

A Quantification of Productivity Growth in Spain. The Role of ICT*

Matilde Mas and Javier Quesada
(Universitat de València and Ivie)

Abstract

The document expands and updates previous results obtained by the authors on Spanish productivity performance over the last two decades. It makes use of the capital service data -recently released by the BBVA Foundation- exploiting its sectoral break down. It concentrates in twenty six industries belonging to the private non-primary sectors of the economy. These industries are further grouped in two clusters according to their intensity in the use of Information and Communication Technologies (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 the modest resurgence of labor productivity in Spain over the 2000-2004 period.

Key words: growth accounting, productivity, ICT
JEL: O47, O52

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*Corresponding author: Matilde Mas. Instituto Valenciano de Investigaciones Económicas (Ivie) c/ Guardia Civil 22, Esc. 2,1º. 46020 Valencia –SPAIN- Fax: 34-963190055. Email: Matilde.Mas@ivie.es.

Since the late nineties, the role played by ICT in the reversal of the slow down of Total Factor Productivity (TFP) has been the object of attention for many authors¹. Direct as well as indirect effects on labor productivity, embodied technological progress and TFP have been claimed as the main mechanisms of transmission of ICT productivity impulses. These issues have been already addressed for the Spanish economy. However, this document expands and updates previous results obtained by the authors (Mas & Quesada, 2005 a,b,c) in at least two directions: i) it concentrates on the private non-primary sector, and ii) it expands the time period up to 2004.

We follow the well established growth accounting framework using a new capital services database -which distinguishes between ICT and non-ICT assets- as well as an indicator of labor qualification. Since data on the ICT production sector are not available, we have to limit ourselves to analyse the impact of the new technologies on the ICT using sectors. The structure of the paper is as follows. Section 1 describes the data. Section 2 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 3 details the time pattern as well as the observed changes in quality experience by labor and capital. Section 4 reports the results of the growth accounting exercise, emphasizing the 2000-2004 recovery while section 5 presents some concluding remarks.

1. 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 labor 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

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

employee is the same in all branches but different throughout time. The labor quality index considers seven types of qualification according to the level of studies. Information on the number of employed workers comes from the *Labor 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 & Uriel (2005). They provide detail for 18 different types of assets, three of which are ICT assets (software, hardware and communications).

2. Aggregate behaviour and industries dynamics

Table 1 shows the evolution of output, employment (in hours) and labor productivity over the whole period 1985-2004 and also for four different sub-periods. Graph 1 plots the series. As mentioned above, gross value added refers to the private non-primary sectors of the economy.

Graph 1.
Real Gross Value Added, employment (hours worked) and labor productivity.
Total Market (non-primary) Economy
 1985=100

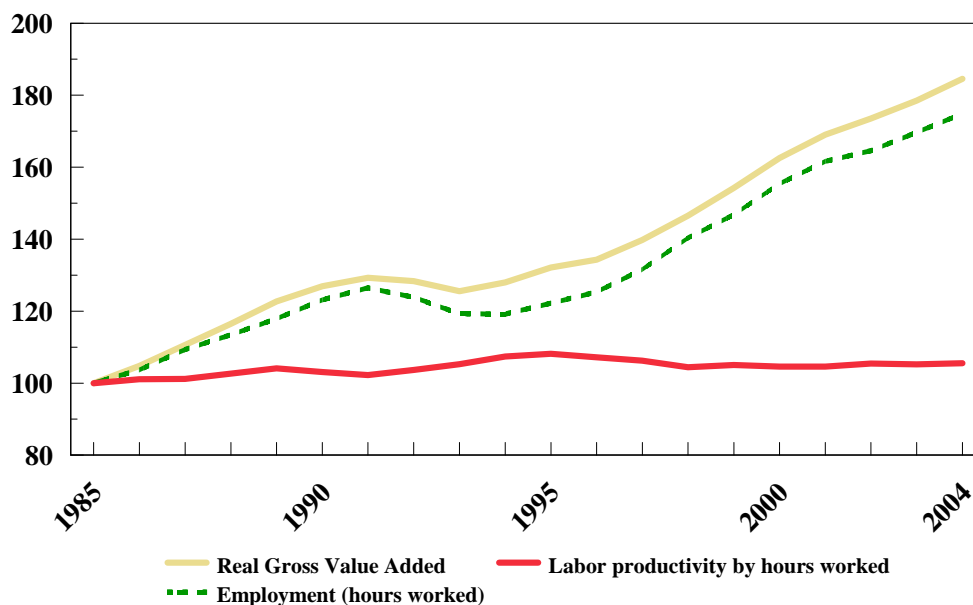


Table 1.
Real Gross Value Added, employment (hours worked) and labor productivity.
Total Market (non-primary) Economy
 Annual rates of growth (%)

	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

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 labor 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 labor 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, labor 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 labor 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. On its part, measurement problems –together with difficulties on how to interpret properly labor productivity improvements- in the public sector recommended to concentrate on the private non-primary branches of the economy.

