16. INFRASTRUCTURES AND NEW TECHNOLOGIES
as Sources of Spanish Economic Growth

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Introduction

The paper revises the impact of infrastructures and Information and Communications Technologies (ICT) on Spanish economic growth. It makes use of the Fbbva/Ivie capital services database recently released (Mas, Pérez and Uriel (2005)) which follows closely OECD (2001a, b) recommendations. The paper also addresses the problem posed by the presence of publicly owned assets, especially when implementing the endogenous approach to the internal rate of return determination. After offering an alternative to the standard approach, it carries out a growth accounting exercise considering explicitly three types of ICT capital assets (software, hardware and communications) and six different types of infrastructures (roads, ports, railways, airports, and water and urban infrastructures).

The point of departure is twofold. On the one hand, there is the role played by infrastructures on the US productivity slowdown of the seventies and eighties -highlighted in his seminal article by Aschauer (1989a). This paper deserved a great deal of attention not only in the US but in other countries as well[246]. Most papers make use of econometric estimations of either production or cost functions where public capital enters explicitly as an argument. The lack of agreement on the value of the output infrastructure elasticity was the dominant result, ranging from 0.73 in Aschauer (1989b) to even negative values obtained by some authors (see Sturm, Kuper and Haan (1996) for a review). The lack of adequate information on capital services provided by the different types of assets did not allow contrasting the econometric results with those obtained from a growth accounting framework. Their present availability for Spain led us to fill this gap.

The second reference is the intensive, as well as extensive, work done since the beginning of the nineties on the contribution of ICT to economic growth. While infrastructures displayed a leading role on the US productivity slowdown of the seventies and eighties, ICT accumulation

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246 Spain was not an exception and an important amount of papers dealing with the subject can be traced (see Mas & Maudos (2004) for details).

was identified as the major responsible factor of the US productivity upsurge since the mid nineties[247]. However, similar impacts were not observed – at least not with generality – in most of the European Union (EU) countries. Seemingly, significant impact was confined to countries with an important presence of the ICT producing sector[248].

In the case of Spain the debate on the role played by infrastructures on economic growth deserved a great deal of attention during the nineties. The issue at hand was not only how to promote growth but, most importantly, the consequences of the different public capital endowments among the Spanish regions in the (lack of) convergence of per capita regional incomes. Over the late nineties the slowdown of Spanish labor productivity, contrasting with the upsurge in the USA, put ICT capital in the center of the debate, substituting somehow the previous prominence of infrastructures in the growth debate.

Within this general framework, the paper follows the next structure. The next section sketches the growth accounting framework taken as reference. The third section reviews the treatment given to publicly owned assets by National Accounts as well as its implications. The fourth section summarizes the data used, and the fifth section illustrates the consequences of using the standard approach to the internal rate of return determination. The sixth section presents the results and the last section concludes.

The Growth Accounting Framework

Suppose that the production function recognizes three different kinds of capital

$$Q_t = Q_t(KP_t^{ICT}, KP_t^{INF}, KP_t^{O}, HL_t, B) \tag{1}$$

where Q_t is real Gross Value Added; KP_t stands for a volume index of capital services with the superscripts ICT, INF and O referring respectively to ICT, Infrastructures and Other forms of (non residential) capital; HL_t represents employment (hours worked); and B indicates the level of efficiency in the use of productive factors.

Standard growth accounting assumptions allow us to obtain:

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

$$\bar{w}_t^{\chi} = 0.5\left[w_t^{\chi} + w_{t-1}^{\chi}\right] \text{ for } \chi = HL;\ ICT;\ INF;\ O \tag{2}$$

Without imposing any additional conditions, the labor share in equation (2) is defined as

$$w_t^{HL} = \frac{\sum_i CE_{i,t}}{TC_t} \tag{3}$$

247 Bailey (2003), Bailey & Gordon (1998), Gordon (1999), Jorgenson & Stiroh (2000), Oliner & Sichel (2000) and Stiroh (2002) among others.

248 Colechia & Schreyer (2001), O´Mahony & van Ark (2003), Pilat (2003), van Ark & Timmer (2006) and Timmer & van Ark (2005).

where CEi is labor compensation in the ith sector and TCt is total cost defined as

$$TC_t = \sum_j \sum_i VCS_{j,i,t} + \sum_i CE_{i,t} \qquad (4)$$

Where VCSj,i,t is the value of the capital services provided by asset j in industry i. defined as:

VCSj,i,t = cuj,t KPj,i,t-1 (5)

with cuj,t representing the user cost of asset j[249]. The share on total cost of each of the three types of capital assets is defined as

$$w_t^{\chi'} = \sum_{j \in \chi'} \sum_i \frac{VCS_{j,i,t}}{TC_t} \qquad (6)$$

With χ' = ICT, INF, O. The growth rate of each variable in (2) is computed as a Törnqvist index. Thus, for ICT capital, the growth rate is defined as

$$\Delta \ln KP^{ICT} = \ln KP_t^{ICT} - \ln KP_{t-T}^{ICT} = \frac{1}{T}\left[\sum_{j=s,h,c} \sum_i \overline{v}_{j,t}^{ICT} (\ln KP_{j,i,t} - \ln KP_{j,i,t-T}) \right] \qquad (7)$$

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

With s = software; h = hardware; and c = communications. The growth rate of infrastructures and of the remaining (other) forms of capital is computed in a similar manner.

If additional assumptions are imposed, namely: 1. Constant returns to scale (CRS) in the production function (1); 2. optimizing behavior by agents; 3. competitive markets; and 4. perfect foresight (in the sense that the ex-post rate of return implicitly computed by national accountants exactly matches the ex-ante rate) then, total cost equals total revenue (TCt =PQt) so that either term can be safely used interchangeably in equations (3) to (6). Additionally, in this case, wtHL + w_t^{ICT} + w_t^{INF} + wtO = 1 and equation (6) measures the output elasticity of each type of capital.

On the User Cost

The user cost expression in equation [5] can adopt different specifications. Let ´s assume that it is given by

cuj,t = pj,t-1 [rt – πj,t + (1 + πj,t) δj,t] (8)

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249 Equation (5) assumes that the user cost for each particular type of asset is the same across industries. This assumption could be inadequate if the level of risk is different between industries –as most probably it is the case. It should be anticipated that the expected return on an asset that is owned and used in a risky industry should be higher than the expected return if the same asset is used in a low-risk industry. I thank P. Schreyer for driving my attention to this important point.

with $p_{j,t-1}$ representing the price of asset *j,* and $\pi_{j,t}$ its rate of variation*;* r_t is the nominal rate of return (common to all assets); and $\delta_{j,t}$ is asset *j* depreciation rate.

