Skills, Technology and Growth is ICT the Key to Success ?

Part I : An Analysis of ICT Impact on French Growth

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SUMMARY

This paper aims at assessing the contribution of ICT to growth in France at the macro-level over the period 1982-2000. The importance of prices in assessing the ICT contribution to value added and hourly labour productivity growth is emphasised. On the labour side, we also evidence the role played by hours worked by stressing the contributions of various factors to the labour quality and the way they intervene in explaining the labour productivity change in the period 1995-00.

The results obtained for France are compared to some big countries, and namely the United States, that provides a useful reference although sometimes a little bit tricky, when the distance between Europe and the USA is considered in terms of economic cycles.

By applying the Jorgenson's method to implement the growth accounting and the one of P. Schreyer from the OECD to assess price series, our estimates of the contribution of ICT to the French growth of value added happen to be slightly higher (0.45% per year over 1995-00) than results obtained in other studies (around 0.35%). Though moderate, the ICT contribution to French growth lies above the one of its big European neighbours except U.K., but it is far behind that of the U.S.. The grounds underlying this gap are to be investigated in ICT investment levels and not in growth rates of investment. ICT investment growth is indeed as much sustained in France as in the U.S., but the proportion of U.S. ICT investment in total investments is ore than twice as high as the French share (the share of ICT investments in value amounts to 30% of total non residential investment in the U.S. and 14% in France).

In France, the contribution of ICT to the hourly labour productivity growth accelerated quite strongly over 1995-00 relative to the previous period. This acceleration was indeed accompanied by an acceleration in the total factor productivity but not by an increase in the quality of the French labour. The latter has indeed increased regularly till the period 1990-95, namely thanks to the contribution of education. Over the period 1995-00, the fall in the quality of French labour is in sync with the rise in hours worked by less well-paid workers and namely young workers. But the latter will accumulate human capital over their life-time, and will then contribute to improve the labour quality, all the quicker they have graduated in school.

ABSTRACT

This paper aims at assessing the contribution of ICT to growth in France at the macro-level. On the labour side, we also evidence the role played by hours worked by stressing the contributions of various factors to the labour quality and the way they intervene in explaining the labour productivity change in the period 1995-00.

One of the reasons why France lags behind the U.S. in terms of ICT contribution to growth is that although ICT investment growth is as much sustained in France as in the U.S., the proportion of U.S. ICT investment in total investments is more than twice as high as the French share.

In France, the contribution of ICT to the hourly labour productivity growth accelerated quite strongly over 1995-00 relative to the previous period. This acceleration was indeed accompanied by an acceleration in the total factor productivity but not by an increase in the quality of the French labour. The latter has indeed increased regularly till the period 1990-95, namely thanks to the contribution of education. Over the last period, the fall in the quality of French labour is in sync with the rise in hours worked by less well-paid workers and namely young workers. But the latter will accumulate human capital over their life-time, and will then contribute to improve the labour quality, all the quicker they have graduated in school.

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RÉSUMÉ

Ce papier propose une évaluation de la contribution des TIC à la croissance en France au niveau macro-économique sur la période 1982-2000. L'importance des prix dans l'évaluation de la contribution des TIC à la croissance de la valeur ajoutée et de la productivité horaire du travail est mise en avant. Nous mettons aussi l'accent sur le rôle de la qualité du travail dans l'évolution de la productivité, notamment sur la période 1995-00 et repérons les facteurs qui favorisent ou au contraire détériorent cette qualité.

Les résultats que nous obtenons pour la France sont comparés à quelques grands pays, notamment les Etats-Unis, qui fournissent une référence utile bien que parfois trompeuse étant donné la distance séparant les Etats-Unis de l'Europe en termes de cycles économiques.

En appliquant la méthode de Jorgenson afin de réaliser la comptabilité de la croissance et celle de P. Schreyer de l'OCDE pour estimer les séries de prix, notre évaluation de la contribution des TIC à la croissance française de la valeur ajoutée est un peu plus élevée (0,45% par an sur 1995-00) que les résultats obtenus dans d'autres études (environ 0,35%). Bien que modérée, la contribution française est supérieure à la contribution de ses grands voisins européens à l'exception du Royaume-Uni, mais reste bien en retrait de celle des Etats-Unis. Les raisons de cet écart sont à rechercher dans le niveau de l'investissement et non dans son taux de croissance. En effet, les taux de croissance de l'investissement en TIC sont aussi soutenus en France qu'aux Etats-Unis mais la proportion des investissements américains dans les investissements totaux est près de trois fois plus élevée que la part française (la part en valeur des investissements en TIC s'élève à 24% de l'investissement total aux Etats-Unis contre 10,5% en France).

La contribution des TIC à la croissance de la productivité horaire s'est sensiblement accélérée entre 1990-95 et 1995-00. Cette accélération, qui se double d'une accélération de la productivité totale des facteurs ne s'est pas accompagnée d'une amélioration de la qualité du travail. Celle-ci a régulièrement augmenté en France jusqu'à la période 1990-95, grâce à la contribution de l'éducation. Cependant, sur la période 1995-00, la baisse de la qualité du travail français est concomitante à la hausse des heures travaillées des catégories de travailleurs moins bien rémunérés, en particulier les jeunes travailleurs. Mais ces derniers accumuleront du capital humain et contribueront à améliorer la qualité du travail d'autant plus vite qu'ils sont diplômés

RÉSUMÉ COURT

Ce papier propose une évaluation de la contribution des TIC à la croissance en France au niveau macro-économique. Nous mettons l'accent sur le rôle de la qualité du travail dans l'évolution de la productivité, notamment sur la période 1995-00 et repérons les facteurs qui favorisent ou au contraire détériorent cette qualité.

L'une des raisons pour lesquelles la France reste en retrait des Etats-Unis quant à la contribution du capital TIC à la croissance est à rechercher non pas dans les taux de croissance de l'investissement en TIC qui sont similaires dans les deux pays mais dans les parts de l'investissement en TIC, la part américaine dans les investissements totaux étant près de trois fois plus élevée que la part française.

La contribution des TIC à la croissance de la productivité horaire s'est sensiblement accélérée entre 1990-95 et 1995-00. Cette accélération, qui se double d'une accélération de la productivité totale des facteurs ne s'est pas accompagnée d'une amélioration de la qualité du travail. Celle-ci a régulièrement augmenté en France jusqu'à la période 1990-95, grâce à la contribution de l'éducation. Cependant, sur la dernière période, la baisse de la qualité du travail français est concomitante à la hausse des heures travaillées des catégories de travailleurs moins bien rémunérés, en particulier les jeunes travailleurs. Mais ces derniers accumuleront du capital humain et contribueront à améliorer la qualité du travail d'autant plus vite qu'ils sont diplômés.

IS ICT THE KEY TO SUCCESS ? AN ANALYSIS OF ICT IMPACT ON FRENCH GROWTH

Johanna Melka, Laurence Nayman, Soledad Zignago[1] and Nanno Mulder[2]

1. INTRODUCTION

The slowdown of American growth in 2001 might convey the view that the ICT story is only a myth. However, the works on information technologies are not outdated in so far as the slowdown in the U.S. is attributed to a decrease in ICT investment and to a depletion of productivity gains. The issue of the contribution of ICT is then still on the hot line.

The stylised facts about the U.S. are now well established in the literature (Jorgenson & Stiroh, 2000; Oliner & Sichel, 2000; Jorgenson, 2001) whereas uncertainties as to what extent Europe lags behind the U.S. persist. As a matter of fact, few country studies related to ICT in Europe were available until recently due to the lack of data. Major inroads have been made by O.E.C.D. (Schreyer, 2000).

For Europe, Van Ark et alii. (2002) evidenced that real investment and capital services increased in Europe at the same pace as in the U.S. The gap with the U.S. is to be measured in terms of structure as the shares of ICT in total investment and capital service flows have been roughly between half to two thirds of the U.S. level throughout 1980-2000. Moreover in their study, ICT capital service flows would explain 0.70% of the real average annual GDP growth in the United States, 0.37% in Europe and 0.27% in France over the period 1995-2000, what lies below the 0.36% found by Cette et al. (2001) for the business sector in France. For the U.K., figures lie at a higher level, 0.57% over 1994-98 (Oulton, 2001), suggesting some variance across European countries.

This paper aims at assessing the contribution of ICT to growth in France at the macro-level. It is a first step towards a thorough identification of the sources of growth across industries, that will help understand more properly the importance of the contribution of ICT to overall productivity in the ICT-using- and producing industries in France. At the macro-level, we assess how large the French lag is, if any. On the labour side, we evidence the role played by hours worked by stressing the contributions of various factors to the labour quality and the way they intervene in explaining the labour productivity change in the period 1995-00. A bracket of estimates for the total factor productivity will then be provided given the

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calculation carried out for the labour quality using alternatively skills by occupation or education cross-classified with other characteristics.

Section 1 describes the methodology used for capital and labour services. Some statistics on labour and capital in the next section will highlight the most relevant factors in explaining the quality of labour and investment trends. In section 3, the growth accounting and contributions to average labour productivity will be presented. The concluding section will put together pieces of evidence given in the preceding sections.

