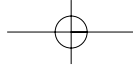
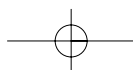
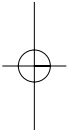


ICTs and transformations in Catalan companies

Jordi Vilaseca i Requena (director) / Joan Torrent i Sellens (co-ordinator)



ICTs AND TRANSFORMATIONS
IN CATALAN COMPANIES



JORDI VILASECA REQUENA (director)
JOAN TORRENT SELLENS (coordinator)

ICTs AND TRANSFORMATIONS IN CATALAN COMPANIES

RESEARCH TEAM:

Carlos F. Cabañero Pisa, David Castillo Merino, Rosa Colomé Perales, Ángel Díaz Chao,
Pilar Ficapal Cusi, Ana Isabel Jiménez Zarco, Josep Lladós Masllorens, María Jesús
Martínez Argüelles, Antoni Messeguer Artola, Dolors Plana Ertá, Inma Rodríguez Ardura,
Jordi Vilaseca Requena, Joan Torrent Sellens

BIBLIOTECA DE CATALUNYA - DADES CIP

ICTs and transformations in Catalan companies. - (Col·lecció d'estudis)

Bibliografia

ISBN 84-393-6541-1

I. Vilaseca i Requena, Jordi, dir. II. Torrent i Sellens, Joan, ed. III.

Cabañero Pisa, Carlos F. IV. Universitat Oberta de Catalunya V. Centre

d'Innovació i Desenvolupament Empresarial (Catalunya) VI. Col·lecció:

Col·lecció d'estudis (Centre d'Innovació i Desenvolupament Empresarial
(Catalunya))

1. Canvi organitzatiu - Innovacions tecnològiques - Catalunya 2. Empreses
- Xarxes d'ordinadors - Catalunya 3. Tecnologia de la informació - Aspectes
econòmics - Catalunya 4. Internet - Catalunya

658.011.56(467.1)

No part of this book may be reproduced in any form without the prior consent of the Centre for Innovation and Business Development (CIDEM).
All rights are reserved with regard to the graphic and artistic design.

© Generalitat de Catalunya

Department of Labour and Industry
Centre for Innovation and Business Development
(CIDEM)

Tel: 34 93 476 72 00

E-mail: info@cidem.gencat.net

www.cidem.com

Authors: This book is the result of the job carried out by a researchers team at the IN3 (Internet Interdisciplinary Institute) of
the UOC (Open University of Catalonia).

Director of the research project: Jordi Vilaseca Requena, professor at the UOC and researcher at the IN3.

Co-ordinator of the research project: Joan Torrent Sellens, professor at the UOC and researcher at the IN3.

Translation: Gisela Ammetller Montes

Design and creation: *Addenda*
Pau Claris, 92. 08010 Barcelona
E-mail: addenda@addenda.es
www.addenda.es

1st issue: July 2004

Publication: 1.000 copies

Copyright registration: B. 30.198-2004

CONTENTS

Prologue	9
Preliminary	11
Introduction. Research methodology	13
1. Business uses for Information and Communications Technologies (ICT)	23
1.1. Digital equipment in Catalan business	24
1.2. ICT uses	28
1.2.1. General uses	29
1.2.2. Internal uses	30
1.2.3. External uses	33
1.3. Attitudes towards ICT	35
1.3.1. Personal attitudes	36
1.3.2. Attitudes related to companies	38
1.3.3. Attitudes related to the environment	44
1.4. Internet equipment and an ICT use indicator	45
2. An analytical approach focused on e-business and the network company	53
2.1. ICT and capital: towards intangible investment and financial equilibrium	54
2.2. ICT and labour: towards self-programming work and wage improvement	60
2.3. ICT and innovation: towards a continual learning and growth process	66
2.4. ICT and business results: clarifying the productivity paradox	78
3. Conclusion: technological change and business activity in Catalonia	93
Bibliography	105

PROLOGUE

Information and communication technologies play an important role in the economic and social development of Catalan business and are causing an unprecedented revolution in the production, sales, organizational and labour structures of our business community.

Through the development of this kind of technology, production structures and society are in a process of change that is moving toward a knowledge-based model. We are in a context of globalization where economic and social relations take place at the global level, and information flows and management have become key elements.

In this context, businesspeople should see technology as an investment, because ICTs make it possible to introduce revolutionary innovations in the production processes of goods and services. It is time to overcome any hesitation that may still exist and fully embrace new ICTs for use in product manufacture and marketing. They should also be used in corporate management, organization and communications. It is clear that ICTs can be a major source of process innovation for companies, which are guaranteed considerable improvements in productivity, competitiveness and work quality.

In short, Catalan companies should take advantage of ICTs to become more competitive and efficient. Their work will improve in quality and they will enjoy a privileged position, together with the public administration and society, with regard to the changes taking place in the information society.

Josep Maria Rañé
Catalan Minister of Labour and Industry

PRELIMINARY

ICTS AND TRANSFORMATIONS IN CATALAN COMPANIES

Description of the research:

The research project *Information and communication technologies and transformations in Catalan companies* has the primary objective of analysing the transformations of the strategy and the organisation of the companies linked to the use of information and communication technologies (ICT). The principal hypothesis to be proved is the following: knowledge economy transforms the business activity, performed by means of computer and telecommunications networks (electronic business or e-business). It defines a new organisational and strategic model based on the network decentralisation of the business lines (the network firm). The empirical contrast has been carried out through a survey of a representative sample of 2038 Catalan firms, stratified in accordance with its activity sector and the company size.

Research director:

Dr. Jordi Vilaseca i Requena, professor at the UOC and researcher at the IN3

Research co-ordinator:

Dr. Joan Torrent i Sellens, professor at the UOC and researcher at the IN3

Research team:

Carlos F. Caba ero Pisa, professor at the UOC and researcher at the IN3

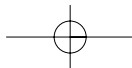
David Castillo i Merino, professor at the UOC and researcher at the IN3

Dra. Rosa Colom  i Perales, professor at the UOC and researcher at the IN3

 ngel D az Chao, researcher at the IN3

Pilar Ficapal i Cus , professor at the UOC and researcher at the IN3

Dra. Ana Isabel Jim nez Zarco, professor at the UOC and researcher at the IN3



Jordi Vilaseca / Joan Torrent

Dr. Josep Llad s i Masllorens, professor at the UOC and researcher at the IN3
Mar a Jes s Mart nez Arg elles, professor at the UOC and researcher at the IN3
Dr. Antoni Meseguer i Artola, professor at the UOC and researcher at the IN3
Dolors Plana Erta, professor at the UOC and researcher at the IN3
Dra. Inma Rodr guez Ardura, professor at the UOC and researcher at the IN3
Dr. Joan Torrent i Sellens, professor at the UOC and researcher at the IN3
Dr. Jordi Vilaseca i Requena, professor at the UOC and researcher at the IN3

With the collaboration of:

Institut DEP: The *Institut d'Estudis i Professions* (Institute of Studies and Professions) collaborated in this research by offering the technical support requested by ONE (NEO, New Economy Observatory) researchers. Specifically, the Institut DEP worked close to the ONE research team, designing and testing the questionnaire as well as helping to generate the sample. The questionnaire survey, codification, purification and checking of questionnaires as well as the initial statistical processing were carried out by the Institut DEP, always respecting the guidelines set by the research team.

Collaborative institutions:

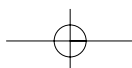
Institut Catal  d'Estad stica (IDESCAT; Catalan Statistics Institute) and *Centre d'Innovaci  i Desenvolupament Empresarial* (CIDEM, Centre for Innovation and Business Development) of the Department of Labour and Industry of the Generalitat de Catalunya.

With the support of:

Generalitat de Catalunya (Autonomous Government of Catalonia)

Research was begun in March, 2002. The survey was carried out in the period January-May, 2003.

Barcelona, 30th July 2003



INTRODUCTION

RESEARCH METHODOLOGY

This document summarises the research report entitled *ICTs and transformations in Catalan companies*.¹ This research analyses the relationship between strategy, organisation and business practices and the uses of the information and communication technologies (ICT) in the Catalan firms from the data of a survey carried out during the winter and the spring of 2003. However, it is clear that this relationship is framed within a wider context: the emergence of the knowledge economy and society. Currently, the economic and business activities are characterised by deep changes that modify the grounds and the behaviour of all economic agents. In general terms, this transformation process is based on a technological revolution —the digitalisation process—, it is built upon a dynamics of spatial and temporal market expansion —the globalisation—, and it feeds back according to the changes of the patterns of demand of families and companies. This process has a clear through-line: the intangible value of the economic activity that, in other words, is the progressive consolidation of a new knowledge-based economy. Indeed, the emergence of digital technologies deeply transforms both the society and the economy. These technologies, grouped under the common label of *information and communication technologies (ICT)*, that comprise the converging areas of microelectronics, computing, telecommunications and optical electronics, as well as recent genetic engineering advances, are applied wholesale to the economic sphere and employed in a wide range of social uses.

Nevertheless, if ICT are not the only causal factor in the global knowledge economy, they are certainly now consolidated as one of the necessary instruments to develop the network and increase the knowledge in the economic sphere. There is no doubt that the complex interaction between the emergence of digital technologies and their production is deeply transforming the economic activity. We could interpret these manifestations from at least two perspectives. Firstly, they are used by a wide number of production branches. Several years have passed since computers, faxes, digital phone lines, electronic remote controls, communication networks and a great deal of other digital applications were first used as production resources in the economic activity. However, the recent arising and productive application of new technological developments, such as the mobile phone, the Internet and the e-mail, have generated a significant, incremental and circular flow within the same compo-

1. See <http://www.uoc.edu/in3/pic/>

Jordi Vilaseca / Joan Torrent

nents of the digitalisation process and its production uses: more powerful computers interconnected in network and with Internet access, cell phones connected to the web, an infinite number of chips applied to consumer goods, production processes and both online supplier and customer relationships and new information management services are just some of the most obvious examples.

Secondly, this transformation has not only focused on the scope of production. Many devices and technologies mentioned above have become mass consumer goods, with a demand that clearly encourages production and an economic mundialisation process that is transforming the traditional concept of the market, regarded as the physical space where both supply and demand are set. Today, many economic and, especially, financial transactions are either performed in a physical space or with the supply and demand coinciding on time: the market is the web. To sum up, on the material basis of a wide range and scale technological revolution, the processing information and communication technologies have begun to affect anyhow all aspects of the human activity. Therefore, it seems that ICT have become more relevant as well as a key component of this economic transformation process, with the arising of a new production sector that extends its synergetic effects not only to the rest of the activity branches, but also to all other economic activities. In fact, this social background of knowledge has impregnated the economic activity to such a point that, currently, we can quote a growing number of interdisciplinary studies that sustain the following hypothesis: ICT are the technical paradigm on which the current dynamics of the industrial revolution is based.² This interactive and interrelated process of economic exchange and social transformation leads us towards a new type of economy and society: the knowledge economy and the knowledge society.

Therefore, in the economic sphere a wide range of processing and product innovations of digital nature have generated the emergence of new manufacturing activities, grouped under the label of the information industry. That is, all the production branches springing from an initial economic application of the digital technologies, or rather, the ICT sector and the digital content sector. Currently, the information industry is surpassing its own technological development and the set of products and services resulting from the production and the information and communication processing are used as a production factor for other economic branches. Thus, the confluence and interrelationships between the digitalisation process and its production uses generate a virtuous circle stretching from the demand for new goods and services to their production, from production to innovation and from innovation to demand once again. This interactive flow between supply and demand, by innovative mechanisms, is revealed through important improvements of productivity and competitiveness of the economies, sectors or business.³ In conclusion, we can state that the knowl-

2. See among other sources Kranzberg (1985), Mokyr (1990), David (1990; 2000), Freeman and P rez (1988), Castells (2000; 2001), Crafts (2000), De Long (2001), Norton (2001), Atkeson and Kehoe (2001), IMF (2001), Instituto de Estudios Econ micos (2001), Vilaseca (2001; 2002), Vilaseca and Torrent (2001a; 2001b), P rez (2002), Rodr guez (2002), Torrent (2002a; 2002b), Stehr (2002), Banegas (2003) and Bai and Yuen (2003).

3. Greenspan (1999).

edge economy is global, digital and it faces a growing demand for merchandises of an intangible nature.

In the social sphere the consolidation of the economy based on knowledge is generating significant changes in all sectors and in all social relationships. Changes in the labour market, the ideological and the cultural effects, the institutional and the political transformations and, definitively, the new ways through which the individual relates to the environment define some of the effects of the economic intensity of knowledge use on its sociological and institutional bases.

However, this incipient third industrial revolution is characterised by a new technical feature: the application of new knowledge and information on knowledge-generating and information and communication-processing devices.⁴ Currently, more than ever, the economic application of knowledge is used to generate knowledge itself. In the digitalisation process we have available, as usual, technologies based on the economic application of knowledge to produce goods in a reproducible way. However, the novelty is that the impact of this knowledge is not limited to technology, since the ICT also influence the generation of knowledge through the widening and extension of the human mind. In other words, we are facing a social stock of wisdom that uses knowledge as an input and contributes directly to the knowledge generation as an output.

Therefore, by using a wide vision of technological processes, seen as the command of man over nature,⁵ the ICT do not only affect the reproduction capacity and the environmental control, but also act directly on the control of man over himself, or more specifically, over the generation of his own knowledge. What is the most significant conclusion that can be drawn from this intrinsic feature of digital technologies? It seems obvious that if our objective is to analyse the economic and social aspects of this technological revolution, we must focus our analysis on knowledge. If we define knowledge from its epistemological definition—the human and the dynamic process of adequate justification of a belief—⁶ we can conceptualize the economic reality of its production, distribution, exchange and consumption, as the act of knowing is an exclusively human act and, as such, it can be referred economically. Thus, appealing to its reproductive nature,⁷ we can distinguish between two knowledge typologies which can be applied to the economic activity: explicit or observable knowledge and implicit or tacit knowledge.⁸ Explicit or observable knowledge can be explained through a formal and a systematic language, so that it is possible to be easily processed and stored. Implicit or tacit knowledge is basically associated to the labour factor based on tech-

4. Castells (2000).

5. McClellan and Dorn (1999).

6. Terricabres (1998).

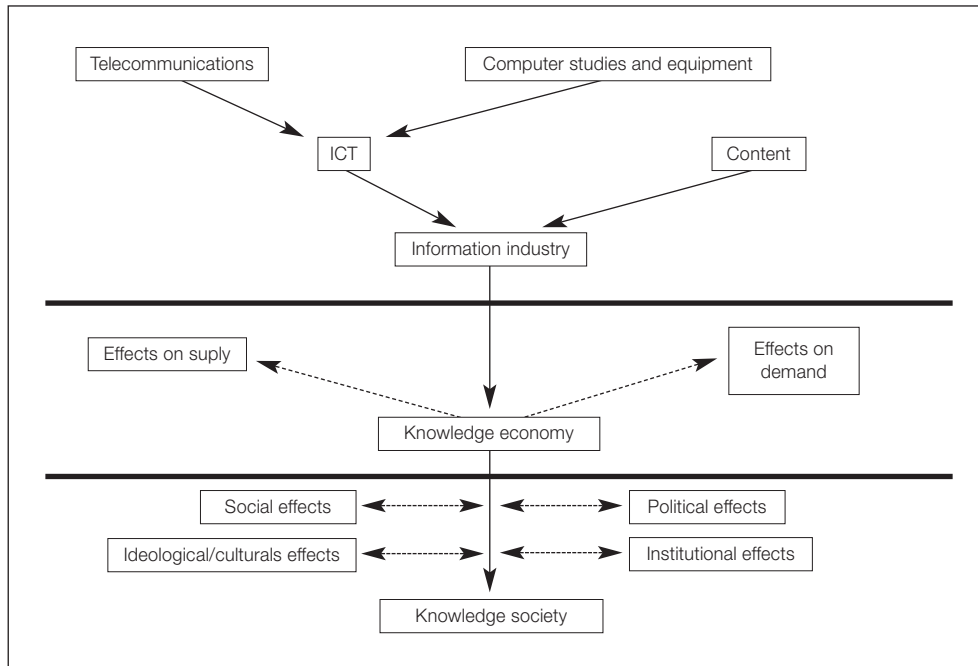
7. See, among other sources, the seminal work by Polanyi (1978), economically applied by Nonaka (1991) and David (1993), among others.

8. This characterisation is clearly compatible with Lundvall and Johnson's ideas (1994) and Foray and Lundvall's (1996), two perspectives revealing four knowledge typologies that separate knowledge as an economic resource: the *know-what*, *know-why*, *know-how* and *know-who*. While the first two are easily reproducible, the second two present difficulties when trying to convert them into information.

Jordi Vilaseca / Joan Torrent

nical or cognitive elements, such as the practical experience, the skills or the qualifications difficult to describe and, therefore, to make explicit.

Figure 1. A diagram of the knowledge society and the knowledge economy



Source: Vilaseca and Torrent (2001a).

How has the digitalisation process affected knowledge production, distribution, consumption and exchange? The answer comes through two main channels.⁹ Firstly, the outstanding improvement in the access and the management of the information flow leads us to a significant lowering of the input barriers to knowledge dissemination, which can be translated as a significant increase of the stock of observable knowledge. Secondly, the improvement in the access and dissemination of the elements affecting tacit knowledge, which in some cases has permitted to transform tacit knowledge into observable knowledge, while on other occasions it has transformed the information and experience skills of the workforce.

On the other hand, the daily economic activity provides us with a number of examples of

9. As the works of Hatchuel and Weil (1995), Foray and Lundvall (1996) and Antonelli, Geuna and Steinmueller (2000) suggest.

knowledge-based merchandise transactions (goods and services),¹⁰ showing that knowledge is no longer just a production resource. Above all, knowledge-based merchandise has particular economic features¹¹ with qualities of a public and experience good, significant externalities and rising performance. Furthermore, as the generated knowledge presents more difficulties in terms of digitalisation, the marginal utility of access to this knowledge and its output barriers tend to decrease.¹²

Therefore, the progressive knowledge used as a resource and as a merchandise of growing economic importance lets us have a vision of the knowledge economy, defined as a branch of the economic analysis that studies the behaviour and the economic facts derived from the productive knowledge application. This approach of knowledge is not only limited to a vision of scientific or technological knowledge, but also comprises the technical knowledge and the skills of the economic agents, whether easily transmissible or not.¹³ In fact, during the nineties, the knowledge linked to the digital technologies changed the behaviour of certain economic agents, generating new activities and transforming some of the existing ones. Precisely, the knowledge economy must be understood in this wider sense. Actually, its basic resource has become one of the explanations of the progresses in the productivity and the competition, and, consequently, of the economic growth and development.¹⁴

In synthesis, if in the global knowledge economy and society productivity and competition increases are based, among other things, on learning (and unlearning) capacities, on innovation, on flexibility and on the entrepreneurial initiatives of the economic agents, there is no doubt that the firm is one of the economic agents most involved in this transformational process. In fact, everything seems to indicate that the use of information and communication technologies in business has been consolidated as one of the basic instruments for strategic and organisational changes. Today, these changes are needed when adapting to the changing needs of a global demand. In other words, the knowledge economy is transferred to the business activity on the basis of a double dynamics: the centralisation of the capital and the decentralisation of the productive activity, of which the consolidation of the network firm and the digital business are two clear exponents, specifically the two study objects of this research.

As stated above, the main research objective presented here is the analysis of the business activity in Catalonia as a result of the emergence of the information and communication

10. From any goods or services that can be digitalised (books, databases, magazines, films, music, stock indexes, websites or football results) to the exchange of capacities between economic agents.

11. Shapiro and Varian (1999).

12. Torrent (2002b).

13. Vilaseca (2001).

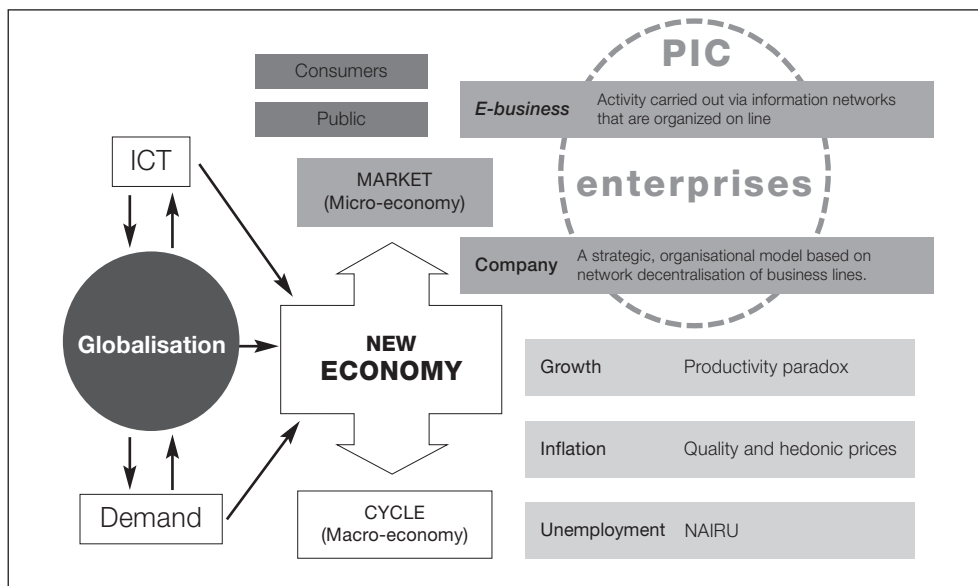
14. Oliner and Sichel (2000), Jorgenson and Stiroh (2001), Nordhaus (2001), the Department of Commerce, USA (2002), Gordon (2003) and Feldstein (2003) for the USA and Schreyer (2000), Colecchia and Schreyer (2001), Van Ark, Inklaar and McGuckin (2002) and OECD (2003a) for other economies reach a similar conclusion: ICT, and therefore, economic knowledge manifestation, explain a majority of the changes in the sources for economic growth that many western economies experienced during the nineties.

Jordi Vilaseca / Joan Torrent

technologies in the productive scope. These transformations give as a result important changes in the two basic business activity inputs (capital and labour), as well as in the business practices and into the determining element of the long term growth—the innovation—. However, these transformations should be empirically contrasted on the basis of a general hypothesis. As it can be observed in figure 2, all convergent ICT, the economic mundialisation process and the changes in the demand patterns of the economic agents have led to a widespread transformation of the economic activity, grouped under the concept of the *new economy* (knowledge economy). From the economic analysis, the economic activity can be looked at both from the economic cycle (macro-economy) perspective and from the market point of view, or it can be seen as the interaction between economic agents (micro-economy). This study specifically focuses on the *firm* as an economic agent.

