	0.7
<i>Non-ICT capital intensity per employee</i>	0.5	0.5	0.9	0.3	0.4
<i>ICT capital intensity per employee</i>	0.5	0.3	0.5	0.8	0.3
Capital intensity per hour [d]	1.1	0.8	1.5	1.2	0.9
<i>Non-ICT capital intensity per hour</i>	0.6	0.5	1.0	0.4	0.5
<i>ICT capital intensity per hour</i>	0.5	0.3	0.5	0.9	0.3
Working time [e]	-0.2	0.0	-0.3	-0.3	-0.4
TFP [f]	1.2	1.1	1.7	1.1	1.2

C - United States

	1980- 2004	1980- 1990	1990- 1995	1995- 2000	2000- 2004
GDP	3.1	3.3	2.5	4.1	2.3
Productivity per employee [a]	1.7	1.4	1.4	2.2	1.9
Productivity per hour [b]	1.7	1.3	1.3	2.4	2.3
Contributions :					
Capital intensity per employee [c]	0.8	0.7	0.7	1.0	1.0
<i>Non-ICT capital intensity per employee</i>	0.3	0.2	0.2	0.2	0.5
<i>ICT capital intensity per employee</i>	0.6	0.5	0.5	0.9	0.5
Capital intensity per hour [d]	0.8	0.7	0.7	1.1	1.1
<i>Non-ICT capital intensity per hour</i>	0.3	0.1	0.2	0.2	0.6
<i>ICT capital intensity per hour</i>	0.6	0.5	0.5	0.9	0.5
Working time [e]	-0.1	0.1	0.1	-0.1	-0.3
TFP [f]	0.9	0.7	0.6	1.3	1.2

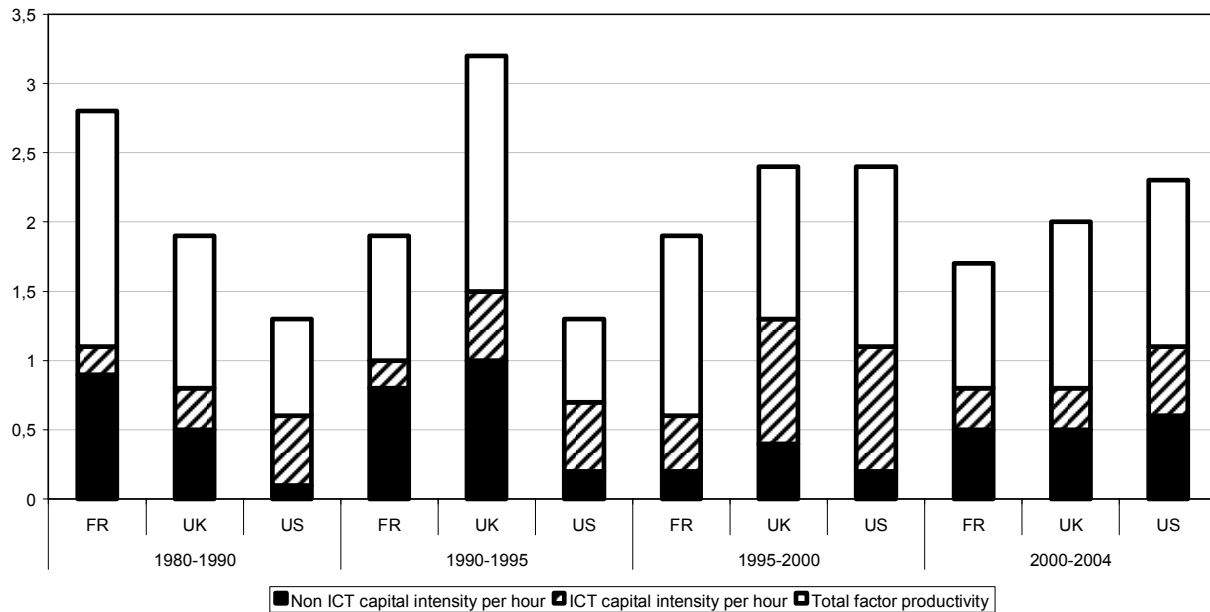
[f] = [a]-[c]-[e] = [b]-[d]

Source: Authors' calculations, see Boxes 1 and 2.