The results obtained in the growth accounting framework will be compared to some big countries, and namely the United States, that provides a useful reference although sometimes a little bit tricky, when the distance between Europe and the USA is considered in terms of cycles.

METHODOLOGY

The method initiated by Dale Jorgenson and described at length in Jorgenson, Gollop and Fraumeni (1987) is used in order to assess the contribution of ICT to growth. After a presentation of the analysis framework (section 1.1), the methodologies used to build the capital and labour services will be described (sections 2 and 3).

1.1. The analysis framework

The accounting method used to assess the contribution of the new economy to growth and labour productivity in France is standard. The methodology applied is the one of Jorgenson and Griliches (1967) whose objective consists in tracing how the quality of inputs evolves with the scope of enhancing the possible substitution schemes between factors of production. The translog function contrary to the one of the Cobb-Douglas allows the interaction of different effects to be evidenced as a breakdown of these effects at the first-order till the n-order can be implemented. Moreover, the discrete-time Tornqvist index is an exact index number if it is applied to the translog function (Hulten, 2000). But some assumptions relating to these production functions may appear strong and deviations from them may bias results, namely the residual of the function. By assuming that production inputs are properly compensated against the services they render, they must be interpreted with caution. These limitations will be explained further in section 2.

The production function is assumed to be:

$$Y_t = F(K_t, L_t, T) \tag{1}$$

where: X_t expresses a vector of inputs, K_t capital services, L_t labour services, T total factor productivity.

In the translog production function (*transcendental logarithmic production function*), production is an exponential function of the logarithms of inputs.

$$\ln Y_i = \alpha_0^i + \alpha_X^i \ln X_i + \alpha_K^i \ln K_i + \alpha_L^i \ln L_i + \alpha_A^i A + \frac{1}{2}\beta_{XX}^i (\ln X_i)^2 + \beta_{XK}^i \ln X_i \ln K_i$$

$$+ \beta_{XL}^i \ln X_i \ln L_i + \beta_{XA}^i \ln X_i * A + \frac{1}{2}\beta_{KK}^i (\ln K_i)^2 + \beta_{KL}^i \ln K_i \ln L_i + \beta_{KA}^i \ln K_i * A$$

$$+ \frac{1}{2}\beta_{LL}^i (\ln L_i)^2 + \beta_{LA}^i \ln L_i * A + \frac{1}{2}\beta_{AA}^i * A^2$$

A represents total factor productivity (technical progress), the α and β coefficients being the respective weights of labour and capital in production. i stands for the industry.

The shares in value of inputs are equal to the elasticities of production to these factors, the returns to scale are constant and product and factors markets are assumed to be perfectly competitive.

Under the above-mentioned hypotheses, equation (2) can be transformed as follows:

$$\Delta \ln Y = \bar{v}_{K,t}\Delta \ln K_t + \bar{v}_{L,t}\Delta \ln L_t + \Delta \ln A_t \qquad (3)$$

Δ: first difference,

$\bar{v}_{K,t}$ is the average share of capital in domestic income, and $\bar{v}_{L,t}$ is the average share of labour in income.

$$\bar{v}_{K,t} + \bar{v}_{L,t} = 1,$$

The contribution of each factor of production to growth is determined from equation (3). The contribution of a factor of production to growth is equal then to the input growth rate in volume (including the evolution of quality of this factor of production) weighted by its return share in value added.

The average hourly labour productivity

By changing equation (3), the contribution of factors of production to growth of the average hourly labour productivity can be expressed in the form:

$$\Delta \ln y_t = \bar{v}_{K,t}\Delta \ln k_t + \bar{v}_{L,t}(\Delta \ln L_t - \Delta \ln H_t) + \Delta \ln A_t \qquad (4)$$

with:

$$y_t = \frac{Y_t}{H_t} \; ; \; k_t = \frac{K_t}{H_t}$$

where *H* represents the volume of hours worked.

Growth of the average hourly labour productivity then stems from:

The "capital deepening", or substitution of capital for labour, involved by a capital accumulation,

The improvement of the labour quality defined as the difference between the rate of growth of the weighted labour input and hours worked,

Growth of total factor productivity.

1.2. Capital services

The construction of capital services (or the like) involves that the efficiency of each type of asset is taken into account.

In that respect, each type of asset *i* at time *t* can perfectly be substituted for another asset *i* at time *t-1*. Actually, it is assumed that data on investment at constant prices allow for differences in the performance of the various assets. It means that price series used to deflate the investment series at current prices reflect the efficiency of assets. For some assets like computers and some parts of communications equipment, hedonic prices are used (for instance in the US and France). The asset price is regressed upon a set of related qualitative characteristics in ordre to retain quality and construct a constant quality price index. Roughly, it consists in extrapolating series backwards in order to get the missing prices for brand-new equipment or forward for older equipment.

The specificity of the approach assumed by Jorgenson and Griliches (1967) relies upon the construction of the asset rental prices, i.e. the cost of capital, that reflects the cost of using the asset at a given point of time. This cost embodies the price that will be paid by an agent to use the asset (put for rent)[3].

1.3. Labour services

Labour services are constructed along the same lines as capital services. Their purpose consists in retracing the evolution of the quality of labour. Following the works of Jorgenson (1987, 2000, 2001, 2002), changes in the composition of labour must be considered as an essential component of the labour volume. Hours worked must be disaggregated according to their different characteristics in order to account for the quality in labour services. If this disaggregation is not performed, neither substitution between the different inputs nor the growth of productivity can be identified properly.

Jorgenson's method (1987) is replicated to construct a constant quality index of labour volume with a translog function. The growth rate of the index of labour input, i.e. the

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[3] The method is described extensively in appendix 1.

labour services, is a weighted average of the growth rates of its components[4]. Labour services are measured by the growth rate of total hours worked in the economy weighted by the share of compensation of each individual characteristic of labour in total labour compensation. Each component is weighted by its marginal product under the neo-classical hypothesis according to which labour is compensated at its marginal productivity. This very strong assumption means that women would be less paid than men because they would provide a lesser effort at work than men. But fortunately, we will see that with respect to results of the contribution of gender to the quality of labour, this drawback will be discarded. Along the same lines, younger workers being less compensated than older ones are assumed to be less productive. This can be understood as training and the acquisition of experience will benefit the young worker as the more he ages, the more compensated he will be. Another critic that can be directed to the use of the translog function is that market shortcomings are not allowed for, since insider workers and trade unions can negotiate higher compensation rates than the ones suggested by productivity gains.

2. RESULTS

Results on the evolution of the labour quality in France and the specificities of the labour and French investment markets over the last twenty years will be first displayed before addressing the issue of the contribution of ICT to growth.

2.1. Labour

A short presentation of the data will be followed by an analysis of the labour force. Then, our results related to the evolution of the French labour quality will be discussed.

2.1.1. Data and analysis

Data

Detailed data on employment, hours worked and labour compensation by type come from two sources: the D.A.D.S. and the labour force surveys. The Déclarations Annuelles de Données Sociales (D.A.D.S.) is a form filled in by employers that cover 15 million people. Till 1992, one wage-earner out of 25 was included in the sample operated by the INSEE. Afterwards, the operation of the database is exhaustive. A break in the series occurs in 1993. Hours worked before 1993 have been deduced from the wages duration provided in the D.A.D.S. Series for years 1981, 1983 and 1990 that are not available in the D.A.D.S. have been interpolated and the years 1999 and 2000 extrapolated forward thanks to the Labour force surveys.

A second source has been used in order to get skills by education: the labour force surveys that cover households. The poll rate of this survey amounts to 1/300. As wages are not available before 1982, the period under review spans 1982-2001 in that database. The

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[4] For more details, see appendix 1.2.

database has been wiped out in order to fit in the same field definition as the D.A.D.S.. Ratios are calculated on the distribution of total hours and wages on gender, age and degrees relative to total hours and wages summed on gender and age. These ratios are then applied to the D.A.D.S. database. We mean to keep the highest consistency by maintaining a common distribution by gender and age (the one of the D.A.D.S.).

After integrating degrees in the D.A.D.S., ratios are calculated on gender, age and degrees by year and then applied to the series of hours worked and labour compensation found in the national accounts in order to remain consistent with the growth accounting framework. The series used are total employment times average hours. For the year 2000, hours worked were estimated with the labour force surveys figures. Underlying this extrapolation is that average hours have decreased by a rate of 3% due to the extension of the 35-hour week in France.

In the final database, we have chosen to separate out three categories: gender, age and degrees. Gender regroups 2 (men, women), and age gathers 4 (<25 years old, 25-34, 35-54, >54) characteristics. Age brackets have been cut off that way in order to be comparable with the results obtained by Jorgenson in the framework of the KLEMS project.

By integrating degrees in the D.A.D.S., we include six extra dimensions: postgraduates (A level + 4 years), university or high vocational degree (A level + 2), A level (high school or vocational), low vocational school degree (C.A.P., B.E.P. or equivalent), mid- secondary school leaving certificate (B.E.P.C.), no degree or almost none (C.E.P). The quality of labour when calculated with gender, age and degrees entail 48 (2*4*6) categories.