Despite the efforts made by several public and private institutions, the secondary information available is not entirely adequate to describe the important changes that ICT are generating throughout the economic and business activity sectors. Even though we now have relevant information regarding the ICT penetration into companies and some of their most direct uses,¹⁵ we still do not have reliable and representative statistics on how the ICT trans-

Figure 2. The new economy and the research project *ICT and Transformations in Catalan Businesses*



Source: own creation.

15. See IDESCAT (2003a; 2003b) and DURSI (2003) for Catalonia and the European Commission (2002) and e-Business W@tch (2003), for all European Union countries.

form all the business activity, defined as the set of elements affecting the strategy, organisation and practices of a business.¹⁶ In this sense, the research project *ICTs and Transformations in Catalan Companies (PIC)* has a general objective: to obtain, structure, analyse and interpret sufficient reliable information in order to know and understand the impact of the ICT uses in Catalan firms and to observe the changes in companies that do use ICT. With this aim, the fundamental hypothesis to contrast is that the new economy transforms the business activity carried out through information and telecommunication networks, or e-business, and defines a strategic and organisational model based on the network decentralisation of the business lines, or network firms.

At this point, it should be noted that the aim of this research is analytical. However, we do not want to underline the descriptive value of the information obtained; among other reasons, because it is relevant to deepen on a phenomenon, which, although new, is highly relevant. Therefore, we aim to make an analytical contribution by contrasting hypothesis responding to transformations in strategy, organisation and business practices, as a result of ICT uses concerning the Catalan firms. Likewise, the scene described in this research is only a part of a much greater project, the *Project Internet Catalonia (PIC)*, which analyses the transformations in the society, in the schools, in the universities, in the autonomous and local administrations and in some hospitals. See the research reports of the other investigations of the project in order to better understand the context of the social transformations and Catalan institutions.¹⁷

Between January and May 2003 we carried out a survey by questionnaire, consisting of a face-to-face interview of one-hour duration, on a representative sample of 2,038 Catalan firms. In this sample, approximately one third of the companies show a medium or an advanced ICT use level, while the remaining two thirds reflect a low use percentage. Therefore, most of the companies interviewed do not use ICT intensively, even when they have access to an acceptable equipment level. However, apart from ICT business uses, we also studied certain general features of the Catalan firms, such as the transformations of their main value elements and the impact of the digital technologies on the four main conditioners of any business activity: capital, labour, innovation and organisational and production practices. The questionnaire, quite complex, includes 128 questions, as well as additional observations. The interviews, held with entrepreneurs or company directors who have a global vision of the whole activity, were generally well received and the collaboration of the interviewed was high. Furthermore, the survey was presented as a research of the Universitat Oberta de Catalunya (Open University of Catalonia) with no commercial aim,

16. This research team published a working document a few months ago that exhaustively analysed the empirical evidence relating to ICT uses and modifications in business activity. In this study 106 indicators to follow these transformations were proposed and we reached the conclusion that it was essential to build primary information statistics on e-business and the network firm. See Vilaseca, Torrent and Díaz (2002b).

17. See Castells, Tubella, Sancho, Díaz de Isla and Wellman (2002), as well as the other web research reports: <http://www.uoc.edu/in3/pic/cat/index.html>.

Jordi Vilaseca / Joan Torrent

under the guarantee of compliance with the statistical secret, of a complete independent analysis and the free publication of the results. Here, we would like to extend our gratitude for the helpful collaboration of all the entrepreneurs and company directors interviewed, as well as of all the researchers, professors and professionals who have helped us throughout this research. In addition, we have completed the questionnaire information with economic and financial information available to the general public in the *Registre Mercantil* (Mercantile Register), obtained through the SABI program. The reason for including these new variables was to complete the questionnaire information, mainly of a qualitative nature, by using relevant public data, with accounting and registered data of the evolution of the business development.

Figure 3. The questionnaire technical file

Universe	Firms developing their activity in Catalonia.
Range	2,038 personal interviews to entrepreneurs and managing directors.
Error margin	From ± 2.22 for global data with maximum indetermination ($p=q=50$), for a confidence level of 95.5%.
Quotas	By size, in accordance with the number of employees and the business activity sector.
Error margin	Between +4.20 and +5.46 for the different sizes according to employee numbers and from +4.82 to +5.67 for the different business activity sectors, with maximum indetermination ($p=q=50$), for a trust level of 95.5%.
Resulting sample	Fixed by weighting.
Date of field work	From January to May, 2003.
Sample selection	Procedure by marginal quotas. Random company selection.

Source: own creation.

Once the questionnaire answers had been codified and their consistency analysed, we built a database containing the values of the items taken out of the questionnaire plus those obtained from financial and accounting information. At this point, we constructed new variables, some derived from the initial variables or other indicators, by combining several of them. It should be mentioned that to achieve a balanced representation of the Catalan economy, taking into account the overweighting of some production sectors in the sample, which we will analyse more specifically below, we reweighted the database according to certain rising factors regarding the number of Catalan firms. In this sense, the analysis of more than 500 variables, forming a matrix of one million data about the Catalan firm, was carried out according to the common research methodology in social sciences; that is the frequency

analysis, the contingency tables and the regression analysis, crossed with company sizes¹⁸ and economic sectors¹⁹ defined in the research.

Therefore, the document we present contains three sections. After this brief definition of the conceptual analysis framework of the network firm and the e-business, the following chapter describes and analyses the transformations in the Catalan firms regarding the use of the information and communication technologies. The third chapter analyses the causal relationships between ICT uses and the four pillars of all business activity: two inputs (capital and labour), the determining element of its long term growth (innovation) and the result of all productive and organisational practices, putting special emphasis on the productivity. Following this, we present the main conclusions of this research. You can consult the main research bibliography in the original document. Finally, it is important to stress that this document is an initial synthesis of the research. Its aim is to make current information available to the general public with an innovative focus on the transformations of the Catalan firms. Needless to say that the report we present is an initial situational reading of an extremely rich resource, and obviously deeper investigation and new analyses are merited, which we aim to present progressively in the future.

18. We set up the following correlation regarding the company size, stratified into five typologies (companies of five employees or less, from six to nine employees, from ten to nineteen employees, from twenty to ninety-nine employees, and one hundred or more employees). We classify a micro-company as five employees or less. A small enterprise has from six to nineteen employees. We consider a medium-sized enterprise to employ between twenty and ninety-nine employees. Finally, a large enterprise is a company with over one hundred employees.

19. Following international guidelines (OECD, 1999; 2002), we initially defined seven productive sectors: the information industry, low technology industry, medium-low technology industry, medium-high technology industry, high technology industry, less intensive knowledge services and intensive knowledge services. We reduced this grouping to the following six sectors: the information industry, low technology industry (corresponding to the low technology industry), medium technology industry (corresponding to medium-low technology industry), high technology industry (comprising medium-high technology industry and high technology industry) and intensive and less intensive knowledge services.

Jordi Vilaseca / Joan Torrent

Figure 4. Summary table of economic activity according to knowledge intensity

<p>Information industry</p> <hr/> <p>ICT sector Education, R + D and knowledge editing and dissemination activities Digital content industry</p>
<p>Low technology industry</p> <hr/> <p>Agricultural sector Textiles Timber, paper, furniture, recycling and other manufacturing industries Primary activities Other industrial and construction activities</p>
<p>Medium technology industry</p> <hr/> <p>Metallurgical, non-metallic minerals and the metalworking industry Energy industry, cork, plastics and shipbuilding</p>
<p>High technology industry</p> <hr/> <p>Aeronautical and space craft Pharmaceutical products Medical and surgical equipment, orthopaedic apparatus Machinery and equipment Transport material Chemical industry</p>
<p>Less intensive knowledge services</p> <hr/> <p>Commercial activity Hotels and restaurants Transport and postal activities Other services</p>
<p>Intensive knowledge services</p> <hr/> <p>Financial mediation, insurance and real estate activities Business services Social and health services Association activities</p>

Source: own creation.

1

BUSINESS USES FOR INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT)

Below we outline the uses of the information and communication technologies with the aim of analysing the digital impact on the business activity. This research maintains that there are two key elements involved in the transformations of strategy, organisation and business practices related to digital technologies: ICT equipment and ICT uses. In other words, a comprehensive approach to business transformations related to ICT must focus not only on equipment level, but also on the use that is made of it.²⁰

Therefore, on the one hand, we will look at the digital infrastructures a company has available. We will describe the main ICT equipment available to most of the companies: cell phones, computers, Internet connection, websites and e-mail, among others. Companies often require great technological complexity to earn profits through cost reduction and product differentiation in a highly competitive environment. We will calculate to what extent this technological complexity has reached the Catalan companies. On the other hand, we will analyse whether companies make use of this equipment and, even more important, what type of use they make of it. Adequate technology integration into companies allows an increase and an improvement of their productive capacity. For this reason, technology must get adapted so that it can be used as a source for innovation of all kinds. After giving a general description of the main ICT uses in business, we will focus on internal uses—that is, the uses basically related to support organisational activities within the business activity—and on external uses—or rather, the uses associated mainly to the primary activities of the business organisation. Once we have reached this point, we will also present a detailed analysis of each ICT use. Due to the heterogeneity of situations of the Catalan production reality, we could not follow any other approach. Lastly, in order to analyse the perception behind the changes that ICT causes at different company levels, we will look at the personal attitudes and those of the company and its environment. To sum up, this section aims to increase the understanding of the link between the ICT and the business activity, both regarding the equipment and internal and external uses, and to the different approaches as well, as far as it concerns the implementation and the repercussions of these digital technologies.

20. Vilaseca, Torrent and Díaz (2002b).

Jordi Vilaseca / Joan Torrent

1.1. DIGITAL EQUIPMENT IN CATALAN BUSINESS

The digital equipment we will analyse refers both to the Internet and to other digital technologies that have a notable presence in the business sphere. In fact, as we will reveal below, the business activity uses a significant quantity of digital applications for production, distribution, exchange and consumption that, even if generally they are completed with the presence of the Internet, it is clear that they surpass the mere digital application of the World Wide Web. Anyhow, all the equipment we will analyse relates to the digital transmission of information and knowledge that definitively allows communication and exchange, both at internal and external company level.

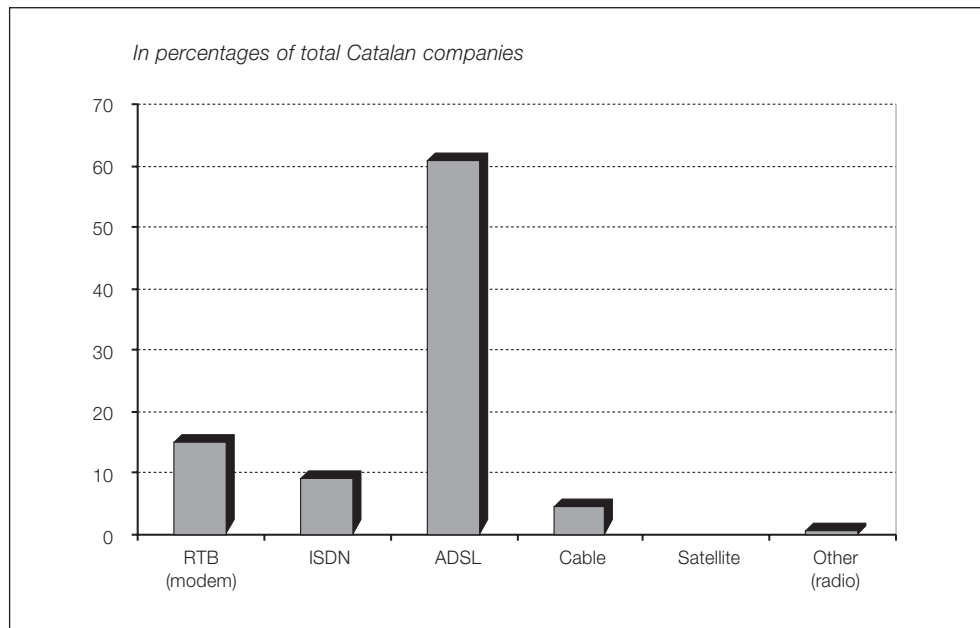
Although owning a cellular phone and a computer gives an initial idea of the digital equipment reality in Catalan companies, studying the Internet connection and the connection type allows a slightly deeper reading of those technologies through which digital communication can be established among the different nodes that structure a company. We will also specify if companies have access to digital equipment allowing them internal communication, such as local area networks, and external communication, such as EDI (electronic data interchange), websites and e-mail.

Most of the Catalan companies use cell phones. Regardless of the size of the firm, 93.2% of companies have cell phones. By business activity sectors, significant differences are obvious, especially in the low technology industry (89.9%), in the medium technology industry (89.8%) and in the less intensive knowledge services (95.6%). Furthermore, 97.3% of Catalan companies have a computer. This high percentage is clearly surpassed by the firms of the information industry and intensive knowledge services. All companies (100%) in these two sectors have a computer. On the other hand, 95.0% of the companies of the low technology sector have a computer, far below of what it could be expected *a priori*, taking into account both the average behaviour of Catalan companies and the weight of this sector within all production activities in Catalonia. In any case, the companies of the medium and high technology industry sectors also have very similar percentages —94.9% and 94.1%, respectively. These data contrast slightly to the corresponding data in the analysis depending on the company size. The percentage of firms with computers is practically the same for micro-companies, small and medium-sized enterprises and large companies. However, the significant result obtained is that all companies with more than ten employees have a computer.

Even though the level of access to the Internet is very high in all Catalan companies —90.9% had an Internet connection as late as last spring— companies of the information industry and intensive knowledge services sectors show significantly higher percentages. Respectively 98.4% and 98.3% of companies in each sector have an Internet connection. On the other hand, the medium technology industry, where only 79.7% of companies are connected to the Internet, shows a lower percentage than other business sectors. At an aggregated level and taking into account the previous levels, the percentage of companies that have a computer but are not connected to the Internet is very low. Since 9.1% do not have a connection and 2.7% of all companies do not have a computer, only 6.4% of compa-

nies do not have Internet access even though they have a computer. As in the case of computers, having an Internet connection does not depend on company size. Although the data analysis shows a certain correlation between size and access to the Internet (as company size grows, the percentage of companies connected to the Internet is greater), there are no significant statistical differences.

Figure 5. Type of Internet business connection



Source: own creation.

Regarding the connection type, practically one out of three companies (67.0% of firms connected to the Internet and 60.9% of Catalan companies) are connected to the Internet via an ADSL connection. The percentage of Catalan companies connected using other broadband systems is very low. Thus, only 5% connect via cable and, as shown in the data obtained, connection to the Internet via satellite is almost imperceptible. Low and medium technology industry sectors show a higher trend for modem (or basic telephone network use) (20.7% and 39.1%, respectively), taking into account that this connection type is chosen by only 16.4% of Catalan companies. For other connection types, ISDN is the third most popular system (10.3%) behind ADSL and the modem.

According to the data obtained, access to computers and an Internet connection do not depend on company size, but when we look at the availability of local area networks (LAN), connected or not to other public or private wide area networks (WAN), these two elements are

Jordi Vilaseca / Joan Torrent

clearly dependent on each other. Companies with more than twenty employees have a greater tendency to use local area networks (between 81.8%, in companies with 20 up to 99 employees, and 90.0% for companies with over 100 employees) than smaller businesses with less than twenty employees (between 51.4% when having from 6 to 9 employees, and 63.5% for companies having between 10 and 19 employees). Internal communication needs, as well as the need to share information among a large number of employees, to ensure that the presence of these technologies is higher in this type of large companies. Therefore it is clear that local area networks constitute a basic tool for internal ICT use, even facilitating network organisation of the business activity. In the same line, not all business sectors have similar percentages of access to local network technologies. Most of the intensive knowledge services companies use local area networks (68.6%) that often allow communication with a specific number of computers located in a defined geographic region. Definitely, these companies can easily organise network tasks, at least, internally. On the other hand, as far as medium-sized enterprises are concerned, only 33.9% have LAN, less than what could be expected according to the aggregated figures corresponding to all Catalan companies. More than half of firms in Catalonia (54.0%) have access to local area networks.

The local area network constitutes the significant element in the network organisation of companies at an internal level, and electronic data interchange systems are used at an external level. Obviously, the network company needs a powerful connection among producers, consumers and suppliers. It should be noted that electronic data interchange systems facilitate the strategic integration of suppliers and customers into the organisation and, in addition, they consolidate all resources used by enabling shared aims and objectives within an overall perspective. This strategic link allows developing synergies for tackling common projects of greater complexity, a necessary requirement to adapt the business activity to the constantly evolving demands of a global nature.

In the same way that the percentage of firms using LAN increases with employee numbers, there is also a similar relationship with the percentage of companies employing electronic data interchange systems with suppliers and customers. While only 29.2% of Catalan companies have access to these systems, in medium and large companies this percentage rises to 46.4% and 66.7%, respectively. In contrast, the penetration ratio in micro-companies and small enterprises is around 30%. If we analyse this variable by activity sectors, the use of these systems that low, medium and high technology industries make is lower than the expected. Around 20% of companies in these three activity branches apply these systems in their organisation, compared to the 36.4% of the information industry companies. Therefore, there is a direct relationship between access to this type of equipment and the network orientation of the today company; both as far as size and activity are concerned.

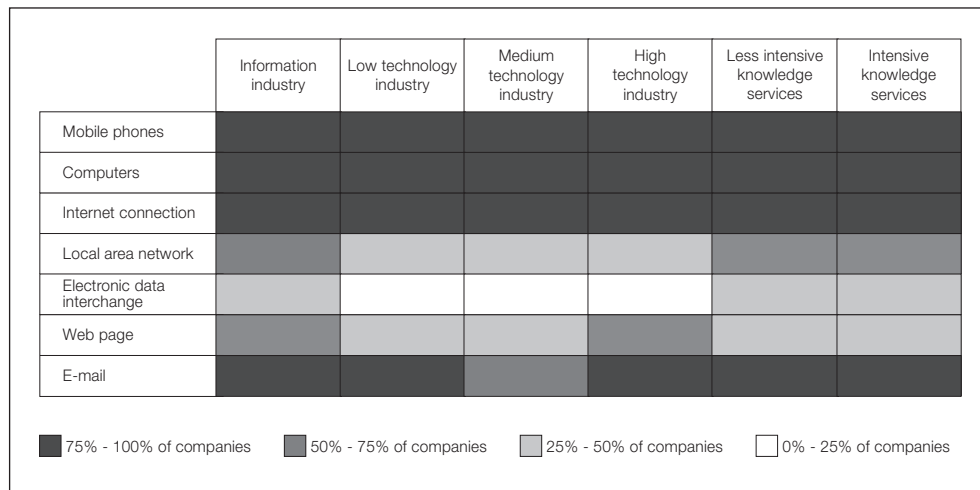
Almost half of Catalan companies have their own website (46.1%). This percentage is also characteristic of the less intensive knowledge services companies (48.2%), due to the weight they represent compared to other sectors. Even though there are small but significant differences among business sectors, it should be stressed that around 60% of Catalan companies of the information industry and high technology industry (60.8% and 55.9%,

ICTs and transformations in Catalan companies

respectively) have an Internet presence through their own website. As in the case of the classification by sectors, the percentage of Catalan companies having their own Internet page practically coincides with the companies with five employees or less (44.1%, compared to 46.1% of all the firms in Catalonia).²¹ As in previous cases (LAN/WAN and electronic digital interchange systems) there is a direct correlation with the number of employees. The greater number of employees, the higher the percentage of companies with own website. Thus, for example, 88.9% of companies with more than one hundred employees have their own website. In contrast, micro-companies return a website ownership percentage of 44.1%.

Apart from electronic data interchange systems (EDI-type) and websites, e-mail is another option available to communicate and interact both internally and externally and it reaches the vast majority of the firms in Catalonia. It is striking that 87.4% of companies have e-mail, which is very close to the percentage of companies connected to the Internet (90.9%). Regardless to the number of employees, most of the firms have e-mail, a fact that does not occur in the case of electronic digital interchange systems (EDI-type) and websites. By activity sectors, the percentages are similar and also very close to the Catalan average. Over all, information industry and intensive knowledge services companies prefer having e-mail, bearing in mind their weight in comparison with other sectors (95.4% and 95.0%, respectively). Low technology (80.6%) and medium technology (69.5%) industries are at the other extreme.

Figure 6. Digital equipment in Catalan companies by economic activity branch

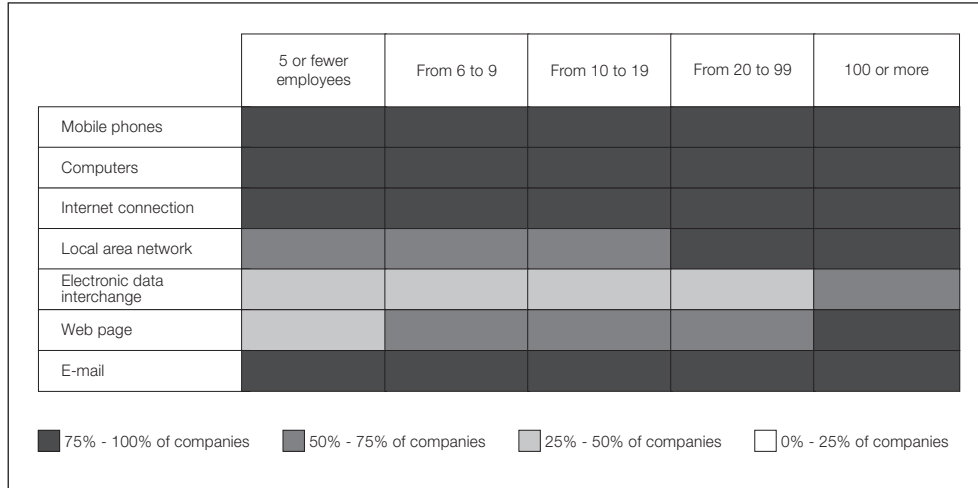


Source: own creation.

21. This size has a more significant weight compared to others: the 51.9% of Catalan companies are micro-companies with five or less employees.

Jordi Vilaseca / Joan Torrent

Figure 7. Digital equipment in Catalan companies by company size



Source: own creation.