Graph 4

Average annual hourly labour productivity growth (in %) and contributions (in percentage points), in France, the United Kingdom and the United States - 1980-2004

Scope: Economy as a whole



Source: Authors' calculations, see Boxes 1 and 2.

- The sub-period 1995-2002 is characterised by a significant rise in GDP growth in all three countries (roughly 1.5 points). However, compared with the first half of the 1990s, productivity growth posted very different movements from one country to the next. In the United Kingdom, productivity growth slowed by approximately 1 point per annum; two thirds of this slowdown can be attributed to a slowdown in TFP growth and one third to a smaller contribution of capital deepening. In France, productivity growth remained stable, the acceleration in TFP – which may have a strong cyclical component - having been offset by a slowdown in capital deepening. The latter development could partly result from the implementation of policies designed to enhance the labour intensity of growth, in particular reducing working time and cutting social contributions targeted at low skilled workers (see Cette, 2004). In the United States, productivity growth gained approximately 1 point; faster TFP growth accounted for two thirds of this acceleration and a greater contribution of capital deepening for the remaining share. According to Gordon (2005), the fact that productivity accelerates in the United States but slows in Europe can be attributed to several factors, among which a predominance of ICT-using industries, public policies that promote entrepreneurship and a better synergy between public research, private research and the financing of innovation;
- Lastly, the sub-period 2000-2004 is characterised by a slight slowdown in productivity growth (by approximately $\frac{1}{4}$ point) in the three countries. The causes of this slowdown are diverse: a smaller contribution of capital deepening in the United Kingdom, of TFP in France and of both variables in the United States.

3.2. The contribution of ICTs to productivity growth

A large number of studies (see Cette, Mairesse and Kocoglu 2002 and 2005 for a review of the literature) are devoted to the issue of the contribution of ICTs to the growth of GDP and productivity per employee. These studies conclude that ICTs have had a positive and significant impact over the past two decades. According to the growth accounting framework, this contribution occurs via two channels:

- Substitution effects linked to the accumulation of ICT capital (capital deepening). The latter stems from the continuous and rapid improvements in the productive performances of ICT investments, which lead to a sharp fall in the price of ICT relative to other capital goods and labour. For example, in the United States, the price of computer hardware posted an average annual decrease of 15% over the 1980-2004 period, while the GDP price deflator rose by 3% per year;
- TFP gains predominantly linked to the technological progress achieved in the ICT-producing industries and to the productivity gains in the ICT-using industries via the externality and spillover effects.

According to Cette, Mairesse and Kocoglu (2000, 2002), the weight attached to these two effects in growth accounting analyses depends to a large extent on the methodological choices made regarding the volume-price breakdown of ICT investment series in value terms. Schematically, the more the volume-price breakdown takes into account the improvements in ICT performances, via hedonic methods for example, the greater the contribution of capital deepening to productivity gains and the lower that of TFP, and vice-versa. In this analysis, given the lack of sectoral data, we will only look at the first effect.

We will start by briefly presenting the importance of ICT investments in the three countries (a) then the changes in ICT prices (b) and finally the contribution of ICT capital deepening to productivity growth (c).

a) *ICT investments*

Assessing ICT investment expenditure raises a number of methodological problems (see Cette, Mairesse and Kocoglu, 2000, for a detailed review). The main problems concern the availability and reliability of the long series, the breakdown between investment and intermediate consumption of ICT expenditure, the assessment of expenditure on the personalisation of prepackaged software and the development of custom software. The solutions provided by the national accounting systems differ from one country to the next as well as over time. For example, at the time the base 2000 was set up and following the OECD recommendations on the international harmonisation of the methods for measuring software GFCF, INSEE, the French National Statistics Institute, changed the breakdown of software expenditure between intermediate consumption and investment on the one hand, and its method for measuring custom software expenditure on the other. As a result, the amount of software investment in 1999 rose from EUR 11 billion under base 1995 to EUR 21 billion under base 2000, i.e. a 90% increase.