Analysis

Figures 4 to 10 presented in the appendix display the hourly labour compensation and hours worked from 1982 to 2000 in the new compiled database. Regressions have been run against a set of dummies: labour compensation values per hour have been regressed on gender, age and education. This means that labour compensation values per hour are corrected for differences of other characteristics. These regressions allow to retrieve the mean with a confidence interval. Next to all results are very significant with a confidence interval below 1%.

Labour services result from the sum of growth rates of hours worked weighted by the compensation share of the characteristic i in total compensation. Hours worked by women accelerate in the second half of the eighties, firms taking advantage of the lower wage rate they are allotted. Men keep on being better paid than women in spite of a rise in women's relative wages. In 2000, the compensation discrepancy between women and men whittles down to 21%. Even if this hardly reflects productivity differences between men and women, the fact that unskilled women are overpaid relative to their marginal productivity balances roughly the fact that skilled women are underpaid (Crépon et alii, 2002). This is confirmed by graph 6: in terms of education, hourly wages of graduated women reached a trough in the 1991-95 period at 68% of graduated men's wages and have gone up

afterwards by some 6 points of percentage. In comparison, women with a mid-secondary school leaving certificate are better paid.

In terms of hours worked, people ageing below 25 and above 54 show the most erratic moves. Over the last period, the growth rate of workers below 25 goes up at last. The upwards trend of the 35-54 age bracket is also a reflection of the funnel-shaped age pyramid.

Over all periods, the strongest wage growth rates by age bracket are recorded by workers above 54 while they are fewer to remain in the working population. This could exemplify the accumulation of human capital over the whole working life, though Crépon and alii. (2002) show that older workers are overpaid relative to their marginal productivity. This could then be related to the theory of labour contract incompleteness according to which informational asymmetries arise as efforts cannot be accurately measured across all workers.

In terms of education, hours worked by those graduating at the university or equivalent have been rising since 1982 while hours worked by unskilled workers have kept on a downwards slope. This could mirror as well a general hike-up of education as a skill-bias of technological change. As it could be suspected, workers with A level + 2 years in the university can be second best substitutes for those with higher degrees since the gap between wages of both categories narrows further (graph 11). Moreover, the implementation of technologies can require all-in-all higher qualifications (in terms of degrees) of those who occupy a new job.

Skills and age should play as an engine in the changes intervening in the quality of labour. Results on the quality of French labour over 1980-00 will be displayed in the light of the stylised facts as described above and will be compared with figures obtained for the United States.

2.1.2. The evolution of labour quality in France

Figure 1 shows the indices of labour volume (labour services), quality and non-weighted hours worked, computed on gender, age, and education characteristics since 1982. Quality has increased steadily since 1982 and has experienced a slowdown at the end of the period on account of hiring of younger employees. Labour services roughly follow the trend of hours worked but the quality effect prevents labour services from falling further from 1993 till 1998.

Graph 1: Convergence of labour input, quality and hours worked indices

In %
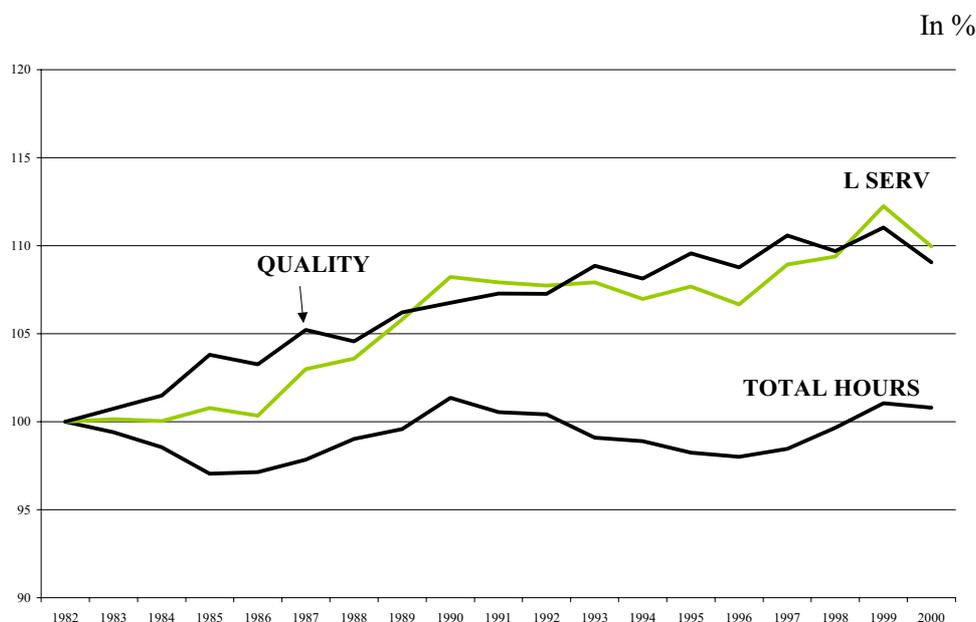
Note: 1999 and 2000 are extrapolated with figures from the labour force surveys. Labour services and quality are calculated with gender, age and degrees characteristics.

Source: D.A.D.S., Labour force surveys and National Accounts, INSEE.

As shown in table 1, the growth in the labour quality index is above all due to the rise in labour services over the whole period 1982-00, as non-weighted hours worked show a small and negative contribution. However, the breakdown in sub-periods allows to make out between the 1990-95 period when hours worked contributed very negatively and the 1995-2000 one when the quality of labour fell back due to the rise in total hours worked.

Contributions to the labour quality show that skills and age loom large in this context, the latter characteristic playing a major role in the deterioration of quality over 1995-00 due to the decrease in unemployment of the youngest. Education is a strong stimulus to the quality of labour. The contribution of education remains strong and has been ever growing over the whole period. As the contribution of gender to the quality index is very weak, part of the criticism bearing on the hypothesis of the production function equalising marginal labour productivity and compensation is in a way played down.

The findings by Jorgenson for the United States (table 2) contrast noticeably with those of France, hours worked and quality contributing positively to labour services throughout all periods. It is worth noting that the hiking of unskilled labour in the US over 1995-00 has also an adverse effect on labour quality. The volume of total hours worked being large in

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the United States relative to France, the French quality index of labour outpaces the American one.

Table 1: Contributions to quality, annual average, in %

	1982-00	1982-90	1985-95	1990-00	1990-95	1995-00
QUALITY	**0.80**	**1.04**	**0.80**	**0.61**	**0.78**	**0.44**
GENDER	-0.02	0.00	-0.04	-0.03	-0.06	0.00
AGE	0.19	0.44	0.22	-0.01	0.26	-0.29
EDUCATION	0.63	0.60	0.62	0.65	0.62	0.69
Σ INTERACTIONS	-0.00	-0.00	0.00	-0.00	-0.04	0.04
LH	**-0.08**	**-0.04**	**-0.06**	**-0.11**	**-0.71**	**0.49**
L	**0.73**	**1.01**	**0.74**	**0.50**	**0.08**	**0.93**

Note: L= labour services, LH= non-weighted growth rate of hours worked. Quality=L-LH.

Source: D.A.D.S. labour force surveys, National Accounts, & authors'calculations.

Table 2: Results from Jorgenson on services and labour quality in the USA

	1980-85	1985-95	1990-95	1995-00
QUALITY	0.41	0.54	0.66	0.31
LH	1.37	1.55	1.22	1.99
L	1.78	2.09	1.88	2.30

Source : Jorgenson & Ho (1999 & revised 2001) and Jorgenson, Ho and Stiroh (2002).

Labour services and the quality of labour will be an input in the value added and productivity growth accounts presented further.

2.2. Capital

We will proceed first to an analysis of the evolution of the ICT price and investment in volume in France and then we will display the results for France of the growth accounts and contrast them with those of other O.E.C.D. countries over the period 1980-00.

2.2.1. Investment series

Data

Out of six assets three are ICT assets (hardware, software and communication equipment); the three other categories are non-residential structures and buildings, transport equipment and other machinery. We use statistics released by the I.N.S.E.E. The underlying hypotheses are shown in tables 10 and 11.

Analysis

The growth of investment in ICT at constant prices has dramatically surged over the last twenty years, due namely to the strong increase in hardware equipment with an annual pace of 30% over the period 1980-00, as investments in software grew at the same time by 14% and those in communication equipment increased by only 8%. Moreover, the growth in investments has mainly taken place over the last five years (1995-00).

When comparing the evolution of ICT investments in volume in the United States and in France[5], it comes forth that ICT investment growth in France was about the same as in the United States in the second half of the decade. Over 1995-00, the growth rate of French investment in hardware and software (46% and 20% respectively) even topped the American one (43% and 18% respectively). Conversely, the growth rate of investments in communication equipment in France (10%) featured a substantial difference with that of the United States that posted 18%.

Another difference is worth being emphasised: although the share in value of GFCF in GDP for the business sector in France is the same as the American share (17%) in 2000 (see table 12), the share of ICT investment in GDP in France (2%) notched quite under the American level (4%), what can amount to substantial differences in terms of catch-up in a growth accounting framework.

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[5] The comparison deals with the business sector in the United States and with total economy in France when the comparison is made on volumes and both on the business sector when the comparison relates to investment in value.

