# Diffusion of ICTs and Growth of the French Economy over the Long-term, 1980-2000

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Gross domestic product (GDP) growth has slowed significantly in the United States and in Europe since late 2000. This slowdown has followed a period of strong growth by companies specializing in information and communications technologies (ICTs). It might therefore appear paradoxical to continue to pay particular attention to the relationship between capital inputs in ICTs and GDP and productivity growth. However, the paradox vanishes upon closer inspection. In fact, one of the origins of the reversal (a major one in the United States) appears to have been an abrupt slowdown in the demand for ICT products, not a downturn in productivity growth on the supply side. This slowdown in the demand for ICT products follows a period of continuously rising demand, which increased significantly in the second half of the 1990s, due perhaps in part to the fears associated with the Y2K bug. Numerous recent studies have analyzed the ICT contribution to output and labour productivity growth using national accounts data and standard growth accounting assumptions. Nearly all of them have concluded, with a variety of nuances, that business ICT expenditures have had a favourable impact on labour productivity.

The impact of ICT investment expenditures on labour productivity shows up in growth accounting studies as two types of effects: capital deepening, associated with capital accumulation in ICTs; and total factor productivity (TFP) growth, related particularly to progress in ICT-producing sectors. The roles attributed to these two types of effects are critically dependent on the methods adopted by national accountants for decomposing nominal capital input series into price and volume components. This warning is stressed in many analyses.[1] It should always be kept in mind in assessing the economic significance of possible shifts in estimated TFP growth.[2] Other uncertainties result from the difficulties of taking into consideration the conditions for achieving (in terms of the skill level of the workforce and the organization of work) productivity growth through ICT diffusion, as shown by the growing number of econometric studies involving firm data.[3]

Moreover, certain accounting uncertainties related to the measurement of capital inputs in ICTs result in more difficulty in conducting growth accounting studies and making comparisons between countries. For example, a recent study by Lequiller (2000) shows that the apportioning of expenditures on computer equipment,

especially software, between final use and intermediate use is apparently very different in the United States than in European countries. These differences can have a significant relative impact on the estimation of GDP growth that favours the United States, and an even greater impact on the estimation of the ICT contribution to this growth.

In the framework of growth accounting analyses, this study is aimed at providing a set of estimates of the impact of ICTs on output and labour productivity growth in France in the 1980s and 1990s. In this study, as in most similar studies, ICTs include computer equipment, software and communications equipment. ICTs therefore include both "older" technologies that in the past experienced continuous and rapid growth, such as computer equipment; and newer methods of communicating, accessing and processing knowledge, such as the Internet. In our study, like in most others, the various methological and statistical uncertainties mentioned above have, for the most part, been ignored. Firms are assumed to behave optimally on the whole in adopting and using the old and new technologies, taking into account their relative costs as given in a competitive environment. In particular, we do not consider the possibility of a recent overaccumulation of capital inputs in ICTs, and hence our estimates for the second half of the 1990s compared to earlier periods, are not immune from a possible overestimation.

## An Accounting Analysis of Growth and Productivity in the French Economy

The results of the accounting analysis of value-added and labour productivity growth observed in France during the period 1980-2000 were obtained using the methodology described in Box 1 and data from the national accounts. They are summarized in Tables 1-A and 1-B. These two tables give rise to the following observations:

- The ICT contribution to value-added and productivity growth directly related to ICT diffusion and capital deepening is modest but nonetheless sizeable: 0.25 per cent per year over the 20 years between 1980 and 2000. This contribution has tended to increase in recent years, to 0.36 per cent per year since 1995. Therefore, even though ICT capital inputs were four times smaller than other types of capital inputs, the ICT contribution was only two to three times lower than the contribution of other types of equipment in the 1980s and first half of the 1990s. It even became comparable by the second half of the 1990s, in a period when the ICT contribution increased and that of the other types of equipment dipped dramatically. The increasing ICT contribution not only represents the results of capital deepening, linked to the exponential decrease in the relative prices of ICTs, but perhaps also reflects an overaccumulation of ICT capital inputs, fuelled to some extent by fears associated with the Y2K bug.
- Total factor productivity fluctuates with the business cycle, suggesting a large cyclical component. TFP fluctuations were greater among non-ICT producers than among ICT producers; TFP has accelerated since 1995, almost as much for non-ICT producers as for ICT producers.

