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Raul L. Katz*

The Economic and Social Impact of Telecommunications Output

A Theoretical Framework and Empirical Evidence for Spain

Economists, management researchers and sociologists have all examined the impact of the spread of information and communication technologies. There has until now, however, been relatively little interconnectivity and cross-fertilisation of their findings. The following paper attempts to derive a set of integrated "causality frameworks" and tests the resulting hypotheses using data for Spain.

The study of the economic and social impact of telecommunications output is not a new research discipline. Economists, political scientists, sociologists and management researchers have been interested in this topic ever since they started to determine that information and communication technologies (ICT) were being widely adopted in the industrialised world. The questions triggering this interest were not only the assessment of the true economic impact of ICT, but also what lessons could be extracted from its impact in industrialised countries to the developing world.

While the interest has been widespread across the social sciences, it is difficult to identify interconnectivity and cross-fertilisation of findings. For example, while economists had determined empirically that ICT investment had a lagged effect on productivity, investigation of reasons for this lag was limited.¹ On the other hand, management research has been studying the processes of diffusion of innovation and adoption of technologies by firms, which could have shed some light on the explanation of the so-called "lag-effect". In another example, sociologists had been measuring the increase in "information-intensive" occupations, therefore coining terms such as "the information society", which could have naturally led economists to leverage those empirical findings to determine the rate at which ICT is adopted.² As a result, the first objective of this paper is to attempt to link different bodies of research into a set of integrated "causality frameworks" that could generate some hypotheses to be further tested.

Along these lines, our second objective is to provide some preliminary empirical data from the Spanish

economy aimed at supporting these hypotheses. While our data focuses on Spain, the intent is to present it in the context of research results for the United States, where research has been conducted for many more years.

A Theoretical Framework

Our starting-point is what has been called the "information or knowledge sector of the economy". Machlup³ defined the knowledge industry as consisting of education, research, publishing, and broadcasting occupations and estimated that 31% of the total workforce in the United States was employed in those sectors. Bell⁴ also measured the share of knowledge workers in the United States, but, considering Machlup's definition too broad and all inclusive, he relied on a stricter definition of the sectors (excluding information transmitters). His estimate of knowledge workers was 12.2%.

Porat⁵ introduced the concept of the "information society". In his measurement, Porat considered information workers to be all occupations engaged in creat-

¹ Exceptions to this are the research by Basu and Fernald, and Oulton and Srinivasan. S. Basu, J. Fernald: Information and Communications technology as a general purpose technology: evidence from US industry data, Federal Reserve Bank of San Francisco Working paper 2006-29, 2006; Nicholas Oulton, Sylaja Srinivasan: Productivity Growth and the Role of ICT in the United Kingdom: An Industry View, 1970-2000, in: CEP Discussion Papers dp0681, Centre for Economic Performance, LSE, 2005.

² Again, exceptions to this statement are Jonscher's economics dissertation at Harvard University. C. Jonscher: Economic causes of the rising of information-intensive societies, unpublished paper, 1980.

³ F. Machlup: The production and distribution of knowledge in the United States, Princeton, NJ, 1962, Princeton University Press.

⁴ D. Bell: The coming of post-industrial society, New York 1973, Basic Books.

⁵ M. Porat: The information economy, unpublished Ph.D. dissertation. Stamford University, 1976.

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Table 1
Information Workers as a Percentage of the Economically Active Population

Country	Percentage of Information Workers
Denmark	54
Germany	54
Greece	45
Italy	51
Netherlands	58
Portugal	35
Spain	40
United Kingdom	53
Average Europe	50
United States	48
Canada	47
Average North America	48
Argentina	29
Brazil	21
Chile	30
Colombia	27
Mexico	25
Peru	23
Venezuela	21
Average Latin America	24
Korea	36
Japan	37
Taiwan	40
Singapore	48
Thailand	13
Average Asia	31

Source: ILO Laborsta, <http://laborsta.ilo.org/>; analysis by the author.