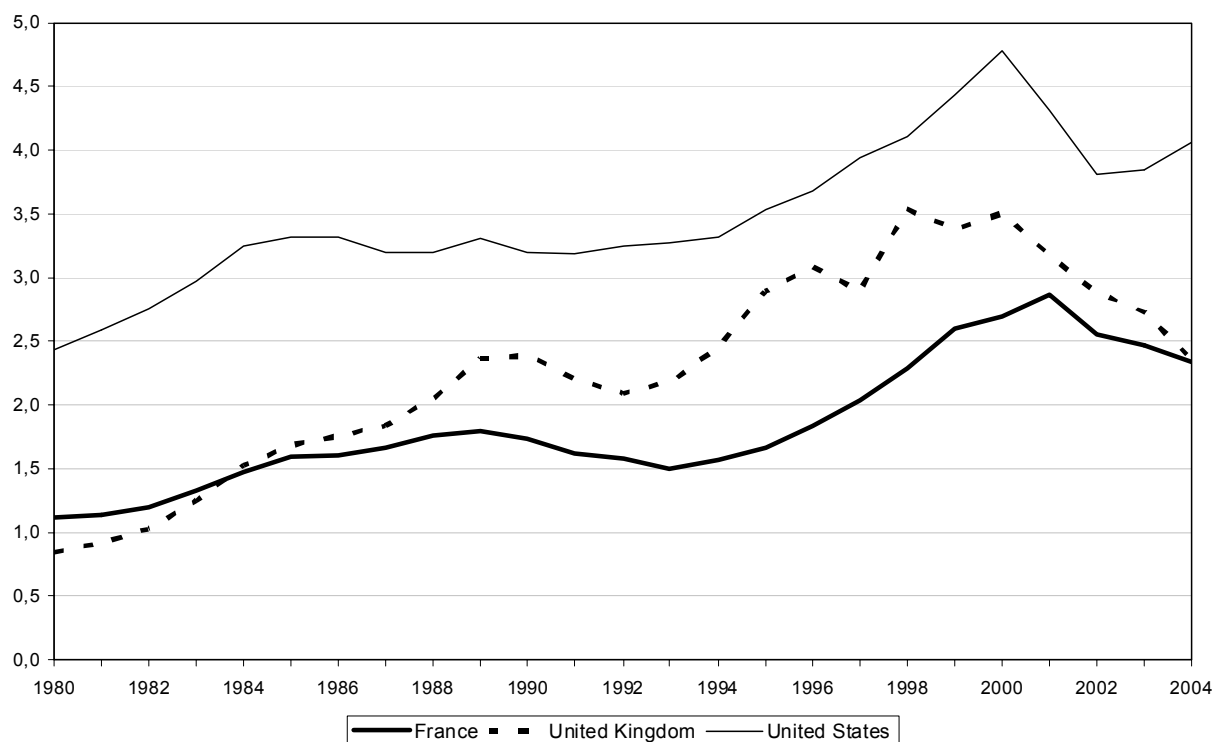
Graph 5 shows the ICT investment ratio in the three countries under review. The following observations can be made:

- In 2004, ICT investment in the United States accounted for 4% of GDP against only 2.5% in France and the United Kingdom;
- The ICT investment ratio displayed a relatively similar trend across the three countries. It accelerated from 1980 to 1985 and from 1995 to 2000, and remained stable or even declined from 1985 to 1994 and from 2001 to 2004;
- The bursting of the Internet bubble in 2000-2001 led to a substantial drop in the ICT investment ratio in the three countries. In the United Kingdom, the most affected country, the ICT investment ratio slid from 3.5% to 2.4% between 2000 and 2004. Whereas it picked up in the United States as from 2003, it continued to fall in France and the United Kingdom. This drop may be interpreted as a correction of the over-accumulation of ICT capital at the end of the 1990s, which had been partly fuelled by the financial market euphoria and the fears surrounding the Y2K bug.