As we have pointed out, there are a number of uncertainties surrounding the measurement of business ICT investment. The impact on estimates of two types of uncertainties that are particularly significant are shown in Table 2.

The first uncertainty concerns the apportioning of capital inputs between volume and price. The effects can be demonstrated with two extreme scenarios:

- In the first scenario (the "strong price trend scenario"), it is assumed that the price change for software and communications equipment

**Box 1: Accounting Breakdown of Growth and Productivity: Methodology**

The accounting method used to break down output (here gross value-added or GVA) and labour productivity growth is the standard method. In this approach, the contribution to growth of a factor of production is estimated as the product of the growth rate of the volume of this factor multiplied by its share in value-added. This estimate assumes a production function with substitutable factors of production and constant returns to scale, perfect competition in factor markets as well as product markets, and an optimum choice of production techniques resulting, for all pairs of factors, in a ratio of marginal productivities that is equal to the ratio of marginal costs. The share of a capital factor in value added is estimated in the standard manner as the product of its relative user cost (in proportion to its price) by the ratio of its value to value added.

The series on value-added volume and price, average employment and hours worked, volume and price of capital inputs in non-ICT equipment and in buildings and infrastructures were drawn directly from the national accounts (base 1995). For ICT products, the series of capital inputs were drawn from the national accounts since 1978 and, for earlier periods when such data are not available, the series were retropolated as described in Mairesse, Cette and Kocoglu (2000: Appendix 2). For the price of ICT capital inputs, national accounting indices (base 1995) were used for communications equipment, while U.S. indices, corrected for changes in the exchange rate, were used for computer equipment and software (Mairesse, Cette and Kocoglu, 2000: Appendix 2). A comparison of the methodologies used by national accountants in France and the United States to construct the series of prices for various types of capital inputs is provided in Cette, Mairesse and Kocoglu (2000).

The capital input series are calculated by the so called permanent inventory method assuming a constant depreciation rate of 30 per cent for computer equipment and software, 20 per cent for transport equipment, 15 per cent for communications equipment and non-ICT and non-transport equipment, 5 per cent for buildings and 2.5 per cent for infrastructure.

The distinction between ICT producers and non-ICT producers was based on the 40-sector French industry classification system (NAF). ICT industry activities and ICT service activities identified here are much broader than the three ICT products (computer equipment, software and communications equipment).

is identical to that of computer equipment. This scenario assumes that the productive performances of software and communications equipment will improve each year as rapidly as the productive performance of computer equipment. Accordingly, over the second half of the 1990s, it assumes an average annual price change of -18.8 per cent for the three ICT components, instead of 2.8 per cent for software and -4.1 per cent for communications equipment. This means that the software and communications equipment component of real capital input grows much more rapidly and makes a greater contribution to growth. The contribution of ICTs overall has thus doubled compared to the base case, reaching 0.71 per cent annually in the second half of the 1990s. The contribution of TFP to growth, however, decreased by the same amount that the contribution of ICTs increased.

- In the second scenario ("weak price trend scenario"), it is assumed that the price change for computer equipment and software is identical to that of communications equipment. This is equivalent to ignoring most of

**Table 1-A**

**Contributions to Value-added for the French Business Sector**

(Average annual rate of growth)

| | 1980-2000 | 1980-1990 | 1990-2000 | 1990-1995 | 1995-2000 |
|---|---|---|---|---|---|
| Real GDP | 1.88 | 2.42 | 1.35 | 0.50 | 2.20 |
| Total ICT, including | 0.25 | 0.24 | 0.27 | 0.17 | 0.36 |
| Computer equipment | 0.11 | 0.11 | 0.12 | 0.08 | 0.15 |
| Software | 0.08 | 0.07 | 0.09 | 0.05 | 0.12 |
| Communications equipment | 0.06 | 0.05 | 0.07 | 0.05 | 0.09 |
| Other types of equipment | 0.56 | 0.63 | 0.49 | 0.57 | 0.40 |
| Buildings and infrastructures | 0.36 | 0.43 | 0.29 | 0.44 | 0.14 |
| Labour, including | -0.47 | -0.60 | -0.34 | -0.83 | 0.15 |
| Employment | -0.11 | -0.20 | -0.01 | -0.69 | 0.67 |
| Average hours worked | -0.36 | -0.40 | -0.32 | -0.14 | -0.50 |
| Total Factor Productivity | 1.19 | 1.74 | 0.64 | 0.15 | 1.13 |

Source: Estimates by the authors.