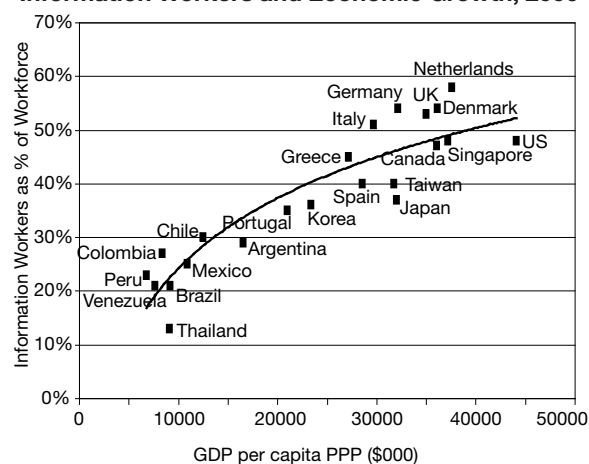
ing or processing information. By including knowledge producers *and* users, Porat was more inclusive than either Machlup or Bell. He estimated that 45% of the economically active population of the United States had information related occupations. Porat's work triggered a number of studies attempting to replicate his US analysis for other countries.⁶ In general terms, all of them confirmed the worldwide trend towards information-based economies.

We have recently replicated our own analysis of the worldwide proportion of information workers⁷ for

⁶ J. Barnes, D. Lamberton: The growth of the Australian information society, quoted in: D. Lamberton: The theoretical implications of measuring the communications sector, in: D. Lamberton, M. Jussawalla (eds.): Communication Economics and Development, New York 1976, Pergamon Press; S. D. Wall: Four sector Time Series of the U.K. Labour Force 1841-1971, London 1977, UK Post Office, Long Range Studies Division; S. Lange, H. Rempp: Qualitative and quantitative aspects of the information sector, Karlsruhe Institut für Systemtechnik und Innovationsforschung, 1977; K. Uno: The role of communication in economic development: the Japanese experience, in: M. Jussawalla, D. M. Lamberton (eds.): Communication Economics and Development, Elmsford, NY, 1982, Pergamon Press.

⁷ R. Katz: The information economy: an international perspective, New York 1988, Praeger.

Figure 1
Information Workers and Economic Growth, 2006



Sources: The Economist, 2007; ILO Laborsta, <http://laborsta.ilo.org/>; analysis by the author.

2006, which confirmed a continuing growing trend (cf. Table 1).

As Table 1 indicates, while the proportion of information workers in North America has stabilised at around 47%⁸ since the 1970s, the number in Europe has reached 50%, while in Latin America it is 24% and for selected Asian countries 31%. Furthermore, this increase in information workers continues to be directly related to the level of economic development (cf. Figure 1).

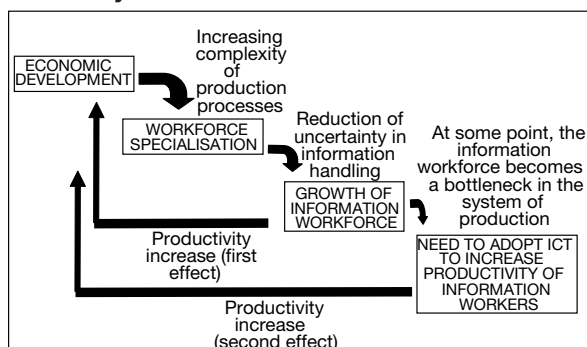
However, so far the data has just provided an empirical confirmation of a socio-economic trend. How about the link between “information-based occupations” and “information and communication technologies”? Charles Jonscher in his economics dissertation at Harvard University⁹ raised the question that if we can measure the microeconomic impact of ICT on firm productivity, we should also be able to link, at the macroeconomic level, the growth in informational occupations and the adoption of technology to improve their productivity. This is what we label the first causality effect depicted in Figure 2.

According to this causality framework, economic growth leads to increasing complexity in production processes. Complexity in production processes results in the growing fragmentation of value chains and increases functional complexity within firms. The first response to this effect is the specialisation of the workforce and the resulting emergence of workers whose

⁸ M. Porat, op. cit., estimated the percentage of information workers in the USA in 1970 to be 46.4%.

⁹ C. Jonscher, op. cit.

Figure 2
First Causality Model: ICT Innovation and Diffusion is Driven by the Growth of the Information Workforce



primary function is the manipulation of information for purposes of organising the production of goods: these are the “information workers”. In other words, economic growth leads to an increase in production complexity which results in more information workers. At some point, information processing workers become a bottleneck in the economic system. They cannot keep growing for ever because that would reduce the availability of resources in other occupations. Furthermore, when information workers become a large proportion of the workforce, the complexity of information processing itself becomes a bottleneck. This is where ICT comes in. Its development and adoption is aimed at increasing the productivity of information workers and addressing the bottleneck.