Graph 5

ICT investment ratios (in %) in France, the United Kingdom and the United States - 1980-2004

Scope: Economy as a whole



Sources: See Box 1.

b) Changes in ICT prices

As mentioned above, one of the main difficulties – and consequently uncertainties – of measuring the contribution of ICT to growth lies in the volume-price breakdown of investment expenditure. National accounting systems are gradually adopting hedonic methods to account for the rapid improvements in ICT performance. However, there are substantial differences in the way in which countries apply these methods (see Cette, Mairesse and Kocoglu, 2000, 2002). To prevent these differences from affecting our comparison, we chose to use as price index for each one of the three ICT products in France and the United Kingdom the price index that corresponded to an equivalent price trend for this product relative to the GDP price deflator used in the US national accounts. This method, also used by Colechia and Shreyer (2001), implies that the price trend for each ICT product (excl. general inflation) is the same in all three countries.

Table 5 presents ICT price trends by sub-period in the three countries under review. The price of ICT is calculated as the weighted average of the price trends of computer hardware, software and communication equipment. The differences between countries stem from (i) differences in GDP price deflator trends and (ii) the breakdown of ICT investments between computer hardware, communication equipment and software. Over the 1980-2004 period, the average annual decline in ICT prices was of the same magnitude in the United Kingdom and the United States (roughly 6%). In France, prices decreased to a lesser degree (4% per year on average) mainly on account of the smaller weight of computer hardware⁵, which experienced the largest price fall relative to other ICT products⁶. The most pronounced price drops were recorded in the 1995-2000 period.

⁵ On average over the 1980-2004 period, computer hardware accounted for 25% of ICT investment in France, against 43% in the United Kingdom and 37% in the United States.

⁶ Between 1980 and 2004, computer hardware prices in the United States posted an average annual decline of 15%, compared with roughly 1% for software and communication equipment.

Table 5**Average annual ICT price growth (in %) in France, the United Kingdom and the United States - 1980-2004**

	1980-2004	1980-1990	1990-1995	1995-2000	2000-2004
France	-4.1	-6.3	-5.8	-6.7	-4.5
United Kingdom	-6.5	-3.8	-7.8	-10.6	-6.3
United States	-6.0	-5.0	-6.3	-8.6	-4.9

Sources and calculations: See Boxes 1 and 2.

c) The contribution of ICTs to productivity growth

The contribution of ICTs to labour productivity growth is shown in Table 4 and Graph 4. The main findings are the following:

- Over the entire 1980-2004 period, the contribution of ICT capital to productivity growth per employee is roughly the same as that of non-ICT capital in France and the United Kingdom, and much greater in the United States. Except for France, the same observations can be made concerning the contribution of ICTs to hourly productivity growth;
- The contribution of ICT capital to average annual productivity growth (per employee or per hour) ranges depending on the period from ½ point to 1 point in the United States, from ¼ point to 1 point in the United Kingdom and finally from ¼ point to ½ point in France. Although the ICT investment ratio is considerably lower in the United Kingdom than in the United States (see Graph 5), the contribution of ICTs to productivity growth is roughly the same in the two countries. This can be attributed to the significantly faster average annual growth rate of the capital stock per capita in the United Kingdom than in the United States (18% as against 14%). In France, the investment ratio is low and the annual growth rate of ICT capital per capita is slightly lower than in the United States (13% on average);
- In all three countries, the contribution of ICT capital is the largest over the 1995-2000 period. It amounts to roughly 1 point in the United States and the United Kingdom and roughly ½ point in France. At the same time, the contribution of other equipment and buildings declined considerably in France and the United Kingdom compared with the previous period. The faster decline in ICT prices over this period (Table 5) seems to have accelerated the substitution between ICT capital and non-ICT capital;
- Lastly, after 2000, the fall in ICT investment is directly reflected in the contribution of ICT capital to productivity growth. This effect is more pronounced in the United Kingdom and the United States (about – ½ point) than in France (-0.1 point).

On the whole, the results presented here are in keeping with those obtained in the most recent international comparative studies, such as those by Jorgenson and Kuong (2005), the OECD (2003) or Van Ark and Piatkowski (2004), presented in Table 6. As regards France, they are consistent with our previous assessments (see Cette, Mairesse and Kocoglu, 2005b). For the United Kingdom, they are not directly comparable with the recent assessments by Oulton and Srinivasan (2005) on the market economy; although their profile is similar, the contribution of ICTs is lower. According to these authors, the contribution of ICT capital deepening accounts for 0.7 point of the average annual increase in hourly labour productivity between 1979 and 1990 and for 1 point over the 1990-2000 period. As regards the United States, our results are very close to those of Jorgenson, Ho and Stiroh (2006), who establish that the contribution of ICT capital deepening accounts for respectively 0.37% and 0.78% of hourly productivity growth in the sub-periods 1973-1995 and 1995-2004.