Graph 2: Evolution of French and American ICT investments at chained prices, 1995=100
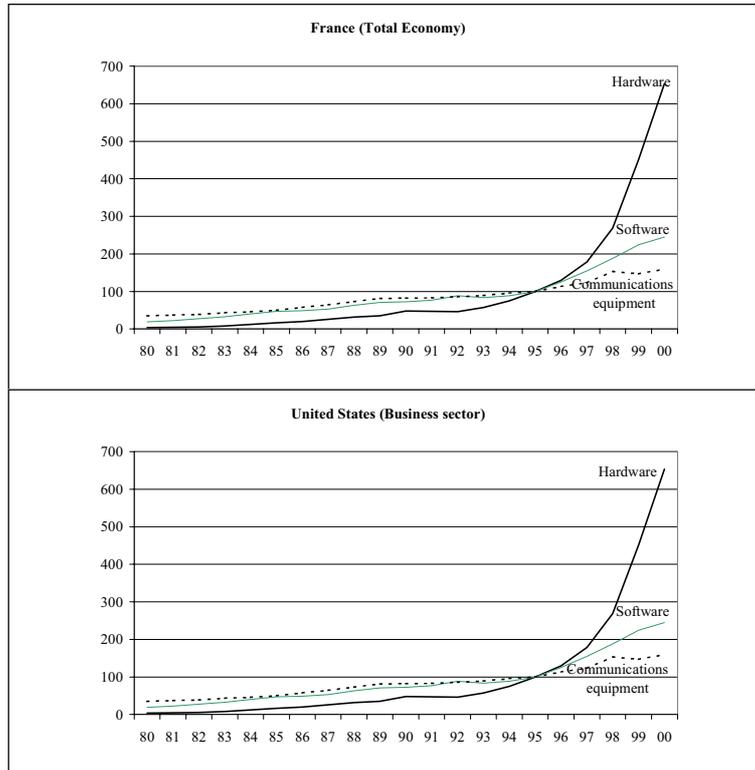
Note: 1996 prices for the U.S. and 1995 prices for France. Prices used derive from the application of the Schreyer's method to B.E.A. price series.

Source: INSEE, BEA and CEPII, authors' calculations.

2.2.2. Price series

Data

By applying the methodology suggested by Jorgenson, efficiency and substitution between assets can be taken into account. To do so, it is assumed that prices reflect the evolution of efficiency and then the quality of assets. Nonetheless, statistical offices have been constructing hedonic price series only for a short time. In France, the I.N.S.E.E. constructs such time series only for hardware (microcomputers and peripherals). Other methods are used to construct index prices adjusted for quality of other types of assets (namely the matching method). Different approaches to elaborating methods can account for a very large gap between the U.S. and the European figures. For example, the assessment of software prices in France, if estimated in the same way as in the U.S., software investments

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in volume would be at least twice as high as their present figures (see Lequiller, 2000; Oulton, 2001).

So, two ways of settling the price issue can be contemplated in order to make prices consistent with the U.S.:

either use American IT prices corrected for 50% of the exchange rate with the dollar. This method is chosen by Cette, Mairesse and Kocoglu [2000]. With this correction, it is assumed that half of ICT equipment is imported. The growth rate of the price index is equal to the moving average over three periods of the BEA price index growth rate plus half the dollar/FF exchange rate change.

Or construct new price series by applying the method elaborated by Schreyer [2000] which consists in applying the difference between non ICT equipment prices and ICT prices prevailing in the USA to French prices of non ICT equipment.

The evolution of French hardware imports points to a significant change in the share of investments in imports over time. Thus, it cannot be assumed that this share is constant and identical for hardware and software.

The Schreyer's method suits us better in so far as the gap between American prices of ICT and non ICT equipment fluctuates throughout the period and is different according to the type of ICT equipment. By applying this method to obtain the French price series for the different types of ICT equipment, the evolution of non ICT equipment in France is taken into account.

Nonetheless, these two price series (the BEA's and the Schreyer's ones) will be used alternatively in order to emphasise the differences, if any, that arise in the results on ICT contribution to growth.

Analysis

Firstly, the method used to construct price series greatly influence the increase in ICT investment prices, as could be expected.

We also notice a strong divergence in the evolution of ICT prices by type of asset. Hardware prices fall very steeply over the period 1980-00, whereas software and communication equipment prices increase up to the mid-80s.

Graph 3: Evolution of ICT prices (calculated with the Schreyer's method), 1995=1
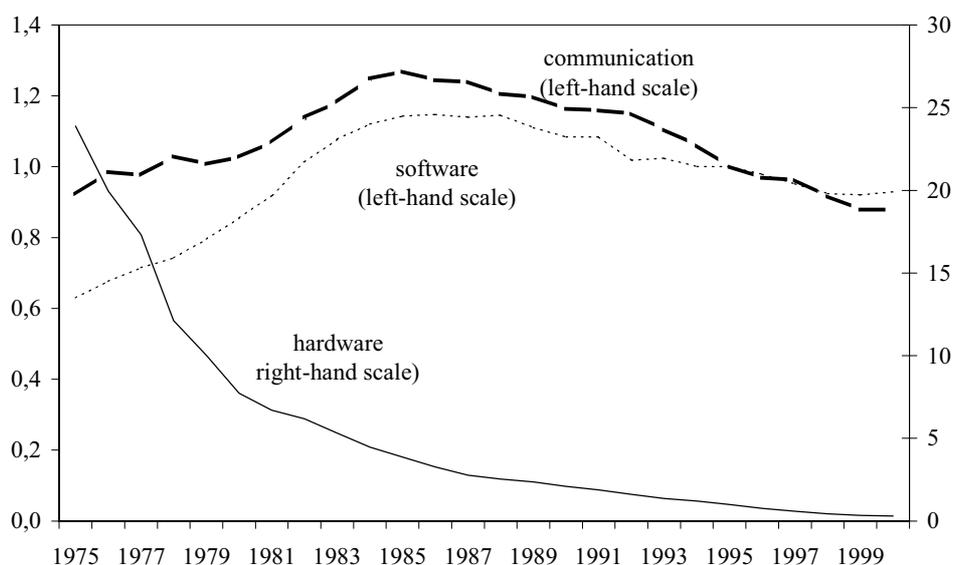
Source: BEA, INSEE and CEPII, authors' calculations

Let's now turn to the results related to the ICT contribution to the French growth. To do so, results based on estimates using U.S. hedonic prices for hardware and software investments will be compared to estimates that result from the calculation of new price series with the method applied by Schreyer. We will contrast our results with those of Cette, Mairesse and Kocoglu, and then we will compare the contribution of ICT to the French growth with the ones of other O.E.C.D. economies. Lastly, we will focus on the contributions of capital substitution for labour and quality of labour to the average hourly labour productivity in France.

3. GROWTH ACCOUNTING

As ICT growth accounting studies are few in Europe compared to the United States, the contribution of ICT to the French growth and to the average hourly labour productivity is a useful exercise that should be completed later by econometrics on total factor productivity (TFP) in order to assess the relevant factors explaining it. In this section, the emphasis will be put on the evolution of the French labour quality and its role in the impact of the spread of ICT on the performances of the French economy.

3.1. Contributions of ICT to the growth of the French economy

Several issues could be mooted following our estimates of the contribution of ICT to the growth of the French economy. The choice of price series which is crucial is one of them. The contribution of ICT to the growth of the French economy is over- or underestimated according to the price series used (see table 8 in Appendix).

Leaning on estimates run with the price series resulting from the Schreyer's method (table 3), the contribution of ICT to growth experiences a strong acceleration from 0.21% per year over the period 1990-95 to 0.46% per year over 1995-00. Moreover, the contribution of ICT has dramatically increased relative to the contribution of other equipment goods. Over 1995-00, ICT goods and services have greatly contributed to growth, along with TFP and labour services. This more balanced growth over the last period contrasts with the previous one, when growth was almost exclusively towed by capital services. The contribution of labour services to growth is noticeably strong over the period 1995-00. Let us spell out that, had we applied non weighted total hours worked instead of labour services, the contribution of labour to growth would have been almost twice as less important.

The strongest contribution brought to the growth of ICT investment is chiefly carried out by hardware, and to a lesser extent by software. ICT equipment goods and services explain about 43% of the contribution of capital services to the growth of value added (22% being attributable to hardware, 13% to software and 7% to communication equipment) over 1995-00. The weakness of the contribution of communications equipment points to a sluggish investment effort over that period. In terms of acceleration, hardware and software investments have nearly doubled their contribution between 1990-95 and 1995-00. Meanwhile, the contribution of non residential structures has kept falling back throughout the period.

In order to point to differences between the ways of calculating ICT investment prices (the Schreyer's method and the BEA ICT prices), we have also implemented growth accounting with the B.E.A. prices (see table 8 in appendix). Results of the growth accounting are not very different when calculated with the B.E.A. prices from results shown in table 3. They lie slightly under our first set of results. The contribution of ICT sets at 0.41% against 0.46% with the Schreyer's method.

The US economy performs better regarding the value added growth rate, than the French economy. ICT contributed already for half of capital services over the period 1990-95. What is striking in comparing French and American figures is the still buoyant capital services use in the American economy over the last period. The contribution of the TFP happens to lie under the French one.