This is why economists have found that ICT is directly linked to economic growth. Independently of the issues raised around the direction of causality, every study attempting to link economic growth and ICT has concluded that technology adoption has an impact on economic growth. In particular, ICT has been found to

have a direct influence on the economy at four levels (cf. Table 2).

For example, Jorgenson et al.¹⁰ studied the impact that ICT would have on aggregate productivity. According to these researchers, the rapid price declines in IT which took place between 1995 and 2000 acted as a positive supply shock (memory chips declined 41% in 1974-96; logic chips 54% in 1985-96; the price of computers declined less because chips represent <50% of computer costs). This resulted in a high rate of investment in IT which, coupled with more efficient combination of inputs, led to increased productivity. But Jorgenson and others identified another effect. While from 2000 onwards, investment in IT receded considerably, labour productivity continued to improve (cf. Figure 3).

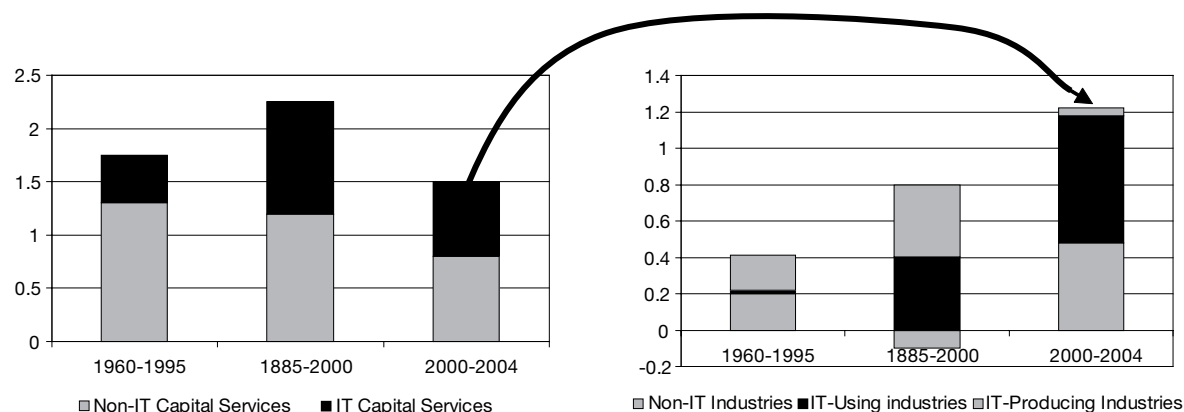
According to Jorgenson et al., rising productivity in the later period was driven by a combination of structural and transitory factors (e.g. flexible labour markets). However, this lag could also be explained by another set of firm-related factors. Having studied how technology is adopted by individual firms and how it can actually have an impact on the firm's productivity, management science could contribute to the identification of such factors. We start by stating that purchasing ICT is not the only requirement for improving productivity. In fact it has been well documented, in both the management and the economics literature, that for information technology to have an impact on a firm's efficiency, the business processes it supports have to be modified accordingly (sometimes dramatically revamped). Independent of the pace at which ICT is being adopted (purchased), the impact on ef-

¹⁰ D. Jorgenson, M. S. Ho, K. Stiroh: The industry origins of the American productivity resurgence, October 2006; D. Jorgenson, M. S. Ho, J. Samuels, K. Stiroh: Productivity growth in the new millennium and its industry origins, Presentation to the 2006 Intermediate Input-output Meeting July 26-28, Sendai, Japan 2006.

Table 2
Economic Impact of ICT

Areas of Impact	Benefits
Productivity	<ul style="list-style-type: none"> Improvement of total factor productivity, particularly in those industries that are ICT-intensive but also in those that are not
Creation/relocation of enterprises	<ul style="list-style-type: none"> Relocation of enterprises based on the availability of high capacity telecommunications networks (as one of many infrastructure factors) and quality of life (driven by availability of networks in schools, hospitals, public administration etc.)
Employment	<ul style="list-style-type: none"> Creation of employment as a result of relocation of companies searching for labour cost arbitrage Creation of qualified self-employment resulting from the availability of communication networks Creation of employment in manufacturing and installation of telecommunications equipment
Economic growth	<ul style="list-style-type: none"> Increase in efficiency of industries with high transaction costs (retail distribution, finance etc.) Consumer surplus generated by the availability of new telecommunications services, reduction of travel time and transportation etc.

