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Matilde Mas Ivars
Javier Quesada Ibáñez

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Matilde Mas Ivars [1,2]
Javier Quesada Ibáñez [1,2]

[1] *UNIVERSITY OF VALENCIA*
[2] *INSTITUTO VALENCIANO DE INVESTIGACIONES ECONÓMICAS (Ivie)*

Abstract

The paper presents a quantification of Spanish productivity performance over the last two decades — with a special mention to the role played by Information and Communication Technologies (ICT). It makes use of the capital service data — recently released by the BBVA Foundation — exploiting its sectoral breakdown. It concentrates on twenty six industries belonging to the business (non-primary) sectors of the economy. These industries are further grouped in two clusters according to their intensity in the use of ICT capital. Our results show that the ICT cluster as a whole has presented the most dynamic behaviour. However, some important differences can be detected, both among the industries included in the cluster and also over the period under consideration. A growth accounting exercise allows us to conclude that the Spanish economy shows notable inefficiencies, as identified by negative *Total Factor Productivity* (TFP) contributions to productivity growth during the period 1985-2004. However, the ICT intensive cluster has reversed its behaviour since 2000, driving a modest resurgence of labour productivity in Spain over the 2000-2004 period.

Key words

Growth accounting, productivity, information and communication technologies.

Resumen

En este documento de trabajo se realiza una cuantificación del comportamiento de la productividad del trabajo en España durante las dos últimas décadas, analizando con especial atención el papel desempeñado por las Tecnologías de la Información y la Comunicación (TIC). Se hace uso de las series de capital —recientemente publicadas por la Fundación BBVA— y su desglose sectorial, concentrándose en las 26 ramas que pertenecen al sector privado no agrario de la economía. Estas ramas son, además, clasificadas en dos grupos según su intensidad en el uso de capital TIC. Los resultados muestran que el grupo más intensivo en el uso de activos TIC ha presentado en conjunto una conducta más dinámica. Sin embargo, se pueden apreciar algunas diferencias importantes, tanto entre los subsectores incluidos en el grupo como también entre distintas etapas del periodo considerado. Mediante el método de la contabilidad del crecimiento se concluye que la economía española presenta ineficiencias notables, identificadas mediante la contribución negativa de la Productividad Total de los Factores (PTF) al crecimiento de la productividad durante el periodo 1985-2004. Sin embargo, el grupo intensivo en TIC ha invertido su conducta desde 2000, responsabilizándose del modesto resurgimiento experimentado por la productividad del trabajo en España durante el periodo 2000-2004.

Palabras clave

Contabilidad del crecimiento, productividad, tecnologías de la información y la comunicación.

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C O N T E N T S

1. Introduction

SPAIN and most of the rest of the European Union (EU) countries have experienced a productivity slowdown since the middle of the nineties. During the same period, the United States (U.S.) showed an upsurge of productivity that lasted until now. Information and Communication Technologies (ICT) were soon identified as a major force in the reversal of the productivity slowdown in the U.S.[1]. In contrast, no strong evidence in this direction is yet available for most of the EU countries. Many studies concentrate on the aggregate behaviour — referring either to total output or to business sector output. However, it became soon evident that at least a distinction should be drawn between ICT producing sectors and the rest of the economy. Particularly, for those countries without a strong ICT production sector, the classification of the different industries according to the intensity of their ICT use was a great step forward.

We follow this latter approach using a database recently released by the BBVA Foundation (Mas, Pérez and Uriel, 2005), which provides capital services estimates for thirty-three industries and eighteen assets, three of which are ICT assets (software, hardware and communications). We concentrate on the business (non-primary) sectors of the economy. Most likely, this set of industries is the best sample to analyze the productivity performance of a country for two reasons: 1. productivity measurement problems in the non-market sectors and 2. the continuous and intensive increase in productivity observed in the primary sectors as a result of an accelerated process of job destruction.

The current absence of information on the ICT producing sectors forced us to concentrate on the impact on productivity of using rather than producing ICT. Accordingly, we partitioned the business sector into two subgroups based on their intensity of ICT use. The evolution of these two clusters — as well as the individual industries that make up the groups — are analyzed in detail for the period 1985-2004. Then, we follow the well

1. Bailey (2003), Bailey and Gordon (1988), Colechia and Schreyer (2001), Gordon (1999), Jorgenson and Stiroh (2000), Oliner and Sichel (2000), O'Mahony and Van Ark (2003), Pilat (2003), Stiroh (2002), Van Ark and Timmer (2004) and Timmer and Van Ark (2005).

established growth accounting framework to obtain the sources of growth decomposition. This exercise allows us to identify and quantify the contribution to productivity growth — with its corresponding slowdown — made by i) capital deepening — distinguishing ICT from non-ICT capital — ii) improvements in labour qualification, and iii) Total Factor Productivity (TFP).

The rest of this paper is structure as follows. Section 2 describes the data. Section 3 presents the aggregate behaviour, proposes a taxonomy of industries based on the intensity of ICT use and explains their dynamics over the 1985-2004 period. Section 4 es details the time pattern as well as the observed changes in quality experience by labour and capital. Section 5 reports the results of the growth accounting exercise, emphasizing the 2000-2004 recovery of productivity, while section 6 presents some concluding remarks.

2. Data

OUTPUT data come from the Spanish National Accounts. Since residential capital is not considered part of the definition of productive capital, we exclude two items from gross value added: namely, rents from dwellings and incomes from private households with employed persons. We measure labour in hours worked. The employment figures come also from National Accounts. The number of hours worked per employed person has been taken from OECD and was available at the Groningen Growth Development Centre, *60 Industry Database*. They assume that the number of yearly working hours by employee is the same in all branches but different throughout time. The labour quality index considers seven types of qualification according to the level of studies. Information on the number of employed workers comes from the *Labour Force Survey* (INE, *Instituto Nacional de Estadística*) and the corresponding wages from the *Wage Structure Survey*, also compiled by INE for the years 1995 and 2002. The data for capital services come from Mas, Pérez and Uriel (2005). They provide detail for 18 different types of assets, three of which are ICT assets (software, hardware and communications).

3. Aggregate Behavior and Industries Dynamics

TABLE 3.1 shows the evolution of output, employment (in hours) and labour productivity over the whole period 1985-2004 and also for five different sub-periods. Panel a) refers to the total economy while panel b) concentrates on the business non-primary sectors of the economy (that is, excluding agriculture and fishing as well as all non-market sectors). Graphic 3.1 plots the series for the latter aggregate.