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Table 3: Contributions to the average annual growth of gross value added (in %)

(ICT prices assessed with the Schreyer's method)

| | FRANCE | | | | UNITED | STATES |
	1982-00	1982-90	1990-95	1995-00	1990-95	1995-00
GVA	**2.18**	**2.57**	**1.09**	**2.65**	**2.35**	**4.20**
Capital services	1.10	1.22	0.96	1.07	1.25	2.27
• *Total ICT:*	0.31	0.28	0.21	0.46	0.55	1.11
Hardware	0.16	0.15	0.11	0.24		
Software	0.08	0.06	0.04	0.14		
Communication	0.07	0.07	0.06	0.08		
• Non-residential structures	0.48	0.53	0.55	0.34		
• Transport	0.08	0.06	0.06	0.12	0.71	1.15
• Other equipment	0.23	0.34	0.15	0.14		
Labour services	0.51	0.72	0.06	0.62	0.86	1.30
• Hours	-0.06	-0.04	-0.48	0.33	0.63	1.13
TFP (with labour services)	0.56	0.63	0.06	0.96	0.23	0.63

Source: CEPII, authors' calculations for France. Jorgenson, Ho and Stiroh (2002) for the US.

These results suggest to focus on the growth of total factor productivity, which in theory accounts for changes in the structure of the economy, say, technical progress.

Analysis of total factor productivity

The total factor productivity is calculated as a residual over the sum of the different contributions of inputs. Thus, the more accurate our estimation of the contribution of factors of production (capital, labour) is, that is to say the better it accounts for the improvement in the quality of labour and capital, the weakest the total factor productivity (Jorgenson and Griliches, 1967). Even though, the residual is too big to be interpreted solely as some measurement errors. It is rather "a measure of our ignorance" as pointed out by Abramovitz[6].

It is thus difficult to make out in the total factor productivity growth what share is attributable to economic fluctuations (Gordon, 2002), to other factors such as deviations from the underlying hypotheses of the translog function (perfect competition,…), to changes in capital shares or to structural changes such as technological and organisational innovations not captured in physical or human capital.

Any reversal in the cycle may impact on total factor productivity. Cette, Mairesse and Kocoglu [2002] assess that the contribution of total factor productivity to growth of value

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6 Quoted in Hulten (2000). Moreover, for an extensive review, see Hulten (2000).

added would be explained by more than 30% by cyclical factors over 1980-00. Then, some 70% at most could be due to structural factors.

International comparison

Few studies besides those by Cette et al. [2001, 2002] and Colecchia et al. [2001] have used an accounting framework including ICT. It is neither easy to compare our results with these studies in so far as the mapping is different. Contrary to our work based on the aggregate economy, the studies mentioned above assess the contribution of ICT to growth for the business sector. Results are compared in table 9 (in appendix). Ours come out with higher ICT contributions.

Table 4 presents our results against the findings of Colecchia et al. for 9 other O.E.C.D. countries. As a difference, Colecchia and Schreyer, as already mentioned, use their own method.

In absolute terms, the contribution of ICT to growth is then quite stronger in the United States than in Japan (0.86% and 0.38% respectively over the period 1995-00). In relative terms, when dividing the contribution of each asset by the growth of value added, the ICT **relative** contribution is less strong in the United States than the one of Japan over 1995-00. ICT equipment goods and services explain 34% of the Japanese growth whereas they account for 19% of the American one, 18% of the German and Italian ones. The relative contributions of ICT to the French and Canadian growth (O.E.C.D. results) amount to 12%. Surprisingly, ICT does not contribute as much in Finland with a relative share of only 3.5% over 1995-00.

As for France, its contribution is closer to that of U.K. In other studies [Oulton (2001), Van Ark, (2002)], the French contribution (0.24% for Van Ark et al.) sets at a lower level than ours (0.46%).

Altogether, it pops up from this comparison that the contribution of ICT to growth in France is stronger with our series and our method. This difference can be explained by a steeper fall in IT prices when the prices resulting from the Schreyer's method are used rather than prices from the B.E.A. corrected for exchange rates.

Table 4: International comparison

		France	France (Ours)	Germany	USA
GVA	80-85	1.48	1.85	1.13	3.35
	85-90	3.46	3.13	3.59	3.31
	90-95	0.97	1.09	2.22	2.64
	95-99	2.60	2.37	1.73	4.43
	95-00	2.81	2.65	2.06	4.40
Total Contribution of ICT capital services	80-85	0.18	0.29	0.20	0.44
	85-90	0.22	0.38	0.27	0.43
	90-95	0.18	0.21	0.30	0.86
	95-99	0.33	0.46	0.35	0.86
	95-00	0.35	0.46	0.38	0.87

Note: Total Contribution of ICT capital services= Total office & computer machinery, communication equipment and software.

Source: Colecchia and Schreyer (2001) and CEPII for France's results shadowed in grey.

In other respects, the growth of average hourly labour productivity in France must be considered to be contrasted with the American trend over the last ten years. How large is the magnitude of the accumulation of ICT capital is a question worth being examined.

3.2. The average hourly labour productivity

The growth of average hourly labour productivity slows down noticeably over the 80s and 90s (table 5). Over the last period 1995-00, it improves due to the fall in hours in the manufacturing sector, to the moving to a 35-hour--week, although some economic policy measures could have counterbalanced these effects. As a matter of fact, the French policy regarding the reduction in social contributions upon the low wages and the employment of young people was started in 1993. These measures have been further fostered from 1995 on. They have led to a significant slow-down of labour quality, on account namely of a negative contribution of age to quality. Let's spell out that, had education not been included in the estimation of labour quality, then the contribution of labour quality to labour productivity growth should have been negative over 1995-00.

The growth of the average hourly labour productivity can be explained by the substitution of capital for labour ("capital deepening") and the improvement of the TFP that both have a positive impact on the growth of average hourly labour productivity.

A substitution of capital for labour has a positive impact on labour productivity as it makes workers more productive. An alternative explanation may be the skill-biased technological change argument. Thus, any increase in the substitution of capital for labour should improve the quality of labour.

The hourly labour productivity happens to slow down between 1982-90 and 1990-00. Over the last decade, the substitution of capital for labour and the quality of labour slows down, in spite of the increasing contribution of ICT. The acceleration is twice as high with respect to hardware and even thrice as high when software is considered.

Over 1995-00, the growth of the total factor productivity explains about 44% of the increase in labour productivity. The fall in the quality index points to an increase in the employment of young people, with the underlying perspective of a new boost in the quality of labour as these young people will accumulate human capital over their life-time.

Compared with the U.S., the American labour productivity growth hinges more on capital deepening and heavily on ICT capital over the last period. Growth of labour productivity is more due to the extension of factors of production (capital and labour) than to changes in the TFP. The acceleration of ICT capital intensity doubles as in France but departing from a much higher absolute level over 1990-95 (0.45% that is the 1995-00 level for France).

In the U.S., TFP and the quality of labour are below the French level. About TFP, as often alleged, the French comply with stricter regulations in the labour market than in the U.S. and then implement probably strategies of capital replacement making workers more productive. Furthermore, the composition of the labour force is younger in the U.S. than in France. Then, the quality of labour turns to be lower in the United States relative to France. Composition effects cannot be ignored when both countries are compared.

Table 5: Growth sources of average hourly labour productivity (in %)

(ICT prices assessed with the Schreyer's method)

	FRANCE				U.	S.
	1982-00	**1982-90**	**1990-95**	**1995-00**	**1990-95**	**1995-00**
ALP	**2.26**	**2.60**	**1.80**	**2.16**	**1.28**	**2.21**
Capital deepening	1.12	1.21	1.19	0.90	0.81	1.40
of which, ICT:	0.31	0.28	0.23	0.45	0.49	1.00
Hardware	0.16	0.15	0.12	0.23		
Software	0.08	0.06	0.05	0.14		
Communications	0.07	0.07	0.06	0.08		
Quality of labour	0.57	0.76	0.54	0.29	0.24	0.17
Cont. age	0.14	0.32	0.18	-0.19		
Cont. education	0.44	0.44	0.43	0.46		
TFP	0.56	0.63	0.06	0.96	0.23	0.63

Note: ICT refers to hardware, software and communication. ALP: Average labour productivity.
Sources: CEPII, authors' calculations for France; Jorgenson, Ho and Stiroh (2002) for the US.

Table 12 in Appendix gives the respective contributions of factors of production and TFP when the same share of factor compensation in value added is considered as in the works of Jorgenson et al. (2002) for the United States. The difference between ICT contributions in France and in the U.S. narrows to stand at about 0.40% then showing a relative minor gap between both countries. The capital shares used in the growth accounts have then a bigger impact than the use of B.E.A. prices versus the implementation of the Schreyer's method. According to Hulten (2000), it could then mean that TFP could be biased if one believe TFP is identified with technical change at all.

CONCLUSION

Assessing the contribution of ICT to growth can turn out to be a tricky exercise as the results are conditioned by the quality of the series.

The contribution of ICT to the French growth of value added remains moderate. It is comparable to the British contribution (about 0.46% per year over 1995-00) but it is far behind that of the United States. The grounds underlying this gap are to be investigated in ICT investment shares and not in growth rates. ICT investment growth is indeed as much sustained in France as in the U.S., but the proportion of U.S. ICT investment in total investments is almost thrice as high as the French share (the share of ICT investments in value amounts to 30% of total non residential investment in the U.S. and 14% in France).