After these modifications, we were left with information for twenty six industries. The next step was to classify these branches according to their intensity in the use of ICT

assets. We have used one basic criterion²: 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 of the twenty six industries is shown in table 2.

Table 2.
Industries Taxonomy

I Intensive ICT users	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

Table 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-Intensive*. 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

² We follow Stiroh (2002) and O'Mahony & van Ark (2003) but using Spanish data instead of those of the US.

Construction industry experienced an even higher increase: over five percentage points (from 8.56% in 1985 to 13.97% in 2004).

Table 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	1.02	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

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, labor productivity was higher in this cluster. Table 4 provides the figures. Taken together, labor 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 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 4.
Labour productivity
Total Market (non-primary) = 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	54.16	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	111.35	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

Table 5 presents the dynamics of the 26 industries over the analysed period. It shows the contribution of each industry –and cluster- to aggregate GVA, employment, and labor productivity growth³. 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 labor 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

³ All rates of growth are computed using Törnqvist indexes.

Electricity, gas and water supply (0.14). On the contrary, 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 concentrate the responsibility of the Spanish productivity drop: *Construction* (-0.52); *Wholesale & Retail trade; Repairs* (-0.28); and *Hotels and Catering* (-0.16). If we eliminated their negative contribution, labor productivity would have presented a positive rate of growth of 0.67%, instead of the actual negative rate of -0.29% over the period 1995-2004.

Table 5.
Industries contribution to real GVA, employment and productivity growth Labour productivity. 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

3. The sources of growth

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

Capital accumulation

The FBBVA/Ivie dataset allows us to distinguish among 18 different capital assets, three of which (Software, Communication and Hardware) are ICT assets. Table 6 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.

Labor qualification

Human capital (specific and generic) is an important determinant of productivity growth. We propose in this section a synthetic index of labor qualification. We will use it later on the growth accounting exercise.

Spain has experienced a great transformation in labor qualification over the period under study. Table 7 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 all⁴. 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. However, the most radical change took place at the secondary school level (including

⁴ The percentages are higher when we include agricultural employment.

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 6.
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 7.
Employment structure by educational levels.
Total Market (non-primary) Economy
Percentages

	1985	1995	2004
TOTAL MARKET ECONOMY (non-primary)	100.00	100.00	100.00
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
Secondary Educ. (2nd level)	9.12	10.53	14.10
Professional Training	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 labor qualification based on the growth rates of employment in each of the seven levels of education, weighted by their relative wages⁵. The index improves if the high-educated workers gain weight in total employment, improving the composition of the labor force towards higher skilled workers. Table 8 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.

Table 8.
Industries contribution to the labor qualification index growth.
Total Market (non-primary) Economy
 Percentages

	1985-1995	1995-2004
TOTAL MARKET ECONOMY (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 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 (2005a) for details.

It is interesting to note that over the years 1995-2004 the contribution to the labor qualification index of the *ICT Intensive* cluster almost double that of the *Non-Intensive* (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 5). The main contributors to the improvement of the labor 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.

4. 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. The impact of ICT on output and productivity growth can follow several transmission mechanisms that can be summarized in three different testing hypotheses⁶: 1. Labor 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 labor 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

$$Q_t = g (KP_t, HL_t, KH_t, B) \quad [1]$$

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 labor

⁶ Stiroh (1998), Jorgenson & Stiroh (1999), Bresnahan (1986), Bartelsman et al (1994)

qualification) and $B =$ the level of efficiency in the use of productive factors. Standard growth accounting assumptions allow us to obtain⁷

$$\Delta \ln Q_t = \bar{w}^{HL} \Delta \ln HL + \bar{w}^{ICT} \Delta \ln KP^{ICT} + w^O \Delta \ln KP^O + \Delta TFP$$

$$\bar{w}_t^\chi = 0.5 \left[w_t^\chi + w_{t-1}^\chi \right] \quad [2]$$

With $\chi = HL, ICT, O$. Where O refers to Non-ICT and non-residential capital. TFP is Total Factor Productivity.

$$w_t^{ICT} = \sum_{j \in ICT} \sum_i \frac{VCS_{j,i,t}}{TC_t} \quad [3]$$

With $VCS_{j,i,t} = p_{j,t-1} [r_t + d_t - f_{j,t}] KP_{j,i,t-1}$ and $TC_t = \sum_j \sum_j VCS_{j,i,t} + \sum_i CE_{i,t}$.