TABLE 3.1: Real Gross Value Added, employment (hours worked) and labour productivity. Annual rates of growth

(percentage)

a) Total Economy

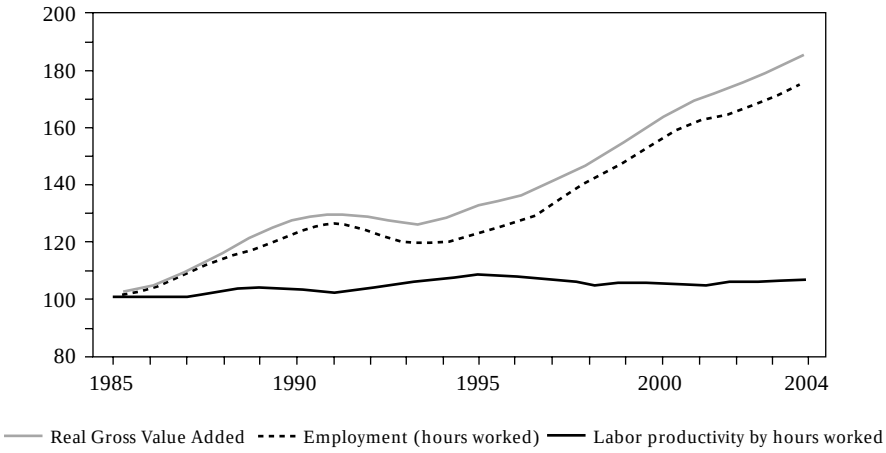
	1985-2004	1985-1990	1990-1995	1995-2004	1995-2000	2000-2004
Real GDP	3.21	4.75	0.98	3.57	4.05	3.00
Employment (hours worked)	2.25	3.11	–0.56	3.39	4.05	2.55
Labor productivity per hour worked	0.96	1.64	1.54	0.19	0.00	0.45

b) Total market (non-primary) Economy

	1985-2004	1985-1990	1990-1995	1995-2004	1995-2000	2000-2004
Real GDP	3.23	4.78	0.82	3.69	4.12	3.18
Employment (hours worked)	2.93	4.16	–0.15	3.98	4.81	2.94
Labor productivity per hour worked	0.30	0.61	0.98	–0.29	–0.69	0.23

Source: INE and own calculations.

GRAPHIC 3.1: Real Gross Value Added, employment (hours worked) and labour productivity. Total Market (non-primary) Economy



The first thing to notice is the remarkable influence of the primary and the non-market sectors on the performance of productivity in Spain. Labour productivity grows faster in the total economy than in the business non-primary sector. This is mainly due to different rates of employment growth. Essentially, this effect is brought about by the destruction of employment in the agricultural sector.

If we concentrate on the business (non-primary) sectors, panel b) informs us that, for the entire period the three variables show a positive trend, but with very different intensities. The average annual growth rate of real output for 1985-2004 was 3.23% and that of employment 2.93%, so productivity grew at a very modest rate of only 0.30%. It is interesting to note that labour productivity growth had different drivers. In the first sub-period (1985-1990) the slight increase in productivity was due to the rapid increase of output (4.78%) over an also significant positive rate of employment creation (4.16%). In the second period (1990-1995) productivity growth was the result of a very modest output growth (0.82%) and a reduction of employment (-0.15%). The combination of both forces made this second period the fastest labour productivity growing sub-period of all. During the period 1995-2000 real GDP grew at a very fast rate (4.12%) but employment creation was even stronger (4.81%). As a consequence, labour productivity growth was negative (-0.69%). Finally, over the last sub-period (2000-2004) both, output (3.18%) and employment (2.94%) slowed down from their previous fast growth rates, allowing a very modest labour productivity recovery of only 0.23% per year.

The aggregate behaviour might hide from view potential differences among the distinct sectors. In fact, the very sharp reduction of agricultural

employment over the period — and its corresponding extremely fast productivity growth — recommended the removal of the primary sector (agriculture, cattle farming and fishing) from the analysis. The reason for excluding also the public sector from our definition of output is twofold. First, there are severe measurement problems of public output. Second, it is quite difficult to interpret properly labour productivity improvements in the public sector.

After these modifications, we were left with information for 26 industries. The next step was to classify these branches according to their intensity in the use of ICT assets. We have used one basic criterion [2]: the relation between the value of ICT capital and total capital services in each industry over the period 1995-2004. If the ratio of a particular industry is above the average we include it in the *Intensive ICT users* group. Otherwise, it is considered part of the *Non-Intensive ICT users* group. Additionally, we use a second indicator: the ratio of ICT capital services over employment (hours worked). The proposed taxonomy is shown in Table 3.2.

TABLE 3.2: Industries Taxonomy

I	Intensive ICT user	II	Non-intensive ICT users
1	Electricity, gas and water supply	9	Food, drink and tobacco
2	Pulp, paper, printing & publishing	10	Textiles, clothing, leather and footwear
3	Electric, electronic & optic equipment	11	Chemicals
4	Transport and communications	12	Rubber & plastics
5	Financial intermediation	13	Other non-metallic mineral products
6	Business services	14	Fabricated metal products
7	Private health & social services	15	Machinery & mechanical equipment
8	Other community, social & personal services	16	Transport equipment manufacturing
		17	Wood & products of wood & cork; Miscellaneous manufacturing
		18	Wholesale & retail trade; Repairs
		19	Hotels & catering
		20	Real estate activities
		21	Private education
		24	Mining and quarrying
		25	Mineral oil refining, coke & nuclear fuel
		26	Construction

Source: INE and own calculations.

2. We follow Stiroh (2002) and O'Mahony and Van Ark (2003) but using Spanish data instead of those of the U.S.

Table 3.3 shows the weight that each industry — as well as the two clusters — have in the aggregate private non-agricultural sector. The following comments are in order. First, the weight of the *Intensive ICT* cluster on total gross value added and employment is lower than that of the *Non-Inten-*

TABLE 3.3: Share of each industry on total market economy. Gross Value Added and Employment (hours worked). Total Market(non-primary) Economy

(percentages)