Lastly, among the reasons that companies give for not having a website or e-mail—that is, the fact of not using the Internet as a possible channel to interact directly with suppliers and customers—it should be highlighted that the main reason is that they do not need it. In fact, 77.4% of companies that have neither website nor e-mail give as a reason for not having them, that they do not need them. This is an argument mainly used by the low technology industry (97.0%) and the less intensive knowledge services (74.0%), as well as by companies with more than one hundred employees (77.7%). Other reasons—such as still being in the construction phase or the lack of finance—are cited by 11.0% and 9.4% of Catalan companies, respectively.

1.2. ICT USES

After analysing the digital equipment in Catalan companies, below we will look at the results of uses made of this equipment. If, by company, we understand the organisation and combination of certain resources to achieve a specific objective, the interpretation of the elements in the business activity value chain as well as the influence the ICT use has on them are absolutely essential in order to understand the transformations in the Catalan firms. After a general description, we will divide the ICT use analysis in two parts. The first refers to internal and the second to external ICT uses. Even though we will analyse these uses separately, we should bear in mind that the emergence of ICT breaks with the classic limit of decentralisation of the activities and allows a design based on the network interconnection of all the elements

of the value chain. We must not lose sight of the fact that this interconnection enables us to view the company as a network. The first group encompasses the value element activities in marketing and after sales services as well as in organisation and human resources. This first group corresponds to one of the primary activities, which puts means to purchasers, such as advertising, through which they can purchase the product, or feel induced to do so. Related to marketing, service activities and service offers to maintain or increase product value are included in this group of internal uses. Lastly, internal uses also include value elements relating to the organisation and management of human resources. The external uses group includes the activities of the operations value elements, all the primary activities of production, supply and distribution. In this section we analyse the ICT use in those activities associated to goods delivery, warehousing and availability of raw and semi-finished materials for the productive activity. On the other hand, it also deals with the digital use of production activities associated to the transformation of resources into finished products.²² Lastly, a reference to warehousing and distribution activities of the finished product is made.

1.2.1. General uses

The main uses the firms in Catalonia make of information and communication technologies (ICT) are management, administration and accounting tasks. The 44.4% of companies mention these tasks, compared to other options, such as principal digital uses. Next, 29.3% of Catalan companies declare using digital technologies, especially the Internet, to obtain information, while an additional 27.4% employ it in their relationship with customers and suppliers. Communication is a fourth significant element. This use is cited by 23.4% of Catalan firms. Therefore, at first sight, Catalan companies use digital technologies in production to become more efficient in internal administrative tasks and to improve their external relations through the communication, particularly with the customers in general, with the two external agents most directly linked to the business activity: customers and suppliers. Furthermore, these two uses, one internal and the other external, are integrated or interrelated through another important function of ICT: obtaining information.

Apart from these four major digital use options, there are many less significant applications, which also play their role in the progressive consolidation of the network company through the use of the digital business. Obtaining permits and banking administration lead the second use group, employed by 15.2% of Catalan companies, followed by e-mail (13.3%), marketing and website (6.9%) and internal communications (6.6%). Therefore, ICT are a basic work tool for 15.6% of Catalan companies, a statistic that gives us an idea of the

22. Strictly following Porter's (1985) layout of value elements, business activities related to production would correspond to a primary activity, which could be associated to an internal use, from an ICT use perspective. Likewise, the network conception of the business activity is closely linked to the productive activities and its two immediate external uses: supply and distribution. In order to contrast this link, this research has considered that it is worth to treat these production activities from the point of view of external ICT uses.

Jordi Vilaseca / Joan Torrent

progressive implementation of the digital business in the Catalan economy. Definitively, all the data seems to indicate that the main ICT uses in business are aimed to facilitate the development of all those activities providing support to the entire value chain. In this sense, ICT would be an appropriate service instrument for improving the productive efficiency by reducing routine tasks.

By sectors, concerning the main productive use of ICT —the support of the infrastructure value element—, this application is only considered as a main use by 24.0% of companies of the information industry. In contrast, the information industry does consider communication with customers and suppliers (34.2%) and obtaining information (38.0%) as important digital uses. This pattern is also shared by the high technology industry and the intensive knowledge services, which behave fairly similar (33.3% and 40.7%, respectively). The 35.1% of these companies mainly use ICT for communication and 31.9% to obtain information. Lastly, regarding the ICT use as a basic business tool, we should stress once again that the information industry and the intensive knowledge services follow more differentiated patterns, clearly surpassing the Catalan average (25.6% and 28.2%, respectively). On the other hand, all main uses given by the surveyed companies did not show any connection with the size of the company, except for the digital use in internal communications. Even if the Catalan average is situated at 6.6%, 33.3% of large companies (with one hundred or more employees) use ICT mainly for aspects related to internal company communications.

Table 1. Main business uses of ICT

In percentages of total Catalan companies	
1. Management, administration and accounting	44.4%
2. Obtaining information	29.3%
3. Customer/ supplier relationships	27.4%
4. Communication	23.4%
5. Basic work tool	15.6%
6. Procedures, banking and financial operations	15.2%
7. E-mail	13.3%
8. Marketing and web pages	6.9%
9. Internal communications	6.6%

Source: own creation.

1.2.2. Internal uses

As above mentioned, this section looks at ICT uses in the scope of marketing and after sales services, and human resources and organisation. In both cases, apart from providing a full

description of percentages of use at both aggregated and disaggregated levels (by business sectors and company size), we will describe the main reasons for not having implemented the corresponding technologies. Finally, we will analyse some aspects dealing with security within the company related to the information it generates and administrates. Security copies of information generated, anti-virus programs and emergency computer plans are key aspects in order to foresee the effects of any incident occurring in the company, as well as being a good indicator of the commercial predisposition towards the digital business.

The incorporation of ICT into marketing and marketing research can improve consumer knowledge, so that the latter can be incorporated more rapidly into new product creation. Therefore, improvements in information and knowledge flow management allow greater efficiency not only in the research of a constant changing demand, but also in the very internal functioning of the marketing area. Thus, in terms of this area, 22.3% of Catalan companies use an integrated system, such as CRM, to obtain and manage information generated through the company's contact with potential or current customers. By sectors, the low technology industry and the medium technology industry present significantly lower percentages (10.4% and 13.8%, respectively) of what it could be expected considering the weight they represent compared to the whole Catalan economy and the average of all Catalan firms. In contrast, less intensive knowledge services reflect a significant high participation in these customer-orientated digital systems (28.1% of companies).

Moreover, according to the results obtained these systems show a trend to be more used by medium-sized and large companies (40.0% and 55.6%, respectively). On the other hand, with percentages hovering around the Catalan average, small enterprises and micro-companies do not have the same propensity to use them. Likely, the volume of information generated through the company's contact with customers is significantly lower in smaller companies than in the larger ones.

In the same line, 67.6% of companies that do not have CRM-type systems argue that the main reason for not having them is that they do not need them. This percentage is significantly higher, rising to 78.7% in the low technology industry sector. The company type (14.5%) and the customer profile (5.3%) are other reasons that justify companies not having applied any system for working with all the information related to the contact with customers.

ICT use is more widespread in the other internal area of the company's value chain, which is the organisation and human resources. The vast majority of Catalan companies (82.7%) use operational systems for accounting and invoicing, such as Contaplus, Contawin, Facturaplus, among others. However, the use of other systems and equipment more sophisticated is not generalised, and its use becomes more specific depending on the sector and the company size. For example, approximately one out of three companies (31.9%) has a wage payment system that uses ICT. The implementation and utility of these systems are strictly related to company size. In most cases the organisation of medium-sized (64.3%) and large (88.9%) companies needs their use, in contrast with the micro-companies, of which only the 29.6% has these systems. Lastly, 37.1% of companies with more than six employees and less than nine have them, and so do the 50% of the rest of small companies.

Jordi Vilaseca / Joan Torrent

Even though we previously saw that the percentage of companies considering internal communications to be a main ICT use only represents 6.6%, the 15.5% declare having internal communication systems. This percentage also contrasts with the fact that the most of the companies are prepared to acquire internal communication systems (we have also seen that 54.0% of companies initially used local/wide area networks: LAN/WAN). Once again this element is closely related to company size. The 80% of direct communications in large companies use internal communications systems. In these large companies, the direct communications established by the generalised use of internal communication systems offer the possibility to organise multidisciplinary working groups, variable and specific depending on every business project. In conclusion, they make easier the network tasks inside the business organisations. On the contrary, most of the medium-sized companies (47.3%) and those with 10-19 employees (30.1%) still do not have these internal data transmission systems, even though there is a growing tendency as company size increases. In fact, micro-companies are right at the opposite extreme, close to the Catalan average (13.4%).

Although information management is very important in the company organisation and strategy, since it promotes direct communication with very low transaction costs, only 11.7% of Catalan companies have data management programs or systems (Datwarehouse) or information exploitation tools (Data mining, OLAP). The rest of human resources' systems studied are minority systems in Catalan companies. The 6.5% of Catalan companies use a management information system (EIS) and 5.2% have integrated management systems. Anyhow, it should be stressed that these three applications are clearly present in companies with more than 100 employees (77.8%, 55.6% and 44.4%, respectively), with percentages substantially higher than the Catalan average. Moreover, a significant higher use can be observed in the case of the intensive knowledge services (12.4, 7.8 and 6.6%, respectively).

The two main reasons given by companies for not having any of the equipment above mentioned, in reference to ICT use in the area of organisation and human resources, are that either they do not need it or that they have the corresponding service externalized. Regardless of the business sector and its size, 45.4% of Catalan companies state that an external company provides them with the associated service, and 45.0% affirm that they do not need any of these systems.

A highly important element in organisations is the capacity to manage the information they generate. Thus, the capacity to make security copies of this information using the ICT becomes essential for guaranteeing the efficiency and the efficacy of this management, so that any incidence can be foreseen. Even though 91.1% of Catalan companies periodically make security copies of their relevant information, only 39.4% store them outside their own company. By size, even though large companies manage greater amounts of information, most of them store their security copies outside their habitual company site (66.7%). By sectors, companies of the medium technology industry are those which somehow assume greater risks, since only 30.0% place their security copies externally, a percentage that contrasts with the 41.2% of companies of the intensive knowledge services.

Apart from security copies, the fact that most of the companies are connected to the Internet (90.9%) and have access to e-mail (87.4%) mean they also take other measures to avoid the possible destruction or corruption of their information, produced in the communication through ICT. Therefore, anti-virus programs constitute a basic tool. The vast majority of companies use updated anti-virus programs (86.8%). However, it should be noted that this percentage increases up to 94.7% in the intensive knowledge services business sector, which means that all large companies react positively to this contingency.

Even though the most of the companies make security copies and use updated anti-virus programs, it should be mentioned that only 35.1% of Catalan companies have at their disposal an updated emergency computer plan to cover any incident. The sectors with few companies possessing emergency plans are the low technology industry and the intensive knowledge services, with 29.4% and 26.4%, respectively. At the same time, more than half of medium-sized companies and 77.8% of large companies declare having planned this contingency.

1.2.3. External uses

At the beginning of this research we said that the consolidation of the network firm especially starts from the possibility of decentralizing the economic activity to such a point that the company could have as many business lines as the number of products/services commercialised. This strategic option entails two requirements. Firstly, an organisational requirement; that is, a change in the organisation of overall business activities to respond to this new production focus. Secondly, there is the technological requirement. Actually, e-business is built upon a technological possibility: an intensive use of ICT. The operational area is precisely the value element in which production decentralisation must be clear, since it is in production where internal elements relate to the closest external agents, such as suppliers and customers. The analysis of ICT use in this area will allow us to confirm to what extent companies use digitalisation processes to consolidate a network inter-relationship of all components. Particularly, in the operational area, an external ICT use means that supply and distribution activities (whether considered part of the demand or the supply) surpass the classic conception focused on making the necessary resources available to the production system. Thus, the knowledge economy gives a new meaning to this function, integrating all different business units with a high degree of strategic relationship (and even participating in their design).

This section will focus on the ICT uses within the operational area of the firms in Catalonia, that is, in the scope of production and of immediate external relations: suppliers and customers. In both cases we have detailed usage percentages at an aggregated and disaggregated level (by business sector and company size) and we will look at the main reasons the companies give for not having implemented the corresponding technologies. In the operational area, 26.6% of Catalan companies have a production planning system and, if

Jordi Vilaseca / Joan Torrent

applicable, a system for planning the service offer through ICT. The low technology industry is the sector with the greatest tendency to use computer programs and telecommunications networks (32.6%) for planning this production activity. In contrast, medium technology (17.2%) and intensive knowledge services (23.4%) companies reflect a lower percentage to the expected if we take into consideration their importance in the overall Catalan economy and the average behaviour of Catalan companies. It is also worth mentioning that the information and the high technology industries show slightly higher participation levels than the Catalan average. If the complexity of production activities in the larger companies is more important, it should necessarily imply greater ICT use in order to plan the production in the most adequate way to the reality of every company. The data obtained confirm this association, since there is a clear correlation between company sector and company size. Therefore, while micro-companies (25.3%) and small enterprises (between 25.7% and 37.0%) in some cases have software and hardware and communication networks to plan production, most of the medium-sized and large companies do have these information and communication systems. Almost half of medium-sized companies (47.3%) and a great number of large companies (77.8%) have them as well.

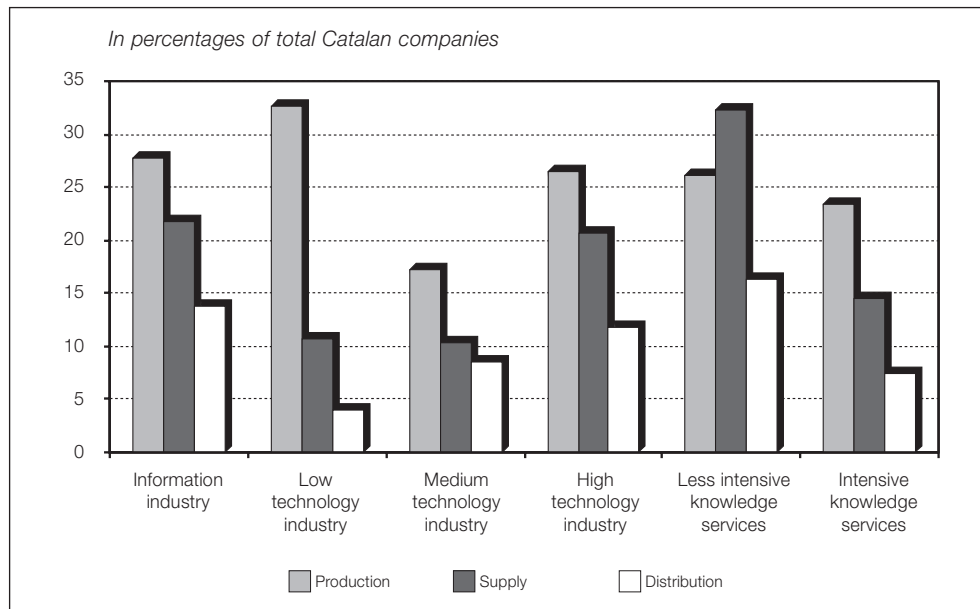
Regarding to supply activities, it should be noted that the ICT application ratios are very close to those reached in the scope of operations. Therefore, 23.5% of Catalan companies have a digital system for external planning with suppliers. By sector, the medium technology industry (10.3%) and the intensive knowledge services (14.5%) show a fairly similar pattern to the one of production activities. In other words, they reflect percentages that are significantly lower than the Catalan average. Instead, and contrary to the previous situation, the low technology industry is also placed clearly below other companies in Catalonia (10.7%). Finally, the less intensive knowledge services (32.3%) is the sector with the greatest tendency to make its purchases through a computer programme and telecommunications networks. Even though in terms of size there is not such a direct relationship as in production activities, since company size does not influence the percentages obtained in each option, most of the large companies (55.6%) have computer and communication systems with which they develop their supply activities. Other companies are situated around the Catalan average.

Lastly, the third activity in the area of operations to be analysed is related to distribution. ICT use in this value element is lower than in production and supply activities. The 11.9% of Catalan companies use an external planning system with distributors through computer programs and communication networks. As in the case of supply, the less intensive knowledge services (16.3%) is the sector with a significant higher percentage of ICT use in distribution. In contrast, the low technology industry is situated at a very low (3.9%) level. Regarding to company size, the data obtained suggest a similar pattern to the analysed for supply activities. Even though size does not significantly influence ICT use in distribution, larger companies have the highest percentages (33.3%).

On the other hand, the main reason why the most of the Catalan companies have neither computer programmes nor telecommunications networks to carry out production, sup-

ply and distribution activities is that they do not find them necessary. That is the main reason stated by the 58.8% of the firms that do not have these systems. The 16.7% of companies cite the type of product (or service) as another reason, especially the firms of the intensive knowledge services sector (35.1%). A further reason for not having these systems is company size (10.3%). Since only micro-companies and small enterprises mentioned this last reason, it can be understood that these systems are especially useful for medium-sized and large companies. Most of them have these systems. Finally, the economic situation (2.8%), the fact of preferring the use of alternative procedures (2.2%), the type of suppliers (6.2%) and the fact of being in this study phase (4.0%) are other reasons which explain why no computer and telecommunications systems have been applied in the scope of operations.

Figure 8. Business uses of ICT in the operations area



Source: own creation.

1.3. ATTITUDES TOWARDS ICT

The idea of strategic and organisational change in companies can only be understood if there is a cultural change at an internal level. We already commented that networking is the basic organisational form of the knowledge economy and that the consolidation of the network firm goes through an internal cultural change towards this new organisational form. A way to contrast this new company attitude is its predisposition to ICT uses. In this section,

Jordi Vilaseca / Joan Torrent

we will go through these attitudes, both personal and those referring to the company and to the environment, insofar as ICT uses are concerned.

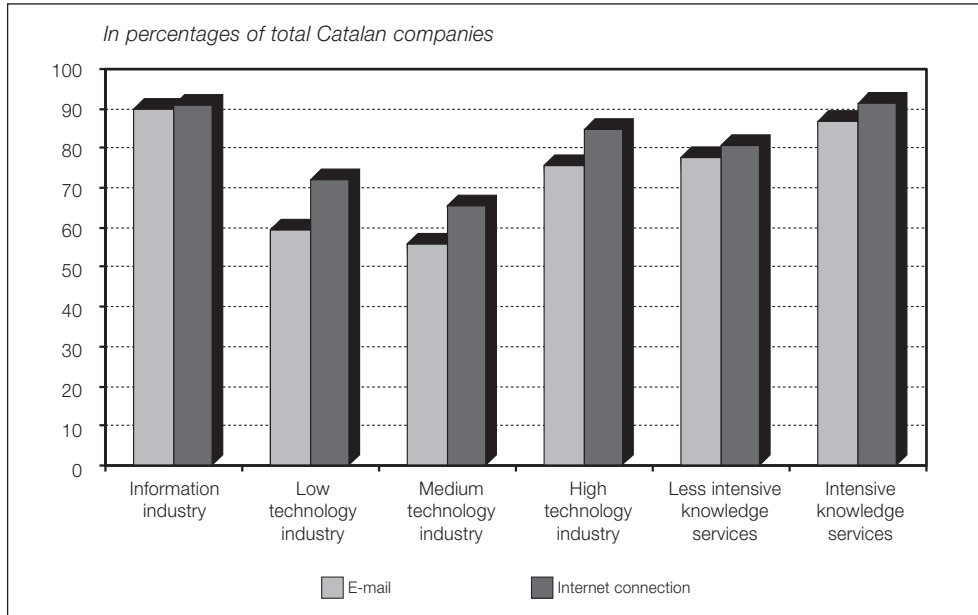
1.3.1. Personal attitudes

This section deals with the personal attitudes towards ICT. We will analyse how firms use the ICT, professionally and individually speaking, both at executive personnel and support personnel levels. This double approach allows us to have an idea about the extent of this normal use in the development of professional tasks.

When studying the equipment we have seen that the vast majority of the firms in Catalonia have access to e-mail (87.4%). Regarding the habitual use (in the last week) of e-mail, the persons in charge of the companies, responsible for answering the questionnaire, stated in 76.3% of the cases that they had sent and received e-mail messages within the previous week. In the case of having support personnel (secretary), the 84.8% answered that they had also sent and received e-mail messages in the previous week. Therefore, almost all Catalan companies with access to e-mail use it habitually, both to send and to receive electronic messages. Among the companies with e-mail access, there are no significant differences depending on the different activity sectors. Nevertheless, the information industry has the highest use percentage at an executive level (92.8%). On the other hand, low technology and medium technology industries show slightly lower percentages, 70.9% and 70.2%. Among companies with support personnel (secretary) common use of e-mail is especially high in the intensive knowledge services sector (90.3%).

The percentages decrease when looking at slightly more sophisticated ICT uses. Even if habitual use of e-mail is reasonably high, only 52.4% of managers transferred files electronically during the week previous to the survey date. Considering only the companies to which the question was pertinent (companies with access to some electronic system by which they can send digitalised information in file format), the information industry, the high technology industry and the intensive knowledge services (67.5%, 66.6%, and 66.0%, respectively) are the sectors where more companies often transfer files electronically. As in the previous case, low and medium industry companies reflect the lowest percentages (40.5% and 51.1%, respectively). Asked about whether their support personnel usually used ICT to transfer files electronically, the percentage of company responsables who answered the question affirmatively increased significantly in comparison to the value obtained at executive level. The support personnel of 68.5% of the Catalan companies (employing support personnel) had transferred files electronically in the last week. Even though the Catalan average is reasonably high, it should be noted that the low and medium technology industries have a percentage of use of 55.9% and 55.2%, respectively. Other sectors report values close to 70%.

Figure 9. ICT use by Catalan entrepreneurs



Source: own creation.

From the equipment perspective, it was seen that the Internet access level is very high in all Catalan companies: 90.9% have access to an Internet connection. However, to what extent is the Internet connection used individually? The 89.8% of managing directors of Catalan companies with Internet access had connected during the week prior to the survey date. Company support personnel had accessed in 84.5% of the companies. These results are very similar to those obtained in the case of e-mail use. Therefore it can be concluded that regardless of the size of the company and the activity sector, most of the managers and the support personnel (more than 75.0% of the cases) in Catalan companies habitually use e-mail (to send and receive messages) and connect to the Internet. However, it should be pointed out that companies in low and medium technology industries report slightly lower percentages.