**Table 1-B**

**Contributions to Labour Productivity for the French Business Sector**

(Average annual rate of growth)

| | 1980-2000 | 1980-1990 | 1990-2000 | 1990-1995 | 1995-2000 |
|---|---|---|---|---|---|
| Real GDP | 1.88 | 2.42 | 1.35 | 0.50 | 2.20 |
| Employment | -0.14 | -0.26 | -0.01 | -1.13 | 1.11 |
| Real GDP per worker | 2.02 | 2.69 | 1.36 | 1.63 | 1.09 |
| Total ICT, including | 0.25 | 0.24 | 0.27 | 0.20 | 0.33 |
| Computer equipment | 0.11 | 0.11 | 0.12 | 0.08 | 0.15 |
| Software | 0.08 | 0.07 | 0.09 | 0.05 | 0.11 |
| Communications equipment | 0.06 | 0.05 | 0.07 | 0.06 | 0.08 |
| Other types of equipment | 0.56 | 0.63 | 0.49 | 0.77 | 0.21 |
| Buildings and infrastructures | 0.36 | 0.43 | 0.29 | 0.66 | -0.08 |
| Hours worked | -0.36 | -0.40 | -0.34 | -0.14 | -0.54 |
| Total Factor Productivity, including | 1.19 | 1.74 | 0.64 | 0.15 | 1.13 |
| ICT producers | 0.35 | 0.31 | 0.40 | 0.14 | 0.65 |
| Non-ICT producers | 0.66 | 1.21 | 0.11 | -0.17 | 0.39 |
| Structural effects | 0.18 | 0.22 | 0.14 | 0.18 | 0.09 |

Source: Estimates by the authors.

the quality improvement in measuring price changes in computers. Given the minor differences in software and communications equipment price trends, this scenario has a significant impact only on the estimate of the contribution made by computer equipment. Overall, the ICT contribution to growth appears to have decreased only slightly and TFP contribution appears to have just barely increased.

The second uncertainty relates to the allocation of ICT expenditures between final and intermediate expenditures. Lequiller (2000) shows that in the United States, in 1995, business investment accounted for 55 per cent of the total business expenditures for computer equipment and 50 per

**Table 2**
**Three Scenarios for Calculating Contributions to Value-added in the French Business Sector**
(Average annual rate of change)

| | Strong price trend scenario | | Weak price trend scenario | | Scenario based on U.S. share of ICT expenditure between intermediate consumption and investment | |
|---|---|---|---|---|---|---|
| | 1980-2000 | 1995-2000 | 1980-2000 | 1995-2000 | 1980-2000 | 1995-2000 |
| Real value-added | 1.88 | 2.20 | 1.88 | 2.20 | 1.88 | 2.20 |
| Total ICT, including | 0.50 | 0.71 | 0.17 | 0.31 | 0.48 | 0.68 |
| Computer equipment | 0.11 | 0.15 | 0.04 | 0.06 | 0.23 | 0.31 |
| Software | 0.18 | 0.31 | 0.08 | 0.16 | 0.19 | 0.28 |
| Communications equipment | 0.20 | 0.25 | 0.06 | 0.09 | 0.06 | 0.09 |
| Other capital | 0.92 | 0.54 | 0.92 | 0.54 | 0.92 | 0.54 |
| Labour | -0.47 | 0.15 | -0.47 | 0.15 | -0.47 | 0.15 |
| Total Factor Productivity | 0.93 | 0.80 | 1.26 | 1.20 | 0.95 | 0.83 |

Source: Estimates by the authors.

cent for software, according to the national account data. In France, the shares were 30 per cent and 20 per cent respectively. Such discrepancies between the two countries are very unlikely and are largely explained by differences in statistical methods and sources. It is thus interesting to estimate the ICT contribution to growth in France under the hypothesis that the investment share in computer equipment and software resources in France was the same as in the United States (the investment share in communications equipment is very similar in both countries). The result is a very significant increase in investment and capital inputs in computer equipment and software, and therefore, in their contribution to growth. The total ICT contribution to growth appears to have doubled in comparison to the base case. In the second half of the 1990s, it increased from 0.36 per cent annually in the base case to 0.68 per cent. The TFP contribution to growth decreased by the same amount.

Whereas the first two scenarios confirm the importance of using harmonized price series in cross-country comparisons of estimates of the contribution of ICTs to growth, the third scenario shows that the problem of comparability in dividing ICT expenditures by firms in investment and intermediate comsumption is also a significant factor and deserves close attention.