The next step is the determination of r_t in (8). For this one can follow either an exogenous or an endogenous procedure. According to the former one the rate of return must be related, in one way or another, to the market nominal rates of interest. By contrast, the endogenous procedure obtains the internal rate of return from equating Gross Operating Surplus (GOS) to capital revenues.

As it is well known, both procedures have their pros and cons. For the exogenous approach the main difficulty lies on the selection of the most suitable interest rate, while its main advantages can be summarized as follows: 1. no restrictive assumptions are needed, especially with regard to returns to scale and perfect competition; 2. it can easily deal with the presence of public goods; and 3. it allows to model r_t as an *expected* rate of return (no perfect foresight assumption needed).

On its side, the endogenous approach has the main advantage of conforming to main stream assumptions, namely that the production function presents constant returns to scale (CRS) in a perfectly competitive environment. The need to fulfill these assumptions becomes also its main inconvenient. To this, Schreyer, Diewert and Harrison (2005) add an additional problem. According to these authors, an endogenous rate of return for the total economy cannot be calculated because there is no independent estimate of *GOS* for government assets.

Before turning to this point, let's follow Jorgenson and Landfeld (2004) and further assume that r_t is a weighted average of the nominal interest rate and the internal rate of return, ρ_t:

$$r_t = \beta_t\, i_t + (1 - \beta_t)\, \rho_t \tag{9}$$

That is, it is assumed that r_t *combines an exogenous component* (i_t) *together with an endogenous one,* ρ_t*. Equation [9] shows a standard financial structure for private firms, where the market interest rate reflects debt financing and the endogenous rate reflects equity financing. With this assumption, equation [8] becomes:*

$$cu_{j,t} = p_{j,t-1}\,[r_t - \pi_{j,t} + (1 + \pi_{j,t})\, \delta_{j,t} \tag{10}$$

We now turn to the problem posed by the presence of public assets.

The treatment of public assets

The presence of assets owned by the public sector becomes a problem –at least potentially- for the endogenous approach. The reason lies on the National Accounts (NA) practices. National Accounts do not assign a net return to the flow of services provided by public capital. The only recognized flow is fixed capital consumption. Jorgenson and Landfeld (2004) address the main problem in the following terms: "While the existing accounts do treat government expenditures on capital goods as investment, they include only a partial value for the services of government capital by counting the value of depreciation on government capital (no value is included for the services of nonprofit capital)…The present treatment of government capital implicitly assumes that the net return to government capital is zero, despite a positive opportunity cost". And they continue, "the net return to the capital stock must (be) estimated and added to depreciation to develop a service value. This estimation raises conceptual issues relating to the appropriate opportunity cost and empirical issues in estimating this cost" (pg. 12).

The above paragraph summarizes the main issues, with the following important implications:

1. The Gross Operating Surplus (GOS) figures provided by National Accounts are underestimated because the value of capital services provided by public capital is not fully considered.
2. Consequently, the value of output is also underestimated in NA figures, affecting both its level and rate of growth.
3. If the endogenous approach is used when computing the rate of return, points 1 and 2 above will have, at least potentially, consequences on:
   – The implicit rate of return
   – The input shares
   – The growth accounting results
4. If the exogenous approach is adopted, only point 2 above will have consequences on the growth accounting exercise.

Let's assume that the property of a given asset *j*, is divided between the public and private sectors. Thus, $KP_{j,t} = KP^{p}_{j,t} + KP^{g}_{j,t}$ -where the superscripts *p* and *g* denote respectively private and government property of asset *j*. According to National Accounts (NA), the Gross Operating Surplus (GOS) is computed as:

$$GOS^{NA} = GOS^{NA,p} + \sum_j \sum_i \delta_{j,t} p_{j,t-1} KP^{g}_{j,i,t-1}$$

That is, *GOS* in the *National Accounts* is *GOS* of the private sector plus depreciation of government assets. From an analytical perspective, and under the assumptions of the endogenous approach, the private sector *GOS* will equal private sector capital services. So, $GOS^{NA,p} =$ So, $GOS^{NA,p} = \sum_j \sum_i cu_{j,t} KP^{p}_{j,i,t-1}$ and it follows that:

$$GOS_t^{NA} = \sum_j \sum_i cu_{j,t} KP^{p}_{j,i,t-1} + \sum_j \sum_i \delta_{j,t} p_{j,t-1} KP^{g}_{j,i,t-1} \quad [11]$$

Thus, according to NA, the services provided by a given amount of capital are dependent on public or private asset ownership. Even so, most researchers are not aware of the specific methodology followed by *NA*. This is especially true when the internal rate of return is computed –as it usually is -from an equation such as (12):

$$GOS_t^{NA} = \sum_j \sum_i cu_{j,t} \left[KP^{p}_{j,i,t-1} + KP^{g}_{j,i,t-1} \right] \quad (12)$$

The fact that the usual way of computing the internal rate of return according to the endogenous approach is incorrect does not impair this procedure from being applied once the public ownership of some assets is fully recognized. As an alternative, the internal rate could be computed reordering equation [11] to get

$$GOS_t^{NA} - \sum_j \sum_i \delta_{j,t} p_{j,t-1} KP_{j,i,t-1}^g = \sum_j \sum_i cu_{j,t} KP_{j,i,t-1}^p = \tag{13}$$

$$= \sum_j \sum_i p_{j,t-1} \left[\beta_t i_t + (1-\beta_t) \rho_t - \pi_{j,t} + (1+\pi_{j,t}) \delta_{j,t} \right] KP_{j,i,t-1}^p$$

Once ρ_t has been computed according to [13] one can apply Nordhaus (2004) basic principle for measuring non-market activities: "Non-market goods and services should be treated as if they were produced and consumed as market activities. Under this convention, the prices of non-market goods and services should be imputed on the basis of the comparable market goods and services" (pg. 5). Thus, if one assumes the same rental price for capital $cu_{j,t}$ independently of who owns the asset[250], we can revise the National Accounts figures, in order to obtain a revised Gross Operating Surplus estimate, GOS^R, in the following way:

$$GOS_t^R = GOS_t^{NA} + \sum_j \sum_i cu_{j,t} KP_{j,i,t-1}^g - \sum_j \sum_i \delta_{j,t} p_{j,t-1} KP_{j,i,t-1}^g \tag{14}$$

Growth Accounting Implications

As already indicated, the explicit recognition of the provision of capital services by public assets –beyond capital consumption- affects the value, as well as the growth rates, of two of the variables involved in any growth accounting exercise: value added and capital input.
Let's PQ_t^{NA} be the aggregated nominal value added in year t according to National Accounts, while PQ_t^R denotes the revised nominal value added corresponding to the alternative approach proposed here. Equation (15) defines nominal value added in branch i, $PQ_{i,t}^R$, as:

$$PQ_{i,t}^R = PQ_{i,t}^{NA} + \sum_j cu_{j,t} KP_{j,i,t-1}^g - \sum_j \delta_{j,t} p_{j,t-1} KP_{j,i,t-1}^g \tag{15}$$