TC stands for total cost, VCS for Value of Capital Services, and CE represents labour compensation⁸. $p_{j,t}$ is the price of asset j and $f_{j,t}$ its rate of change (computed as a three year centered moving average); $d_{j,t}$ is the depreciation rate of asset j and r is the nominal interest rate in period t . w_t^O is defined equivalently. As for w^{HL} :

$$w_t^{HL} = \frac{\sum_i CE_{i,t}}{TC_t} \quad [4]$$

The growth rate of each variable in [2] is computed as a Törqnvist index. Thus, for ICT capital, its growth rate will be given by [5]

⁷ In equation [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, TFPR as given by equation [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.

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

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

$$\bar{v}_{j,t} = 0.5 \left[\frac{VCS_{j,i,t}}{\sum_{j=s,h,c} \sum_i VCS_{j,i,t}} + \frac{VCS_{j,i,t-T}}{\sum_{j=s,h,c} \sum_i VCS_{j,i,t-T}} \right] \quad [5]$$

Where s = software; h = hardware; and c = communications.

Finally, the rate of growth of labor productivity will be given by:

$$\Delta \ln Q - \Delta \ln HL = \bar{w}^{ICT} \left[\Delta \ln KP^{ICT} - \Delta \ln HL \right] + w^O \left[\Delta \ln KP^O - \Delta \ln HL \right] + \Delta TFP \quad [6]$$

Table 9 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 labor productivity as given by equation [6]. Finally, the bottom part –containing the contributions of labor qualification and the estimates of *TFP*- is shared by both equations.

Table 9.
Growth Accounting. Total Market Economy (excluding primary sectors)
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

Source: Own calculations

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 proof 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. Labor productivity presented a negative growth rate (-0.29%) again as a consequence of the negative TFP behavior, while the improvements in the capital/labor ratio (0.39) and in the qualification of labor (1.03) were positive. ICT capital deepening contribution to productivity growth (0.26) doubles that of Non ICT capital (0.13). Hardware shows the highest contribution (0.18), even higher than total Non-ICT capital.

When distinguishing between the two sub-periods it is worth noticing that the negative sign of labor productivity growth over the whole period was originated in the first sub-period, 1995-2000. It was then, when its growth rate plummeted 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. Labor 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 10 shows the factors lying behind the improvement experienced by the Spanish economy since 2000. The recovery is due to the positive behavior of the *ICT Intensive* cluster, which experienced a labor 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, labor qualification (0.74) and capital deepening (0.60) of both, ICT (0.30) and Non ICT capital (0.30). On the contrary, the *Non ICT Intensive* cluster experienced a negative TFP growth rate (1.28%), together with modest increases of the remaining sources of growth.

Table 10.
Growth Accounting. Total Market (non-primary) Economy. 2000-2004
 Percentages

	Total	Intensive 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: Own calculations

Table 11 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 originated 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 labor 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 labor productivity growth.

Table 11.
Growth Accounting, 2000-2004. Total Market (non-primary) Economy. Labor 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	2.34	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: Own calculations

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; 2. Relative small share of ICT investment on total investment (**this ratio was lower in Spain in 2000 than in the US in 1980**)⁹; 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 US 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/equipments 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 US).

5. Concluding remarks

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

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

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 1995-2004 period. However, this rate has become slightly positive during the period 2000-2004, after the 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 labor 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 labor productivity growth were the improvements in labor qualification and capital deepening, particularly ICT capital, while the contribution of TFP was negative. The severe drop in labor 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 labor productivity in the last sub-period, 2000-2004, had its origin in the *ICT Intensive* user cluster, which presented an annual growth rate of 1.43% against -0.52% of the *Non ICT Intensive* cluster. All the sources of growth contributed to this recovery, including TFP. However, a closer look to the individual branches data 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 labor 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 behavior not only of

Spain but also of most of the EU non ICT producing countries could most probably be found in miss measurement problems.

In 2000, the European Union launched the Lisbon Agenda aimed to becoming, by 2010, the most advanced knowledge society of the world. Productivity enhancing policies are key instruments for this ambitious objective, but homogeneous data sets to monitor their degree of success were not available. Being aware of this difficulty, the European Commission has gotten underway the EU KLEMS project within the 6° FP devoted to improve the statistical foundations on which to rely for policy purposes. It is by adequately comparing the role of ICT on output growth in different countries that we will be able to shed more light on the best way to improve labor productivity over time.

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