The contribution of ICT to the hourly labour productivity growth can also entail an improvement in the labour force quality and produce an increase in the efficient combination of input. The acceleration of ICT capital deepening between 1990-95 and 1995-00 was accompanied indeed by such a rise in the total factor productivity but not by an improvement in the labour quality. The quality of the French labour has increased regularly till the period 1990-95. Over the last period, the fall in the quality of French labour is in sync with the rise in hours worked by less well-paid workers and namely young

workers. What is heartening is the strong contribution of education to the labour quality, maybe testifying that labour costs for young graduates have fallen further as the general education level has hiked up. This upgrading of education could have then dampened the demand effects for higher skills induced by the possible technological bias towards skilled labour.

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APPENDIX

1. METHODOLOGY

1.2. Methodology for the construction of capital services

First step: construction of a productive stock of capital: the permanent inventory method.

According to the permanent inventory method, the capital stock is defined as the weighted sum of past investments. The weights are defined by the relative efficiency of capital assets of different ages.

The capital stock for the asset *i* at time *t* is defined by:

$$K_t = \sum_{\tau=0}^{T} d_\tau I_{t-\tau}$$

where K_t is the capital stock (of a given asset) at time t, d_τ represents the efficiency of capital at age τ relative to the efficiency of a new capital good bought at time $t - \tau$.

It is then necessary for the follow-up of our study to know the pattern acknowledging the loss of efficiency. For our part, the rate of depreciation chosen is the geometric rate.

The capital stock is defined by:

$$K_{i,t} = K_{i,t-1}(1 - d_i) + I_{i,t} = \sum_{\tau=0}^{T} (1 - d_i)^\tau I_{i,t-\tau}$$

with:

d: geometric rate of depreciation,

I : investments at constant prices.

τ : age of capital.

2ⁿᵈ step: construction of the rental price of capital services (or cost of capital).

Our next objective is to construct costs of capital in the same way as Jorgenson (1987).

The cost of capital is equal to the cost of financing the asset *i* minus the loss or gain in capital.

$$c_t = p_{t-1}(r_t + d_t) - (p_t - p_{t-1})$$

p_t : price of the asset at time *t*,

r_t : rate of return of capital.

The first term reflects the cost of financing the asset *i* with $p_{t-1}r_t$ being the opportunity or the financial cost borne at the time of the acquisition of the asset,

$p_{t-1}d_t$: the cost related to the declining efficiency of the asset since its acquisition.

The second term points to the gain or the loss in capital generated by the reselling of this asset after use.

The rental price of capital services is thus equivalent to the price of using the asset during a given period of time, under the consideration of its declining efficiency during this period and its reselling at the end of the period.

Which rate of return must be chosen?

To compute the cost of capital, the alternative between external rates of return (ERR) such as the long rates on government bonds and an internal rate of return (IRR) comes forth.

The internal rate of return is calculated from the following accounting identity:

Income from capital =Gross value added (GVA) – labour compensation.

Capital income is then defined by the national accounts (NA). Symmetrically, as capital income is the product of the capital stock in volume and the price of capital, the rate of return can be deduced from the following formula:

$$\text{Income from capital} = c_t K_t = p_{t-1}\left(r_t + d_t - \frac{p_t - p_{t-1}}{p_{t-1}} \right) K_t$$

The choice of a IRR or a ERR reveals numerous drawbacks. If a ERR is adopted, the cost of capital used as a weight (the average share of each component in the value of property compensation) to estimate capital services, is determined externally. As a result, income from capital defined by the product of the cost of capital by the capital stock is different from capital income defined in the national accounts.

As for the IRR, its use implies that the function of production has constant returns of scale and that markets are perfectly competitive. Moreover, with an internal rate of return, the cost of capital can turn out to be negative, whereas it is not the case for the ERR. As a

matter of fact, due to high asset inflation rates and low depreciation rates, relative to the interest rate, the cost of capital can come out negatively[7].

In spite of this drawback, the IRR will be chosen in order to keep consistency in the accounting framework.

3rd step: construction of the aggregate index of capital services.

The aggregate index of capital services for all assets is assumed to be a translog function of individual capital services (Jorgenson, 1987). The index of aggregate capital is defined by:

$$\Delta \ln K_t = \sum_k \bar{v}_k \Delta \ln K_k^t$$

The weights are given by the average shares of each asset type in total property compensation:

$$\bar{v}_k = 0.5(v_{k,t} + v_{k,t-1})$$

$$v_{k,t} = \frac{c_{k,t} K_{k,t}}{\sum_i c_{k,t} K_{k,t}}$$

where c_k is the cost of capital of each asset k.

1.3. Labour services

Labour services are measured by the growth rate of total hours worked in the economy weighted by the share of compensation of each individual characteristic of labour in total labour compensation. Each component is weighted by its marginal product under the neo-classical hypothesis according to which labour is compensated at its marginal productivity.

$$\Delta \ln L = \sum_l \bar{v}_{Ll} \Delta \ln H_l$$

with L, labour services, H, hours worked and v, the weight, the overstrike stands for an average. The weight bears on the share of compensation of each characteristic in total compensation and is computed with a Törnqvist index, where $P_l L$ is compensation related to the considered characteristic:

$$v_l = \frac{P_l^L L_l}{\sum P_l^L L_l}$$

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[7] For a more extensive explanation, see Jorgenson, Ho and Stiroh (2002).

$$\overline{V}_{Ll} = 0{,}5 * \left[V_{Ll}(t) + V_{Ll}(t-1) \right]$$

The use of the translog function allows to get interactions of different characteristics. For each characteristic of the labour force (for example, gender, age, occupation, etc.), the growth rate of hours worked weighted by the compensation share of the considered category is computed to get first-order partial indices. For instance, the first-order index computed over gender is the growth rate of hours worked by women and men weighted by the corresponding compensation of women and men. Then, the different characteristics are combined with each other to get second-order indices (for example gender and age: the growth rate of hours worked by women and men that are less than 25 years old, between 25 and 34,...weighted by their relative compensation rate), 3rd-order indices (the combination of gender, age and occupation), 4th-order indices (the interaction of gender, age, occupation and part-time jobs) and 5th-order indices (the combination of all characteristics). The last order will constitute the labour services as the weighted growth rates of each characteristic are summed to get the final labour services.

Contributions to labour quality

The ratio of labour services computed on the different orders to the growth rate of hours worked (that are not weighted) is designed to measure the quality of labour input. The index of quality is the constant that allows hours worked to be transformed into flows of labour services. It gives the measure of the contribution of substitution between components of the labour input relative to the volume of hours worked.

$L_L = Q_L * H$, or:

$Q_L = L_L / H$, L being labour services, product of Q_L, the quality of labour and H, non weighted hours worked.

$$\Delta \ln Q^L = \sum_l \overline{V}_{Ll} \Delta \ln H_l - \Delta \ln H$$

If components of hours worked grow at the same pace, the index of quality of labour Q_L remains unchanged. The index of quality increases when components generating the most labour services – workers whose marginal product is high – grow faster than the other characteristics. On the contrary, it decreases when the least efficient hours worked grow faster than the others.

Contributions to the growth of the quality index allow changes in the composition of hours worked by each characteristic to be captured. Contributions of the different characteristics to the growth of the quality index are computed from the partial indices and hours worked.

Partial first-order indices of labour input differentiated relative to the growth rate of hours worked indicate the contribution of the characteristic to the growth of the index of labour

quality. Partial second-order indices of labour input differentiated against the growth rate of hours worked reflect the interaction between two characteristics excluding the effect of all others. This calculation is continued till the last order.

A-2. GRAPHS AND TABLES

Graph 4: Growth rate of hours worked by gender, 1982=100
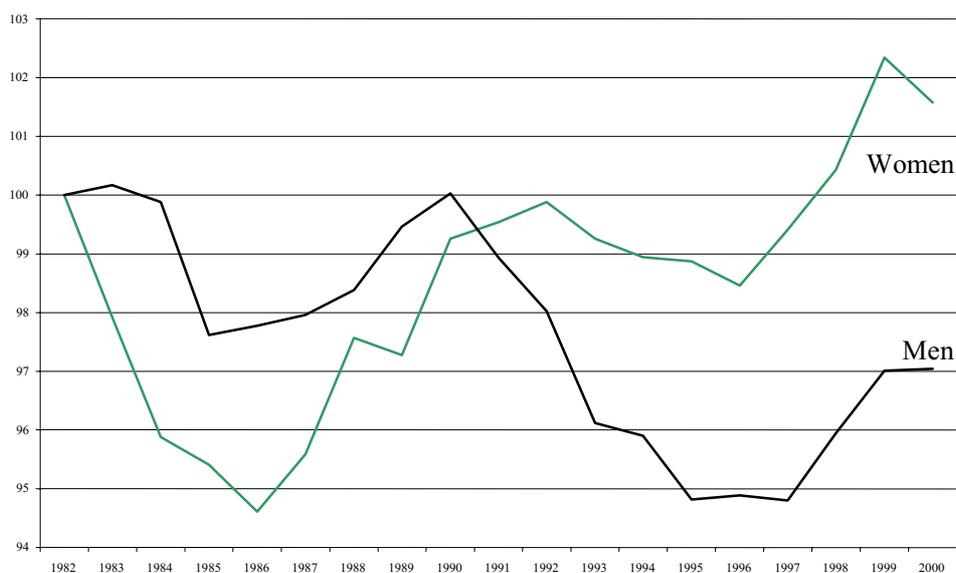
Note: break in series in 1993

Source: INSEE, D.A.D.S., Labour Force surveys and National Accounts; CEPII, authors' calculations.