Real value added in sector i, $Q^R_{i,t}$, is obtained using National Accounts deflators (P^{NA}):

$$Q_{i,t}^R = PQ_{i,t}^R / P_{i,t}^{NA}; \qquad P_{i,t}^{NA} = PQ_{i,t}^{NA} / Q_{i,t}^{NA}$$

The rate of growth of aggregate real output (Q^R) is computed using a Törnqvist index as given by (16)

$$\frac{1}{T}\left[\ln Q_t^R - \ln Q_{t-T}^R\right] = \frac{1}{T}\left\{\sum_i 0.5\left[\frac{PQ_{i,t}^R}{\Sigma_i PQ_{i,t}^R} + \frac{PQ_{i,t-T}^R}{\Sigma_i PQ_{i,t-T}^R}\right]\left[\ln Q_{i,t}^R - \ln Q_{i,t-T}^R\right]\right\} \tag{16}$$

The growth rate of capital is given by an equation similar to (7) where VCS is computed in (5) using the alternative user cost given by (13). Before comparing –in the fifth section below- the results provided by both approaches the next section provides a brief description of the data characteristics and sources.

250 This assumption is also very useful since it prevents that changes in the organization of the public sector affect the performance of the economy. For instance, when the provision of capital services previously provided by the public sector (according to NA) it is now supplied by a public entity (now considered by NA similar to a private enterprise).

The Data

Fundación Banco Bilbao Vizcaya Argentaria (FBBVA) and the *Instituto Valenciano de Investigaciones Económicas* (Ivie) elaborate the Spanish capital database. The methodology follows the one proposed by the OECD in two Manuals: *Measuring Capital and Measuring Productivity*[251]. The Volume Index of Capital Services, KP_t, is constructed using a Winfrey S-3 Retirement Function and a Hyperbolic Age-Efficiency Function. The FBBVA-Ivie estimates consider 43 industries and 18 asset types. Table 16–1 presents the classification of industries and table 16–2 the 18 asset categories.

The information is available on a yearly basis for the period 1964–2002[252]. The FBBVA-Ivie database makes a clear distinction between assets owned by the private sector and those owned by the public sector[253]. The latter appear under the heading *Public Administration* in table 16–1 consisting of ten different industries (31–40). It is interesting to note that infrastructures enter twofold in the Spanish estimates: as assets in table 2, and also as industries in table 16–1. Infrastructures owned privately (such as highways or some water infrastructures) are included in the *Transport, Storage and Communication* industry (branches 23–26) or *Electricity, Gas and Water Supply* (branch 19). Publicly owned infrastructures are assigned to the branch *Public Administration* in table 16–1 (branches 31–36), together with non-market health, education, social work and the rest of public administration.

Table 16–3 will contribute to clarify the way investment in each type of infrastructure is treated in the Spanish capital estimates. For each year *t* we have a matrix with 18 different types of assets -detailed in table 16–2 in columns-, and the 43 industries in rows. For urban infrastructures it is only the public administration that carries out any investment in Spain. With respect to the remaining assets, either the private or the public sector can accumulate them. Take for example the asset “roads” in column 10. If the public administration is the active agent, we will record the amount invested in the row 31, *Road infrastructures*, under the *Public Administration* heading. However, if it is a private toll road we will record it in row 23 *Road infrastructures* under the heading *Transport, Storage & Communication*[254].

The information for the variables GOS^{NA}, PQ^{NA} and Q^{NA} comes from the Spanish National Accounts released by the Spanish *Instituto Nacional de Estadística* (INE). The total values have been obtained by the aggregation of the forty three industries detailed in table 16–1. 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

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251 The details can be found in Mas, Pérez and Uriel (2005, 2006).

252 For the purpose of this exercise the information has been updated to 2004 on a provisional basis.

253 The public sector corresponds exactly with NA definition. That is to say, total public Gross Fixed Capital Formation figures in the Spanish capital services estimates are taken directly from NA.

254 The above procedure has a limitation, originated by the lack of sufficiently detailed information. This constraint deals with the one-to-one correspondence between assets and industries. A more realistic view would take into account that a given industry, lets say Airport, uses different types of assets coming from 16. other constructions n.e.c, 17. software, 8. other transport equipment, and so on. We are presently working on this important issue, but no definitive results are available yet.

T 16 – 1 Classification of industries

Industry	Descriptionww	Code CNAE-93 = Code NACE Rev. 1
1	Agriculture, hunting and forestry	1–févr
2	Fishing, fish farming and related service activities	5
3	Mining and quarrying of energy producing materials	10–déc
4	Mining and quarrying except energy producing materials	13–14
5	Manufactures of food products, beverages and tobacco	15–16
6	Manufacture of textiles and wearing apparel; dressing and dyeing of fur	17–18
7	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	19
8	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	20
9	Manufacture of pulp, paper and paper products; publishing, printing and reproduction of recorded media	21–22
10	Manufacture of coke, refined petroleum products and nuclear fuel	23
11	Manufacture of chemicals and chemical products	24
12	Manufacture of rubber and plastic products	25
13	Manufacture of other non-metallic mineral products	26
14	Manufacture of basic metals and fabricated metal products, except machinery and equipment	27–28
15	Manufacture of machinery and equipment n.e.c.	29
16	Manufacture of electrical and optical equipment	30–33
17	Manufacture of transport equipment	34–35
18	Manufacture of furniture; manufacturing n.e.c.; Recycling	36–37
19	Electricity, gas and water supply	40–41
20	Construction	45
21	Wholesale and retail trade; repairs	50–52
22	Hotels and restaurants	55
	Transport and storage and communication	60–64
23	Road infrastructures	
24	Railways infrastructures	
25	Airport infrastructures	
26	Port infrastructures	
27	Rest of Transport and storage and communication	
28	Financial intermediation	65–67
29	Real estate activities	70
30	Renting of machinery and equipment and other business activities	71–74
	Public administration	75, 80P, 85P
31	Road infrastructures	
32	Water infrastructures	
33	Railways infrastructures	
34	Airports infrastructures	
35	Ports infrastructures	
36	Urban infrastructures	
37	Non-market education	

Industry	Descriptionww	Code CNAE-93 = Code NACE Rev. 1
38	Non-market health	
39	Non-market social work	
40	Rest of public administration	
41	Market education	80P
42	Market health and social work	85P
43	Other community, social and personal services	90–93

T 16–2 Classification of Assets

Product	Description	Code CNPA96 = Code CPA96
1	Agricultural, livestock and fish products	1-mai
2	Metal products	28
3	Machinery and mechanical equipment	29
4	Office machinery and computer equipment	30
5	Communications	313, 32, 332–333
6	Other machinery and equipment n.e.c	31 (ex. 313), 331, 334–335, 36
7	Motor vehicles	34
8	Other transport material	35
9	Dwellings (Residential Construction)	45P
	Other constructions	45P
10	Road infrastructures	
11	Water infrastructures	
12	Railway infrastructures	
13	Airport infrastructures	
14	Port infrastructures	
15	Urban infrastructures	
16	Other constructions n.e.c.	
17	Software	72
18	Other products n.e.c.	Rest of codes

private household with employed persons[255]. The Bank of Spain publishes data for the nominal interest rates, i_t, and the ratio β_t. For the former one medium and long-term corporate loan rates are used, and for the latter one the ratio external funds/(external funds+equity) comes from a survey published yearly by the Bank of Spain's *Central Balance Sheet Office*.