	Gross Value Added			Employment (hours worked)		
	1985	**1995**	**2004**	**1985**	**1995**	**2004**
Total Market (non-primary)	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Intensive ICT users	**36.54**	**38.33**	**38.40**	**30.75**	**32.29**	**32.06**
Electricity, gas and water supply	3.76	3.42	2.40	1.02	0.81	0.54
Pulp, paper, printing & publishing	2.20	2.11	1.93	1.74	1.77	1.67
Electric, electronic & optic equipment	2.42	1.76	1.27	2.10	1.63	1.21
Transport and communications	9.56	9.79	9.59	9.12	7.89	7.31
Financial intermediation	6.70	6.62	6.01	4.60	3.59	2.62
Business services	5.88	7.72	9.85	5.57	8.57	10.16
Private health & social services	1.45	2.32	2.63	1.95	2.63	2.99
Other community, social & personal services	4.58	4.60	4.74	4.67	5.40	5.57
Non-Intensive ICT users	**63.46**	**61.67**	**61.60**	**69.25**	**67.71**	**67.94**
Food, drink and tobacco	5.45	3.98	2.84	4.73	4.12	2.96
Textiles, clothing, leather and footwear	3.45	1.91	1.21	4.78	3.15	2.17
Chemicals	3.06	2.44	2.05	1.81	1.46	1.11
Rubber & plastics	1.08	1.02	0.94	0.87	0.90	0.86
Other non-metallic mineral products	2.32	1.89	1.60	1.92	1.71	1.44
Fabricated metal products	5.05	3.76	3.68	4.13	3.40	3.48
Machinery & mechanical equipment	2.11	1.56	1.53	1.79	1.53	1.42
Transport equipment manufacturing	2.07	2.70	2.30	2.92	2.42	2.07
Wood & products of wood & cork; Miscellaneous manufacturing	2.30	1.72	1.47	3.18	2.82	2.44
Wholesale & retail trade; Repairs	15.46	15.51	14.27	20.51	21.32	19.99
Hotels & catering	6.40	9.51	9.93	7.45	8.51	8.77
Real estate activities	2.29	2.58	3.08	0.91	0.75	1.19
Private education	1.80	1.92	1.92	2.30	2.38	2.28
Mining and quarrying	0.97	0.55	0.36	0.50	0.50	0.26
Mineral oil refining, coke & nuclear fuel	1.08	0.57	0.43	0.11	0.08	0.06
Construction	8.56	10.05	13.97	10.82	12.65	17.43

Source: INE and own calculations.

sive. However, the former group has won some weight over the period. More specifically, in 2004 the gross value added generated by the *ICT Intensive* cluster represented 38.40% of total value, two percentage points more than in 1985 (36.54%). It is interesting to note that not all the industries included in this cluster have experienced an increase in their weight. In fact, only three out of eight had a higher weight in 2004 than in 1985, being *Business Services* the one experiencing the highest increase, four percentages points (from 5.88% in 1985 to 9.85 in 2004). Only the *Construction* industry experienced an even higher increase: over five percentage points (from 8.56% in 1985 to 13.97% in 2004).

Secondly, notice that employment followed a similar time pattern in the *ICT Intensive* cluster, but with a lower weight in total employment than in value added. In 2004, employment in this cluster represented 32.06% of the total *versus* 38.40% in terms of value added. As a consequence, labour productivity was higher in this cluster. Table 3.4 provides the figures. Taken together, labour productivity was almost 30% higher in the *ICT Intensive* cluster in 2004. However, the behaviour of the eight branches included in this group is not homogenous. In fact, three of them presented in 2004 lower than average productivity levels. Table 3.4 shows also the sectors with the lowest productivity levels in that year, namely, *Textiles, clothing, leather and footwear; Wood & products of wood & cork;* and the *Construction* industry, the three of them belonging to the *Non-ICT intensive* cluster.

Table 3.5 presents the dynamics of the 26 industries over the analyzed period. It shows the contribution of each industry — and cluster — to aggregate GVA, employment, and labour productivity growth [3]. As it can be seen, the *ICT Intensive* cluster has been the most dynamic group over the last decade, with a contribution to GVA growth ten points higher than its weight in total GVA, and with a similar contribution in terms of employment. As a result, the contribution of this cluster to labour productivity growth in the period 1995-2004 is remarkable. While the aggregate GVA presented a negative value of -0.29% the contribution of the *ICT Intensive* cluster was positive (0.52), thanks mainly to *Transport and Communication* (0.20), *Financial Intermediation* (0.19) and *Electricity, gas and water supply* (0.14). In contrast, the contributions of two of the industries of this cluster (*Business Services* and *Other community, social and personal services*) were negative. Finally, it is interesting to notice that the positive contribution to productivity of the *ICT Intensive* cluster is exactly compensated by the reduction (-0.52) shown by the *Construction* industry. In fact, three industries con-

3. All rates of growth are computed using Törnqvist indexes.

TABLE 3.4: Labour productivity
Total Market (non-primary) Economy = 100

	1985	1995	2004
Total Market (non-primary)	**100.00**	**100.00**	**100.00**
Intensive ICT users	**122.46**	**118.71**	**129.73**
Electricity, gas and water supply	347.90	424.29	698.32
Pulp, paper, printing & publishing	141.67	119.28	130.45
Electric, electronic & optic equipment	61.98	108.13	129.23
Transport and communications	97.17	124.11	144.82
Financial intermediation	188.20	184.23	243.69
Business services	110.12	90.08	97.54
Private health & social services	106.44	87.99	82.08
Other community, social & personal services	99.42	85.09	85.87
Non-Intensive ICT users	**90.02**	**91.08**	**85.97**
Food, drink and tobacco	98.42	96.64	109.70
Textiles, clothing, leather and footwear	54.6	60.68	62.61
Chemicals	141.98	167.17	199.56
Rubber & plastics	113.38	114.34	133.37
Other non-metallic mineral products	90.87	110.30	127.61
Fabricated metal products	104.47	110.60	113.51
Machinery & mechanical equipment	78.77	102.06	122.17
Transport equipment manufacturing	74.80	11.35	118.87
Wood & products of wood & cork; Miscellaneous manufacturing	59.85	61.04	66.82
Wholesale & retail trade; Repairs	80.90	72.73	70.39
Hotels & catering	121.20	111.76	94.41
Real estate activities	259.89	341.31	216.35
Private education	72.19	80.48	77.01
Mining and quarrying	67.79	110.15	126.17
Mineral oil refining, coke & nuclear fuel	522.36	719.45	653.96
Construction	83.74	79.44	65.53

Source: INE and own calculations.

centrate the responsibility of the Spanish productivity decline: *Construction* (-0.52); *Wholesale & Retail trade; Repairs* (-0.28); and *Hotels and Catering* (-0.16). If we eliminated their negative contribution, labour productivity growth would be 0.67%, instead of the actual negative rate of -0.29% over the period 1995-2004.