On the other hand, the use of the video-conference as a communication tool by Catalan companies is extremely marginal. Only 1.6% of managers interviewed connected via video-conference during the previous week to the survey date. Only 2.1% of the support personnel of the companies with adequate equipment use regularly the video-conference. Therefore, the video-conference is not a commonly employed instrument by the management and the support personnel, comparing to the uses analysed above, much more extended in Catalan companies.

Jordi Vilaseca / Joan Torrent

1.3.2. Attitudes related to companies

After analysing the individual uses of ICT by management personnel, below we will look at the advantages and drawbacks that their productive use generates in Catalan companies. In accordance with the data obtained, one of the main advantages of using ICT is the ease and the speed in management, according to 72.1% of Catalan companies. This first advantage, strictly linked to the main business use of ICT (44.4% of the Catalan firms use them for management administration and accounting tasks), shows that the productive application of ICT and its advantages are based on the support of the infrastructure element of the value chain. At first, it should allow a discharge of administrative load of work from some of its most routine tasks. The other advantages mentioned are not all shared by the majority of Catalan companies. Despite this fact, to facilitate the access to information (35.8% of companies) and being a step forward in improving quality and control (22.0%), are the two most often referred advantages.

Among the rest of the advantages mentioned, it should be stressed the cost reduction (17.5%), since in a certain manner it is closely related to the three previous advantages. This is one of the most significant issues of the new organisational models emerging from the ICT integration into companies. The automation of information processes (associated to the first three advantages stated above) allows an optimization of cost structures, displacing fixed costs towards variable costs and reducing management costs.

Table 2. Main perceived business advantages of ICT

In percentages of total companies	
1. Ease and speed of management	72.1%
2. Access to information	35.8%
3. Improvement in quality and control	22.0%
4. Cost reduction	17.5%
5. Facilitating communication	14.0%
6. Increase in reliability and security	13.4%
7. Comfort	12.0%
8. Modernity and innovation	10.7%
9. Business expansion	10.3%
10. Improvement in production	9.9%
11. Process automation	9.4%
12. Provides flexibility and autonomy	9.2%
13. It is a fundamental tool	9.0%
14. Increases of competitiveness	7.9%

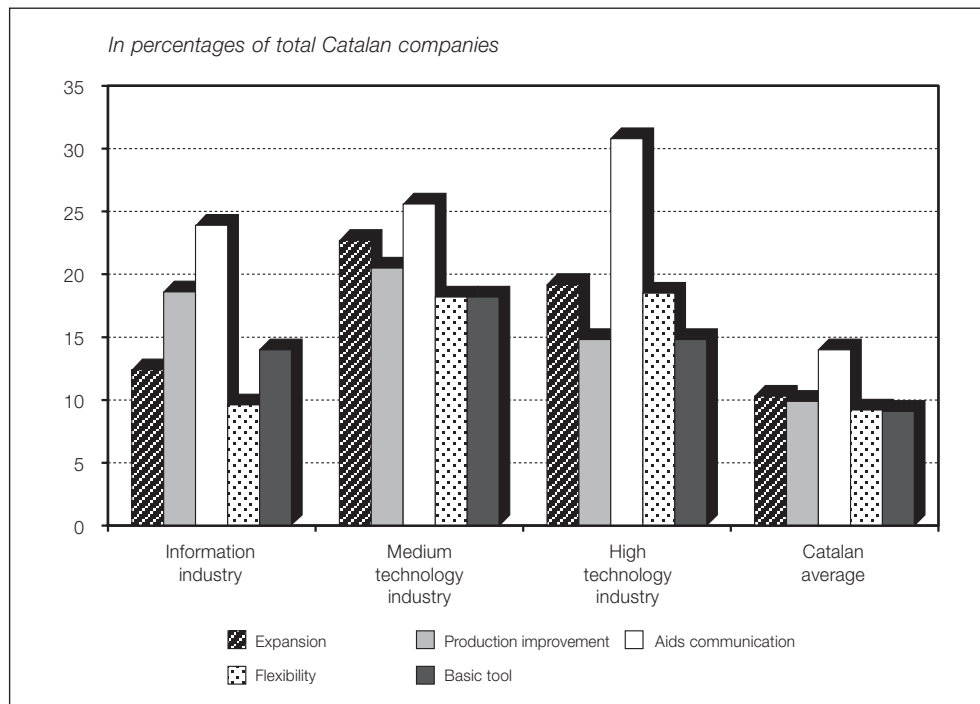
Source: own creation

The perception of advantages of the ICT is not homogeneous among sectors. In fact, even if the medium technology industry and the intensive knowledge services (with percent-

ages close to 80%) perceive this support of the infrastructure element as the most important of all ICT uses, this percentage drops to 59.6% of companies in the information industry. Thus, we can affirm that as the economic activity intensifies technology or knowledge use, the perception of ICT as a fundamental instrument for developing the economic activity increases. Actually, the information industry and the medium and high technology industries are the production sectors that perceive most intensively the synergic effects of the ICT in productive development. The 12.4%, 22.7% and 19.2% of companies in these three sectors perceive digital technologies as an essential tool for business expansion (compared to 10.3% of all Catalan companies), while 18.6%, 20.5% and 14.8% stress that ICT are an important tool for improving production (9.9% of the Catalan average) and 14.0%, 18.2% and 14.8% of companies in the information industry and medium and high technology industries see ICT as a fundamental business tool (9.1% of the Catalan average).

The pattern explained above can also be approached in accordance with the company size. As a company gains employees, the advantages are stressed more often by interviewees. There is a direct correlation between variables. Advantages are mentioned by around 10% of micro-companies. In contrast, this percentage increases progressively up to the 50% of large companies.

Figure 10. Some advantages of ICT, by activity sector



Source: own creation.

Jordi Vilaseca / Joan Torrent

Among the most often-mentioned drawbacks when using ICT for business, there are the system errors or other technical problems (22.3%), as well as those drawbacks caused by extreme dependence on computing, and by its linked undergoing changes (21.2%). While the first drawback is shared in similar percentages by all business sectors and all company sizes, dependence on computers is quoted more often by companies of the information industry (31.4%), high technology industry (36.8%) and intensive knowledge services (31.7%) sectors. Clearly, the heavy dependence of these companies on computing means they consider it as a significant negative factor. Among other referred drawbacks, at least for 10% of companies mentioning one, three drawbacks are stressed. Lack of training is mentioned on the first place. A drawback for 13.8% of companies is the need of certain qualified labour level to use appropriately ICT in the company and take benefit from it. The sectors that most often quote this factor are the low technology industry (22.2%) and the medium technology industry (18.5%). In contrast, companies of the intensive knowledge services sector (7.8%) are less concerned about this drawback.

Secondly, it stands out the lack of security and quality guarantees (12.5%). Similarly, the fact of not perceiving ICT as safe systems providing a minimum quality level is a main drawback of ICT use in all sectors and company sizes. The third and last drawback is the cost that using ICT involves. The 11.0% of companies that quote any ICT use drawback consider that its cost (telecommunications, computer systems and other general equipment) is a significant drawback. Once again, the sectors that show the highest dependence percentages on ICT are the information industry (17.4%), the medium technology industry (18.5%) and the high technology industry (15.8%). On the contrary, companies of the intensive knowledge services, who are clearly dependent on ICT and its use, only mention this drawback in 9.9% of the cases.

Table 3. Main perceived business drawbacks of ICT

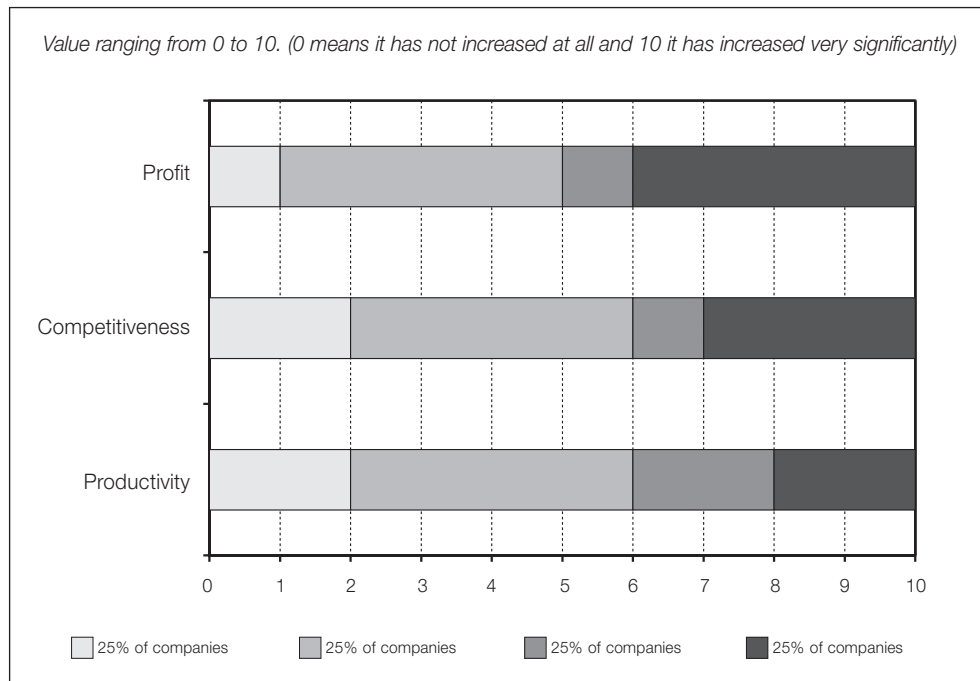
In percentages of total companies	
1. System errors and other technical problems	22.3%
2. Dependence on computers	21.2%
3. Lack of training	13.8%
4. Lack of security and quality guarantees	12.4%
5. Cost	11.0%
6. Rapid technological advance	8.0%
7. Loss of aptitude and personal contact	7.7%
8. Lack of co-ordination between senders and receivers	6.9%
9. Excess of information	6.4%
10. Slowness of the system	5.8%
11. Lack of assessment	1.5%
12. Increase in competition	1.0%
13. Loss of jobs	0.9%
14. Subordination to commercial criteria	0.9%

Source: own creation.

After analysing the main advantages and drawbacks of ICT use in firms, we will focus on certain specific aspects more directly related to company organisation and strategy. Next we are interested in the influence of ICT on productivity, competitiveness, profits and labour relations in Catalan business. To analyse the impact of digital technologies on these four elements we will study the perceptions of its use. Specifically, we asked how this influence is valued. In order to measure this influence, we used a scale of 0 to 10, where 0 means «It has not increased at all» and 10 «It has increased very significantly». In the figure below we have situated the quartiles obtained for each question at an aggregated level; that is, without taking into account the different sectors or company sizes.

By using this scale from 0 to 10, the surveyed companies, as a representative sample of the whole Catalan economy, value the influence of ICT on productivity increase with an average of 5.3 points. The 25% of companies consider that the productivity has not increased at all, or the increase has been insignificant (valuing it as 2 or less), while another 25% consider that there has been a significant or a high significant increase of productivity (valuing it as 8 or more). The resting 50% consider there have been increases (even though not very significant) in productivity due to ICT use.

Figure 11. Perceived influence of ICT on certain business results



Source: own creation.

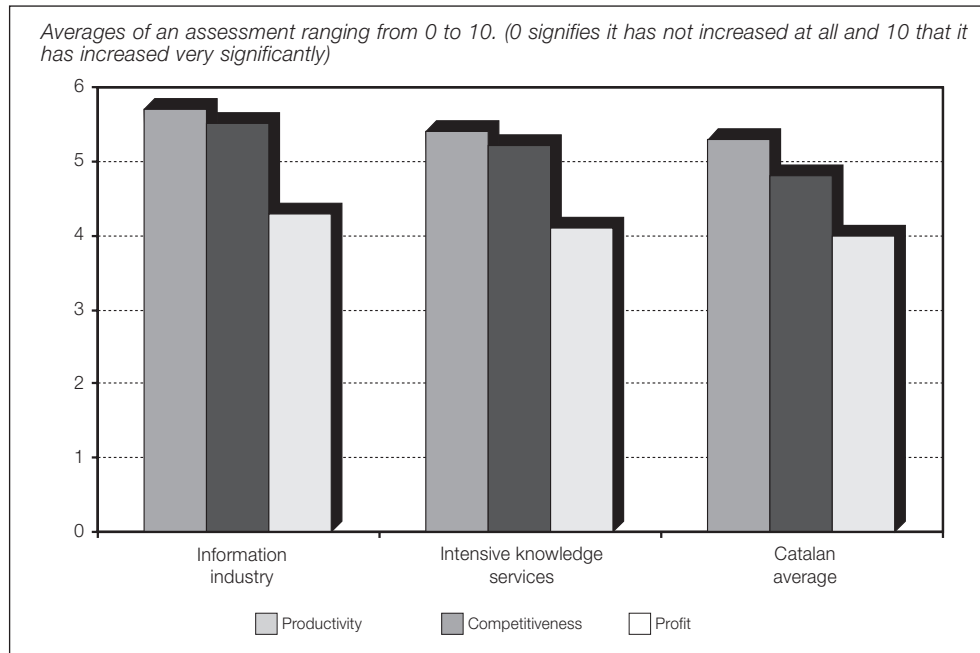
Jordi Vilaseca / Joan Torrent

Even though all the assessments approach the value of 5 points, there are significant differences depending on business sectors. The companies of the information industry (5.7 points) and service companies, both less intensive (5.5 points) and intensive in knowledge (5.3 points), have a greater perception that ICT have increased productivity. In contrast, the rest of the industry does not have such a clear perception of a significant increase and its average assessment rounds the 4.5 points. Despite large companies value the increase in productivity significantly higher (6.9 points), by company size there are not significant differences between the groups. Nevertheless, this high appraisal is not reflected in the corresponding statistics, due to the weight of these companies respecting to the total number of companies in the whole Catalan economy.

As far as competitiveness is concerned, the results are very similar to those of productivity. Using the same scale from 0 to 10, where 0 equals minimal impact and 10 a high relevant impact, Catalan business values it in 4.8 points. On the one hand, 25% of companies consider that either the competitiveness has not increased at all or there has been an insignificant increase (valuing it as 2 or less). In addition, the percentage of companies considering there has been a significant or a high significant increase (valuing the competitiveness as 8 or more) drops to the 10%. The remaining 65% of the companies consider there has been some increase in competitiveness due to ICT use. By sectors, the information industry and the intensive knowledge services consider that ICT have had the greatest influence on an increase in company competitiveness (5.5 and 5.2 points, respectively). Concerning the rest of the sectors, low technology (4.3 points) and medium technology (4.2 points) industries give the lowest value. As in the case of productivity, most of the large companies, with 6.4 points, consider that ICT have influenced the competitiveness and increased it significantly. As far as companies with less than 100 employees, they are clustered around 5 points.

In contrast to the two previous business results, the effect ICT in increasing profits is considered significantly lower: the perception of Catalan firms is placed at 4.0 points. Only 5% of Catalan companies value the increase in profits from ICT use as highly significant (greater than 8). In any case, it is important to state that 50% of Catalan companies value the profit increase generated by ICT use over the 5 points. The resting 25% of the companies value it at less than 1. Therefore, a quarter of companies consider that ICT have hardly increased their profits at all. Furthermore, there are no significant differences either between sectors or between sizes.

Figure 12. The perceived impact of ICT on certain business results, by activity sectors



Source: own creation.

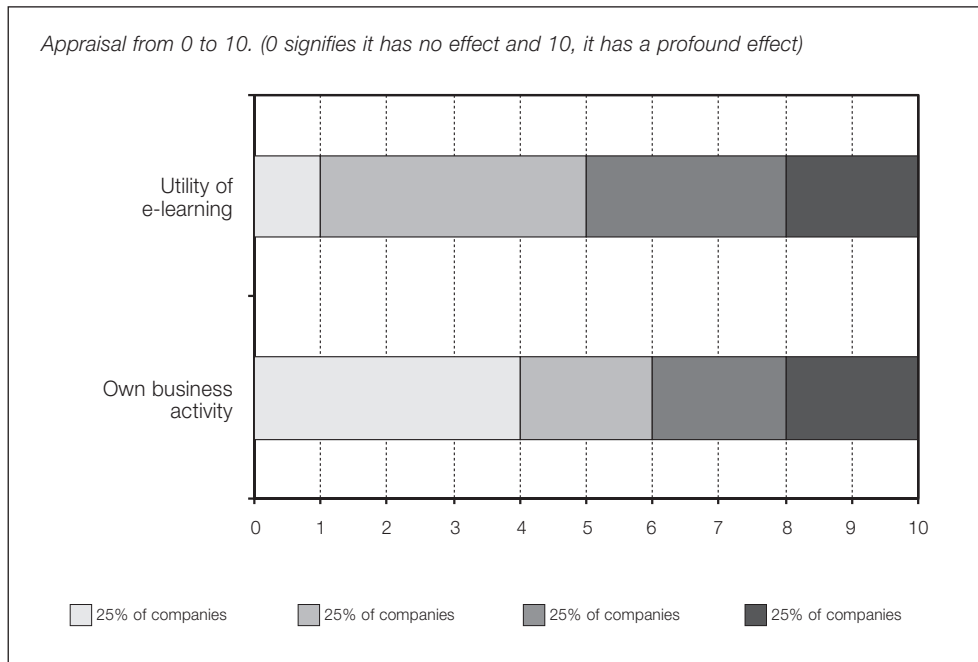
One of the main labour transformations in the company as a result of ICT use is the progressive individualisation and personalisation of relationships between employers and employees. The working flexibility and the diversity in working conditions influence the individualisation of the employees' treatment, according to their aptitudes and attitudes. Although the average of Catalan companies (1.9%) considers that ICT practically do not allow a more individualised relationship with employees (in fact, 0 is the value mentioned by 50% of companies), depending on company size and sector there are some significantly higher appraisals. By sector, the information industry, the less intensive knowledge services and the intensive knowledge services provide a significant higher value, in spite of being fairly low (around 2 points). However, in the analysis by size there are significant differences. There is a clear correlation between employee numbers and the extent to what ICT allow a more individualised relationship with employees. Clearly, in companies with more employees it is more difficult to treat them individually in a face-to-face relationship. In this sense, ICT help these companies to reach each employee in a personalised way. Therefore, while micro-companies and small enterprises place a low value on the influence of ICT in individualised working relationships (between 1.8 and 2.2 points, respectively), medium-sized and especially large companies have a much more favourable perception (3.1 and 5.2 points, respectively).

Jordi Vilaseca / Joan Torrent

1.3.3. Attitudes related to the environment

Previous sections focused on how the emergence of ICT and how the progressive generalisation of its uses are being used as a tool to adapt production, making it flexible enough for a changing global demand. In that respect, it is important to note that to empirically capture transformations in a company—an interrelated combination of strategy and organisation—is necessary to consider not only the changes of the organisational model, but also the changes of the own business activity. Consequently, and following the description of companies perceptions, below we will analyse whether firms hold the view that ICT have modified the economic and business activity (in general) as well, and whether this transformation has had any impact or incidence on the own business activity (in particular).

Figure 13. The impact of ICT on business activity



Source: own creation.

From the data obtained it can be seen that the most common perception within Catalan companies is a business transformation based on ICT use. Regardless of the business sector and the company size, 89.2% of firms consider that ICT use and implementation transform the business activity. In contrast, there are significant differences between business sectors when measuring the influence of these transformations on the own business activity.

On a scale from 0 to 10, where 0 signifies «It has no effect» and 10, «It has a profound effect», the average value given on the previous statement is 5.9 points. The 25% of companies value it above 8 points, as these changes highly influence their business activity. In fact, 75% of companies give a value above 4 points. By sector, significant differences can be appreciated. The changes, due to the use and the implementation of ICT, undergone by the information industry, have considerably influenced (7.1 points) its business activity. In the services sector, both intensive and less intensive in knowledge, there is a significant influence (6.0 points) as well. Other industries give lower valuations (under 5.7 points).

On the other hand, the role of individuals and their knowledge, as new competitive elements in organisations, are a priority for understanding the changes produced by an intensive use of ICT in companies. In that respect, training is the key element allowing an accurate association of individuals to knowledge. In the knowledge economy, work requires particular educational levels, linked to a greater flexibility in order to get adapted to the needs of the moment. This need leads us to continuous trainings as a valid tool to provide a working environment with the necessary attitudes and aptitudes to cope with the changing production. For this reason, this research has questioned the utility of virtual training (e-learning) as an educational modality for companies' needs.

Indeed, e-learning is a training modality within the reach of companies that intensively use information and communication technologies that allows training of both the individual and the workstation. Although the frequency of this option is growing over the time, the average value mentioned by Catalan companies does not surpass the 5 points. It remains at 4.5 (on a scale of 0 to 10, where 0 means «Useless» and 10 «Extremely useful»). Around the 25% of Catalan companies consider that e-learning is almost useless. Only 10% of firms consider it extremely useful for their organisation. By sector, the industries that provide a significant higher value of the utility of e-learning are the high technology industry, with 5.5 points, and the information industry, with 4.8 points. In any case, the values given by the rest of the sectors are very close and approach the 4.2 points.

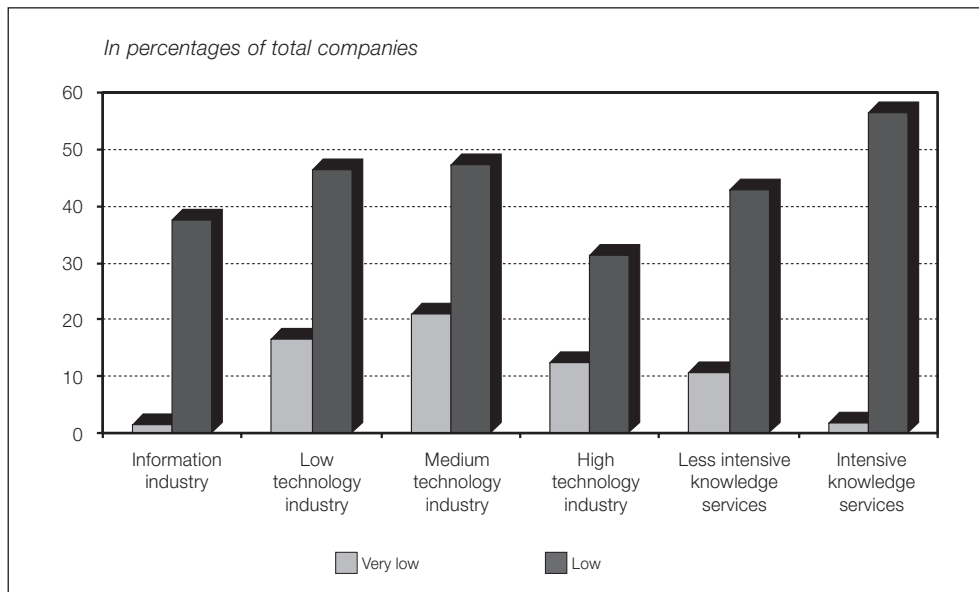
1.4. INTERNET EQUIPMENT AND AN ICT USE INDICATOR

As we have previously seen, business organisations are experiencing changes of significant nature in many of their value elements and activities when using intensively information and communication technologies. Furthermore, these changes are occurring at an external level as well, both in their relationship to suppliers and customers and in their way of understanding the new business environment emerging from the knowledge economy, which is global and in constant change. In this section we will focus on the analysis of the ICT use in Catalan firms. For our purposes, we will first focus on the equipment of Catalan firms and afterwards on the use they make of it internally and externally. In this way we can define an initial approach for measuring the changes currently occurring in the business activity.