Implications of the two approaches

From our perspective, the choice between the standard *vs* the alternative approach here proposed has consequences for the levels of Gross Operating Surplus and Value Added; and also for the growth rates of Value Added and Capital. Graph 16–1 plots the ratios between the two forms of computation for the two variables, GVA and GOS. GVA data for the alternative approach are given by equation (15) and those for GOS from (14). As can be seen, National Accounts underestimate the GVA figures by approximately 5%–6% and the GOS figures by 15%. In both cases the gap has increased since the mid nineties. However, these differences in levels are lower in terms of growth rates. Graphs 16–2 and 16–3 show that the differences in growth rates between the two approaches are practically non existing.

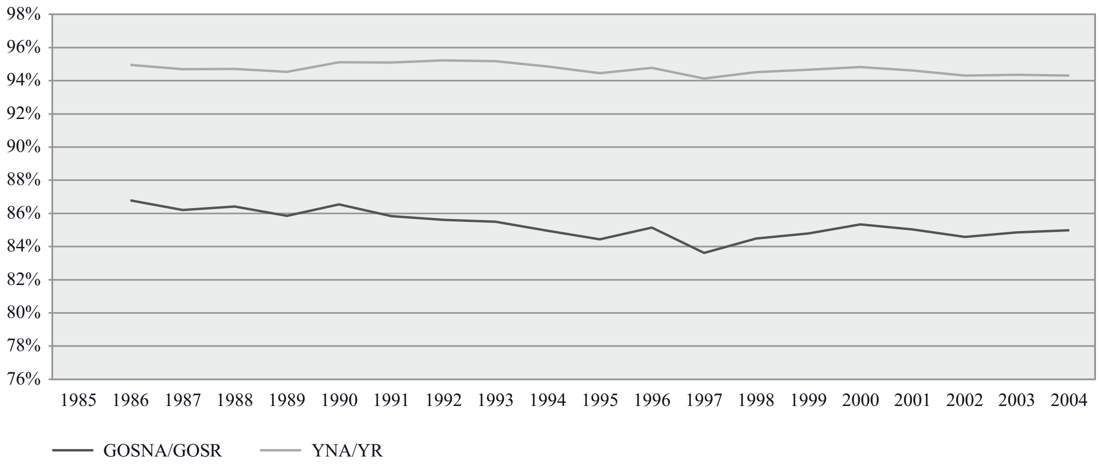
[255] Mas (2005) addresses similar issues but including residential capital, and thus rents, in the calculations.

T 16 – 3 Treatment of Infrastructures in the Spanish capital estimates. An illustration Recording of year t investment in infrastructures

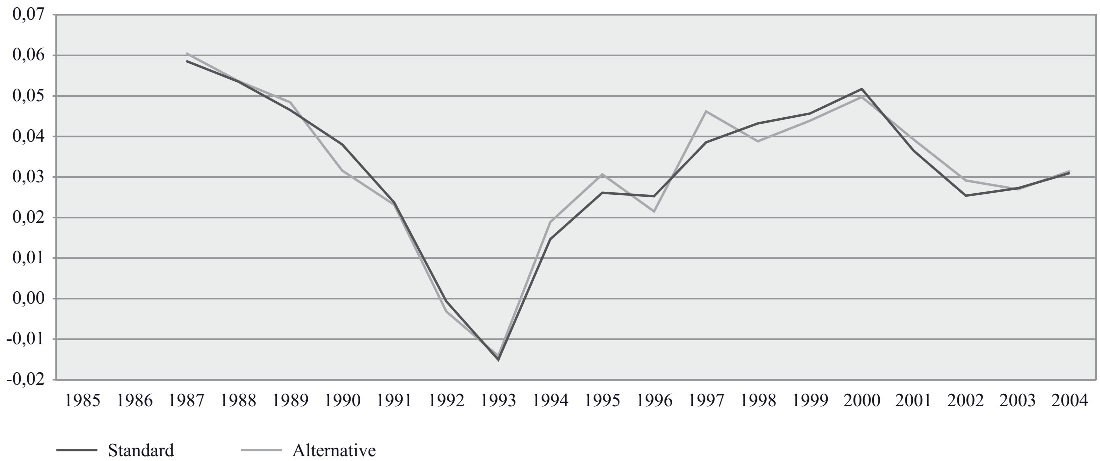
Year t (e.g. 2000)

INDUSTRIES	TYPES OF ASSETS									
	Infrastructures									
	1. Agric.	...	10 Road	11 Water	12 Rail-way	13.Airport	14.Port	15 Urban	...	18.Other
1. Agriculture, hunting & forestry										
2. Fishing										
...										
19. Electricity, gas & water supply				Private I						
…										
Transport, storage & communication										
23. Road infrastructures			Private I							
24. Railways infrastructures					Private I					
25. Airport infrastructures						Private I				
26. Port infrastructures							Private I			
27. Rest of transport, storage & communication										
...										
Public Administration										
31. Road infrastructures			Public I							
32.Water infrastructures				Public I						
33. Railways infrastructures					Public I					
34. Airport infrastructures						Public I				
35. Ports infrastructures							Public I			
36. Urban infrastructures								Public I		
...										
43. Other community, social & personal services										