Our estimates for the French Business Sector as a whole have also been computed for five major sectors: IT manufacturing, non-IT manufacturing, IT services, non-IT services and other business sector industries (including agriculture). These sectoral estimates are presented in Cette, Mairesse and Kocoglu (2002). They show, among other things, that the contribution to growth from ICTs is always much greater in service activities than in other sectors. This difference is related to the fact that ICT expenditures are only counted as separate ICT investment if they correspond to a physically isolated product (not when they are a component embodied in a larger product). ICT components that are embodied in production equipment such as machine tools and robots are not classified as ICT investment but rather as intermediate consumption by companies producing these items. The relative ICT share in total capital inputs (excluding buildings and infrastructures) is thus significantly higher in the service sector (about 30 per cent in 1999) than in the industrial sector (6 per cent). This convention does not, however,

**Table 3**
**TFP Contributions to Gross Value-added in the French Business Sector**
(Average annual rate of change)

| | 1980-2000 | 1980-1990 | 1990-2000 | 1990-1995 | 1995-2000 |
|---|---|---|---|---|---|
| Total Factor Productivity, including | 1.19 | 1.74 | 0.64 | 0.15 | 1.13 |
| Cyclical component | 0.06 | 0.17 | -0.06 | -0.28 | 0.15 |
| Structural component | 1.13 | 1.57 | 0.70 | 0.43 | 0.98 |

Source: Estimates by the authors.

affect the estimation of the value of total investment expenditures, but only their breakdown by product.[4] It explains largely why ICT investment appears, in national accounts, to be much more concentrated in service activities, where they take, to a large extent, the form of specific goods (such as large systems or personal computers), than in manufacturing activities.

As we already noted, our results show that TPF growth is procyclical. This finding is, of course, not at all surprising, since TFP is affected by cyclical changes in the utilization of factors of production not explicitly taken into account here in the growth accounting decomposition. Although hours of work are explicitly taken into account, two other indicators of intensity of use are not: use of productive capacity and equipment operating time. One way to separate the cyclical from the structural component in the TFP contribution to output growth is to estimate an elasticity with respect to changes in the use of factors of production. We have thus estimated a large number of regressions, both at the sectoral level and in the overall business sector, between TFP growth and changes in capacity utilization and equipment operating time, growth of ICT capital inputs, and the changes in the share of ICT capital inputs in total capital inputs, with different lag structures. The only estimates that appear reasonable and statistically significant are those obtained for the business sector as a whole, using current changes (and possibly one year lags) in the rate of capacity utilization as an explanatory variable.

On the basis of this result, we can differentiate between the cyclical component and the structural component of TFP contribution to growth. The result of this decomposition is presented in Table 3. The cyclical component of TFP growth has, on average, been positive and quite strong (0.17 per cent per year) over the 1980s, principally due to a very strong economy at the end of the decade, and negative, but fairly weak, (-0.06 per cent) over the 1990s. The favourable conditions in the second half of the 1990s were not sufficient to offset unfavourable developments in the first half of the decade. If we break down the 1990s, we find that the cyclical component of TFP growth is negative and fairly strong on average (-0.28 per cent) over the first half, and positive and somewhat weaker (0.15 per cent) over the second half. The structural component of TFP contribution is not constant, but varies quite a bit, even if not as much as TFP growth itself. Our breakdown between cyclical and structural components of TFP growth thus remains very crude.

## International Comparisons

Growth accounting analyses of ICT contribution to economic growth comparable to our study are limited for other industrialized countries, the exception being the U.S. economy — see works by Jorgenson (2001) and Jorgenson and Stiroh (2000), Oliner and Sichel (2000) and the CEA

(2001).[5] Oulton (2001) did a comparable study for the United Kingdom. As regards France, apart from this study and our earlier works (Cette, Mairesse and Kocoglu (2002) and Mairesse, Cette and Kocoglu (2000)), the study by Crepon and Heckel directly based on firm level accounting information should be mentioned.[6] The international comparisons for OECD countries by Schreyer (2000) and Colecchia and Shreyer (2001) are also to be pointed out.