Jordi Vilaseca / Joan Torrent

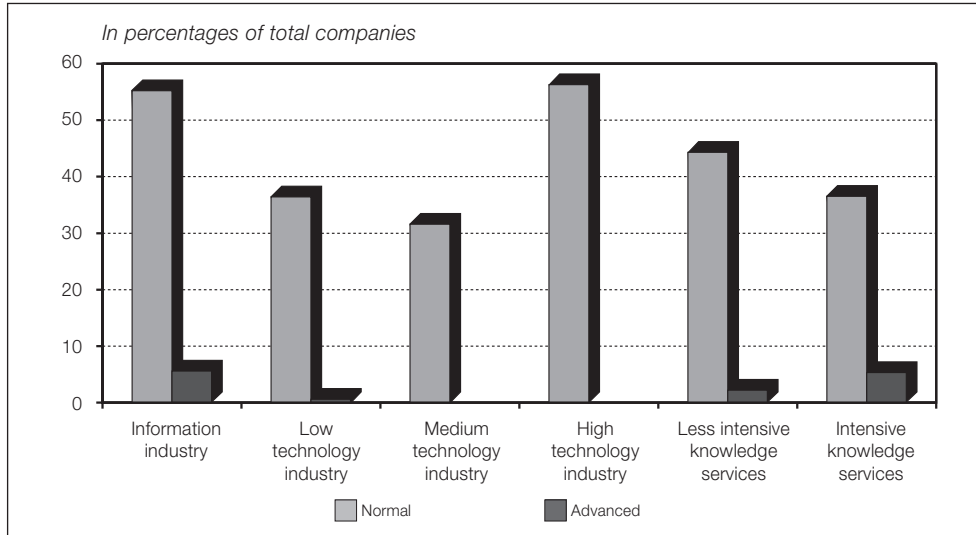
The equipment level, and more specifically the Internet equipment level in Catalan companies, is between low and normal. The 46.0% of companies possess equipment that could be described as low (they have Internet connection, but not a website), 41.9% possess a normal level of Internet equipment (with a narrow-band Internet connection and a website), and only 2.7% of companies have an advanced level of Internet equipment (companies with a broadband Internet connection and a website). Finally, it should be noted that 9.5% of Catalan companies have an Internet equipment level that is clearly very low (they do not have an Internet connection).

Figure 14. Low and very low Internet connection equipment in Catalan companies by activity sectors



Source: own creation.

Figure 15. Normal and advanced Internet connection equipment in Catalan companies by activity sectors



Source: own creation.

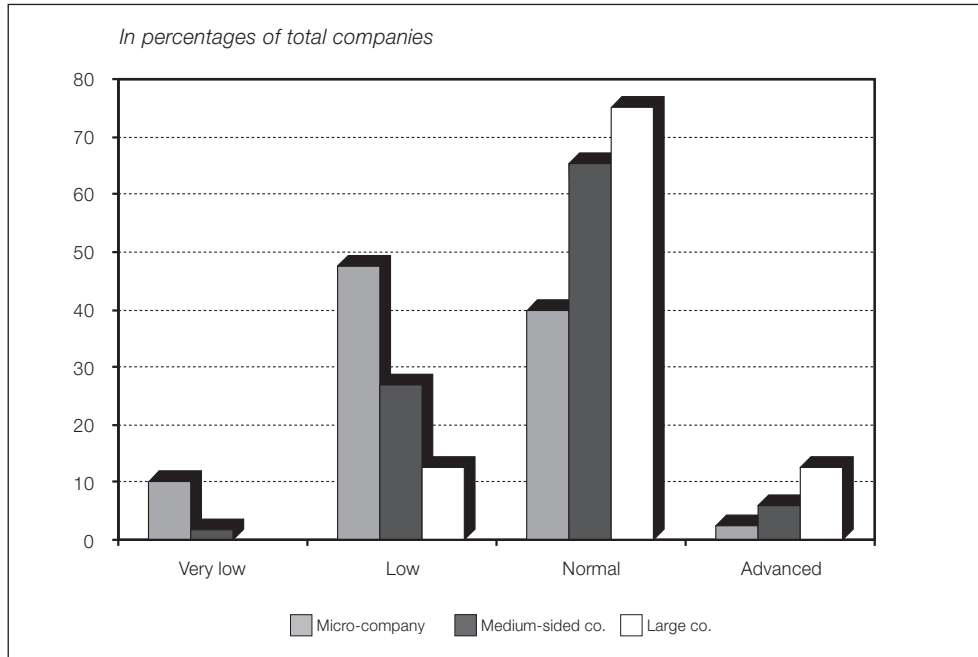
Even though these percentages correspond to a general description of Catalan firms, there are very significant differences when we analyse the equipment level by business sector and company size. In general terms, it can be affirmed that the information industry and the high technology industry possess an Internet equipment level that is predominantly normal (55.2% and 56.3%, respectively). However, special attention should be paid to the fact that the information industry and more intensive knowledge services show the highest penetration rate for advanced equipment (5.6% and 5.3% of companies, respectively). Nevertheless, the latter sector reflects a significant duality: despite 36.5% of service companies show an Internet equipment level that could be considered as normal, most of the service companies are placed at a low equipment level (56.5% of companies). On the other hand, low technology industry and medium technology industry companies in general have low equipment levels (46.4% and 47.4%, respectively, close to the Catalan average), but they show a clear tendency of not having Internet connection. The 16.6% of companies in the previous sector and the 21.1% in the latter have a very low level of Internet equipment.

As far as company size is concerned, there is a clear correlation between the level of Internet equipment and the size: the larger number of employees, the more advanced equipment level. In the following graphic we see that a clear majority of medium-sized and large companies have a normal equipment level (in fact, 12.5% of large companies have an advanced level). On the other hand, small companies cluster around 50.0% with normal equipment, and a significant percentage of them have a low level of equipment. Finally,

Jordi Vilaseca / Joan Torrent

micro-companies would be at the low level of Internet equipment, and 10.0% of them at the very low.

Figure 16. Internet equipment in Catalan companies, by size



Source: own creation.

Regardless of the business sector and the company size, and as far as other equipment is concerned, it is important to note that a high percentage of companies have e-mail (87.4%) as well as connection to the Internet and website. It should be also mentioned that most of the companies (54.0%), and basically large companies (90.0%) and intensive knowledge service companies (68.6%) have local/wide area networks (LAN/WAN). The volume of information they generate and manage makes the use of local networks more relevant in this type of firms.

To sum up, as illustrated in the following table, the penetration of digital equipment in Catalan firms, basically the Internet and e-mail, shows a marked upward trend in the recent years. Small companies should also be included in this tendency. Special attention should be paid to the expansive evolution of websites and e-commerce, in spite of having a limited presence in the business activity.

Our conclusion of the ICT uses of Catalan companies is the following: while equipment level (both Internet and other types) can be generally considered acceptable (more than 80%

ICTs and transformations in Catalan companies

of companies have between low and normal levels), ICT uses show more relevant dualities. Thus, a high significant part of Catalan companies actually makes an insufficient use of ICT in the areas of operations, marketing and organisation and human resources. The 73.4% do use ICT to plan production (or their services offer). The 75.7% do not have an external technological planning system to deal with suppliers or distributors. The 77.6% of companies do not have integrated systems in order to obtain and manage information generated by the customer and therefore make an insufficient use of ICT in marketing.

Figure 17. An evolution of ICT uses and equipment

In percentages of total companies

Equipment and digital uses	2000 ¹	2001 ¹	2002 ¹	2003 ²
Internet connection	83.8%	92.1%	94.7%	90.9%
E-mail	82.7%	86.9%	92.8%	87.4%
Website	49.9%	52.7%	54.8%	46.1%
Purchase via Internet	10.1%	15.0%	24.4%	21.7%
Sales via Internet	9.0%	7.0%	9.6%	11.0%

1. Companies with 10 or more employees. 2. Companies with 1 or more employees.

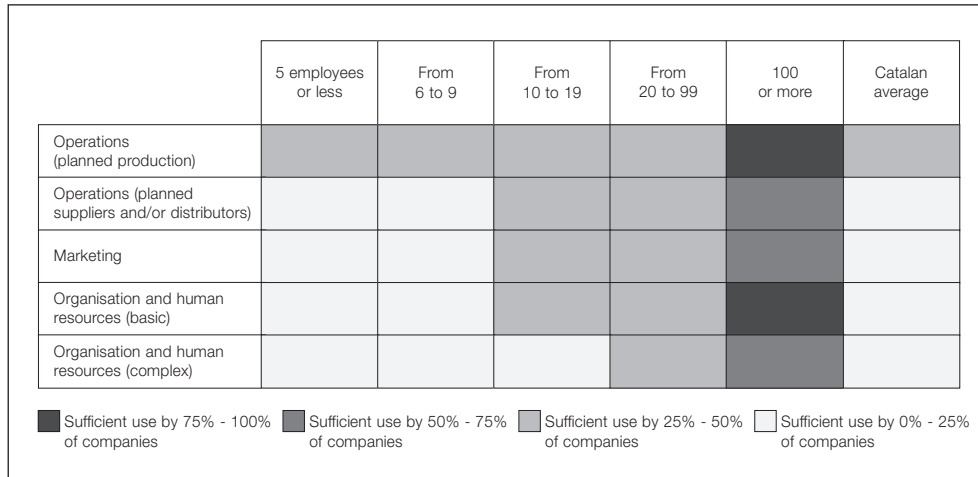
Source: IDESCAT and DURSI for the years 2000-2002, and own creation for 2003.

Finally, only 15.4% of companies make a sufficient use of the basic equipment in organisation and human resources (compared to the 84.6% that do not use it). It means having accounting and invoicing, wage payment or internal communications systems. Only a 6.5% make a more complex use of ICT, implying the use of at least two of the following systems: data management and information exploitation, executive information system (EIS) or enterprise resource planning (ERP).

This general description of ICT uses shows an ICT use level in the different value elements of the business activity with clear space for improvement. In spite of that, it is important to point out the significant and relevant differences by sector and by size. By sectors, it stands out that the high technology industry and the less intensive knowledge services lead the sufficient uses. By size, most of the large companies use sufficiently the ICT in all their operational elements (77.8% of companies plan production and 55.6% in the case of suppliers and distributors), marketing (55.6%), and organisation and human resources (77.8%), far above the Catalan average of 22.4%. Even though there is a certain correlation with the number of employees, less than 50% of the rest of the companies with less than 100 employees make sufficient uses of ICT.

Jordi Vilaseca / Joan Torrent

Figure 18. ICT uses in value elements of Catalan companies by size



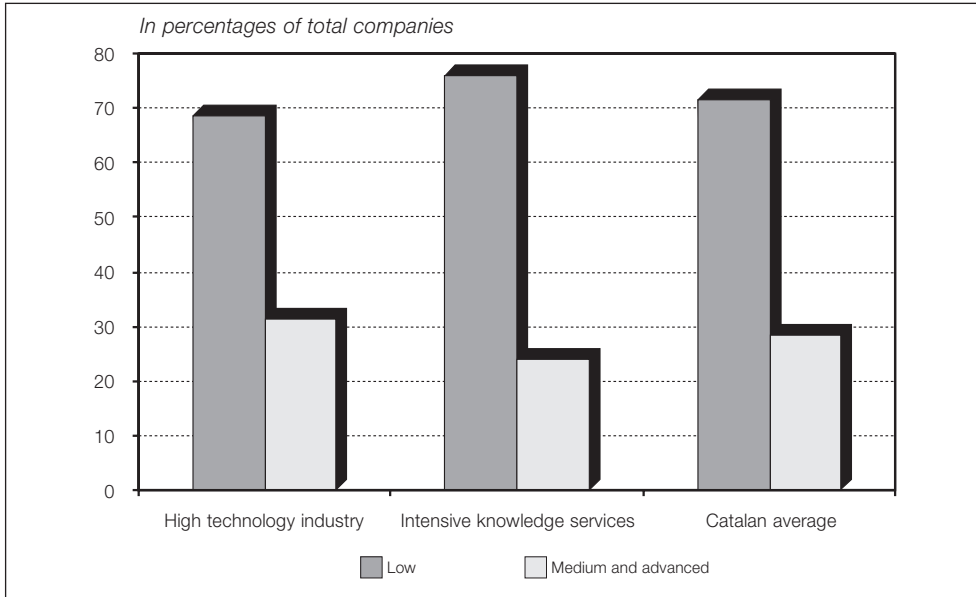
Source: own creation.

Below we present the ICT uses in each element of the value chain. The general ICT usage level in Catalan firms is certainly low: the 71.7% of Catalan companies make an insufficient use of the ICT. They do not possess any technological system in operations (production and suppliers/distributors), marketing and organisation and human resources (basic and complex), or just one system for one of the five areas. As far as average uses are concerned, 24.2% of all companies have systems for two or three of the five areas. Finally, 4.1% of Catalan companies have systems for four or five of the value elements described (advanced uses).

As observed in the case of Internet equipment, the data obtained shows clearly significant differences between activity branches and company size. On the one hand, even though low uses are present in more than two thirds of the companies, there are high relevant differences. In fact, 68.6% and 65.5% of companies in the high technology industry and in the less intensive knowledge services show the lowest ICT usage level. Therefore, the penetration of medium and advanced ICT uses is basically more relevant basically in the high technology industry (with 22.9% of companies with medium ICT uses and 8.6% of companies with high ICT uses). Companies of the intensive knowledge services follow the firms of the information industry in application of advanced ICT uses (5.7% of Catalan companies).

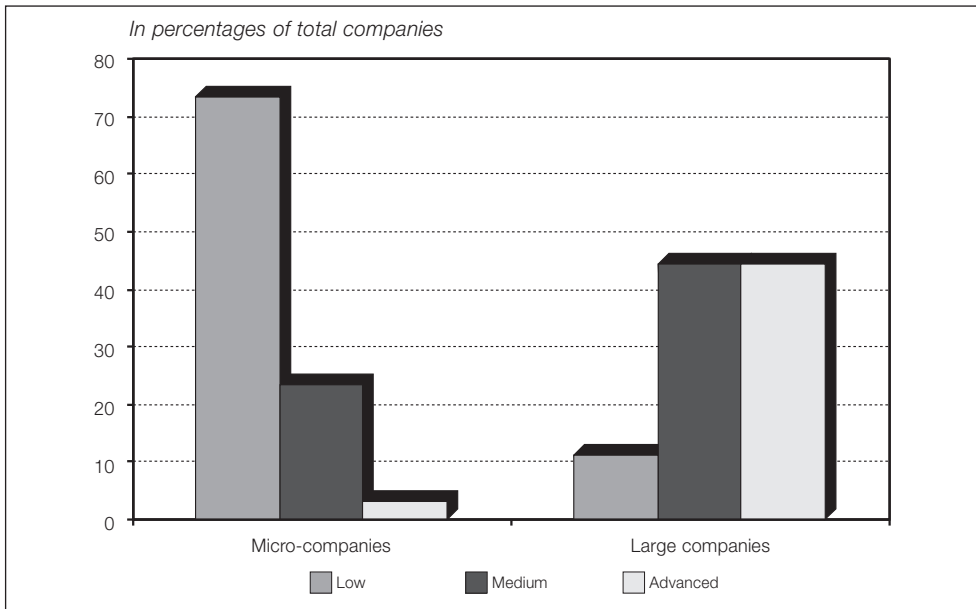
ICTs and transformations in Catalan companies

Figure 19. ICT uses in Catalan companies by sectors



Source: own creation.

Figure 20. ICT uses in Catalan companies by size



Source: own creation.

Jordi Vilaseca / Joan Torrent

On the other hand, different patterns of behaviour can be certainly observed when analysing the company size. Companies with less than ten employees generally reflect low ICT usage levels (between 73.3% and 75.2%). A significant percentage of small companies with more than ten employees (32.9%) and medium-sized companies (41.1%) make a medium use of ICT in their organisation. Lastly, most of the large companies reflect medium and advanced uses (44.4% of large companies show this use typology).

Finally, concerning the attitudes associated to ICT use, 89.2% of companies consider that ICT implementation and use transform their business activity. These transformations in the business activity imply, to a greater or lesser extent, increases in productivity, competitiveness, profits and individual relationships. Even in an initial stage, the use of basic ICT is generalised and extended (except, for example, the e-mail and the Internet connection). Moreover, taking into account the main advantages of these uses, it is possible to think about a progressive increase of the transformation aiming at organising the company as a network both internally and externally (the network firm).

2

AN ANALYTICAL APPROACH FOCUSED ON E-BUSINESS AND THE NETWORK FIRM

As commented in the methodological introduction of this report, the primary objective was analytical. That is, our main intention is to study business transformations linked to digital technology uses. However, as it often occurs when studying the economic and social reality, its implications are of a much more complex nature than a simple unidirectional relationship. Thus, it is more than evident that the study of the digital impact on companies cannot be isolated either from the deeper processes in which it is involved, or from the structure and form of the economic agent object of our study. In other words, strategic, organisational and production changes in Catalan business associated to ICT uses cannot be interpreted in all their complexity without prior analysis of the impact on production, distribution, exchange and consumption of the main engine of this transformation: the globalisation of the economic activity. However, we should bear in mind that Catalan firms have certain highly defined features that doubtless lead towards the knowledge economy. Actually, the main objectives of the previous sections of this report have been to describe and characterise the current situation of the Catalan firms, to study the equipment levels and the main ICT uses and to explain the transformations of each value element of the business activity. Below we will go further and we will analyse the impact of ICT uses on the four main aspects of any productive activity. That is, the two productive factors (capital and labour), the incorporation of technical change and the results of its organisational and productive practice, putting special emphasis on productivity.

We have built two synthetic indicators: ICT uses and Internet equipment to contrast the impact of the digital uses on these four crucial elements of the business activity. In terms of ICT uses, its construction was carried out in four phases. In the first stage, we generated five intermediate variables that gathered different ICT registered business uses. Specifically, production planning (which we call operations), planning related to suppliers and distributors (operations 2), integrated systems for managing information on demand (marketing), accounting and invoicing systems, wage payments and access to an Intranet (organisation and basic human resources) and data management systems, executive information systems (EIS) and enterprise resource planning (ERP) systems (organisation and complex human resources). In the second stage, these five indicators were split into the values 0 (insufficient use) and 1 (sufficient use) as follows: the operations indicator takes the value 1 if it is present and the value 0 if it is not. The indicator 2 of operations takes the value 1 (sufficient use) if the company plans with suppliers and/or distributors, and the value 0 (insufficient use) if it does not plan production either with suppliers or distributors. The marketing indicator takes the value 1 (sufficient use) if the company uses such systems and the value 0 (insufficient use) if it does not. The

Jordi Vilaseca / Joan Torrent

organisation and basic human resources indicator takes the value 1 (sufficient use) if the company uses operational accounting and invoicing systems, wage payment systems via ICT use and internal digital communications systems, and takes the value 0 (insufficient use) if it does not use accounting and invoicing systems and/or wage payment systems and/or internal communications systems. Finally, the organisation and complex human resources indicator takes the value 1 (sufficient use) if it uses two of the following three systems: data management systems or programs, executive information tools or enterprise resource planning systems; and it takes value 0 (insufficient use) if it does not use any or only one of the following systems: data management systems or programs, executive information tools or enterprise resource planning systems. In the third stage, after dichotomizing the five sub-indicators obtained, they are added. Therefore, we obtained the values of 0, 1, 2, 3, 4 and 5. In the fourth and last stage, we have built an aggregated indicator that includes the re-codified five values obtained in the previous stage. It takes the values 0 and 1 when the ICT uses are low, the values 2 and 3 when the companies present medium ICT uses and the values 4 and 5 when the use of ICT is advanced. On the other hand, we have built the equipment and the Internet uses indicator as well. This indicator uses four values, depending on the Internet equipment and its business uses. The very low level corresponds to those companies that have no Internet connection, the low level to those firms that do have Internet connection but not website, the normal level relates to the firms having narrow-band Internet connection and website, and finally, the advanced level is present in those firms with broadband Internet connection and website.

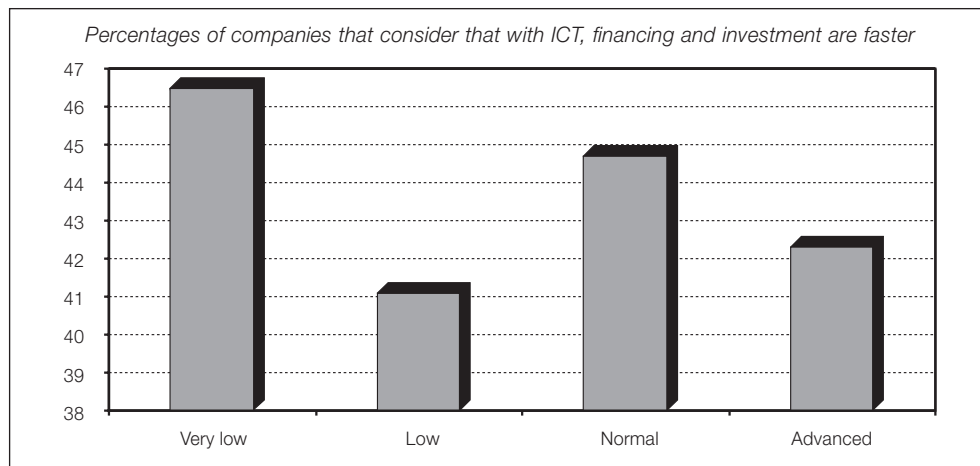
2.1. ICT AND CAPITAL: TOWARDS INTANGIBLE INVESTMENT AND FINANCIAL EQUILIBRIUM

We indicated that the investment and financing cycle defines the circuit of the financial resources in the company's economic activity. Production application of ICT affects the configuration of this flow from a dynamic and a static perspective. In fact, the improvements in the management and the capability to generate relevant economic and financial information, as well as communication developments of the agents participating in the business capitalization process, set up the basis of an accelerated transformation of saving into financing, and of its ulterior conversion into production applications. These implications on the capitalization of the cycle dynamics become static assets. From the point of view of the financial structure, ICT influence in the potential ability of the company to tend to a more balanced financial composition, in terms of the relative costs of the obtained resources. Moreover, from the point of view of the economic structure, ICT influence the nature of investments, which progressively becomes intangible. ICT also influence the functionality (application) of these investments. To evidence the transformations of the capitalization process of Catalan firms linked to ICT uses, below we revise the ideas described in the section on investment and financial flow and we analyse its behaviour according to ICT and Internet equipment uses.