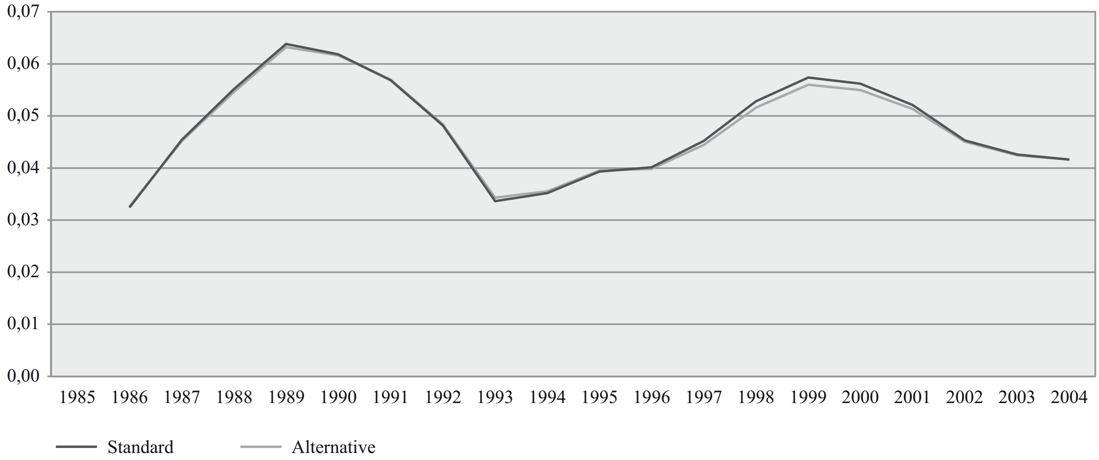
**Gross Value Added and Gross Operating Surplus.
Ratio National Accounts/Alternative Approach** **G 16–1**



Growth Rates of Value Added. Standard vs. Alternative Approach **G 16–2**



Growth Rates of Capital. Standard vs. Alternative **G 16–3**



ICT and Infrastructures. Results

From now on, the results shown were obtained under the *alternative* approach assumptions. But before turning to the growth accounting results it is interesting to take a closer look to some of its determinants. The first one is the user cost. According to equation [10] the user cost expression has two elements: the price of the asset, $p_{j,t}$, and the user cost per euro invested: $[\beta_t i_t + (1 - \beta_t) \rho_t - \pi_{j,t} + (1+\pi_{j,t}) \delta_{j,t}]$. Table 16–4 presents the estimated total user cost -as well as each of its two components- for six infrastructures and three ICT assets.

The first thing to notice is that the user cost has increased for all the assets included in the infrastructures and ICT groups, with the only exception of *Office machinery and computer equipment* (hardware for short). At the beginning of the period, the user cost was lower for infrastructures than for ICT capital as a consequence of both, lower prices indexes and lower unit user costs. In contrast, in 2004 the user cost for hardware was lower than for infrastructures due to the strong price reduction of the former. In fact, while hardware experienced more than a six fold (6.3) accumulated price reduction, infrastructures prices more than doubled (2.4) between 1985 and 2004. Notice too that, as expected, the unit user cost of ICT assets has always been higher than for infrastructures due to the conjunction of two combined effects: higher depreciation rates -as a result of shorter services lives- and capital losses originated by falling prices, especially in hardware.

As already mentioned, most of the papers devoted to the analysis of the role of infrastructures on economic growth start by estimating an equation such as (1) –usually highlighting only infrastructure capital. They frequently impose constant returns to scale (CRS) and perfectly competitive markets. So the estimated coefficient is identified as the infrastructure's output elasticity. Under these assumptions, total cost (*TC*) equals total revenue (*PQ*) and equation (6) provides the expression for infrastructures' value added elasticity. Its computation is provided in table 16–5.

T 16 – 4 User cost and its components. Infrastructures and ICT

			1985	1990	1995	2000	2004
1. Asset Prices [$p_{j,t-1}$] and GDP Deflator (Pt)							
	Infrastructures		0.551	0.746	0.959	1.098	1.328
	ICT						
		4.2.3. Office machinery and computer equipment	1.656	1.473	1.095	0.428	0.268
		4.2.4.1. Communications	0.697	0.895	1.003	0.918	0.866
		4.3.1. Software	0.908	0.998	0.978	1.128	1.223
	GDP Deflator		0.541	0.764	1.000	1.131	1.326
2. Unit user cost [$\beta i_t+(1-\beta)\rho_t-\pi_{j,t}+(1+\pi_{j,t})\delta_{j,t}$]							
	Infrastructures						
		2.1. Road infrastructures	0.089	0.126	0.120	0.110	0.115
		2.2. Water infrastructures	0.098	0.137	0.133	0.124	0.130
		2.3. Railway infrastructures	0.101	0.139	0.133	0.124	0.125
		2.4. Airport infrastructures	0.103	0.139	0.132	0.119	0.121
		2.5. Port infrastructures	0.093	0.130	0.124	0.114	0.119
		2.6. Urban infrastructures	0.096	0.131	0.125	0.115	0.120
	ICT						
		4.2.3. Office machinery and computer equipment	0.410	0.403	0.432	0.437	0.382
		4.2.4.1. Communications	0.223	0.253	0.248	0.295	0.260
		4.3.1. Software	0.602	0.622	0.592	0.601	0.617
3. User cost (=2*3)							
	Infrastructures						
		2.1. Road infrastructures	0.049	0.094	0.115	0.120	0.153
		2.2. Water infrastructures	0.054	0.102	0.127	0.136	0.172
		2.3. Railway infrastructures	0.056	0.104	0.128	0.136	0.166
		2.4. Airport infrastructures	0.057	0.104	0.126	0.131	0.161
		2.5. Port infrastructures	0.051	0.097	0.119	0.126	0.158
		2.6. Urban infrastructures	0.053	0.098	0.120	0.126	0.160
	ICT						
		4.2.3. Office machinery and computer equipment	0.679	0.593	0.473	0.187	0.102
		4.2.4.1. Communications	0.156	0.226	0.249	0.271	0.226
		4.3.1. Software	0.547	0.621	0.580	0.678	0.755

Source: Own elaboration

For total capital, the estimated gross value added elasticity is around 0.37, while for non-infrastructures non-ICT is approximately 0.1 of a percentage point lower. Infrastructures elasticity increased over the period, presenting values around 0.05–0.06 since 1995. This figure is very close to the one obtained by Mas *et al* (1996) for Spain (0.086) and higher than in Goerlich and Mas (2001) for the fifty Spanish provinces (0.02). The aforementioned elasticities were computed from an econometric estimation of a production function equation similar to (1). The lower value of the elasticity when provincial data are used can be interpreted by the presence of spillover effects among contiguous territories. These figures reconcile the results obtained from the two alternative strategies, econometric estimation and growth accounting. However, it also contradicts a previous results obtained by Mas *et al* (1996) where, after the recursive estimation of a production function, the elasticity diminishes and does not increase as it is now the case.