The following observations emerge from a comparison of the studies for the United States and ours for France:[7]

- From the first oil crisis to the beginning of the 1990s, the contribution to labour productivity growth from capital deepening in ICT products was twice as strong in the United States as in France (0.4-0.5 per cent per year versus 0.25 per cent). Over the first half of the 1990s, it grew by about 0.25 per cent in the United States and shrank slightly in France. Lastly, over the second half of the 1990s, it doubled in the United States (reaching about 1 per cent) and in France (reaching about 0.35 per cent). In total, over the second half of the 1990s, the contribution of ICTs to labour productivity growth was more than three times greater in the United States than in France. This differential may be explained, at least in part, by a lag in ICT diffusion in France compared to the United States. This lag may be itself related to a small extent to the fact that the drop in ICT prices in France was dampened by the rise in the U.S. dollar relative to the franc and then the euro over the past decade. A good part of the differential may result from differences in national accounting conventions, as pointed out earlier.
- In both countries, the contribution to growth from the effect of capital deepening in ICT products appears to have increased during the second half of the 1990s, compared to other components of fixed capital.

**Table 4**

**Decomposition of the Change in Labour Productivity Growth in the United States and France after 1995**

(Average annual rate of change)

**A United States Business Sector (1995-1999 with reference to period 1973-1995)**

| Category | Jorgenson and Stiroh (2000) | Oliner and Sichel (2000) | Council of Economic Advisors (2001) | Robert Gordon (2000a,b) |
|---|---|---|---|---|
| Labour productivity | 0.9 | 1.2 | 1.5 | 1.4 |
| Cycle | n.a. | n.a. | n.a. | 0.7 |
| Trend | 0.9 | 1.2 | 1.5 | 0.7 |
| Contribution of: | | | | |
| Capital per worker | 0.3 | 0.3 | 0.5 | 0.3 |
| IT capital | 0.3 | 0.5 | n.a. | n.a. |
| Other capital | 0.0 | -0.2 | n.a. | n.a. |
| Labour quality | 0.0 | 0.0 | 0.1 | 0.1 |
| Multi-factor productivity | 0.7 | 0.8 | 0.9 | 0.3 |
| Production of IT | 0.3 | 0.3 | 0.2 | 0.3 |
| Other sectors | 0.4 | 0.5 | 0.7 | 0.0 |

The acceleration is measured relative to a base of 1973-95. The estimates of Jorgenson-Stiroh extend only through 1998.

Source : Bosworth and Triplett (2001, p. 23).

**B French Business Sector (1995-2000 with reference to periods 1980-1995 in first column and 1990-1995 in second column)**

| | Reference period 1980-1995 | 1990-1995 |
|---|---|---|
| Labour productivity (output per worker) (slowdown), including: | -1.3 | -0.6 |
| Cyclical component of TFP | 0.1 | 0.4 |
| Structural components of labour productivity, including: | -1.4 | -1.0 |
| Effect of capital - labour substitution | -1.0 | -1.2 |
| ICT capital inputs | 0.1 | 0.1 |
| Others | -1.1 | -1.3 |
| Hours of work | -0.2 | -0.4 |
| Structural TFP growth | -0.2 | 0.6 |
| ICT-producing | 0.3 | 0.3 |
| ICT-using | -0.5 | 0.3 |

Source: Estimates by the authors.

- In both countries, TFP growth apparently accelerated in the second half of the 1990s relative to the first half of the decade, more in

France, however, than in the United States. This acceleration was similar in the ICT sector and non-ICT sector.

Moreover, the acceleration in TFP growth in the American economy is very recent: it only began in the mid-1990s (see Table 4A, reproduced from Bosworth and Triplett (2000). The estimates for France on the accounting decomposition of the changes in productivity growth after 1995 with reference to the periods 1980-1990 and 1990-1995 (Table 4B), show significant differences with United States:

- First, it is a slowdown in labour productivity that requires explanation in France, and not an acceleration, as in the United States. This slowdown is of course one of the results of policies aimed at "enhancing the employment component of growth" by reducing payroll taxes on the one hand and the hours of work on the other. Some information on these policies is provided in Box 2.
- Second, faster output growth in France produced a cyclical rebound in TFP growth, with the result that the total structural slowdown in labour productivity growth was close to 1 point on average annually relative to 1990-1995 and 1.4 points relative to 1980-1995, compared to an acceleration of 0.9 to 1.5 points in the United States.
- The effects of capital deepening in ICT products accelerated somewhat in both countries after 1995. However, in France, these effects slowed down dramatically for the other forms of capital inputs, but did not change significantly in the United States. The effect of capital-labour substitution on productivity growth during this period was positive and weak in the United States, and negative and strong in France.
- Overall, in France, the slowdown in the effects of input substitution and, to a lesser extent, the effects of reduced hours of work could explain the structural slowdown in productivity growth on an output per worker basis. TFP growth apparently accelerated in ICT-producing sectors and accelerated or decelerated in ICT-using sectors, depending on the base period that is used (1990-1995 or 1980-1995).