Graph 5: composition of wages by gender, in %
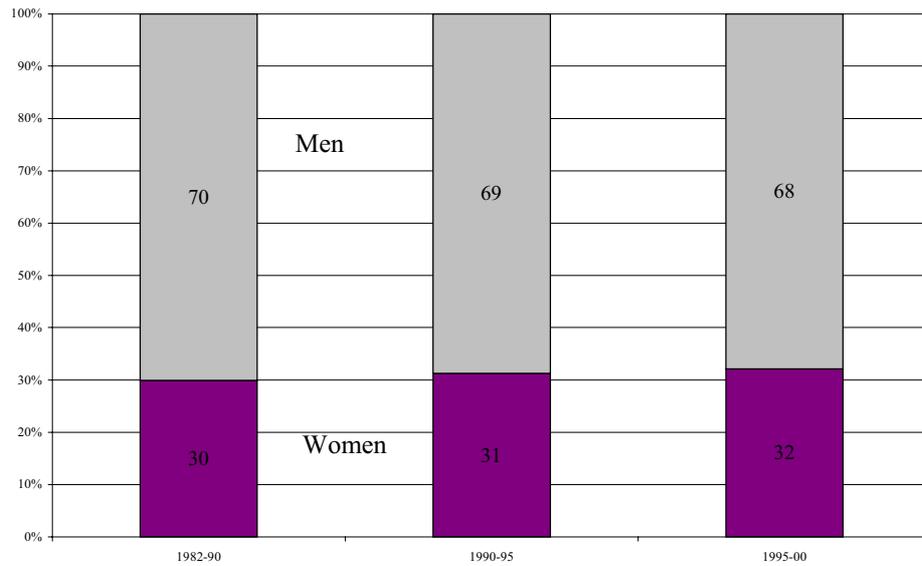
Source: INSEE, D.A.D.S., Labour Force surveys and National Accounts; CEPII, authors' calculations.

Graph 6: Hourly wage of women/men by skills (education)
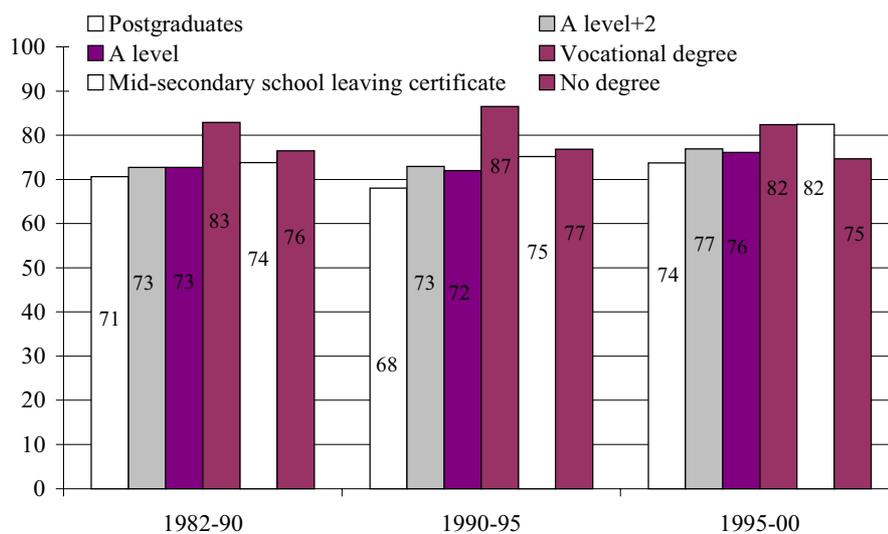
Source: INSEE, D.A.D.S., Labour Force surveys and National Accounts; CEPII, authors' calculations.

Graph 7: Growth rate of hours worked by age bracket, 1982=100
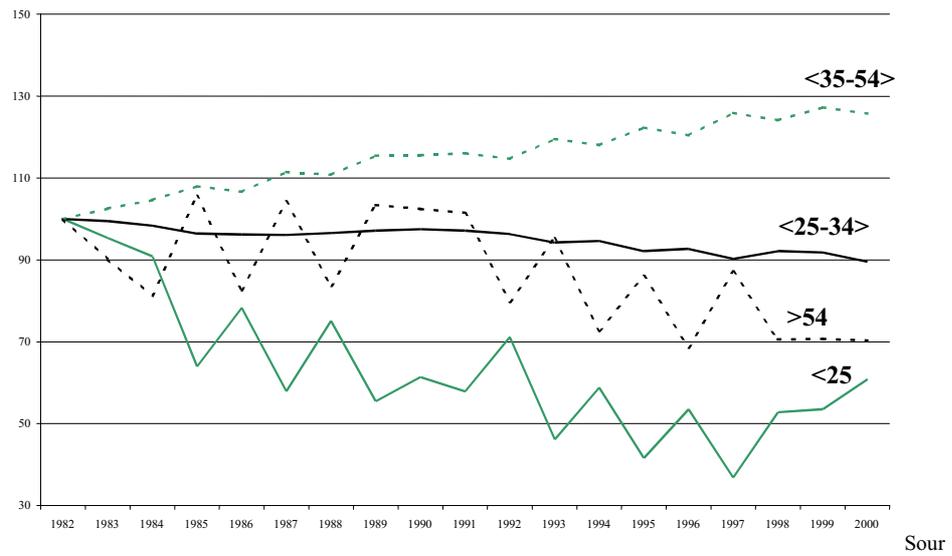
Source: INSEE, D.A.D.S., Labour Force surveys and National Accounts; CEPII, authors' calculations.

Graph 8: composition of wages by age bracket, in %
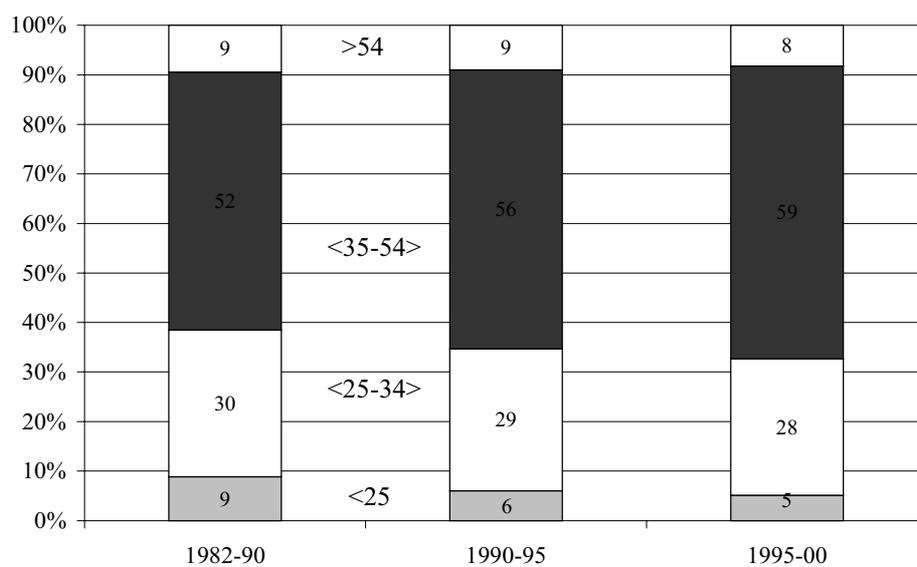
Source: INSEE, D.A.D.S., Labour Force surveys and National Accounts; CEPII, authors' calculations.

Graph 9: Growth rate of hours worked by education level, 1982=100
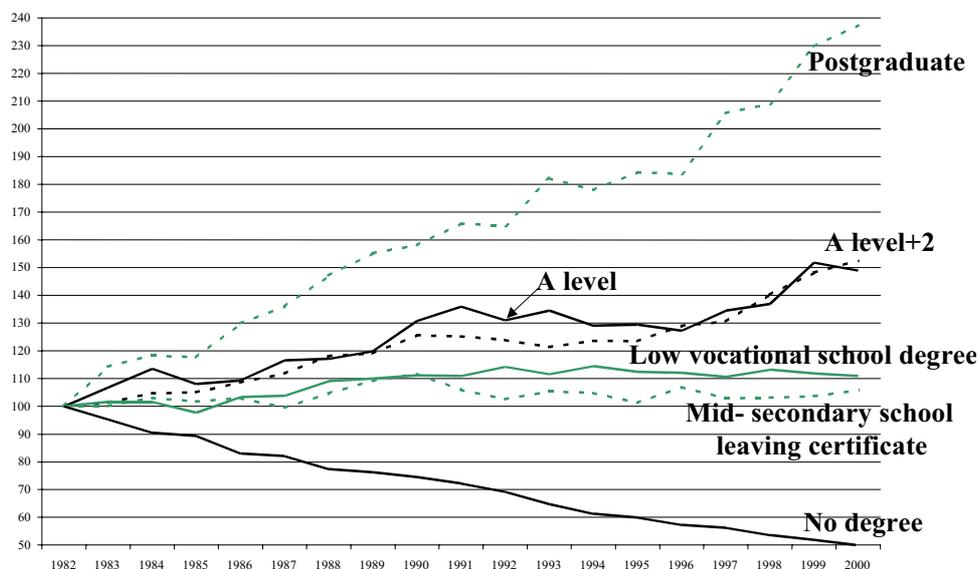
Source: INSEE, D.A.D.S., Labour Force surveys and National Accounts; CEPII, authors' calculations.