T16–5 User cost and its components. Infrastructures and ICT

		1985	1990	1995	2000	2004
Total Infrastructures		**0.038**	**0.047**	**0.057**	**0.053**	**0.060**
	Private	0.012	0.013	0.013	0.012	0.015
	Public	0.026	0.035	0.043	0.041	0.046
2.1. Road infrastructures		**0.013**	**0.018**	**0.023**	**0.023**	**0.026**
	Private	0.004	0.004	0.004	0.003	0.003
	Public	0.010	0.014	0.020	0.020	0.022
2.2. Water infrastructures		**0.012**	**0.014**	**0.015**	**0.013**	**0.014**
	Private	0.001	0.001	0.001	0.001	0.001
	Public	0.011	0.013	0.014	0.013	0.013
2.3. Railway infrastructures		**0.007**	**0.008**	**0.009**	**0.008**	**0.010**
	Private	0.005	0.005	0.006	0.005	0.007
	Public	0.002	0.003	0.003	0.003	0.003
2.4. Airport infrastructures		**0.001**	**0.001**	**0.002**	**0.002**	**0.002**
	Private	0.000	0.000	0.001	0.001	0.002
	Public	0.001	0.001	0.001	0.001	0.001
2.5. Port infrastructures		**0.002**	**0.003**	**0.003**	**0.003**	**0.003**
	Private	0.002	0.002	0.002	0.002	0.002
	Public	0.000	0.000	0.001	0.001	0.001
2.6. Urban infrastructures		**0.002**	**0.004**	**0.005**	**0.005**	**0.006**
	Public	0.002	0.004	0.005	0.005	0.006
ICT		**0.033**	**0.042**	**0.043**	**0.044**	**0.040**
4.2.3. Office machinery and computer equipment		0.009	0.013	0.012	0.009	0.008
4.2.4.1. Communications		0.020	0.022	0.022	0.023	0.019
4.3.1. Software		0.005	0.008	0.009	0.012	0.013
Non-Infrastructures, non-ICT		**0.297**	**0.277**	**0.260**	**0.257**	**0.280**
TOTAL		**0.368**	**0.367**	**0.359**	**0.355**	**0.380**

Source: Own elaboration

The database allows the distinction of infrastructures according to their ownership, private or public. However, from an economic standpoint this distinction has no consequences, since we are assuming that who owns the capital is not relevant for the impact of a given asset on the economy. Taken all together, the output elasticity of ICT assets is lower than that of infrastructures and it has remained fairly stable since 1990. The highest value corresponds to communications and the lowest to hardware, while software is the ICT asset showing the strongest elasticity increase.

The user cost values in table 16–4, allows us to compute the marginal product of each asset. If we keep assuming *CRS* and perfect competitive markets, profit maximization implies that the value of the marginal product of each factor of production must equal its price. Thus, the value of the marginal product of labor must equal the nominal wage. Similarly, the optimality condition implies that the value of the marginal product of capital must equalize the user cost. If we are interested in the physical marginal productivity, then the condition is that marginal productivity equals the user cost divided by the price of output.

However, we do not have a price for the assets -nor for output- but a price *index* equal for both to 100 in the base year (2000). Therefore, we do not have information on relative price *levels*, only about comparable inflation rates. This means that -if we want to compare the marginal productivities of different assets in a given year- we should make use of the information provided by section 2 in table 16–4, refered to unit user cost[256]. If, alternatively, we are interested in the time profile of marginal productivities, we should divide the user cost by the price index of output. This last calculation is provided in table 16–6 where the user cost in section 3 of table 16–4 has been divided by the GDP deflator in section 1 of the same table[257].

The information in section 2 of table 16–4 tell us that marginal productivities of ICT assets have always been higher than for infrastructures, specially for software due its short service life and consequently high depreciation. The time profiles provided by table 6 inform us that marginal productivities have been steadily decreasing along the period for ICT assets. This is not the case for infrastructures where it depends on the period under consideration. If we take 1985 as the initial year, marginal productivities have increased. But if we consider the period 1990–2004 we find a fairly constant path, or even a slight reduction.

The contribution of the different assets to output growth depends on two factors: their elasticity as well as their rate of growth. The latter ones appear in table 16–7. The rate of growth of total (non residential) capital has been rather strong in Spain, averaging 4.78% over the period 1985–2004, not showing a cyclical profile. ICT accumulation was even stronger, experiencing a marked slowdown during the period 1990–1995, when the Spanish economy went through a severe recession. The opposite profile was shown by public infrastructures, with their highest rate of growth precisely during those years. Since 1995

[256] In the base year, the user cost and the unit user cost are the same. In the remaining years the differences are due, exclusively, to the time evolution of asset prices.

[257] This procedure assumes that the marginal product of an asset is independent of the branch to which it is assigned. Alternatively, we could divide the user cost of an asset in industry i by the deflator of this same branch obtaining different marginal productivities depending on the branch using the asset.

T 16 – 6 Marginal Productivities (User Cost/GDP Deflator)

		1985	1990	1995	2000	2004
Infrastructures						
	2.1. Road infrastructures	0.091	0.123	0.115	0.106	0.115
	2.2. Water infrastructures	0.100	0.134	0.127	0.120	0.130
	2.3. Railway infrastructures	0.103	0.135	0.128	0.120	0.125
	2.4. Airport infrastructures	0.105	0.136	0.126	0.116	0.121
	2.5. Port infrastructures	0.095	0.127	0.119	0.111	0.119
	2.6. Urban infrastructures	0.097	0.128	0.120	0.111	0.120
ICT						
	4.2.3. Office machinery and computer equipment	1.254	0.776	0.473	0.166	0.077
	4.2.4.1. Communications	0.287	0.296	0.249	0.240	0.170
	4.3.1. Software	1.010	0.812	0.580	0.599	0.569

Source: Own elaboration

public infrastructures have shown a noticeable deceleration that has been matched by a parallel upsurge of private infrastructures. While in 1985–1990 the rate of growth of private infrastructures was a modest 1.87% per year, in the last sub-period 2000–2004 it was four times higher, reaching 8.70%, mainly due to the extraordinary increase experienced by railways and airport infrastructures[258].

We have now all the ingredients needed to move to growth accounting. As already mentioned, infrastructures enter twice in the Spanish estimates: as assets in table 16–2, and also as industries in table 16–1. Therefore, from the perspective of the growth accounting framework, infrastructure capital affects the aggregate figures through its impact on two specific industries. Public infrastructures contribute to the growth rate of the value added generated by the *Public Administration* industry –and thus to aggregate value added- while privately owned infrastructures affect the growth rate of the *Transport, Storage and Communication* industry. Table 8 presents the result of the growth accounting exercise, taking as reference equation (2) but referred to labor productivity instead of total output.

Labor productivity grew at a rate of 1.08% per year during the period 1985–2004 but it went through very different phases. During the expansion years 1985–1990, as well as along the recession period 1990–1995, productivity growth averaged, respectively, 1.92% and 1.67%, well over 1.5% per year. Things changed in the following nine years of important

[258] Over the last twenty years, Spain has carried out an intensive process of privatization of the main public companies closely related to the provision of public services: telephone and telecommunication, airports, air and maritime transport, energy, water resources and distribution, among others. Also, in railways and airport infrastructures, investments are now carried out by public entities not included as publicly owned infrastructures. In the Spanish estimates, if an asset is supplied until a given year by the public sector, and it either becomes privatized or it is managed by a public enterprise -not considered part of the definition of Public Administration-, then the investment on that year and thereafter is recorded in the row Transport, storage & communication in table 3.