TABLE 3.5: Industries contribution to real GVA, employment and labor productivity growth. Total Market (non-primary) Economy

(percentages)

	GVA		Employment		Productivity	
	1985-1995	**1995-2004**	**1985-1995**	**1995- 2004**	**1985-1995**	**1995-2004**
Total Market (non-primary)	**2.82**	**3.69**	**2.00**	**3.98**	**0.81**	**–0.29**
Intensive ICT users	**1.16**	**1.77**	**0.79**	**1.25**	**0.37**	**0.52**
Electricity, gas and water supply	0.09	0.14	0.00	0.00	0.09	0.14
Pulp, paper, printing & publishing	0.03	0.08	0.04	0.06	–0.01	0.02
Electric, electronic & optic equipment	0.12	0.04	–0.01	0.01	0.13	0.03
Transport and communications	0.37	0.44	0.05	0.24	0.32	0.20
Financial intermediation	0.01	0.21	–0.02	0.01	0.03	0.19
Business services	0.35	0.57	0.45	0.55	–0.10	0.02
Private health & social services	0.07	0.11	0.11	0.15	–0.04	–0.04
Other community, social & personal services	0.12	0.19	0.17	0.24	–0.05	–0.04
Non-Intensive ICT users	**1.66**	**1.92**	**1.21**	**2.73**	**0.44**	**–0.81**
Food, drink and tobacco	0.06	0.05	0.03	0.01	0.03	0.04
Textiles, clothing, leather and footwear	–0.01	0.00	–0.09	0.00	0.08	0.00
Chemicals	0.06	0.06	0.00	0.01	0.07	0.05
Rubber & plastics	0.03	0.05	0.02	0.03	0.01	0.02
Other non-metallic mineral products	0.08	0.06	0.02	0.03	0.06	0.03
Fabricated metal products	0.06	0.16	0.00	0.15	0.06	0.01
Machinery & mechanical equipment	0.07	0.08	0.01	0.05	0.06	0.03
Transport equipment manufacturing	0.12	0.07	0.00	0.05	0.11	0.02
Wood & products of wood & cork; Miscellaneous manufacturing	0.04	0.05	0.02	0.06	0.01	–0.01
Wholesale & retail trade; Repairs	0.33	0.39	0.50	0.67	–0.17	–0.28
Hotels & catering	0.26	0.21	0.27	0.37	0.00	–0.16
Real estate activities	0.09	0.11	0.00	0.09	0.09	0.02
Private education	0.08	0.05	0.06	0.08	0.02	–0.03
Mining and quarrying	0.00	–0.01	–0.04	–0.01	0.04	0.00
Mineral oil refining, coke & nuclear fuel	0.02	0.00	0.00	0.00	0.02	0.00
Construction	0.36	0.61	0.42	1.13	–0.06	–0.52

Source: INE and own calculations.

4. The Sources of Growth

WE have considered the two traditional factors of production, labour and capital, but we have taken into account explicitly differences in their quality.

4.1. Capital accumulation

The BBVA Foundation / Ivie dataset allows us to distinguish among 18 different capital assets, three of which (Software, Communication and Hardware) are ICT assets. Table 4.1 presents these figures. The rate of accumulation of non-residential capital in Spain was quite strong over the 1995-2004 period, averaging an annual rate of 5.64%, almost one point higher than in the previous decade (4.85%). The ICT capital growth rates almost doubled those of total capital, reaching 9.7% in both sub-periods. Non-ICT capital accumulation was more modest and stronger in the period 1995-2004 than in the previous one. As expected, ICT capital accumulation concentrated on the *ICT Intensive* branches, specifically in *Business Services* and *Financial Intermediation*. In the sub-period 1995-2004 over 68% of total ICT capital growth originated in the *ICT Intensive* cluster.

4.2. Labour qualification

Spain has experienced a great transformation in labour qualification over the period under study. Table 4.2 shows that only 20 years ago, 61.30% of the Spanish workers had a level of education no higher than primary school, and 8.61% were illiterate or had no studies at all [4]. In 2004 these numbers had been reduced to 18.98% and 2.51% respectively. On the opposite side of the educational range only 7.64% of the workers had a college educational level in 1985. This percentage had risen to 18.24% in 2004. How-

4. The percentages are higher when we include agricultural employment.

ever, the most radical change took place at the secondary school level (including professional training) where the rate rose from 31.04% in 1985 to 62.78% in 2004. As a result of this outstanding change, the proportion of Spanish workers with at least a secondary school level of education more than doubled, rising from 38.7% in 1985 to 81.02% in 2004.

TABLE 4.1: Industries contribution to capital services growth. Total Market (non-primary) Economy
(percentages)

	Total		ICT Capital		Non-ICT Capital	
	1985-1995	1995-2004	1985-1995	1995- 2004	1985-1995	1995-2004
Total Market (non-primary)	**4.85**	**5.64**	**9.74**	**9.70**	**3.98**	**4.66**
Intensive ICT users	**2.44**	**2.79**	**7.31**	**6.63**	**1.51**	**1.86**
Electricity, gas and water supply	0.01	0.17	0.23	0.18	–0.03	0.17
Pulp, paper, printing & publishing	0.16	0.12	0.24	0.21	0.15	0.10
Electric, electronic & optic equipment	0.14	0.16	0.38	0.39	0.10	0.10
Transport and communications	0.88	1.08	2.15	2.85	0.65	0.66
Financial intermediation	0.51	0.32	2.55	1.37	0.10	0.07
Business services	0.41	0.53	0.92	0.95	0.32	0.42
Private health & social services	0.04	0.07	0.09	0.17	0.03	0.05
Other community, social & personal services	0.29	0.34	0.74	0.50	0.21	0.30
Non-Intensive ICT users	**2.42**	**2.85**	**2.43**	**3.07**	**2.47**	**2.80**
Food, drink and tobacco	0.24	0.31	0.32	0.35	0.15	0.30
Textiles, clothing, leather and footwear	0.06	0.06	0.10	0.12	0.14	0.05
Chemicals	0.07	0.15	0.16	0.20	0.05	0.14
Rubber & plastics	0.06	0.07	0.06	0.08	0.17	0.07
Other non-metallic mineral products	0.16	0.11	0.16	0.15	0.07	0.10
Fabricated metal products	0.15	0.14	0.20	0.21	0.14	0.12
Machinery & mechanical equipment	0.06	0.06	0.10	0.09	0.05	0.05
Transport equipment manufacturing	0.16	0.25	0.14	0.23	0.17	0.25
Wood & products of wood & cork; Miscellaneous manufacturing	0.07	0.08	0.08	0.11	0.07	0.07
Wholesale & retail trade; Repairs	0.56	0.66	0.69	0.94	0.54	0.60
Hotels & catering	0.20	0.17	0.12	0.11	0.22	0.19
Real estate activities	0.43	0.41	0.10	0.17	0.50	0.47
Private education	0.02	0.04	0.02	0.05	0.02	0.03
Mining and quarrying	0.01	0.03	0.02	0.02	0.00	0.03
Mineral oil refining, coke & nuclear fuel	–0.01	0.02	0.03	0.03	–0.02	0.02
Construction	0.19	0.29	0.12	0.21	0.20	0.31

Source: INE and own calculations.