From the ICT use point of view there is a growing relationship between usage levels and the perceived speed of investment and financing flow. In spite of that, this positive relation is not obvious, partly because the companies with advanced ICT uses have already integrated their effects into their management indicators, which form part of their normal reference framework. Additionally, when we focus on Internet equipment and uses, we reach an important conclusion: one of the channels for viewing the synergic effects of ICT on the business activity is its use in investment and financing mechanisms. In fact, a clear pattern of behaviour can be detected in companies with low and advanced levels of Internet equipment. Most of such firms consider that ICT do not contribute to reduce the exploitation cycle. In contrast, a higher percentage of companies with very low and normal equipment levels consider that ICT do allow them to invest and finance more quickly.

On the other hand, we also wondered whether there is any difference between the origins of the financing means of Catalan companies given the use, more or less important, of ICT. On average, close to 20% of the financing sources in Catalan firms come from company owners: the shareholders. The data obtained indicate that ICT usage level is not a discriminating variable when analysing a company's financial structure. However, it should be stressed that it is the companies with lower ICT uses that more often have to rely on external financing, since they present the lowest percentage of self-financing (17.5%). Nevertheless, there is a statistical significance between Internet equipment and the structure of financing. In fact, the data seem to indicate an inverse relationship between financing with own funds and Internet equipment levels. That is, as Internet equipment is reduced, the participation of company owners increases. Yet, as occurred with cycle speed, companies with an advanced Internet equipment level (around 3% of all Catalan companies) break the trend, possessing a financial structure with an own resources level that is clearly higher than the Catalan average (25.6%).

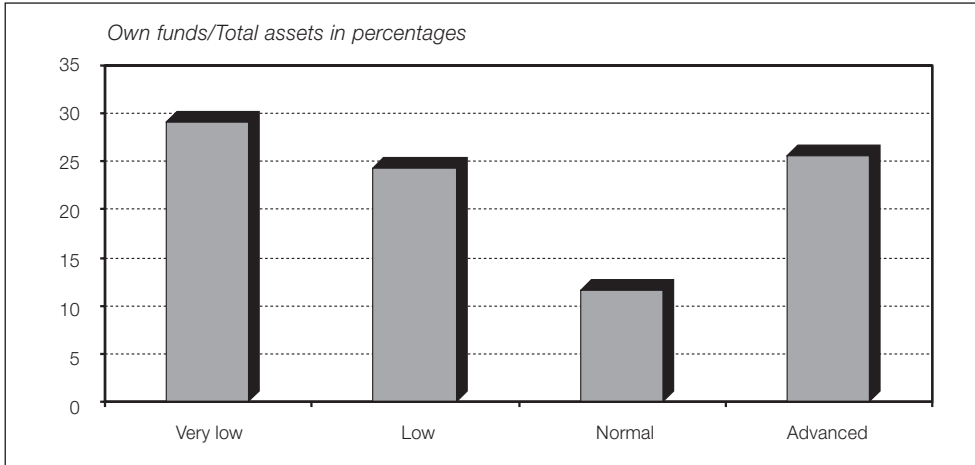
Figure 21. The investment and financial cycle and Internet equipment in Catalan companies



Source: own creation.

Jordi Vilaseca / Joan Torrent

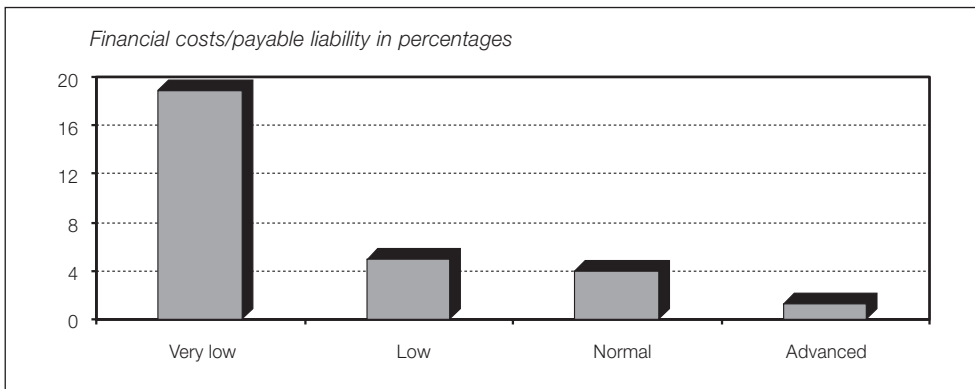
Figure 22. Own funds and Internet equipment in Catalan companies



Source: own creation.

From the descriptive analysis we guessed that a greater integration of digital technologies allows a company to obtain external funding at a lower cost. Actually, if we look at the cost of external funding of Catalan companies depending on Internet equipment, we can see a cost reduction in external resources as the level of Internet equipment increases. In this sense, the financial cost borne by companies that still have not incorporated this equipment is four times higher than the one immediately above (that is, those companies that have access to the Internet but do not have website).

Figure 23. The cost of financing and Internet equipment in Catalan companies



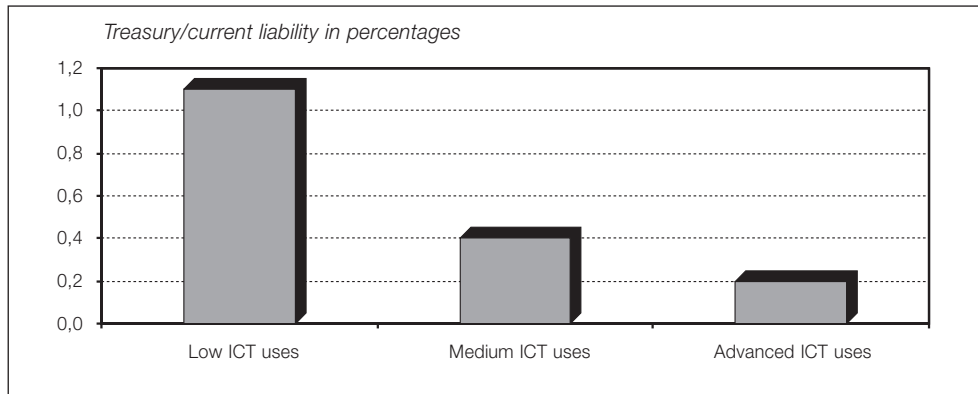
Source: own creation.

The funding cost is an element that clearly conditions the degree of debt of a company. In an initial approach, it is logical to analyse whether there is a relationship between these two variables. As expected, the data show that the lower the cost of external funds, the more necessary it is to rely on external financing. Therefore, we can state that the lower the Internet equipment level, the higher the cost of external resources and, consequently, the lower the debt percentage. In order to go further in the analysis of the business debt dynamics depending on digital uses, we have broken it down according to its temporal structure. That is the long-term maturity date, of more than one year, and short-term debt of less than a year. With this aim we use the long term rate payable/total payable. In that respect, it is important to indicate that the higher the long-term debt, the better the company's financial situation is. The data obtained show that Catalan firms present a significant predominance of short-term debt. As far as ICT use is concerned and, in spite of the fact that Internet equipment is statistically significant in relation to this ratio, there is no visible causal relationship between an increase in Internet uses and the debt level.

To finalise the analysis of the financial structure in Catalan companies and its relationship to ICT uses, below we analyse whether there is the necessary correlation between financial resources and business investments, so as to satisfy payment obligations when maturing. We will use two ratios: the ratio of circulating assets/current liability (technical solvency) and the ratio of treasury/current liability. The data obtained for technical solvency show that Catalan firms present a slightly higher ratio to which is considered as the normal interval (from 2 to 2.5 points). Therefore, we can state that in general terms the transformation of the investments into cash enables facing the different financing sources, taking into account that they will expire. Even though the Internet equipment variable is statistically significant, we do not find any causal relationship between an increase in intensity of this equipment and a difference in the degree of the technical solvency ratio. The second ratio we analysed is the treasury/current liability. Digital crossover shows that both the ICT use variable and the Internet equipment variable are statistically significant. The Catalan business average is 0.9 points, a value that is once again slightly higher than the interval considered normal (situated between 0.2 and 0.3). At an aggregated level it indicates an excess of immediate cash and therefore a potential loss of financial income. If we make the analysis from the point of view of ICT uses, we see a reduction of the ratio as the usage level increases. ICT incorporation into business management seems to be associated to adjusted treasury forecasts and to a prompt detection of deviations. This fact allows reliable planning for treasury excesses which are invested, instead of lying idle, thus generating an additional gain and improving the global profitability. Indeed, as ICT uses increase, so does the investment in financial assets. However, the profitability obtained from these assets does not follow so clearly this increasing trend.

Jordi Vilaseca / Joan Torrent

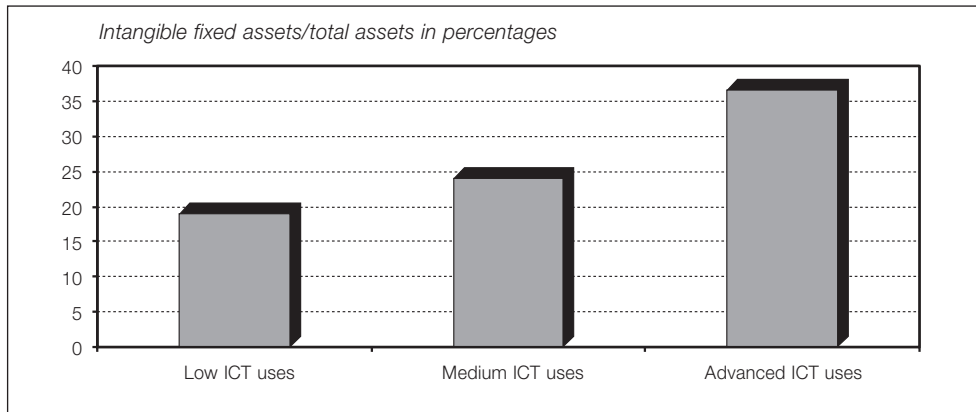
Figure 24. Treasury management and ICT uses in Catalan companies



Source: own creation.

After analysing the financial funds of the Catalan firms and how the ICT influence the composition of the financial structure, below we will see the repercussion of the digital impact on the economic structure of the companies. From this perspective, we wanted to verify whether the digital intensity is caused by a change in the investment nature. Therefore, we will focus on investment in intangible assets as a mechanism for improving the economic profitability of both production investments and as a basis of the efficiency of the production activity. At this stage, it is important to note that most companies' economic structures do not include financial activity as their final aim. It is rather the opposite: production assets represent over the 90% of global applications in the representative Catalan company. For the Internet equipment parameters and ICT uses, the data obtained on Catalan firms show that an increase in participation in financial assets is parallel to the increase in company ICT uses. This fact seems to be related to the improvement in treasury management when possessing more advanced Internet equipment or achieving more intensive ICT uses. In relation with the ratio intangible fixed assets/total assets, approximately 20% of the total productive infrastructure in Catalan companies corresponds to intangible nature elements. From an ICT usage-level analysis, it is important to point out the clear increase in investment percentage in intangible assets, as ICT use level intensifies.

Figure 25. Intangible assets and ICT uses in Catalan companies



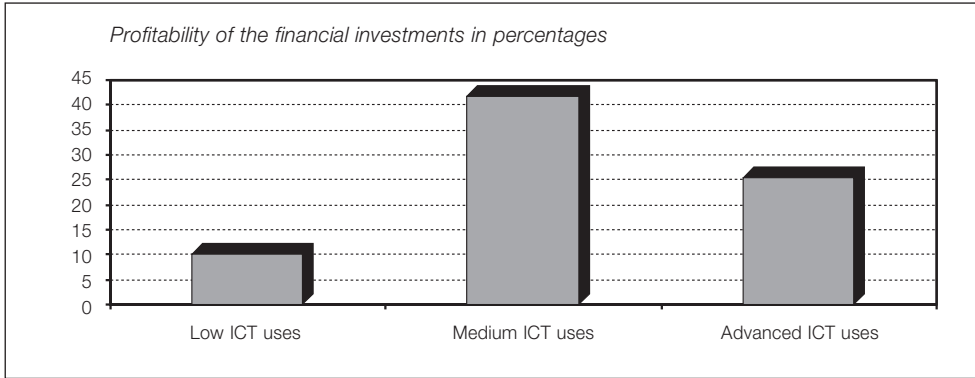
Source: own creation.

Next we deal with the second effect detected in business investments: a reduced investment in financial assets thanks to the possibilities the ICT offer for improving performance in these applications. Indeed, Catalan firms maintain a reduced immobilisation in financial assets: on average, 8% of the total of its financial funds. The data obtained show an increase in financial investments as investment in Internet equipment levels increases. However, we stress that companies with normal equipment levels break this upward trend, as they reflect the lowest investment percentage in financial assets.

On the other hand, through the financial intangible assets/financial assets ratio, we can trace the weight of long-term financial investments over the total financial applications. In that respect, the data obtained from Catalan companies show that almost the whole set of financial assets has an expiring date of less than one year. From the digital impact perspective, this trend towards the short term is not surprising when taking into account the main ICT uses, in supporting the infrastructure value element, which have a clear direct effect. Furthermore, when analysing data, it can be seen that the average profitability of financial investments in Catalan firms is around 20%. Segmentation in accordance with ICT uses shows a clear differential between low use levels and medium and high use levels. It seems to suggest that investing in ICT brings incremental profits derived from the application of resources on financial assets. Lastly, we contrast the idea of external financing from the optimisation of the relative cost from the two digital impact perspectives. According to Internet equipment, we can observe that, in most of the cases, the idea of this optimisation is accomplished, with differentials of more than 15% in companies with a low and normal level of equipment. It should be outlined the negative differential in companies with a very low level of equipment, with a cost of 18.9% and with almost non-existent profits. However, if we focus on the ICT use levels, the compliance is positive in the three levels without exception.

Jordi Vilaseca / Joan Torrent

Figure 26. Financial performance and ICT uses in Catalan companies

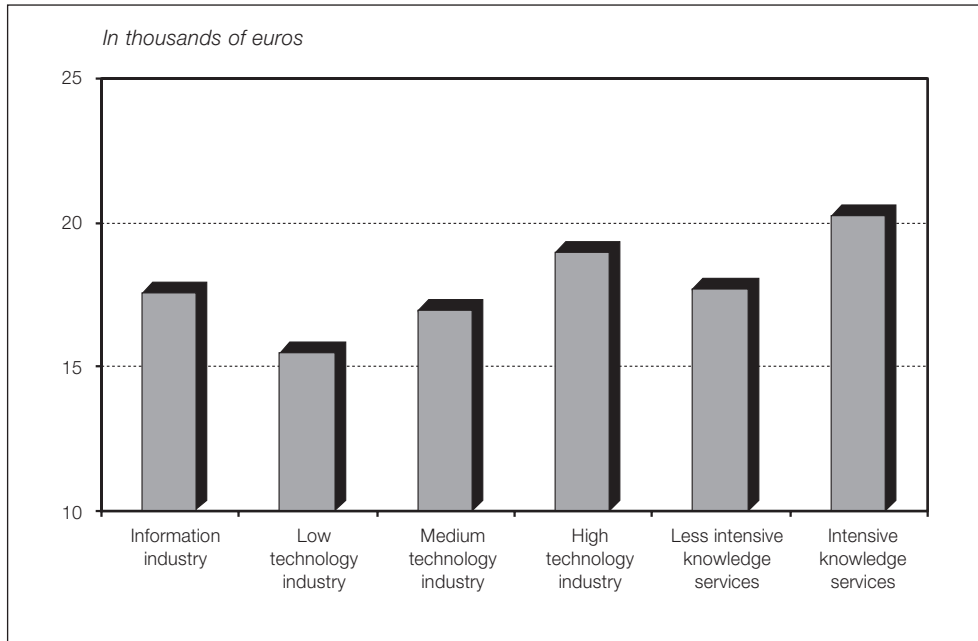


Source: own creation.

2.2. ICT AND LABOUR: TOWARDS SELF-PROGRAMMING WORK AND WAGE IMPROVEMENT

The impact of technological change on employment is the combined result of innovations in the different productive branches, of specific conditions in the labour market and of the institutional framework in which economic activity is developed. When a company intensifies its knowledge use, it is innovating and this implies an increase in employment. The effects on the whole labour market are indirect and are carried over into other sectors. Therefore, loss of employment due to technological change tends to be centred in the manufacturing sector workforce and on less qualified employees, while new positions demand higher qualifications and are concentrated in services. The final impact is positive when there are the necessary conditions that permit an efficient transition, principally the macro-economic stability and the micro-economic efficiency, and furthermore, these conditions are combined with the necessary adaptations to the changing labour market and the institutions influencing it.

Figure 27. Gross average wage per employee in Catalan companies by activity sector



Source: own creation.

Currently, the adaptation to the new global frequency and changing demand through ICT use is two-sided, and it could be represented by the dichotomies that the generalisation of the enterprise and the network generate on the economic aspect of working. Indeed, the consolidation of new production schemes is not only a synonym for stable and qualified work, but additionally digital technologies are used to endanger and disqualify work. As it has occurred in any other moment of technical change, we can currently identify three contradictions that the impact of globalisation and ICT produce in the workforce. Firstly, a three-fold process in substituting skills, leading to a) a change in the capabilities demanded by the labour market, from the most to least manual; b) a liberalisation of working time through immediate productivity increases generated by the introduction of ICT; and c) a generation of new routine tasks and generic work linked to the capabilities and the core production sectors of the information industry. It is this complex and interactive process of generation/substitution of skills that establishes the second dichotomy of the labour market: self-programming work versus generic work. Depending on the required skills and the company's organisational and productive schemes, work either acquires the features of qualified, operatively flexible work, or it will be unqualified and lacking of self-programming capabilities. Lastly, the third dichotomy is established between stable and defined labour relations and a more widely defined and flexible relationship framework between employers and employees with new

Jordi Vilaseca / Joan Torrent

commitments and values to be assumed. It should be noted that in the long term the balance has always tipped towards an intensification of knowledge presence in the labour market if the economic conditioners of efficiency and flexibility are present, and the institutional determiners promoting the current change are coordinated in the same direction. In order to understand this set of transformations in the Catalan firms, we will make use of the description given in the section on human resources of this report and we will analyse the correlations between wages determination and intensive technology uses.

The data obtained on average wage show that employee salary in Catalan companies is situated at around 18,000 euros gross per year. In spite of that, the differences existing between different activity branches are significant. In industry, wages differ by 22% from the average perceived in the high technology industry compared to the low technology industry. In the same way, the difference existing in services between the tertiary branches of intensive knowledge use and those not belonging to that branch is around 14.5%. This analysis of the wage structure seems to confirm the existence of a premium wage for employees in the production sectors using technology and knowledge more intensively. On the other hand, it should be mentioned that wage differences are not statistically significant from the company size viewpoint, even though the highest wages are paid in largest companies. Concerning the growth in Internet equipment used by Catalan companies, there is a clear wage difference according to this technological variable. Indeed, companies having very low Internet equipments have an average wage under 14,000 euros gross per year, which implies a 25% difference compared to the average wage of the Catalan business sector. On the contrary, companies owning advanced Internet equipments have average wages of over 19,000 euros per year, which implies a differential of more than 9% with respect to the total average wage and 45% compared to the very low Internet uses. Furthermore, wage dispersion, measured by the typical deviation, increases with Internet equipment.

Figure 28. The gross average wage per employee and Internet equipment in Catalan companies



Source: own creation.

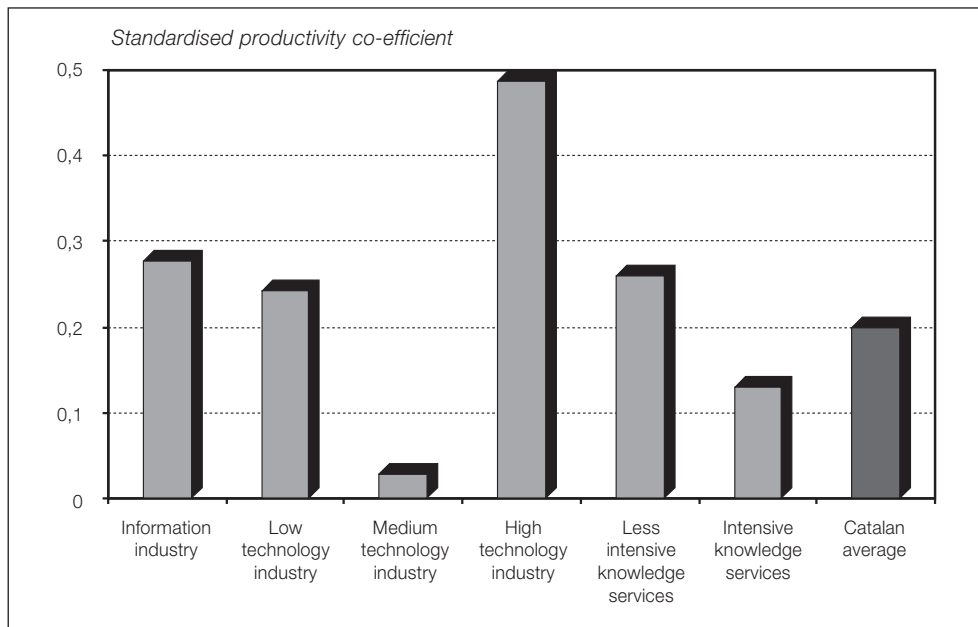
On the other hand, the data show that there is a significant effect on productivity per employee on the average gross wage per employee. In other words, everything seems to indicate that it is possible to establish a direct and positive relationship between wage and productivity per employees (a productivity increase of one percent implies a wage increase of 0.2 points for the whole Catalan business sector). Furthermore, disaggregating the industry by technological intensity shows that this effect is greater as wages increase, as for example in the information industry and high technology industry. Therefore, in the case of the high technology industry, a productivity increase of one percent can be translated as a wage increase of almost 0.5 percent (three decimals above the Catalan average). It is worth mentioning that this relationship is not satisfied by all medium technology companies. This perspective should be interpreted within an analysis of a transversal nature, so that the lack of significance of these industries may denote structural or conjuncture overall changes in these same companies.