Figure 3
Lag Effect between ICT Investment and Productivity



Source: D. Jorgenson, M. Ho, J. Samuels, K. Stiroh: Productivity growth in the new millennium and its industry origins, presentation to the 2006 Intermediate Input-output Meeting, Sendai, Japan, 26-28 July 2006b.

efficiency and productivity is driven by what has been called “accumulation of intangible capital”.¹¹ First, certain companies, by virtue of the innovativeness of their management and their willingness to transform their enterprises, are the leaders that will initially reap the benefits of ICT.¹² However, this is not enough to register in the national productivity numbers. It is the first level of adoption depicted in Figure 4.

Having completed the first step (leading innovative companies), the second wave of adoption is concen-

trated on industrial sectors whose structure and value chains tend to generate higher transaction costs. We refer to network oriented industries such as financial services, transportation or distribution. These are the industries whose complexity costs are so high that, regardless of increasing the number of information workers, they need to adopt technology to improve their productivity. At this point, we have moved from firm-related adoption drivers to industry structure. However, even at this point, it might not be that easy to (paraphrasing Solow) “see the impact of ICT in the productivity numbers”. It is only in those economies in which the concentration of industrial sectors more prone to adopt ICT (what Jorgenson calls “IT intensive”) is higher where we are going to see the macro-

¹¹ S. Basu, J. Fernald, op. cit.

¹² A classical example, well studied in the management literature, is Citibank under John Reed, when the institution adopted check processing technology and changed all related business processes to reduce total operating expenses.

Figure 4
ICT Productivity: Three Levels of Causality

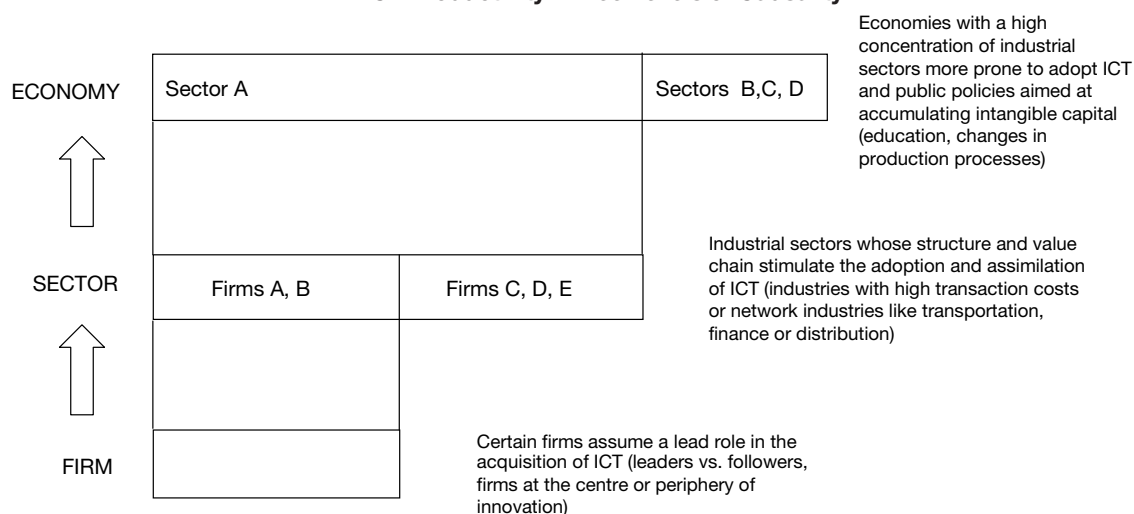
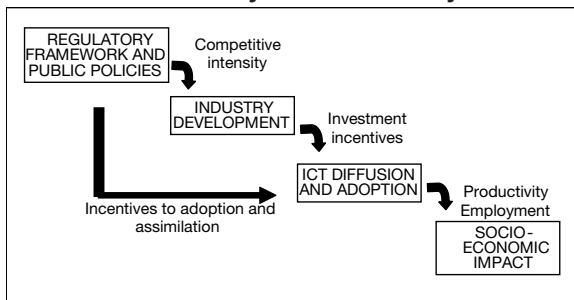


Figure 5
Second Causality Model: Socio-economic Impact
is Driven by ICT Public Policy



impact of ICT on productivity. Therefore, we contend that the transition in ICT adoption from firm to industry sector to economy could also explain some of the lags that have been observed in the data.