T16–7 Productive capital. Annual growth rates

Percentages

	1985–2004	1985–1990	1990–1995	1995–2000	2000–2004
Total Infrastructures	**4.82**	**4.95**	**5.40**	**3.92**	**4.76**
Private	4.12	1.87	2.79	3.42	8.70
Public	5.10	6.20	6.27	4.07	3.56
2.1. Road infrastructures	**5.65**	**6.27**	**7.36**	**4.43**	**4.28**
Private	1.62	0.82	1.19	1.30	3.58
Public	6.65	8.05	8.77	4.95	4.38
2.2. Water infrastructures	**2.95**	**3.41**	**3.57**	**2.60**	**2.03**
Private	0.77	-0.15	-0.04	0.41	3.36
Public	3.10	3.68	3.80	2.71	1.96
2.3. Railway infrastructures	**4.63**	**3.16**	**3.37**	**3.74**	**9.04**
Private	5.03	2.50	3.06	4.03	11.92
Public	3.64	4.63	3.99	3.18	2.54
2.4. Airport infrastructures	**6.03**	**3.86**	**3.99**	**4.98**	**10.67**
Private	14.53	8.31	19.52	13.36	17.53
Public	-0.95	2.95	-1.83	-2.41	-2.90
2.5. Port infrastructures	**3.60**	**3.31**	**4.01**	**2.86**	**4.09**
Private	2.64	2.31	2.70	2.52	3.15
Public	8.11	10.61	10.36	4.10	7.17
2.6. Urban infrastructures	**7.43**	**11.04**	**7.49**	**5.77**	**4.95**
Public	7.43	11.04	7.49	5.77	4.95
ICT	**9.92**	**13.42**	**5.87**	**11.18**	**7.53**
4.2.3. Office machinery and computer equipment	17.40	20.11	8.94	21.94	17.63
4.2.4.1. Communications	6.04	8.00	3.77	7.10	4.95
4.3.1. Software	10.81	20.20	6.82	9.14	4.71
Non-Infrastructures, non-ICT	**4.84**	**5.13**	**5.30**	**4.32**	**4.29**
TOTAL	**4.78**	**5.24**	**4.24**	**4.98**	**4.54**

Source: Own elaboration

output –and especially labor- growth. During the years 1995–2000 labor productivity growth was slightly negative (-0.08%) but it recovered its pulse – though modestly – over the years 2000–2004 (0.62%)

Over the whole period, 1985–2004, capital deepening contribution was responsible for most (89%) of total productivity growth. Infrastructures contributed with 12.96%, half the magnitude of ICT capital. It is interesting to concentrate on the last two sub-periods. The negative increase in labor productivity during the second half of the nineties originated in the combination of two factors: a strong deceleration of the capital endowments per worker, together with a negative contribution of Total Factor Productivity (TFP) growth. Capital deepening slowdown affected all forms of capital, with the sole exception of ICT capital. For the remaining forms of capital their contribution was almost nil, being private infrastructures contribution slightly negative.

T 16 – 8 Growth Accounting. Labor productivity

Percentages

	1985–2004	1985–1990	1990–1995	1995–2000	2000–2004
1. Labor productivity growth (=2+6)	**1.083**	**1.924**	**1.670**	**-0.081**	**0.621**
2. Contribution of capital endowments per hour worked (=3+4+5)	**0.957**	**0.789**	**1.747**	**0.329**	**0.731**
3. Infrastructures. Total	**0.132**	**0.079**	**0.311**	**-0.007**	**0.126**
Private	0.026	-0.015	0.043	-0.008	0.082
Public	0.106	0.095	0.268	0.001	0.044
2.1. Road infrastructures	**0.069**	**0.049**	**0.163**	**0.009**	**0.042**
Private	-0.002	-0.009	0.007	-0.009	0.003
Public	0.071	0.058	0.157	0.018	0.039
2.2. Water infrastructures	**0.009**	**0.004**	**0.059**	**-0.020**	**-0.007**
Private	-0.001	-0.003	0.000	-0.003	0.001
Public	0.010	0.007	0.059	-0.018	-0.008
2.3. Railway infrastructures	**0.020**	**0.000**	**0.033**	**-0.003**	**0.057**
Private	0.017	-0.003	0.020	-0.000	0.057
Public	0.003	0.004	0.012	-0.002	-0.000
2.4. Airport infrastructures	**0.009**	**0.001**	**0.007**	**0.002**	**0.016**
Private	0.012	0.001	0.009	0.007	0.020
Public	-0.003	-0.000	-0.001	-0.006	-0.003
2.5. Port infrastructures	**0.004**	**0.001**	**0.013**	**-0.003**	**0.004**
Private	0.001	-0.002	0.008	-0.003	0.001
Public	0.003	0.002	0.005	0.000	0.003
2.6. Urban infrastructures	**0.022**	**0.024**	**0.036**	**0.009**	**0.014**
Public	0.022	0.024	0.036	0.009	0.014
4. ICT	**0.278**	**0.391**	**0.274**	**0.312**	**0.211**
4.2.3. Office machinery and computer equipment	0.130	0.181	0.117	0.190	0.133
4.2.4.1. Communications	0.073	0.101	0.095	0.069	0.051
4.3.1. Software	0.076	0.109	0.063	0.053	0.027
5. Non-Infrastructures, non-ICT	**0.547**	**0.319**	**1.161**	**0.025**	**0.394**
6. TFP (=1-2)	**0.126**	**1.134**	**-0.077**	**-0.410**	**-0.110**

Source: Own elaboration

Things changed in period 2000–2004. ICT capital deepening decelerated (from 0.312 to 0.211) while other forms of capital recovered their impulse. Especially noticeable was the increase experienced by infrastructures, which moved from a negative value (-0.007) in the years 1995–2000 to a positive one (0.126) in the last sub period. Even most important were the recovery of the non-infrastructures non-ICT capital (from 0.025 to 0.394) and the reduction of the negative contribution of TFP (from -0.410 to -0.110)[259].

[259] Further details can be found in Mas & Quesada (2005a,b & 2006)

Concluding remarks

New capital services data released by Fbbva/Ivie have made possible to carry out – improving and updating previous studies- an analysis of the impact of infrastructures and new technologies on Spanish growth. Used data include 43 industries and 18 different types of assets (including 6 types of infrastructures and 3 types of ICT capital). The chosen approach was growth accounting while most previous studies were forced to use –due basically to the lack of suitable data- an econometric perspective. National Accounts data are modified in order to take explicitly into account the capital services provided by public capital, especially when the endogenous approach to the internal rate of return determination is adopted. Accordingly, *GVA* figures provided by *NA* are underestimated by 5%–6% while Gross Operating Surplus is also underestimated by around 15%. However, the growth rates of both, *GVA* and that of the Volume Index of Capital Services, are not significantly affected.