Table 6

Average annual contribution of ICT to the growth of GDP or labour productivity (in %) in France, the United Kingdom and the United States
Results of some international comparisons

	Jorgenson and Kuong (2005)*		OCDE (2003)*		Van Ark and Piatkowski (2004)**
	1989-1995	1995-2003	1990-1995	1995-2001	1995-2001
France	0.2	0.4	0.2	0.3	0.3
United Kingdom	0.3	0.6	0.3	0.6	0.6
United States	0.5	0.9	0.5	0.9	0.7

* Contribution to GDP growth, ** Contribution to the growth of labour productivity per employee.

As mentioned above, national accountants are faced with a number of methodological problems when assessing ICT investment expenditure and establishing the volume-price breakdown. Let us consider the case of investment expenditure on software. Measuring this type of expenditure raises several problems, and in particular the assessment of (i) software integrated into the hardware, (ii) expenses incurred to adapt prepackaged software to the needs of the company and (iii) the expenditure undertaken to create custom software. Methodological differences may result in different measurements of software investment. For example, whereas the share of software investment in total ICT investment jumped from roughly 16% in 1980 to 40% in 2004 in the United Kingdom and the United States, it dropped from 58% to 50% in France. Providing an economic explanation for these differences seems difficult. In order to measure the effect of these uncertainties on the assessment of the contribution of ICT capital to productivity growth, we suggest a variant in which the ratio of software expenditure to computer hardware expenditure in France and the United Kingdom is the same as that in the United States. Table 7 presents the results under this assumption.

As expected, this assumption reduces the contribution of ICTs to productivity growth by approximately 0.1 point in France and raises it by roughly 0.1 point in the United Kingdom. The effect seems therefore limited in the long-run. The noteworthy result is that, under this assumption, the contribution of ICTs to productivity growth between 1995 and 2000 is greater in the United Kingdom than in the United States. It is therefore important to bear in mind the fact that these methodological differences may affect the conclusions of studies on the contribution of ICT capital to growth.

Table 7

Average annual contribution of ICT to the growth of productivity per employee (in %) :
Software expenditure variant

	1980-2004	1995-2000	2000-2004
France	0.2	0.3	0.2
United Kingdom	0.5	1.0	0.3
United States	0.6	0.9	0.5

Sources and calculations: See Text above, and Boxes 1 and 2.

4. Conclusion

The results of our study, despite being extremely aggregated and global, are nevertheless very rich and difficult to summarise. It is worth mentioning the most striking, not to say the most original, findings. The past 120 years have been characterised by substantial economic growth and productivity gains in the three countries under review, the remarkable catching up of the United States by France and the fact that the United Kingdom has practically reached a par with the United States after having been on a long-term decline.

At present, total factor productivity is very close in all three countries. However, hourly labour productivity is slightly higher in France than in the United States and significantly lower in the United Kingdom. Furthermore, productivity per employee is slightly lower in France than in the United

States and much lower in the United Kingdom. These performances reflect the more or less contrasting developments during the various periods of the analysis, associated with varying contributions of capital deepening and the downward trend in working hours.

Between 1890 and 2005, the faster drop in working time accounts for roughly 25% of the differential in productivity per employee between France and the United States, and just about 5% of that between the United Kingdom and the United States. Similarly, over this same period, the lower contribution of capital deepening explains 15% of the differential in productivity per employee between France and the United States and almost 25% of that between the United Kingdom and the United States. The other growth factors included in the concept of total factor productivity account for 100% of France's catching-up with US labour productivity and for 40% of the decline in British labour productivity compared with the United States. These other growth factors (the decline in working hours and capital deepening being equal) would thus account for the almost three-fold increase in French labour productivity compared with the United Kingdom, i.e. an average annual growth differential over 115 years of 1.0%.

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