Research on the economic impact of telecommunications technology confirms the findings at the ICT aggregate level. For example, telecommunications networks have been found to have an impact at five levels:

- tele-commuting: improvement in quality of life resulting from ability to work remotely;
- labour productivity: greater efficiency in processing of information-related tasks;
- transaction speed: faster completion of inter-firm transactions, with consequent reduction of costs;
- innovation capacity: innovation can be increased by streamlined collaboration among eco-system firms;
- modular and flexible production processes: standardised optimised processes can only be achieved through flexible reconfiguration and simplification.

Furthermore, broadband has been determined to positively impact economic growth and employment creation. For example, Crandall and Jackson¹³ determined that an investment in broadband of \$63 billion in the USA would achieve universal coverage, allowing the maximisation of consumer surplus generated by new services, savings in transportation time and new computer applications; this would result in a cumulative increase to the GDP of \$179 billion. Similarly, Ford and Koutsky¹⁴ found that a comparative analysis of similar cities of which one is served by a broadband

infrastructure shows that this leads to an improvement in economic growth of 28%.

The evidence is also compelling when it comes to employment creation. Crandall et al.¹⁵ estimated that an investment leading to universal broadband coverage in the USA would result in an annual increase of 61,000 jobs. Pociask estimates that the total employment impact would reach 1.2 million (broken down in 166,000 in telecommunications, 71,700 equipment manufacturing and 974,000 in indirect employment effects).¹⁶ Similarly, Kelly¹⁷ observed that an investment in broadband in one of two adjacent cities attracts investment of 140 companies (versus 9 for the other city) generating 4 250 additional jobs. Finally, Lehr et al.¹⁸ estimated that broadband investment at the end of the last century in the USA resulted in an increase in employment of around 1.5% at the aggregate level.

To sum up, the converging findings of ICT-related and telecommunications-related research conclude that in both cases the economy benefits from their investment deployment. There is, however, another set of factors that can affect the social and economic impact of ICT. The first causality model assumes the unconstrained availability of technology, the adoption of which is driven by the need to increase the productivity of information workers. The third step described above is primarily based on firm-related and industry structure variables. There is another explanation regarding the economic impact of ICT that is focused on the supply side: we refer to the impact of ICT public policies on the diffusion and assimilation of technology (cf. Figure 5)

According to this causality flow, an industry regulatory framework (we refer here more to the “communications” component of ICT) tends to determine the level of optimal competitive intensity, which in turn triggers investment incentives in the infrastructure of service providers, which will have an impact on the economy in terms of either employment creation and/or productivity. The first two causalities have

¹³ R. Crandall, C. Jackson: The \$500 billion opportunity: the potential economic benefit of widespread diffusion of broadband access, Criterion Economics Ltd., 2001.

¹⁴ G. Ford, T. Koutsky: Broadband economic development: a municipal case study from Florida, in: American Economic Studies, April 2005.

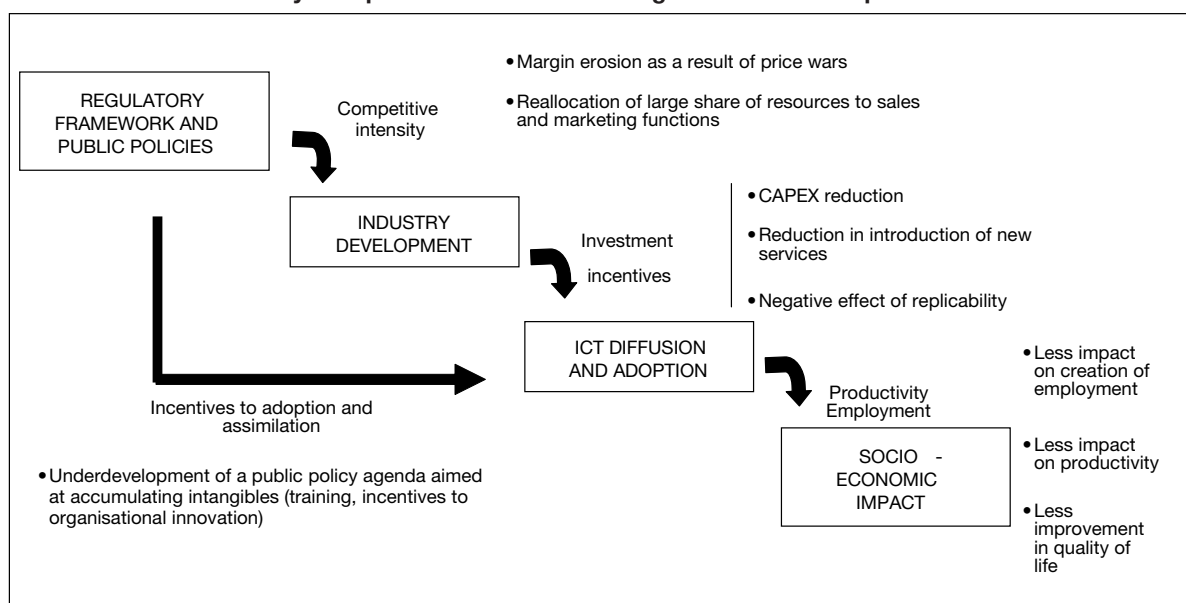
¹⁵ R. Crandall, W. Lehr, R. Litan: The effects of broadband deployment on output and employment: a cross-sectional analysis of US data, Economic Studies Program at the Brookings Institution, 2006.