Under some restrictive assumptions (constant returns to scale, perfectly competitive markets and optimizing behaviour) we compute the elasticities of the different types of assets as well as their marginal products. Computed infrastructures elasticities are similar to those obtained from previous econometric estimates in a range of around 0.06. By contrast, according to our estimates, we find slightly increasing infrastructures elasticities while previous results indicated the opposite trend.

Concerning marginal productivities we find, firstly, that the marginal productivities for the three ICT assets are higher than for infrastructures. And secondly, that ICT assets marginal productivities have decreased steadily and very rapidly, both in the case of hardware and software. By contrast, the marginal products of the six types of infrastructures have been fairly stable since 1990.

Finally, the growth accounting exercise carried out indicates that ICT contribution to Spanish productivity growth has been higher than infrastructures for the entire period 1985–2004. It was also higher in three of the four sub periods considered, being the recession years 1990–1995 the only exception. However, ICT capital deepening contribution slowed down in 2000–2004 compared to 1995–2000 in a general context of recovery of i) labor productivity; *ii*) capital deepening of the remaining forms of capital (including infrastructures) and *iii*) less negative TFP contribution.

References

Aschauer, D. A. (1989a): "Is Public Expenditure Productive?, Journal of Monetary Economics 23, 177–200 .

____________(1989b): "Public Investment and Productivity Growth in the Group of Seven", Federal Reserve Bank of Chicago, Economic Perspectives, 13, 17–25.

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

Bailey, M.N., and R. Gordon (1998): "The Productivity Slowdown, Measurement Issues and the Explosion of Computer Power", Brookings Papers on Economic Activity, 1998(2): 347–420.

Colechia, A. and P. Schreyer (2001): "ICT Investment and economic growth in the nineties: is the United States a unique case? A Comparative study of nine OECD countries", Review of Economic Dynamics, 5, 2, 408–42.

Diewert, E.D. and A. Nakamura (2003): "The Measurement of Aggregate Total Factor Productivity Growth", forthcoming en Heckman and Leamer (eds), Handbook of Econometrics, Volume 6.

Goerlich, F.J. and M. Mas (2001): La Evolución Económica de las Provincias Españolas. Volumen II, Desigualdad y Convergencia, 330 pp. Fundación BBVA, Bilbao.

Gordon, R.J. (1999): "Has the "new economy" rendered the productivity slowdown obsolete?" June, Northwestern University, mimeo.

Jorgenson, D.W., Gollop, F.M. and B. Fraumeni (1987): Productivity and US Economic Growth, Cambridge, MA, Cambridge University Press.

Jorgenson, D.W. and K. Stiroh (2000): "Rising the speed limit: US economic growth in the information age", Brookings Papers on Economic Activity, 1, 125–211.

Jorgenson, D.W. and J.S. Landfeld (2004): "Blueprint for Expanded and Integrated US Accounts: Review, Assessment, and next steps", paper presented at the Conference on Research in Income and Wealth, New Architecture for the US National Accounts, Washington DC, April, 16–17.

Mas, M., Maudos, J, F. Pérez y E. Uriel (1996): "Infrastructures and Productivity in the Spanish Regions", Regional Studies, Vol. 30, nº 7, 641–649.

Mas, M., Pérez, F. and E. Uriel (Dirs) (2005): El stock y los servicios del capital en España (1964–2002). Nueva Metodología, Fundación BBVA, Bilbao, 323 pp.

_____________ (2006): "Spanish New Capital Stock Estimates" in Mas, M. y P. Schreyer (eds.) Growth, Capital and New Technologies, Fundación BBVA, Bilbao, forthcoming.

Mas, M. (2005): "Public Capital, Internal Rate of Return and Growth Accounting" (www. euklems.net).

Mas, M. and J. Maudos (2004): "Infraestructuras y Crecimiento Regional Diez Años Después" in José Villaverde Castro (coord.) Competitividad Regional en la Unión Europea Ampliada, Instituto de Estudios Fiscales, Madrid, 143–168.

Mas, M. and J. Quesada (2005a): Las Nuevas Tecnologías y el Crecimiento Económico en España, Fundación BBVA, 384 pp.

__________ (2005b): "ICT and Economic Growth. A quantification of productivity growth in Spain", OECD Statistics Working Papers, Statistics Directoriate, STD/DOC(2005)4, Organización para la Cooperación y el Desarrollo Económico, París (disponible en Internet http://www.oecd.org/ findDocument/0,2350,en_2649_33715_1_119684_1_1_1,00.html).

__________ (2006): "The role of ICT on the Spanish Productivity Slowdown", Fundación BBVA Working Paper, forthcoming.

Nordhaus, W.D. (2004): "Principles of National Accounting for Non-Market Accounts" paper presented at the Conference on Research in Income and Wealth, New Architecture for the US National Accounts, Washington DC, april 16–17.

Oliner, S.D. and D.E. Sichel (2000): "The resurgence of growth in the late 1990s: is information technology the story?" Journal of Economic Perspectives, 14, fall, 3–22.

O´Mahonny, M. and B. Van Ark (eds) (2003): EU productivity and competitiveness: an industry perspective, Luxemburg, European Commission, Office for Official Publications of the European Communities.

Pilat, D. (2003): "ICT and economic growth: evidence from OECD countries, industries and firms", DSTI, ICCP 2, OECD, Paris.

Schreyer, P. (2004): "Measuring Multi-Factor Productivity when Rates of Return are Exogenous", paper presented in la SSHRC International Conference on Index Number Theory and the Measurement of Prices and Productivity, Vancouver, 30 June–3 July.

Schreyer, P., Diewert, E. and A. Harrison (2005): "Cost of Capital Services and the National Accounts". Paper presented to the meeting of the Canberra Group on Non-Financial Assets, Canberra.

Solow, R. (1957): "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, 39, 3, 312–320.

Stiroh, K. (2002): "Are ICT Spillovers Driving the New Economy?", The Review of Income and Wealth, 48, 1, 33–58.

Sturm, J.E, Kuper, G.H. and J. De Haan (1996): Modelling Government Investment and Economic Growth on a Macro Level: a Review, CCSO Series n' 29, Groningen University.

Timmer, M. and B. van Ark (2005): "Does information and communication technology drive EU-US productivity growth differentials?", Oxford Economic Papers, Vol. 57, nº 4, October, 693–716.

Van Ark, B. and M. Timmer (2006): "Computers and the Big Divide: productivity growth in the European Union and the United States" in Mas, M. y P. Schreyer (eds) Growth, capital stock and new technologies, Fundacion BBVA, Bilbao, forthcoming.

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