In his estimates for the United Kingdom, Oulton (2001) strongly adjusts the national accounts figures on computer and software expenditures to reduce the effects of differences in accounting conventions. Data on software are corrected so that capital inputs correspond to the same share of total expenditures as in the United States. Data on computer equipment are corrected so that the capital input ratio between these products and software is the same as in the United States. As in our estimates, U.S. price indices corrected for an exchange rate effect are used for ICTs. The ICT contribution to labour productivity growth in the United Kingdom is consistently weaker by one-third than in the United States, and stronger by a half than the contribution we estimated for France. The same acceleration was observed in the second half of the 1990s, a period when the ICT contribution was considerably greater than that of other capital input components. Taking into account the adjustments made by the author, the results obtained for the United Kingdom are thus comparable to the French estimates in our third variant based on the U.S. share of ICT expenditure between investment and intermediate consumption (Table 2). The most significant difference between the two countries is therefore a severe slowdown in TFP growth in the second half of the 1990s in the United Kingdom, which is contrary to what we observed in France and the United States.

The results of the recent international comparison by Colecchia and Schreyer (2001) are less detailed but entirely consistent for France with our own estimates. Their main findings are the following:

**Box 2: French Policies to Foster Employment**

The slowdown in labour productivity observed in France in the second half of the 1990s (Table 4) is explained in part by economic policies aimed at "enhancing the employment component of growth" implemented over this period. These policies consist principally of payroll tax reduction measures targeting low wages and reduced hours of work.

Company payroll tax reductions are aimed at correcting a significant price distortion linked to a relatively high minimum wage (the SMIC) in France. One of the effects of such a distortion is to penalize the hiring of poorly qualified workers. These reductions in payroll taxes targets low wages. There was a significant initial development in 1993 (with the Five-Year Employment Law), then a second development in 1995 (with the so-called "Juppé kickback," named for the then French Prime Minister). In 1997, the gross cost of this policy to the public budget represented about 0.5 per cent of the French GDP. Starting in 1998, payroll taxes targeting low wages were again reduced, following the recommendations of the Malinvaud report (1998). This further decrease in payroll taxes was associated with "the 35-hour work week policy," whereby the benefits of the new reductions in payroll taxes were conditional on an agreement between unions and management to reduce the work week to 35 hours. In 2001, the gross cost of reduced payroll taxes represented about 1.2 per cent of GDP.

Reduced hours of work, introduced by the "the 35-hour work week policy" also contributed to "enhancing the employment component of growth." This policy was mainly implemented by two laws (called the Aubry Laws, after the then Minister of Labour) passed on June 13, 1998 and January 19, 2000. These laws reduced the legal work week to 35 hours, with an increase in hourly wages for overtime. Among their various aspects, these laws also made it possible for companies to avoid various Labour Code provisions (within certain limits) on the condition that they be implemented as a "35 hour agreement" between unions and management. Thus, for example, the "35 hours a week" can be organized as an average over a year, within the limit of a maximum of 1600 hours without extra overtime costs, or even averaged over four years using "leave banks". Thus management work time may be calculated in days, rather than hours, to a maximum of 217 annual working days (or more, using "leave banks"). At the end of 2001, over two-thirds of private sector employees potentially affected by this policy were covered by "35-hour agreements". For more details, see Cette (2000).

- The results for France are very comparable to those for Germany, Italy and Japan. The ICT contribution to growth in this group of countries is in the 0.2-0.4 per cent per year range for the period 1980 to 2000, and represents around a quarter to a half of the contribution of other types of capital inputs. This group of countries is therefore clearly differentiated from the United States where the ICT contribution to growth is significantly higher. Australia, Finland, the United Kingdom and Canada constitute a second group that is situated "grosso modo" between the first group and the United States. The ICT contribution to growth in these four countries appears generally higher than in France and the other countries in the first group and tends to approach that of the United States.
- These studies demonstrate strikingly that the very significant increase in the ICT contribution to growth during the past five years (1995-2000), as we observed in France, is a

general phenomenon in all countries that experienced an acceleration in their growth (with the exception of Germany and Japan). However, the United States experienced a much greater increase, which puts it well ahead of the other countries.