Graph 10: composition of wages by education level, in %
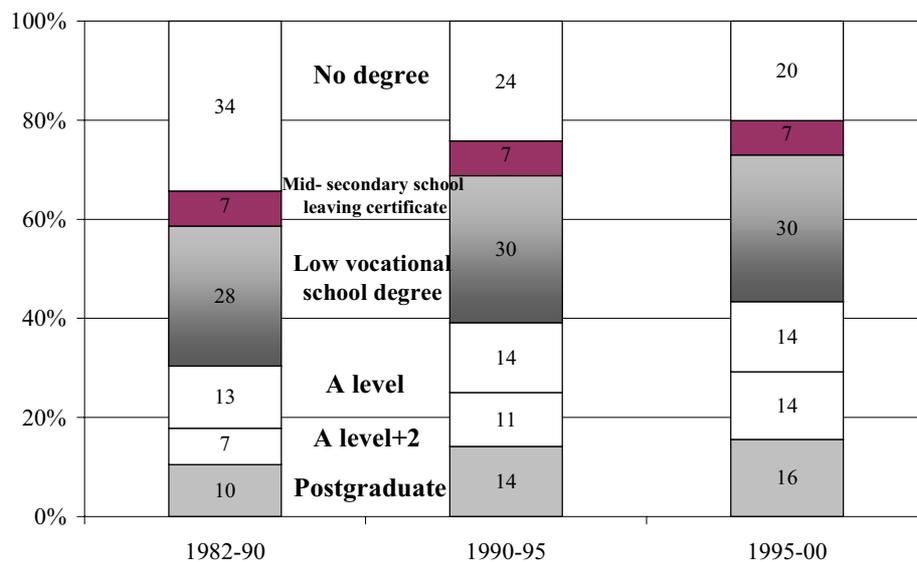
Source: INSEE, D.A.D.S., Labour Force surveys and National Accounts; CEPII, authors' calculations.

Graph 11: comparison of hourly wages of A level+2 & +4 by age bracket, 1 year's service with the firm
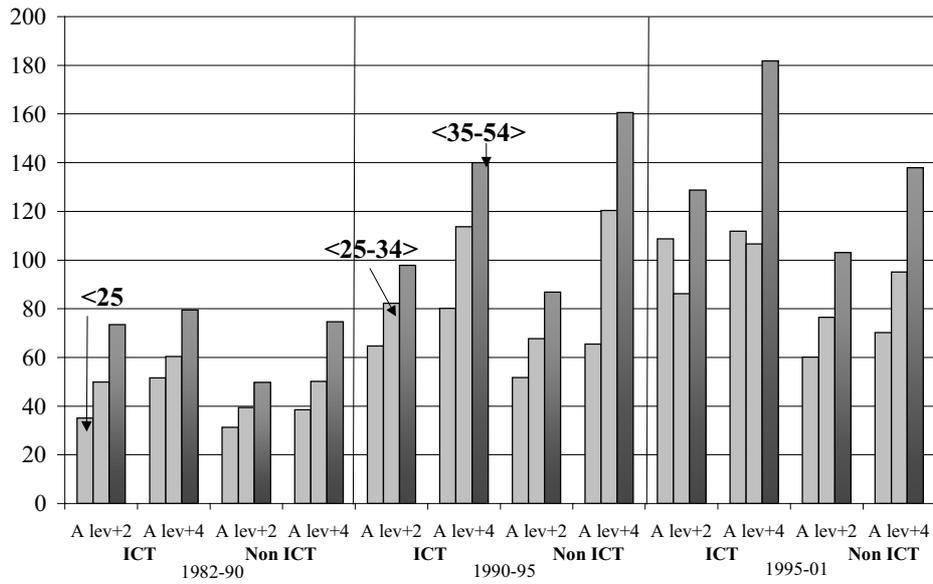
Source: Labour Force surveys; CEPII, authors' calculations.

Table 6: Hypotheses for the construction of capital stocks

Assets	Depreciation	Life time
Software	0.315	5
Hardware	variable	5
Communication	0.11	15
Non residential structures	0.028	60
Transport	0.1906	15
Other equipment	0.132	15

Source: O'Mahony and University of Groningen.

Table 7: Variable depreciation rates for computer equipment over 1980-2000

1980	0.222
1981	0.224
1982	0.227
1983	0.226
1984	0.231
1985	0.235
1986	0.239
1987	0.242
1988	0.242
1989	0.242
1990	0.243
1991	0.243
1992	0.243
1993	0.246
1994	0.250
1995	0.254
1996	0.261
1997	0.270
1998	0.279
1999	0.287
2000	0.295

Source: Marcel Timmer, University of Groningen.

Table 8: Contributions to average annual growth of value added (in %)

(B.E.A. prices for hardware and software, INSEE prices for other assets)

	1982-00	1982-90	1990-00	1990-95	1995-00
GVA	2.18	2.57	1.87	1.09	2.65
Capital services	1.10	1.22	1.00	0.96	1.04
Total ICT:	0.27	0.23	0.29	0.18	0.41
Hardware	0.14	0.13	0.14	0.09	0.20
Software	0.08	0.06	0.09	0.05	0.14
Communication	0.05	0.04	0.06	0.04	0.08
Non-residential structures	0.51	0.58	0.46	0.57	0.35
Transport	0.08	0.06	0.09	0.06	0.13
Other equipment	0.24	0.35	0.15	0.16	0.14
Labour services	0.51	0.72	0.34	0.06	0.62
Non weighted labour	-0.06	-0.04	-0.08	-0.48	0.33
TFP (with labour services)	0.57	0.63	0.52	0.06	0.98

Note: Hypotheses underlying capital services are the same as assumptions used for capital services with prices resulting from the Schreyer's method.

Source: INSEE series; CEPII, authors' calculations.

Table 9: Contributions to average annual growth of value added (in %)

	1980-00			1980-90			1990-95			1995-00		
	Cepii	**cmk**	**CS**	**cepii**	**cmk**	**CS**	**cepii**	**cmk**	**CS**	**cepii**	**cmk**	**CS**
GVA	2.18	1.88		2.57	2.42		1.09	0.50	0.97	2.65	2.20	2.81
ICT	0.27	0.25		0.23	0.24		0.18	0.17	0.13	0.41	0.36	0.27
H	0.14	0.11		0.13	0.11		0.09	0.08		0.20	0.15	
S	0.08	0.08		0.06	0.07		0.05	0.05	0.02	0.14	0.09	0.08
C	0.05	0.06		0.04	0.05		0.04	0.05		0.08	0.09	
K	1.10		1.17	1.22	1.30		0.96	1.18	0.73	1.04	0.91	0.78
L	0.51	-0.47		0.72	-0.60		0.06	-0.83		0.62	0.15	
TFP	0.57	1.19		0.63	1.74		0.06	0.15		0.98	1.13	

Note : CEPII = total economy, calculations performed by using the price indices from the BEA for hardware and software, and price indices from INSEE for the other assets, Rental price calculated with an internal rate of return.

Cepii: 1982-2000 and 1982-90.

CMK (Cette, Mairesse, Kocoglu, 2002) = Business sector,

CS (Colecchia and Schreyer, 2001) = Business sector.

L: Labour services calculated on all characteristics except education.

Source: CEPII, authors' calculations.

Table 10: Sources of average annual hourly labour productivity growth (in %)

(BEA prices for hardware and software, INSEE prices for other assets)

	1982-00	1982-90	1990-00	1990-95	1995-00
Average hourly labour productivity	2.26	2.60	1.98	1.80	2.16
Capital substitution for labour	1.11	1.21	1.03	1.19	0.87
Of which, ICT :	0.27	0.23	0.30	0.19	0.40
Quality of labour	0.57	0.76	0.42	0.54	0.29
TFP	0.57	0.63	0.52	0.06	0.98

Note: ICT = Hardware + software + communication.

Source: CEPII, authors' calculations.

Table 11: Share of current ICT investment in total non residential investment and in GDP for France & the U.S. (Total economy)

	1980	1985	1990	1995	2000
% non res. investment in GDP					
France	15.4	13.6	15.8	13.0	14.2
United-States	16.3	16.2	14.5	14.3	16.2
% ICT in total non res. investment					
France	6.1	9.3	8.7	9.9	14.0
United-States	15.5	21.3	22.8	25.6	29.6
% ICT investment in GDP					
France	0.9	1.3	1.4	1.3	2.0
United-States	2.5	3.4	3.3	3.7	4.8

Source : CEPII, authors' calculations, US : CEPII/Groningen study.

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