TABLE 4.2: Employment structure by educational levels. Total Market (non-primary) Economy
(percentages)

	1985	1995	2004
Total Market economy (non-primary)	**100.000**	**100.000**	**100.000**
Illiterate	8.61	5.48	2.51
Primary Education	52.69	31.13	16.47
Secondary Educ. (1st level)	18.42	27.67	30.85
Secundary Educ. (2nd level)	9.12	10.53	14.10
Professional Trainig	3.50	13.62	17.83
Tertiary Educ. (1st level)	3.73	5.24	7.46
Tertiary Educ. (2nd level)	3.91	6.32	10.78

Source: INE and own calculations.

We have constructed a synthetic index of labour qualification based on the growth rates of employment in each of the seven levels of education, weighted by their relative wages [5]. The index improves if the high-educated workers gain weight in total employment, improving the composition of the labour force towards higher skilled workers. Table 4.3 shows the profiles of the contributions to the index made by the different educational levels. We see a continuous improvement of the index over the whole period, intensified after 1995. This is the result of two complementary elements: a higher rate of employment creation and a simultaneous improvement in education, particularly at the college level.

It is interesting to note that over the years 1995-2004 the contribution to the labour qualification index of the *ICT Intensive* cluster is almost twice as large as that of the *Non-Intensive* group (0.89 vs. 0.46). These figures strongly contrast with the contribution of each cluster to total employment growth, 1.25 the *ICT Intensive* cluster vs. 2.73 the *Non-ICT Intensive* (see table 2.5). The main contributors to the improvement of the labour qualification index belonged to the *ICT Intensive ICT* group, standing out *Business services* (0.41)*; Transports & communications* (0.12)*;* and *Financial intermediation* (0.11). We consider these results of great relevance for the analysis of the ICT contribution to Spanish growth to which we now turn in the next section.

5. We assume that wages are indicators of marginal productivities. We use 1995 and 2002 data from the Wage Structure Survey (*Encuesta de Estructura Salarial*), published by the National Institute of Statistics (INE). See Mas and Quesada (2005) for details.

TABLE 4.3: Industries contribution to the labour qualification index growth. Total Market (non-primary) Economy

(percentages)

	1985-1995	1995-2004
Total Market (non-primary)	**0.96**	**1.35**
Intensive ICT users	**0.63**	**0.89**
Electricity, gas and water supply	0.02	0.02
Pulp, paper, printing & publishing	0.05	0.04
Electric, electronic & optic equipment	–0.03	0.03
Transport and communications	0.13	0.12
Financial intermediation	0.14	0.11
Business services	0.21	0.41
Private health & social services	0.13	0.09
Other community, social & personal services	–0.02	0.06
Non-Intensive ICT users	**0.33**	**0.46**
Food, drink and tobacco	–0.07	0.09
Textiles, clothing, leather and footwear	0.01	–0.05
Chemicals	–0.02	0.03
Rubber & plastics	–0.01	–0.01
Other non-metallic mineral products	–0.01	0.01
Fabricated metal products	–0.04	0.01
Machinery & mechanical equipment	0.06	0.01
Transport equipment manufacturing	0.01	0.05
Wood & products of wood & cork; Miscellaneous manufacturing	0.01	0.03
Wholesale & retail trade; Repairs	0.05	0.15
Hotels & catering	0.13	0.05
Real estate activities	0.05	0.02
Private education	0.06	0.03
Mining and quarrying	0.01	0.01
Mineral oil refining, coke & nuclear fuel	0.00	0.01
Construction	0.08	0.00

Source: INE and own calculations.

5. Growth Accounting. 1995-2004

WE now have the necessary ingredients to analyze the impact of ICT use on Spanish growth over the period 1985-2004. We concentrate in this period since it is when Spanish productivity slowdown took place. The impact of ICT on output and productivity growth can follow several transmission mechanisms that can be summarized in three different testing hypotheses [6]: 1. Labour productivity gains are due to capital deepening (ICT and non ICT). 2. TFP gains should be observed mainly in the ICT producing sector, since this is the sector where most of the genuine technological progress takes place. 3. ICT using industries could show additional labour productivity gains arising from spillover effects and/or embodied technical progress. In our study, the data set does not identify the ICT producing sector of the economy so that hypothesis 2 cannot be tested yet. However we know from other indicators that the relative weight of the Spanish ICT production sector is not very large. Consequently, we turn our attention to hypotheses 1 and 3.

Suppose that the production function is given by

$$Q_t = g\,(KP_t, HL_t, KH_t, B) \qquad (5.1)$$

where Q_t = real output, KP_t = productive capital (a volume index of capital services), HL_t= employment (hours worked), KH_t, = human capital (index of labour qualification) and B = the level of efficiency in the use of productive factors. Standard growth accounting assumptions allow us to obtain [7]

6. Stiroh (1998), Jorgenson and Stiroh (1999), Bresnahan (1986), Bartelsman, Caballero and Lyons (1994).

7. In equation (5.2) TFP measures the apparent Total Factor Productivity. It is the real shift in the production function (primal) or in the cost function (dual) if the production function has constant returns to scale and there is perfect competition. If these requirements are not fulfilled the rate of technical progress measured by the primal or dual will not be the same, nor will be the apparent TFP. In our case, the discrepancy will be present, since by assuming an exogenous rate of return, the output value can differ from total cost. However, as shown by Schreyer (2004), from a practical point of view, TFP as given by equation (5.2) is a good approximation to the rate of technical progress. It has also the advantage of keeping Growth Accounting in a non parametric context. In the opposite case, it would be necessary to run econometric estimates on the returns to scale and/or the mark-ups fixed by firms.

$$\Delta \ln Q_t = \bar{w}_t^{HL} \Delta \ln HL_t + \bar{w}_t^{ICT} \Delta \ln KP_t^{ICT} + w^o \Delta \ln KP_t^o + \Delta TFP_t \quad (5.2)$$

$\bar{w}_t^{\chi} = 0.5\ [w_t^{\chi} + w_{t-1}^{\chi}]$ for $\chi = HL$, ICT and O (= the aggregation of 14 other non-ICT non residential assets).