¹⁶ S. Pociask: Building a nationwide network: speeding job growth, TeleNomic Research LLC, 25 February 2002.

¹⁷ D. Kelly: A Study of the Economic and Community Benefit of Cedar Falls, Iowa’s Municipal Telecommunications Network, 2003, updated 6 July 2004.

¹⁸ W. Lehr, C. Osorio, S. Gillett, M. Sirbu: Measuring broadband economic impact, Paper presented at the 33rd Research Conference on Communications, Information and Internet Policy, Arlington, 23-25 September 2005.

Figure 6
Industry Competitive Scenario Affecting the Economic Impact of ICT

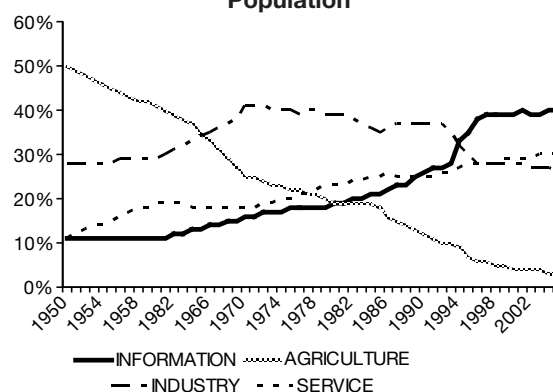


been well studied by researchers like Aghion et al.¹⁹ According to these authors, the study of industry behaviour would indicate that there is an optimal point in terms of competitive intensity that will result in investment incentives. Less competition would reduce the incentive to invest in infrastructure, while too much competition will negate its return. As a result, when the optimal point of competitive intensity in the “inverted U” is reached, investment in telecommunications infrastructure achieves a high point and benefits flow through the adopting economy. Conversely, if that optimal point is not achieved, the supply of innovative services does not occur.

But in addition to the “inverted U” effect which affects the supply of ICT services, policy can also have another effect. As mentioned above, a critical component in achieving an impact of ICT is the accumulation of “intangible capital” (defined as the supply of trained technicians as well as the factors that promote the organisational change needed to achieve an efficiency improvement). In other words, if the “intangibles” are not available, ICT will not achieve its full impact. As it happens, public policy has a direct influence on the accumulation of intangible capital, via the promotion of educational policies and fiscal incentives to innovate. Figure 6 presents a situation where the latter could occur.

According to this Figure, one could formulate the hypothesis that unrestricted asymmetrical regulation reduces the incentive of telecommunications service providers to invest in infrastructure which could result in limited impact on the economy. To sum up, we have attempted to generate a set of causal frameworks that integrate the economic, managerial and policy perspective to the explanation of socio-economic impact of ICT. To what extent can these frameworks be applied to Spain?

Figure 7
Spain: Breakdown of Economically Active Population

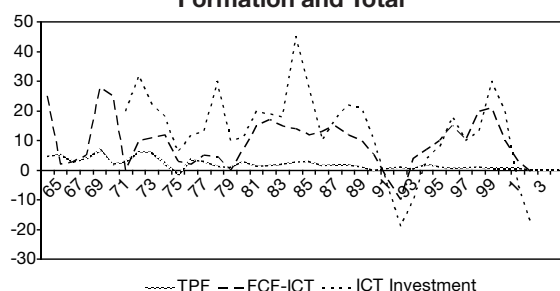


Note: Information workers include executives, managers, administrators, professionals, technicians and clerks.