After analysing the effect of the activity sector on wages, the effect of Internet equipment and the effect of productivity per employee, next we will focus on the effect of the same variable on the total factors productivity. In the same way, we will contrast the double causality that exists between productivity and wages. The aim of this contrast is to prove that interaction between productivity increases and wages operates in a virtuous circle through which

Jordi Vilaseca / Joan Torrent

an incremental relationship becomes evident. There is no doubt that training is the core on which this interaction is based. For this reason, we built a variable that allows us to identify wages according to training type. Specifically, we analysed two variables: the annual gross wage for companies that affirm to have employees currently following a training in homologated face-to-face courses and the annual gross wage for companies which declare having employees currently following a training in homologated virtual courses (e-learning). Furthermore, we segmented the company sample according to those firms using ICT the most (medium and advanced uses) and those with lesser digital intensity (low ICT uses) to better understand the digital impact.

Figure 29. Effect of gross average wage per employee on productivity per employee

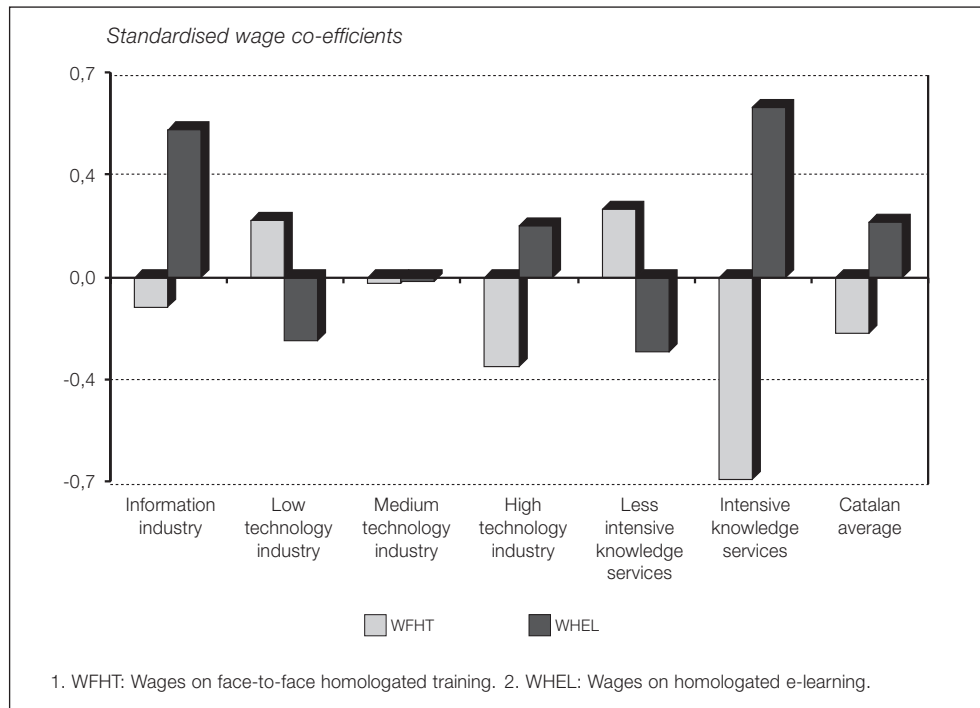


Source: own creation.

As it comes for companies with more intensive ICT use, we see a clear correlation of wages on the total factors productivity. However, this effect is very different depending on the activity sector and the training type. So, as technological intensity or knowledge stock increases, the effect of wages on the productivity of those companies employing electronic methods to train their employees is clearly higher. Furthermore, in the low technology industry and in the less intensive knowledge services, the effect of e-learning is negative. In other words, in companies with high technological intensity, e-learning generates, through wages,

higher productivity increases than those generated by face-to-face training. On the contrary, in companies with less technological intensity, it is face-to-face training (in detriment of e-learning) that generates a higher increase in productivity. When companies make a low usage of ICT, it generates an effect on the sector completely different to which we saw in the case of medium and high uses. On the one hand, both in the case of e-learning and face-to-face training, the effect through wages is significant. However, in the case of the industry, this effect is not significant. Instead, in the case of the services, companies with a higher number of employees being trained in face-to-face environments have clearly positive and significant effects on productivity, which increases with the intensity of knowledge.

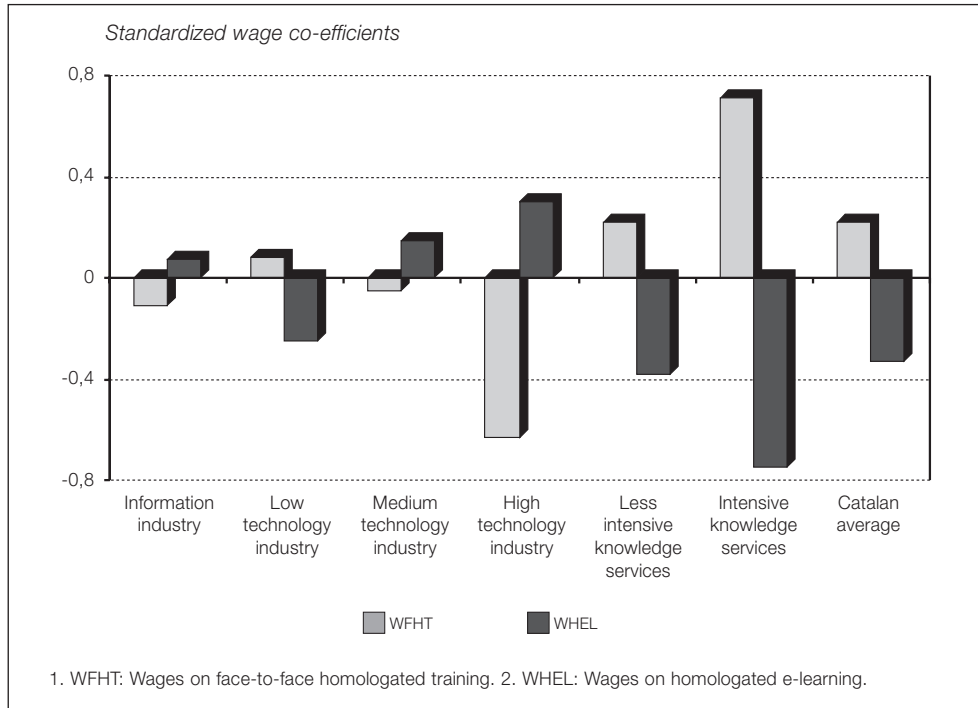
Figure 30. Effect of average gross wage per employee on total productivity of factors in Catalan companies with medium and high ICT uses



Source: own creation.

Jordi Vilaseca / Joan Torrent

Figure 31. Effect of average gross wage per employee on the total factors productivity total in Catalan companies with low ICT uses



Source: own creation.

2.3. ICT AND INNOVATION: TOWARDS A CONTINUAL LEARNING AND GROWTH PROCESS

Currently, innovation is the main engine of change in companies and in the whole economy. In an environment of globalisation and open competition, knowledge and the development of intangible assets become highly valuable competition factors. Therefore, in this knowledge-based economy innovation plays a specific role. The main agent for innovation in a market economy is the firm, even though public policies can also reinforce the generation and economic application of knowledge into the business activity. However, innovation is a complex concept with many different meanings. On the one hand, this is due to the existing relationship between innovative processes and the presence of intangible assets such as investment in R+D+I or in human capital. Nevertheless, we currently understand innovative processes from a wider perspective: innovation is a learning process based on the productive application of knowledge. Consequently, it is a complex process, fed by

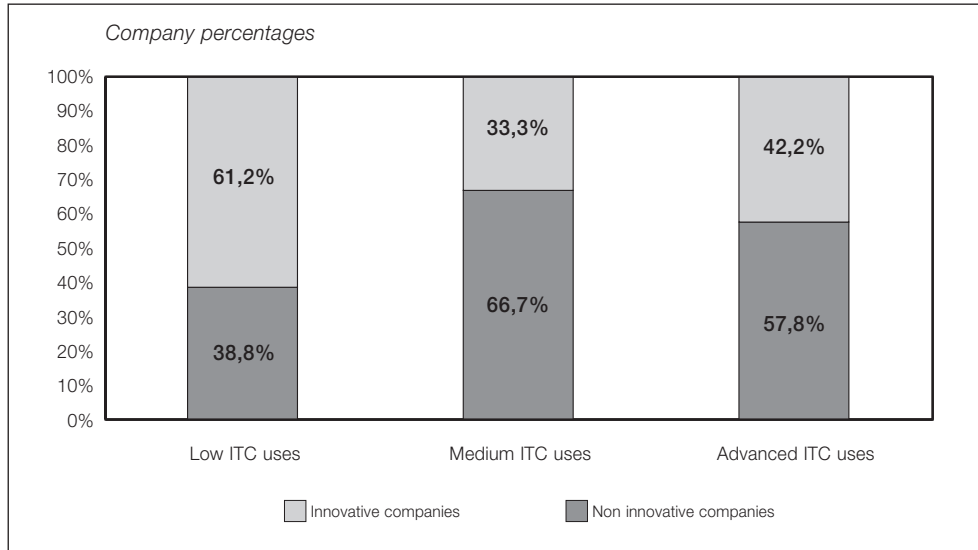
both tacit and observable knowledge, and influenced by both a wide range of internal company factors and other external factors, coming from its environment. Moreover, this process results from highly formalised and informal processes, it benefits from competition and co-operation between companies or institutions, and gives rise to radical technological changes and small incremental improvements that increase the implementation of the existing technologies.

The particularities of the Catalan business reality, as a productive structure characterised by the large predominance of small-sized enterprises, stimulate innovations resulting of two conjunctions: the assimilation of new external knowledge and technologies or the result of internal but not much formalised company processes. Thus, they lead to continual and incremental improvements rather than radical changes in their stock of scientific and technical knowledge. Therefore, the accumulated stock of specific and observable knowledge is probably almost as important as the tacit knowledge provided by employees in their workplace when considering the innovative development of Catalan firms. Consequently, within the system of Catalan innovation, the nature of the production landscape means that both environmental features and the particularities of internal innovative business processes are highly transcendental. This fact has direct consequences on the potential to generate innovations endogenously and on the potential to assimilate new technologies and knowledge from outside. In conclusion, as we did for both capital and labour, in order to analyse the ICT impact on the business innovation process, we will return to the ideas described in the section corresponding to this value element and study the transformations linked to the digital impact.

A primary element we want to highlight is that ICT use, as an innovation means, favours the network organisation of Catalan companies. This is basically due to a three-fold reason. Firstly, because ICT stimulate innovative dynamism in reducing partially the existing obstacles to innovation and making interactions between the agents involved in the innovative process—those both inside and outside the company— more efficient. Secondly, ICT modify the nature of the innovations and allow the development of more sophisticated and interdependent innovative processes. Thirdly, because the complexity of innovative processes induced by ICT means that their use can be considered a sustainable competitive advantage only if these technologies are used in an integrated structure with the available resources and capacities.

Jordi Vilaseca / Joan Torrent

Figure 32. Innovative dynamism in Catalan companies and ICT uses



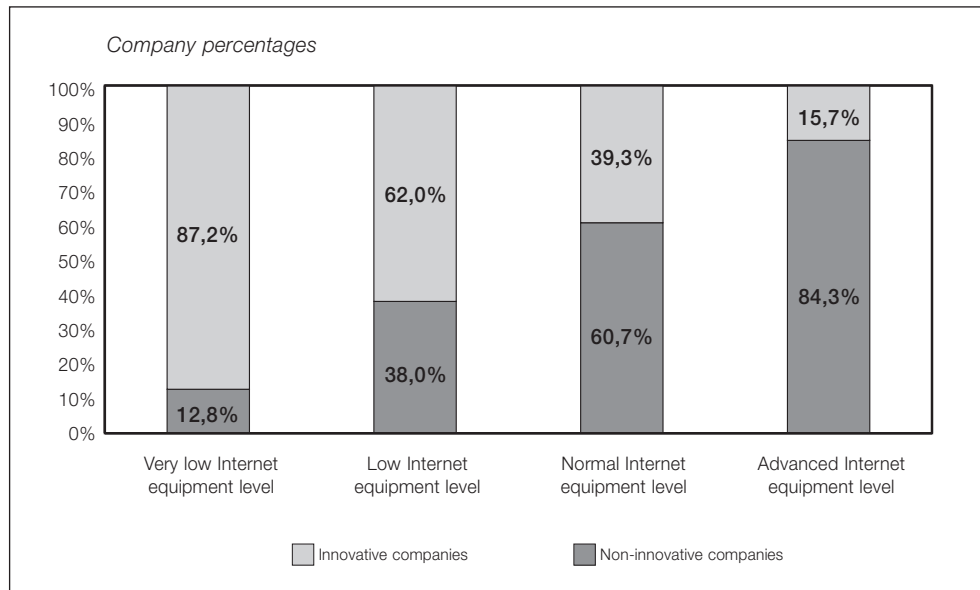
Source: own creation.

The availability of knowledge and material and immaterial resources, how they are structured and managed and the quality of the environment of each company will determine the result of its innovative process. Therefore, it becomes necessary to observe the innovative activity in Catalan companies from the perspective of their internal and external determinants and their consequences for the company. Firstly, we should analyse whether innovative dynamism is related to the sophistication level of ICT uses inside the company, apart from being used as a mean of innovation. The results obtained confirm the strict relationship between a medium and a high level of ICT uses and the development of innovations with the support of these technologies. The use made by Catalan firms of the new information and communication technologies to carry out organisation management, operations, marketing or human resources more efficient, provides a cultural change in the heart of the company and stimulates more innovative behaviour.

Likewise, it can be expected that the Internet use becomes a stimulatory factor of the innovative dynamism of the company, insofar the innovation depends on knowledge generation and it is favourably influenced by both the access to information and the network effect of greater facility to interact with the environment. The existence of a strict correspondence between innovation and the Internet use has been clearly confirmed. Catalan companies with more advanced Internet equipment levels are clearly more innovative. Probably, this effect is the result not only of the innovation represented by the introduction of the Internet into the company, but also of the fact that the company can participate for the first time or can turn its participation into a more efficient contribution in cooperative networks based on

shared development of innovations. The latter would be principally the paradigmatic case of smaller companies that compensate their deficit in economic resources and the lack of a specific department of R+D+I by participating in efforts, risks and means in a cooperative network in order to innovate.

Figure 33. The innovative dynamism of Catalan companies and Internet equipment

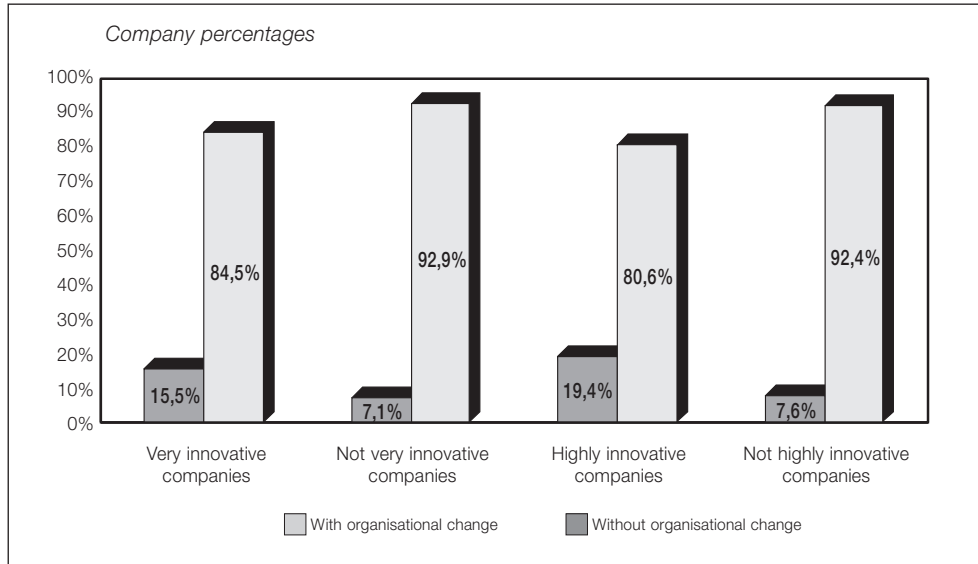


Source: own creation.

With the consolidation of the knowledge economy, innovative dynamism can also be influenced by organisational change within the company. It can be expected that organisation through processes influences favourably the company's innovative process, as it uses flexible work teams and adaptable to the different company's business lines and the supervision of work is based on objectives and on results. Indeed, this is the case of the companies with strong tendency to innovate. That is the case of those companies that conjointly and continually renew their products and processes (highly innovative companies), and of companies that accompany product and process innovation with changes in their organisational structure (that is, highly innovative companies) as well. The results show how organisational change is slowly being introduced into Catalan firms. However, its advance is more intense in companies developing more complex and sophisticated innovation processes.

Jordi Vilaseca / Joan Torrent

Figure 34. Innovative dynamism in Catalan companies and organisational change



Source: own creation.

Other internal factors also condition the success of the business innovation process, and possessing an R+D+I department is one of the most important ones. Only one out of every six Catalan companies has a specific section dedicated to the research and development of innovations. This relatively scarce presence is a direct consequence of the Catalan productive structure, with predominance of small companies and less intensive knowledge activities. Nevertheless, a significant part of the Catalan industry, especially the most intense technologically, has advanced very positively in the systematic and endogenous development of new knowledge from the formalisation of these research structures. The results obtained confirm that the formalisation of research structures in Catalan companies is a highly powerful incentive for directing innovative processes in a continuous and interactive form, especially appropriate for developing more complex innovations. Therefore, the presence of these departments has had a direct influence on the innovation processes of the Catalan firms. One of every three companies that in the last two years has innovated both in its product or service range and in its productive process has an R+D+I department. This is also the case of a quarter of the companies that have introduced organisational improvements simultaneously.

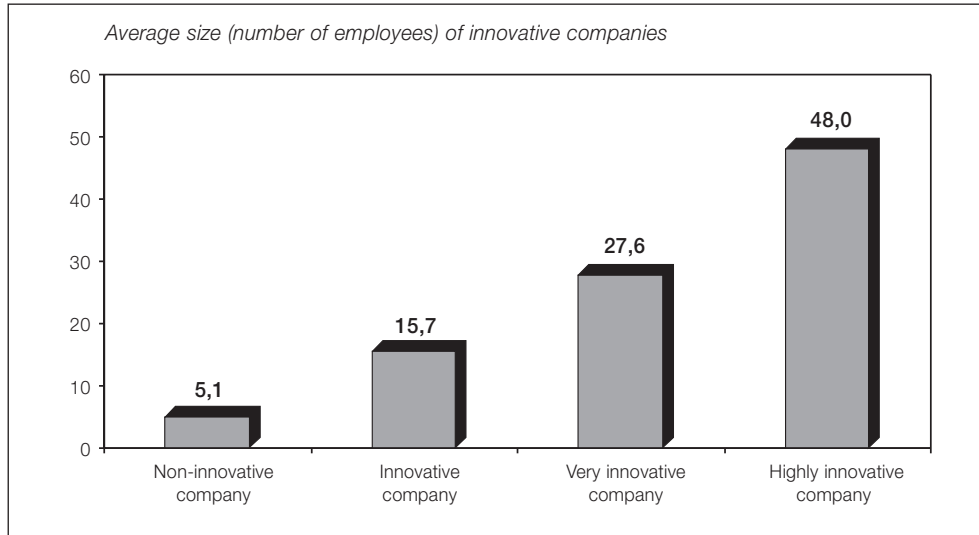
The typical scale economies of these departments, with significant fixed costs and medium-term returns, explain many of the differences between business segments. These economic factors therefore would suggest the existence of a certain necessary size threshold for creating an R+D+I department. Thus, research returns could be more significant and

permit to develop more sustainable competitive advantages over time. In spite of that, the initial investment cost, the tendency to focus on strictly short term benefits as well as daily pressure mean that the formalisation and systemisation of research in many small Catalan enterprises is roughly reduced. Therefore, larger companies are more likely to generate new knowledge endogenously, whereas the innovation processes of smaller companies depends on the support they receive from their immediate environment and therefore on their capacity to benefit from the effects of networking through cooperation. The results obtained confirm that there is a close correlation between company size, business dynamism and innovation complexity.

While the availability of a specific research department is a critical variable in the development and commercialisation of new products as well as in the redefinition of production processes, almost half of innovative companies (48%) declare that their innovations are the product of activities performed by the company's own personnel, albeit personnel not exclusively dedicated to research tasks. This fact shows the presence of informal innovation, probably based more on continual and incremental improvements than on radical changes in the company's stock of scientific and technical knowledge. In that respect, the transcendence of tacit knowledge in Catalan firms becomes obvious, as the development of innovations appears to be in large part due to continual effort and not exclusively to the accumulated stock of specific and observable knowledge. The data seem to confirm this. The predominance of non-specialised internal personnel as a source of innovation based on ICT in Catalan companies is revealed in all innovative companies regardless of their size. In general, it can be stated that the most dynamic small and medium-sized enterprises base their innovation more on this determining factor. However, the differences between companies are not very significant. Human capital, with the knowledge acquired and developed within the company, is revealed as an essential determiner of the Catalan companies' innovation process. Therefore it can be expected that innovative dynamism is closely related to the educational level and qualifications of all company employees, not strictly of its management team. Actually, companies with higher employee qualification levels show a higher tendency to innovate continuously. Training based on higher education enriches the stock of specific knowledge in the company and is one of the inductive mechanisms of the business innovation process.