In equation (5.2) the labour share is defined as

$$w_t^{HL} = \frac{\sum_i CE_{i,t}}{TC_t} \quad (5.3)$$

where CE_i is labour compensation on the i[th] sector [8] and TC_t is total cost defined as

$$TC_t = \sum_j \sum_i VCS_{j,i,t} + \sum_i CE_{i,t}$$

The value of capital services is defined as

$$VCS_{j,i,t} = p_{j,t-1}[r_t + d_t - f_{j,t}]KP_{j,i,t-1}$$

where, in turn, $p_{j,t}$ is the price of asset j, $f_{j,t}$ its rate of variation (computed as a three year centered moving average), r_t is the nominal interest rate and $d_{j,t}$ is the depreciation rate of asset j.

The share of ICT-capital is defined as

$$w_t^{ICT} = \sum_{j \in ICT} \sum_i \frac{VCS_{j,i,t}}{TC_t} \quad (5.4)$$

Similarly for the share of non-ICT, non residential capital

$$w_t^{0} = \sum_{j \in 0} \sum_i \frac{VCS_{j,i,t}}{TC_t} \quad (5.5)$$

The growth rate of each variable in (5.2) is computed as a Törnqvist index. Thus, for ICT capital, its growth rate is defined as

$$\Delta \ln KP^{ICT} = \ln KP_t^{ICT} - \ln KP_{t-T}^{ICT} = \frac{1}{T}\left[\sum_{j=s,h,c} \sum_i \bar{v}_{j,t} (\ln KP_{j,i,t} - \ln KP_{j,i,t-T})\right] \quad (5.6)$$

8. The figures from National Accounts have been modified after reassigning mixed incomes into capital and labor.

where $\overline{v}_{j,t} = 0.5 \left[\frac{VCS_{j,i,t}}{\sum_{j=s,h,c} \sum_{i} VCS_{j,i,t}} + \frac{VCS_{j,i,t-T}}{\sum_{j=s,h,c} \sum_{i} VCS_{j,i,t-T}} \right]$

With *s* = software; *h* = hardware; and *c* = communications. Finally, the rate of growth of labour productivity will be given by:

$$\Delta \ln Q - \Delta \ln HL = \overline{w}^{ICT} [\Delta \ln KP^{ICT} - \Delta \ln HL] + w^{o} [\Delta \ln KP^{o} - \Delta \ln HL] + \Delta TFP \qquad (5.7)$$

Table 5.1 shows the aggregate growth accounting results, referring to the last decade. In the upper part it contains the gross value added decomposition. In the middle part it shows the decomposition of labour productivity as given by equation (5.7). Finally, the bottom part — containing the

TABLE 5.1: Growth Accounting. Total Market (non-primary) Economy
(percentages)

	1995-2004	1995-2000	2000-2004
1. Real GVA growth (= 2 + 8 + 16 + 17)	3.69	4.12	3.18
2. Capital contribution (= 3 + 7)	1.34	1.40	1.12
3. ICT (= 4 + 5 + 6)	0.45	0.54	0.33
4. Software	0.09	0.11	0.07
5. Communications	0.13	0.16	0.10
6. Hardware	0.23	0.27	0.16
7. Non-ICT	0.89	0.86	0.79
8. Working hours contribution	3.03	3.71	2.29
9. Labor productivity growth (= 10 + 16 + 17)	–0.29	–0.69	0.23
10. Contribution of capital endowments per hour worked (= 11 + 15)	0.39	0.30	0.46
11. ICT (= 12 + 13 + 14)	0.26	0.31	0.19
12. Software	0.04	0.05	0.02
13. Communications	0.04	0.05	0.04
14. Hardware	0.18	0.21	0.13
15. Non-ICT	0.13	–0.01	0.27
16. Labor force qualification	1.03	1.06	1.18
17. TFP	–1.71	–2.05	–1.41

Surce: INE and own calculations.

contributions of labour qualification and the estimates of *TFP* — is shared by both equations.

Over the period 1995-2004 real GVA grew at an annual rate of 3.69%. It was mainly due to the strong impulse of employment creation (3.03%), accompanied by improvements in its qualification (1.03%), as well as in increases in capital endowments (1.34%). TFP contributed negatively (-1.71%) to output growth.

This result can be interpreted in two ways: i) as a confirmation of the incapacity of Spain to extract all the benefit from the large improvements in workers' training and educational levels and ii) as evidence that — at least apparently — the quality of capital goods has not been used up by the productive system, showing up as an inefficiency factor. Labour productivity presented a negative growth rate (-0.29%) again as a consequence of the negative TFP behaviour, while the improvements in the capital/labour ratio (0.39) and in the qualification of labour (1.03) were both positive. ICT capital deepening contribution to productivity growth (0.26) is twofold that of Non ICT capital (0.13). Hardware shows the highest contribution (0.18), higher even than total Non-ICT capital.

When distinguishing between the two sub-periods it is worth noticing that the negative sign of labour productivity growth over the whole period originated in the first sub-period, 1995-2000. It was then when its growth rate declined sharply to -0.69%. It was the consequence of both, the worsening of the negative TFP contribution and a severe drop in Non-ICT capital deepening. Labour productivity shows a less negative pattern over the most recent sub-period, 2000-2004. This is the result of the recovery of Non ICT capital deepening and the reduction of the inefficiencies captured by the TFP term that, though still presenting a negative contribution, was reduced substantially.

Table 5.2 shows the factors lying behind the improvement experienced by the Spanish economy since 2000. The recovery is due to the positive behaviour of the *ICT Intensive* cluster, which experienced a labour productivity growth of 1.43%. Contrarily, the corresponding rate for the *Non ICT Intensive* cluster was negative, -0.52%. All sources of growth in the *ICT Intensive* cluster contributed positively, even TFP growth (0.09) but specially, labour qualification (0.74) and capital deepening (0.60) of both, ICT (0.30) and Non ICT capital (0.30). In contrast, the *Non ICT Intensive* cluster experienced a negative TFP growth rate (1.28%), together with modest increases of the remaining sources of growth.