Sources: ILO Laborsta, <http://laborsta.ilo.org/>; analysis by the author.

¹⁹ P. Aghion, N. Bloom, R. Blundell, R. Griffith, P. Howitt: Competition and innovation: an inverted-U relationship, in: Quarterly Journal of Economics, Vol. 120, No. 2, 2005, pp. 701-728.

Figure 8
Spain: Year-on-Year Change in ICT Fixed Capital Formation and Total



Note: ICT investment is calculated in current prices while ICT Fixed Capital Formation is presented in real terms.

Sources: J. Gual, S. Rosello, A. Posino: El problema de la productividad en España: cual es el papel de la regulación?, in: Documentos de Economía "La Caixa", No. 1, June 2006; M. Mas, J. Quesada: Las nuevas tecnologías y el crecimiento económico en España, Madrid 2005, Fundacion BBVA; AETIC: Las Tecnologías de la Sociedad de la Información en la Empresa Española 2005, Madrid, Spain 2006.

The Spanish Evidence

To start with, our analysis of the Spanish economically active population indicates that the Iberian economy has undergone a structural change over the last fifty years transitioning towards an information economy (cf. Figure 7).

As Figure 7 indicates, the proportion of information workers in the Spanish economy climbed from just over 10% in the 1950s to 40% in the 1990s. The increase was parallel to the rate at which the manufacturing workers increased, thereby confirming the first stages of the causality framework that posited that the increase in information workers acted as an enabler of industrialisation.

However, when we tried to ascertain whether ICT adoption had an impact on labour productivity, the time series showed that the causal relationship between ICT investment and productivity is not clear (cf. Figure 8).

The data in Figure 8 show a high level of volatility in ICT investment. In the 1960s and 1970s, given the low level of ICT investment, the high growth (real rate: 9.36%) indicates the beginning of an investment process. The acceleration cycle in the 1980s (real rate: 15.37%), came to a sudden halt in the early 1990s, but started growing again in 1993 until 2000, when the bursting of the internet bubble resulted in a dramatic slow-down.

On the other hand, the rate of change of total factor productivity between 1965 and 2004 indicated a gradual

Table 3
Spain: Growth in Labour Productivity

	1995-2000	2000-02	Change	Impact
Total	0.48%	0.71%	0.23%	
Not ICT intensive	-0.12%	0.30%	0.41%	
ICT intensive	0.67%	1.23%	0.57%	
Paper, print	0.25%	0.93%	0.68%	Lesser impact
Finance	1.22%	5.84%	4.63%	Accelerating
Energy	6.18%	5.89%	-0.29%	High constant impact
Transport and Communication	2.52%	1.93%	-0.59%	Moderate impact

Source: M. Mas, J. Quesada: Las nuevas tecnologías y el crecimiento económico en España, Madrid 2005, Fundacion BBVA.

deceleration between the 1960s and the 1990s, increasing volatility in the 1990s (around an average rate of 3%) and a stable, albeit declining rate from 2000 onwards. As a result, the data would indicate that ICT investment in the 1980s did not result in an improvement in productivity. Two structural features of the Spanish economy explain the lack of impact of ICT on aggregate productivity. In the first place, the aggregate numbers of employment are biased by the construction sector, which is a sector that has generated a large part of employment growth in the last decade. Secondly, the sectors that have benefited more from the development of the telecommunications industry and the generalised investment in ICT are the ICT-intensive industries, which show a major increase in productivity (cf. Table 3).

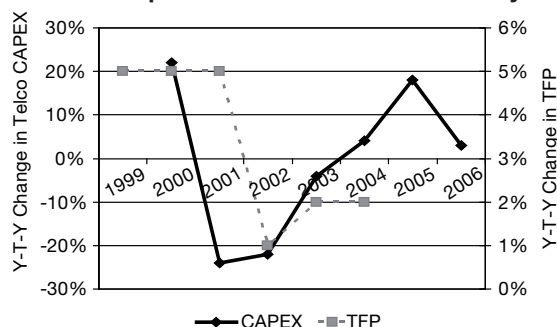
Finally, the structure of the Spanish economy shows a preponderance of small and medium-sized enterprises, a sector that is significantly slower than the rest of firms in adopting ICT.