## Conclusion

The contribution of ICTs to output and labour productivity growth in France is sizeable, yet much less than that in the United States. An important issue is how far into the future the productivity-augmenting effects of ICTs are likely to last. The main gain in efficiency comes from microprocessors, whose capacity has increased unabated, approaching "Moore's Law" (capacity doubles in 18-24 months). But it would not be prudent to extrapolate this trend indefinitely (Jorgenson (2001). The uncertainty surrounding basic human capabilities to take full advantage of such rapidly growing capacities should also be considered.

Another important issue concerns the benefits, in terms of productivity and growth, that industrialized European countries (including, of course, France and the Euro zone countries) could draw from ICT diffusion. In a recent analysis, Gust and Marquez (2000) conclude that the favourable effects of the "New Economy" and the ICTs on labour productivity and TFP will eventually become apparent in all the industrialized countries; the uncertainty is about how big a difference and how much lag there will be in these effects between the United States and the other countries. This uncertainty is increased by our lack of knowledge on the magnitude of spillovers between ICT-using activities and ICT-producing ones. If such spillovers are significant, the gains from ICT diffusion will be weaker in Europe than in the United States given Europe's smaller ICT-producing sector. However, Pilat and Lee (2001, p. 21-22) advance several reasons why having a significant ICT-producing sector is not a necessary condition for a country to obtain full benefit in terms of growth from ICT use: for example, proximity to software producers could be more significant than proximity to computer equipment producers; moreover, many countries (Australia, for example) appear to draw great benefit from ICT use without having a significant ICT-producing sector. The ICT contribution to growth in European countries could thus increase significantly in coming years.

Finally, the recent economic developments suggest, at least for the United States, a possible "overaccumulation" in ICTs in the second half of the 1990s. The impact of ICT capital inputs during this period might not be as favourable as indicated by the standard growth accounting estimates.[8] Of course, as in the case of numerous other economic phenomena, only the passage of time (and a significant improvement in statistical data) will allow us to find out.

## Notes

* This article is an abridged version of Cette, Mairesse and Kocoglu (2002), where the reader can find a more detailed presentation of data, analytical methods and results. The authors alone are responsible for the analysis and estimates in this paper, not the institutions that employ them. Email: gilbert.cette @banque-france.fr, mairesse@ensae.fr, et kocoglu@romarin. univ-aix.fr

1 See, among others, Cette, Mairesse and Kocoglu (2000) and Brynjolfsson and Hitt (2000).

2 See, for example, Gordon (2000b) or Jorgenson and Stiroh (2000).

3 For a survey of this type of study, see, among others, Brynjolfsson and Hitt (2000), and for two studies on France, see Greenan and Mairesse (2000) and Greenan, Mairesse and Topiol-Bensaid (2001).

4 On this point, see, for example, Stiroh (1998), Diewert and Fox (1999), and Mairesse, Cette and Kocoglu (2000).

5 These analyses of the American economy are based on data that predated the major national account revisions in August 2001. Taking these revisions into account would reduce TFP growth by 0.2 to 0.3 points per year in the second half of the 1990s and also, to a lesser extent, the effect of capital deepening in ICT products.

6 The study by Crépon and Heckel (2000) is based on company level accounting data for a large sample of firms. It shows a larger contribution to growth from capital deepening in ICT products than we found in our study based on national accounting data. This divergence arises in large part from differences in sources. A detailed comparison of our results with those of Crépon and Heckel is found in Mairesse, Cette and Kocoglu (2000: Appendix 1, p. 144).

7 Let us recall that, in this comparison, there is no methodological difference in the estimation of price indices for ICTs and in their adjusment for quality changes, since we use the US price indices (corrected for the exchange rate) for computer equipment and software, and the French indices are not significantly different from the U.S. indices for communications equipment.

8 Taking into account (if such were possible) this overaccumulation phenomenon would not affect the estimates of GDP growth or, consequently, labour productivity growth. It might change (downward) the estimates of the growth of ICT capital input services, on account, in fact, of the expected depreciation in ICT capital inputs or the lower marginal productivity of these investments, and consequently the effects of capital deepening in ICT on labour productivity. This change would be carried over (upward) to the residual factor — in other words, to total factor productivity growth; but it would, of course, be incorrect to attribute this growth to ICTs!

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