Table 5.3 takes a closer look to the data by industry allowing us to conclude that: 1. the positive TFP contribution in the *ICT Intensive* cluster is orig-

TABLE 5.2: Growth Accounting. Total Market (non-primary) Economy. 2000-2004
(percentages)

	Total	Intensives ICT users	Non-intensive ICT users
1. Real GVA growth (= 2 + 8 + 16 + 17)	3.18	4.43	2.40
2. Capital contribution (= 3 + 7)	1.12	1.42	0.92
3. ICT (= 4 + 5 + 6)	0.33	0.57	0.17
4. Software	0.07	0.17	0.00
5. Communications	0.10	0.19	0.04
6. Hardware	0.16	0.22	0.12
7. Non-ICT	0.79	0.85	0.76
8. Working hours contribution	2.29	2.18	2.36
9. Labor productivity growth (= 10 + 16 + 17)	0.23	1.43	–0.52
10. Contribution of capital endowments per hour worked (= 11 + 15)	0.46	0.60	0.37
11. ICT (= 12 + 13 + 14)	0.19	0.30	0.11
12. Software	0.02	0.08	–0.01
13. Communications	0.04	0.06	0.02
14. Hardware	0.13	0.17	0.11
15. Non-ICT	0.27	0.30	0.25
16. Labor force qualification	1.18	0.74	0.39
17. TFP	–1.41	0.09	–1.28

Source: INE and own calculations.

inated in only two sectors: *Electricity, gas & water supply* and *Financial Intermediation*. The remaining six industries presented negative TFP contributions. In the *Non ICT Intensive* cluster, all branches presented negative TFP contributions with only one exception, *Fabricated metal products.* 2. This latter industry, together with *Financial Intermediation*, were the only branches showing negative contributions of the labour quality index; 3. Total capital deepening was particularly intense in two industries belonging to the *ICT Intensive* cluster, *Electricity, gas & water supply*, and *Electric, Electronic and optic equipment;* and it was negative in only two branches belonging to the *Non-ICT intensive* group, *Fabricated metal products* and *Real Estate Activities*. Finally, *Financial Intermediation* was, by far, the industry showing the highest contribution of ICT capital deepening to labour productivity growth.

Probably the most remarkable result of the Spanish experience in recent years is the negative contribution of TFP to economic growth. A first

potential answer to this fact could be associated with measurement problems, almost always present in this type of exercises. But there are some additional factors that can explain why the full benefits on TFP of using ICT are not observable as yet in Spain, as well as in some other EU countries. A short list would contain the following items: 1. Small presence of ICT producing sectors [9]; 2. Relative small share of ICT investment on total investment (this ratio was lower in Spain in 2000 than in the U.S. in 1980. Additionally, while in 2000 this share was over 30% in the U.S., it barely reached 15% in Spain. 3. Low penetration of ICT assets (in 2004, the number of personal computers per capita was 0.27 in Spain against 0.74 in the U.S. and 0.46 in the EU); 4. Very poor technical formation and training (in 2003, over 70% of the Spanish population declared that they could not use technological instruments / equipment and over 60% computers. For the EU, the corresponding percentages were 50% and 40% respectively); 5. Low use of ICT at schools (in 2002 only 70% of the Spanish schools used Internet for educational purposes while in the EU the percentage was 80%, and in Finland, Sweden and Denmark 100%). 6. Higher cost of ICT (the access cost to Internet in Spain doubles that of the U.S.).

9. See Mas and Quesada (2005) for a documented description of the Spanish ICT situation.

TABLE 5.3: Growth Accounting. 2000-2004. Total Market (non-primary) Economy. Labour productivity

(percentages)

	Labor productivity	Capital deepening per hour worked						Labor force qualification	TFP
		Total	ICT				Non-ICT		
			Total	Software	Communi-cations	Hardware			
Total Market Economy (non-primary)	**0.23**	**1.48**	**1.21**	**0.02**	**0.04**	**0.13**	**0.27**	**1.18**	**–1.41**
Intensive ICT users	**1.43**	**0.60**	**0.30**	**0.08**	**0.06**	**0.17**	**0.30**	**0.74**	**0.09**
Electricity, gas and water supply	4.34	2.38	0.19	0.07	0.03	0.09	2.20	0.66	1.29
Pulp, paper, printing & publishing	1.47	0.29	0.22	–0.05	0.09	0.17	0.07	2.88	–1.70
Electric, electronic & optic equipment	2.59	2.44	0.62	0.11	0.12	0.39	1.82	1.82	–1.68
Transport and communications	0.67	0.83	0.44	0.12	0.19	0.12	0.39	0.44	–0.59
Financial intermediation	5.06	1.40	1.21	0.86	0.01	0.34	0.19	–0.40	4.07
Business services	1.68	0.29	0.06	–0.14	0.04	0.16	0.23	3.81	–2.41
Private health & social services	–0.01	0.32	0.25	0.01	0.00	0.23	0.07	2.05	–2.38
Other community, social & personal services	0.58	0.62	0.03	–0.09	–0.03	0.16	0.58	1.30	–1.33
Non-Intensive ICT users	**–0.52**	**0.37**	**0.11**	**–0.01**	**0.02**	**0.11**	**0.25**	**0.39**	**–1.28**
Food, drink and tobacco	1.85	2.03	0.33	0.01	0.10	0.22	1.70	1.84	–2.03
Textiles, clothing, leather and footwear	–0.17	1.51	0.35	0.05	0.11	0.19	1.16	1.07	–2.75
Chemicals	3.03	1.71	0.34	0.05	0.09	0.20	1.37	2.03	–0.71
Rubber & plastics	3.24	1.17	0.25	0.00	0.08	0.17	0.92	1.65	–0.48
Other non-metallic mineral products	1.56	1.51	0.31	0.05	0.12	0.13	1.20	2.14	–2.09
Fabricated metal products	0.69	–0.19	0.11	–0.01	0.02	0.09	–0.30	–0.19	1.07
Machinery & mechanical equipment	1.77	0.66	0.16	0.01	0.05	0.10	0.50	1.29	–0.18
Transport equipment manufacturing	0.22	2.27	0.29	0.00	0.10	0.19	1.98	2.59	–4.64
Wood & products of wood & cork; Miscellaneous manufacturing	0.21	1.07	0.27	0.03	0.09	0.16	0.80	1.26	–2.13
Wholesale & retail trade; Repairs	–1.02	0.44	0.15	–0.02	0.02	0.15	0.29	0.64	–2.10
Hotels & catering	–2.27	0.03	0.00	–0.02	0.01	0.02	0.03	0.48	–2.78
Real estate activities	–3.08	–1.63	0.06	–0.10	0.02	0.13	–1.69	0.57	–2.03
Private education	–0.95	0.30	0.10	0.01	0.00	0.08	0.20	0.17	–1.42
Mining and quarrying	2.97	2.75	0.20	–0.01	0.18	0.03	2.55	0.29	–0.07
Mineral oil refining, coke & nuclear fuel	–3.66	0.78	0.43	0.10	0.29	0.04	0.35	4.39	–8.83
Construction	–0.66	0.09	0.06	0.00	0.00	0.06	0.03	0.76	–1.52

Source: INE and own calculations.

6. Conclusions

THANKS to the new series on capital services by assets we have been able to analyze the growth patterns of Spain over the 1995-2004 period, distinguishing the contributions of ICT and non ICT capital, as well as their components. The results at the macro level are derived from the aggregation of the twenty six branches belonging to the market economy — excluding primary sectors — and the two categories in which these have been grouped according to their intensity in the use of ICT assets.