Emerging research regarding the impact of ICT on the Spanish economy is not yet conclusive. On the positive side, Hernando and Nuñez²⁰ argue that ICT investment in 1990 had a positive impact on Spanish productivity. In a study based on enterprise statistics aggregated at the sectoral and economy level, they conclude that ICT contribution to value-added increased from 0.29 pp in 1992-5 to 0.45 pp in 1996-00. In that sense, the ICT contribution has been 0.10 for each percentage point of economic growth (compared to 0.25 in the USA). On the negative side, Gual et al.²¹ argue that given the slowdown in productivity growth

²⁰ I. Hernando, S. Nuñez: The contributions of ICT to economic activity: a growth accounting exercise with Spanish firm-level data, Banco de España, Investigaciones Económicas, Vol. XXVIII, No. 2, 2004, pp. 475-494.

²¹ J. Gual, S. Rosello, A. Posino: El problema de la productividad en España: cual es el papel de la regulación?, in: Documentos de Economía "La Caixa". No. 1, June 2006.

Figure 9
Spain: Year-on-Year Change in Telecommunications Capital Investment and Productivity



Sources: Comision de Mercado de Telecomunicaciones (CMT): Informe Anual, Barcelona, Spain, June 2006; J. Gual, S. Rosello, A. Posino: El problema de la productividad en España: cual es el papel de la regulación?, in: Documentos de Economía "La Caixa", No. 1, June 2006; analysis by the author.

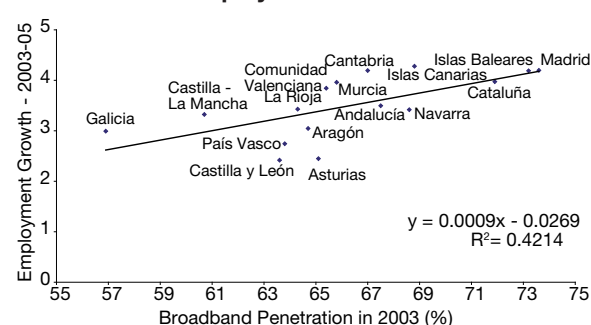
in the 21st century, ICT is not having a positive impact on total factor productivity. According to these authors, productivity grew 2.18% between 1980 and 1994, dropping to 0.68% between 1995 and 2000, while ICT capital stock as a percentage of GDP increased from 1.93% to 4.58%, which indicates the presence of institutional and regulatory barriers limiting the impact of ICT on the economy. Furthermore, Mars and Quesada argue that the major ICT investment has not yet materialised in total factor productivity improvement due to the lack of intangibles (for example, training and business process changes).

On the other hand, our time series regarding the year-on-year change in telecommunications investment and productivity indicate that there appears to be a relationship between the two variables (cf. Figure 9).

While the data set is extremely short, it would seem that when capital investment in telecommunications decreases (2000 to 2001), total factor productivity declines a year later. The inverse is also the case: when capex increases (constantly between 2001 and 2005), total factor productivity follows through. Can we conclude that there is a clear causal relationship? While we need to investigate it further, the data certainly warrant further research.

Furthermore, when it comes to the impact of broadband diffusion on employment generation, consistent with the findings of Lehr et al., broadband penetration in the Spanish business segment appears to have an impact on employment growth (cf. Figure 10).

Figure 10
Spain: Causality between Broadband and Employment Growth



Sources: Instituto Nacional de Estadística - INE; Directorio Central de Empresas - DIRCE; analysis by the author.

According to the data, an increase of 5% in broadband adoption among enterprises (SMEs included) in Autonomous Communities (Spanish political entities which aggregate several provinces) in 2003 resulted in incremental employment growth of 0.6 percentage points.

In sum, we have found a positive relationship in Spain between ICT investment and broadband penetration on the one hand, and productivity and employment growth on the other. The structural transformation of the Spanish economy indicates a transition toward an information society. This transition results in growing causal relationships between the diffusion and assimilation of ICT and economic growth. More specifically, it would appear that a positive relationship between telecom Capex change and TFP change exists. In particular, a 5% increase in broadband adoption by enterprises results in a 0.6 percentage point improvement in job creation.

Conclusions

The implications of these findings are important when it comes to the second causality model discussed above. If productivity growth and employment creation are driven partially by the level of investment in ICT and telecommunications, a decrease in capital expenditures as a result of a certain regulatory framework could have an impact on the economy. A growing regulatory pressure resulting from service-based competition on carriers capable of investing in infrastructure could result in a reduction in capital, impacting also the rate of broadband deployment. This could have a negative impact on productivity growth and employment generation.