The lack of data has not allowed us to analyze the direct impact of the ICT production sector. From other studies we know that this mechanism has been found very relevant in countries that have a large ICT production sector. This is not the case of Spain. Consequently, we have limited the study to the impact of ICT on aggregate growth and productivity through the numerous sectors that use, but not produce, ICT capital. In this sense, we consider Spain more an ICT user than an ICT producer country, although neither should it be regarded as a very intensive user country.

Productivity has become a major issue in Spain mainly because it has shown a negative growth rate during the period 1995-2004. However, this rate has become slightly positive over the period 2000-2004 after a sharp drop experienced in the previous five years. The driver of this upturn must be found in the *ICT Intensive* cluster. This group has been the most dynamic one in terms of output, employment, capital deepening — ICT in particular— and labour quality improvements. Its contribution to growth has been always higher than its share in the economy. However, there exists an important degree of heterogeneity among the different industries included in the ICT cluster. In fact, a given industry cannot be considered all the time the most dynamic one since the ranking changes from period to period.

Over the period 1995-2004 the main engines of labour productivity growth were the improvements in labour qualification and capital deepening, particularly ICT capital, whereas the contribution of TFP — computed as a residual — was negative. The severe drop in labour productivity during the years 1995-2000 was motivated by a deterioration of TFP growth, together with a negative contribution of Non ICT capital deepening. The modest upturn of labour productivity in the last sub-period, 2000-2004, had its ori-

gin in the *ICT Intensive* user cluster, which presented an annual growth rate of 1.43% against -0.52% for the *Non ICT Intensive* cluster. All the sources of growth contributed to this recovery, including TFP. However, a closer look into individual branches informed us that only two industries — *Electricity, gas and water supply* and *Financial Intermediation* — were to be acknowledged for such recovery.

The main conclusion that we reach in this study is that, in Spain, the (presumably beneficial) full effects of ICT capital on total factor productivity growth are not observable as yet. A late start — as illustrated by the evidence provided in the previous section — is probably one of the main reasons for not finding yet clear evidence of a productivity pick up induced by ICT technologies. Also some structural features — like the country's productive structure or its low starting level of labour qualification — can explain this delay in experiencing the positive effects on productivity of a strong ICT technology push. Last, but not least, the reason explaining the poor behaviour not only of Spain but also of most of the EU non ICT producing countries can most probably be found in measurement problems.

References

BAILEY, M. N. (2003): "The Sources of Economic Growth in OECD Countries: A Review Article", *International Productivity Monitor*, 7, Fall 2003.

— and R. J.GORDON (1988): "The Productivity Slowdown, Measurement Issues and the Explosion of Computer Power", *Brookings Papers on Economic Activity*, vol. 19 (2), 347-420.

BARTELSMAN, E. J., R. J.CABALLERO and R. K. LYONS (1994): "Costumer —and Supplier— Driven Externalities", *American Economic Review*, 84 (4) September, 1075-1084.

BRESNAHAN, T. F. (1986): "Measuring the Spillovers from Technical Advance: Mainframe Computers in Financial Services", *American Economic Review*, 76 (4), September, 741-755.

COLECCHIA, A. and P. SCHREYER (2001): "ICT Investment and Economic Growth in the 1990's: is the United States a Unique Case? A Comparative Study of nine OECD Countries", *Review of Economic Dynamics*, April, 5(2): 408-42.

GORDON, R. J. (1999): "Has the 'New Economy' Rendered the Productivity Slowdown Obsolete?", North-western University, June, [mimeo.].

JORGENSON, D. W. and K. STIROH (2000): "Raising the Speed Limit: U.S. Economic Growth in the Information Age", *Brookings Papers on Economic Activity*, (1), 125-211.

MAS, M. and J. QUESADA (2005): *Las nuevas tecnologías y el crecimiento económico en España*, Bilbao, Fundación BBVA.

— F. PÉREZ and E. URIEL (dirs.) (2005): *El stock y los servicios del capital en España (1964-2002). Nueva metodología*, Bilbao, Fundación BBVA.

OLINER, S. D. and D. E. SICHEL (2000): "The Resurgence of Growth in the Late 1990's: Is Information Technology the Story?", *Journal of Economic Perspectives*, 14, Fall, 3-22.

O'MAHONY, M. and B. VAN ARK (eds.) (2003): *EU Productivity and Competitiveness: an Industry Perspective*, European Commission.

PILAT, D. (2003): "ICT and Economic Growth – Evidence from OECD Countries, Industries and Firms", DSTI, ICCP (2003) 2, Paris, OECD.

SCHREYER, P. (2004): "Measuring Multi-factor Productivity when Rates of Return Are Exogenous", paper presented at SSHRC International Conference on Index Number theory and the measurement of prices and productivity, Vancouver, June 30-July 3.

STIROH, K. (2002): "Information Technology and U.S. Productivity Revival: What Do the Industry Data Say?", *American Economic Review*, 92 (5), December, 1559-1576.

TIMMER, M. and B. VAN ARK (2005): "Does Information and Communication Technology Drive EU-US Productivity Growth Differentials?", *Oxford Economic Papers*, vol. 57, n.º 4, October, 693-716.

VAN ARK, B. and M. TIMMER (2004): "Computers and the Big Divide: Productivity Growth in the European Union and the United States" in M. Mas and P. Schreyer (eds): *Growth, Capital Stock and New Technologies*, Bilbao, Fundación BBVA, forthcoming.

*ABOUT THE AUTHORS**

MATILDE MAS IVARS holds a PhD in economics from the University of Valencia. A lecturer in economic analysis at the same university and senior researcher at the Instituto Valenciano de Investigaciones Económicas (Ivie), her specialized fields are growth economics and the analysis of technological change and public capital and regional economics. She has visited numerous research centres and has published nineteen books and more than thirty articles in Spanish and international specialist journals.

JAVIER QUESADA IBÁÑEZ holds a PhD in economics from the University of Cincinnati (Ohio, U.S.). He is professor of economic analysis at the University of Valencia and also a senior researcher at the Instituto Valenciano de Investigaciones Económicas (Ivie). His research interest centres on financial and monetary economics and R&D. He has visited numerous research centres and has published four books and more than forty articles in Spanish and international specialist journals.

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Fundación BBVA

Gran Vía, 12
48001 Bilbao
Tel.: 94 487 52 52
Fax: 94 424 46 21

Paseo de Recoletos, 10
28001 Madrid
Tel.: 91 374 54 00
Fax: 91 374 85 22

informacion@fbbva.es
www.fbbva.es