Jordi Vilaseca / Joan Torrent

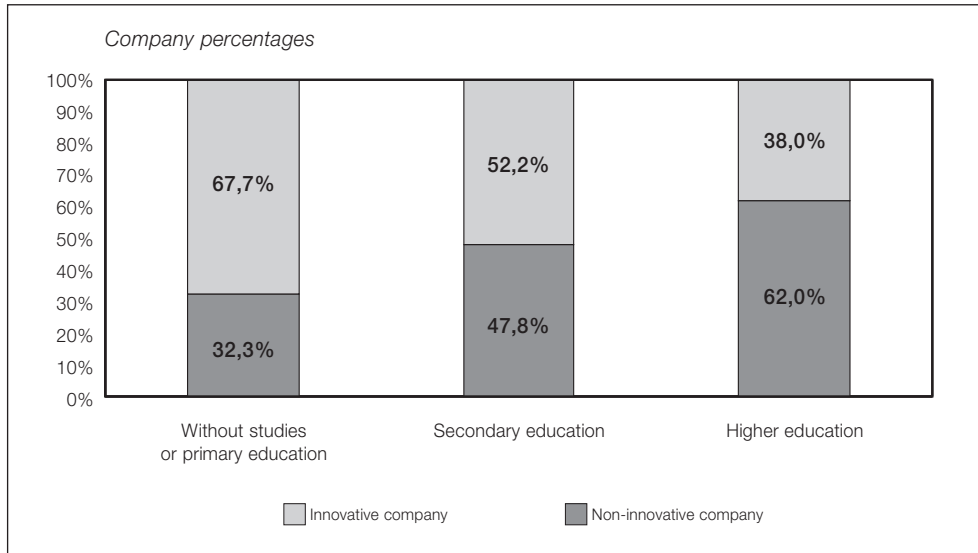
Figure 35. Innovation and Catalan company size



Source: own creation.

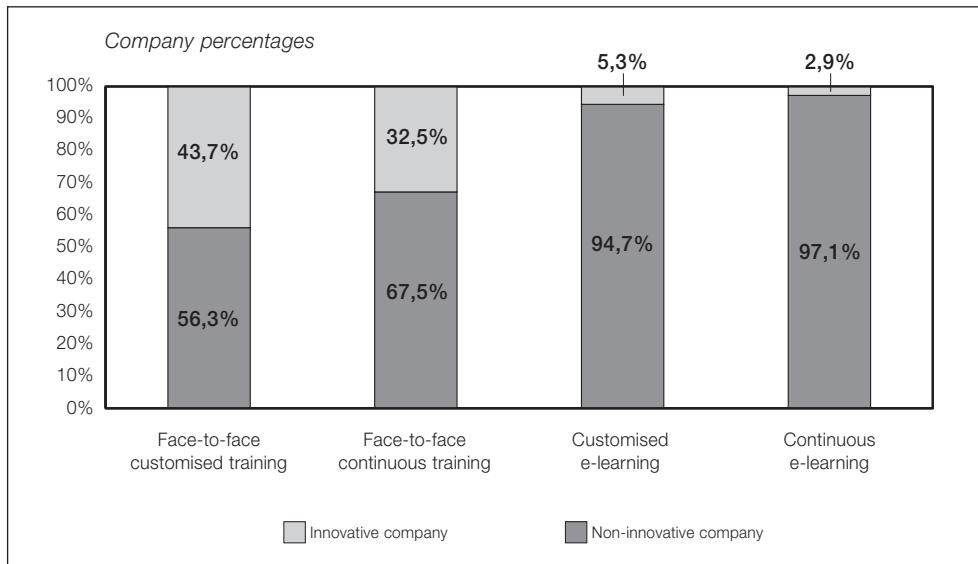
Furthermore, it can also be expected that if in the knowledge economy the creativity and the development of talent are the key factors, then work will become continually more self-programming. In that case, the aim is to allow employees to continually reprogram themselves in terms of new skills and abilities required by the competences in the workplace they occupy at all times. In this line, continual and customised training within the company becomes a decisive element for improving the stock of scientific and technical knowledge that must favour innovative development. The results obtained confirm continual training within the company as one of the decisive aspects of innovative dynamism. Moreover, the results reflect the importance of the role e-learning plays as an instrument for recycling and continual learning throughout one's professional career. Innovative companies are characterised by making use of e-learning. Extremely significantly, the correlation between the two variables is very high. Lastly, there are more employee self-training initiatives in companies that develop independent and more complex innovative processes.

Figure 36. Innovative dynamism and level of homologated employee training in Catalan companies



Source: own creation.

Figure 37. Innovative dynamism and level of continuous, made-to-measure training for employees in Catalan companies



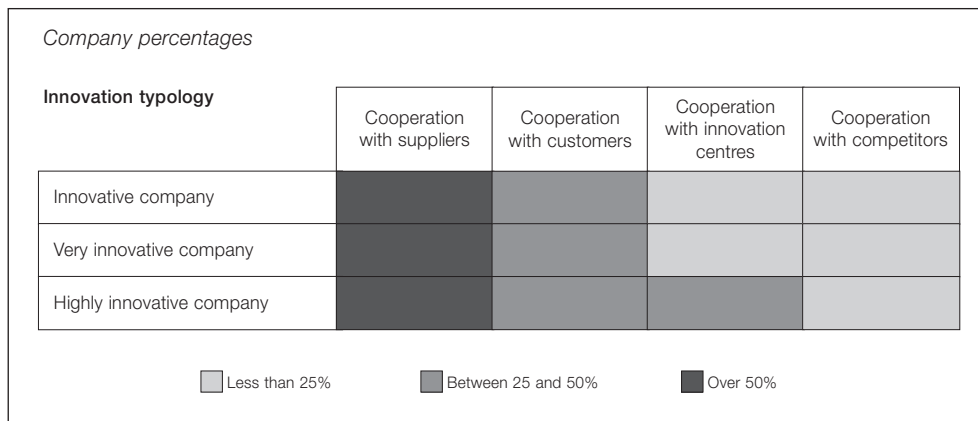
Source: own creation.

Jordi Vilaseca / Joan Torrent

These internal determiners explain how ICT use affects positively the behaviour of business innovation processes. Likewise, it should be borne in mind that a system of innovation is not only based on business activities aimed at developing new products, services or processes. The capacity of innovation in companies is also influenced by the organisation of the supplier-customer chain and by the quality of the company's interactions with its environment. The previous analysis has shown how Catalan innovative business dynamism is strictly linked to company size. In general, it is large companies that promote the most sophisticated and complex innovation projects. However, the system of innovation in Catalonia heavily overlaps the external conditions in which companies develop their activities, due to the smaller average business size. One of the main positive effects of ICT use as an innovation means is the incentive it represents for Catalan companies to build new cooperation networks or to make the existing more efficient.

Indeed, the effects of networking, associated to the use of these technologies in the business innovation process, appear to be significant mainly when developing more complex innovations. In the last two years in Catalonia almost 40% of product innovations that have been accompanied with changes in the production process and half of integral innovations have been carried out in collaboration with other companies or institutions. In particular, cooperation seems to have been strategic for highly innovative companies. The innovations that affect the value chain have been one of the most significant transformations of technological change into development of competitive advantages for the most innovative Catalan companies. The cooperation with innovation centres has been less intensive, but it appears to have been important in developing highly complex innovations. Instead, cooperation between competing companies is still an extremely minor activity in the Catalan productive network.

Figure 38. Cooperation in innovation between Catalan companies



Source: own creation.

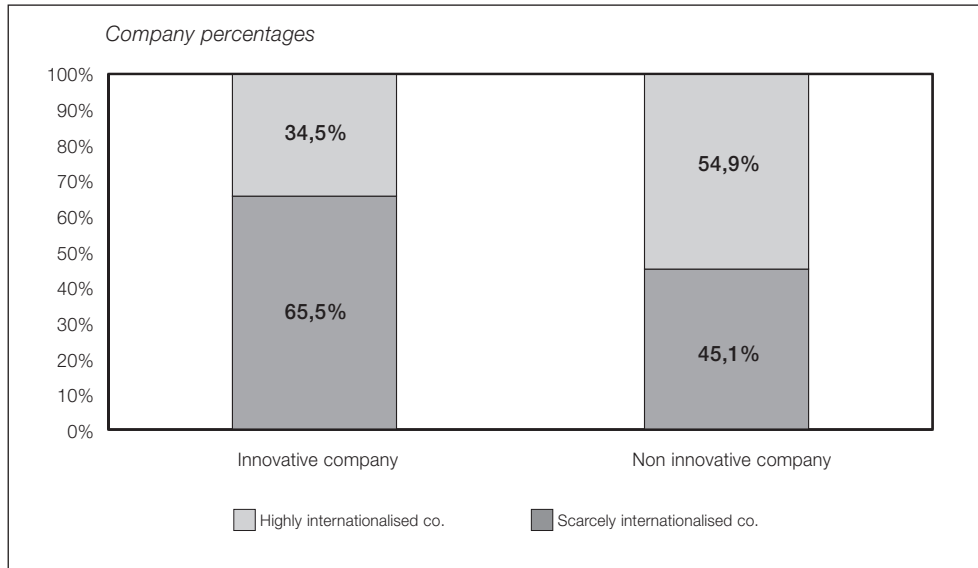
Therefore, it can be confirmed that the way the relationship between companies, suppliers and customers is organised affects directly their innovation capacity. Likely, ICT have significantly favoured interactions throughout the entire value chain, in such a way that a working method with a tendency for innovation based on continuous improvement is encouraged. Thus, it can be deduced that the success causes of innovation include as well the efficiency of the value chain and the orientation of innovations towards the customer. These technologies facilitate the development of the network firm, not only in terms of their internal organisation, but also of their interactions with companies and institutions they collaborate and share interests with. Cooperation throughout the supplier-customer chain for developing innovations will attempt to achieve more efficient production, product or service improvements, a complementary technological level, more production flexibility, and more information on customer needs. It will also try to develop product differentiation strategies through faster reactions to demand changes. All these strategies are critical for competitiveness in the knowledge economy, yet their success demands shared objectives and close contact between all the members of the chain. As ICT can allow frequent, faster and efficient interactions, complicities can be consolidated since they favour teamwork.

Insofar as innovation based on ICT use allows the development of more complex competitive factors, as well as with more potential for competitors' differentiation, it could be expected that the most innovative companies develop sophisticated competitive strategies, different from the product cost. These strategies should allow them to reach more favourable records in terms of external markets penetration and economic returns. Indeed, the data obtained make clear that innovative companies show much more advanced degrees of internationalisation and that the development of complex innovations is accompanied with a greater company predisposition to open new export markets.

This greater presence in international markets must necessarily be linked to the development of competitive strategies in a global environment. As stated earlier, ICT make the innovation process more dynamic, but also more interactive and interdependent. Thus, the most competitive companies turn continual innovation into a crucial strategic factor, as it allows them to develop competitive strategies based on advanced technological applications and frequent quality improvements of the products and services they offer to the market. Therefore, the constant development of innovations reinforces the company's market position in relation to their competitors and allows it to enjoy the benefits of technological leadership, rapidly reducing the technological and product life cycles. Thus, the results obtained confirm that innovations based on ICT use have encouraged the development of more sophisticated differentiation strategies based on technological or brand leadership. On the other hand, companies that compete by developing niche markets based on narrow specialisation or on high product or service quality, preferably develop innovations that combine the introduction of new products with the redefinition of their processes and, many times, with organisational changes.

Jordi Vilaseca / Joan Torrent

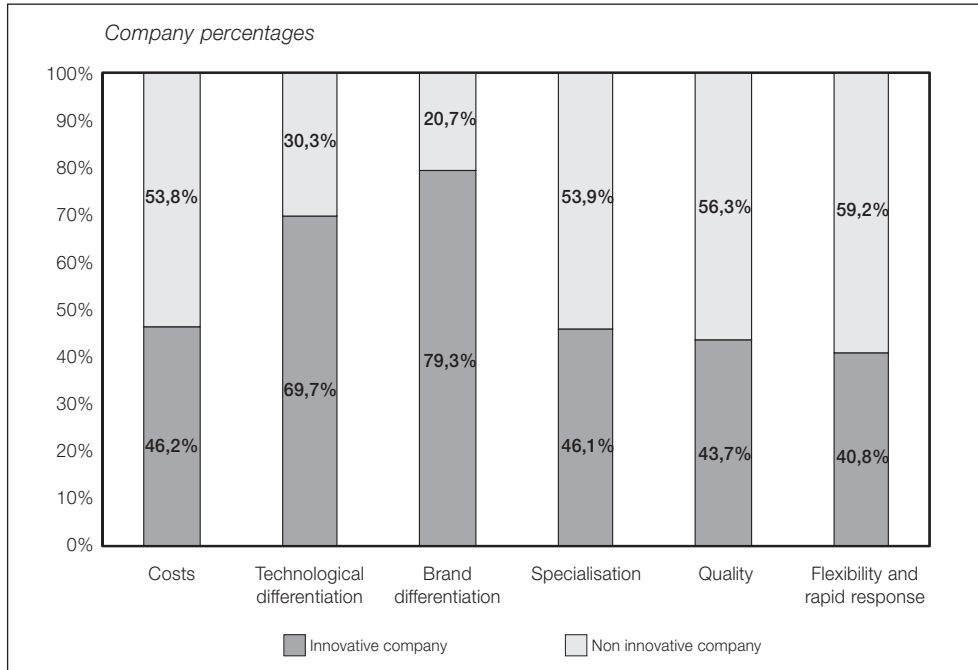
Figure 39. Innovation and internationalisation of Catalan companies



Source: own creation.

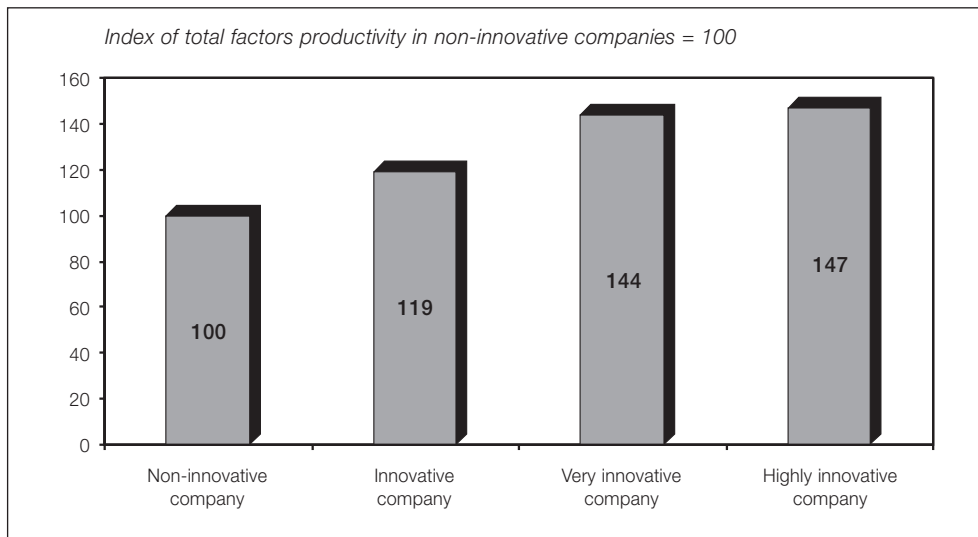
Finally, the economic impact of innovations based on ICT is revealed when we look at the more favourable returns that innovative companies obtain in terms of a higher total factors productivity, higher assets rotation and higher income on their own (or financial) resources. Indeed, the strategic use of these technologies leads to improvements in efficiency and it helps to make resources more productive and makes the business more profitable, although the most favourable effects are generally obtained when the innovation process incorporates organisational changes as well. Therefore, business innovation becomes a high important mechanism for growth and progress in Catalan companies. Even though a considerable part of the productive network of the country still does not use ICT as an innovative means, according to the data obtained we can conclude that the effects these technologies have had on the innovation process, on competitiveness and on return of innovative companies were significant.

Figure 40. Innovation and competitive strategy in Catalan companies



Source: own creation.

Figure 41. Innovation and productivity in Catalan companies



Source: own creation.

Jordi Vilaseca / Joan Torrent

2.4. ICT AND BUSINESS RESULTS: CLARIFYING THE PRODUCTIVITY PARADOX

The functioning of the progressive consolidation of a new type of economy is based on the massive incorporation of knowledge into the economic activity. We previously indicated that one of the main signs of this progressive consolidation is the significant productivity increases that, initially in the USA, and later in other Western economies, have been registered. This upward trend of product growth per capita has been accompanied by an intense academic debate on the sources and sustainability of this growth.²³ From a theoretical perspective, a consensus on the sources of economic growth seems to have been achieved. However, the problems in finding an accurate measure for productivity are still present in practice. According to the professor Gordon (2003): «There is no macro-economic magnitude more significant for the future evolution of an economy than productivity growth, yet neither there is any macro-economic magnitude so difficult to foresee». This difficulty occurs for at least three reasons. The first reason is due to the high percentage of employment in services. It is no secret that official statistics work well when the merchandise to be measured is a tangible market product both in physical and monetary units. However, official measurement of productivity begins to fluctuate as the output becomes more difficult to measure. This is the case of services in general and of the public services in particular, as well as the case of the economy when it becomes tertiary and it is combined with a progressive intangibility of the merchandise subject to economic transaction. Secondly, as companies make progress in networking organisation, the difficulty in gaining productivity increases throughout the value chain of reticular and globalised organisations is more and more difficult. Lastly, we note the mismatch between technological revolutions and their productive impact. Technology history has shown time after time that the temporal leap between the discovery of an invention, its productive generalisation and the consequent productivity increase can be enormous. In the specific case of digital technologies, everything seems to indicate that we are under the effects of the first of a number of investment waves, which will set the basis for significant future productivity growths. Yet, statistical improvements and official USA measurement suggest a quantitative leap in productivity increase in this country from the late nineties, which would be linked to the massive investment in ICT and to an organisational change based on networking. This productivity increase has a cadence that echoes from the productive core of the economic transformation²⁴ into all other activity branches.²⁵ To sum up, investment in ICT

23. For a complete perspective, see the works of Gordon (1999; 2000; 2003), Jorgenson and Stiroh (2001), Oliner and Sichel (2000), Council of Economic Advisers (2001; 2002), Stiroh (2001), Baily and Lawrence (2001), Nordhaus (2001), Department of Labour, USA (2002) and Feldstein (2003) for the USA, and Schreyer (2000), Scarpetta, Bassanini, Pilat and Schreyer (2000), Colecchia and Schreyer (2001), Pilat and Lee (2001), Van Ark (2001), BCE (2001), Milana and Zeli (2002) and Van Ark, Inklaar and McGuckin (2002) for other economies.

24. The empirical studies carried out (IMF, 2001) suggest that productivity increases in the computer industry during the nineties are around 25%.

25. For several years economists at the centre for e-business at MIT (<http://ebusiness.mit.edu>) observed, for a total of 600 large companies in the USA, that between 1987 and 1994, internal company decentralisation and the adoption

and organisational restructuring derived from network connection explain a good part of the labour productivity increase in the USA. The increase of labour productivity was less significant in other areas of the world, but it begins to be perceptible, especially all in the Scandinavian countries, Australia and Canada, and in a lesser degree in other G7 countries and industrialised Asian countries²⁶ as well.

We already know that one of the most relevant economic indicators for explaining long term economic growth is labour productivity, understood as the product per employee or, preferably, per hour worked.²⁷ Productivity can rise as a consequence of an increase of the available capital per hour worked (intensification of capital use) or by a higher degree of economic efficiency, measured through increases in the total factors productivity (TFP). In that respect, an acceleration of the total factors productivity would be a clear indication of the existence of a new economy, since productivity increases would not only be explained through increases in factors stocks, but also would have a significant efficiency leap in the whole economic system. Even so, opposite to labour productivity, TFP cannot be measured directly and its estimation is difficult in practice. In fact, economic growth models that include technological innovation have shown clearly that one of the explanations for the productivity paradox (the low significance of capital per capita in explaining economic growth) is shown precisely by the total factors productivity. This product component per capita is usually attributed to a wide range of elements, from the impact of technological innovation to the institutional elements guaranteeing the micro-economic efficiency and the macro-economic stability.

From the business activity point of view, one of the most widely accepted indicators for measuring the capacity of the company to obtain long-term positive growth results is its potentiality for maximising the quantity of merchandise object of the transaction (and, consequently, its market value) with a specific quantity of production factors (and, therefore, a specific value of productive consumes). In other words, it is the need of the company to minimize input costs spent to generate a specific output level. That means that the company's productivity index is configured to measure the business capacity to obtain profits adequately and is built on an indirect approach to the generation of value derived from its productive activity. Therefore, the productivity index and the company result can be considered two clearly inter-related micro-economic means of measuring the development of the business activity.

of forms of network organisation became necessary conditions for productivity growth. Lucas (1999) has also shown, from case studies, that the income from ICT investment is usually essential for company's approach towards the product, the process and the market.

26. For more information, see the studies of the Department of Economy of the OECD (http://www.oecd.org/dsti/sti/prod/sti_wp.htm).

27. The explanation is very simple. The average number of hours worked per employee has a direct effect when calculating the productivity according to employment (GDP/Employee). In fact, we can break down the ratio (GDP/hours worked)=(GDP/Employee)*(Employee/Hours worked). In a context of a growing significance of part-time work, the use of the product per employee would lead to a clear falling bias in productivity figures, as according to this measure all employees would work the same number of hours, a fact that would increase the denominator and, consequently, reduce the ratio (GDP/Employee).

Jordi Vilaseca / Joan Torrent

The productivity index, as a micro-economic measure of efficiency achieved by the company in performing its production activity, is influenced by both the nature of the factors employed and its own influence in forming the production structure. In that respect, it seems logical to think *a priori* that the productive application of ICT, either as tangible capital (tangible technological infrastructure; that is, equipment and systems), or as intangible capital (intangible technological infrastructure; that is, computer applications) and/or as raw material (information) can have an effect on the value of the previously mentioned indicator.²⁸

This direct effect of ICT on productivity increases is not the only effect of this factor on the productive efficiency process. In fact, a horizontal effect between ICT and the other factors employed by the company can take place. In this sense, there is certain empirical evidence of the reciprocal effects shown by ICT use, together with other factors in the scope of the business productive activity. On the one hand, it has been shown that specific business investment, such as research and development, empowers the emergence of ICT in production uses, becoming priority elements of an innovative strategy with clear positive synergies from the perspective of increasing product generation. On the other hand, it also appears to be empirically confirmed²⁹ that investment in ICT generates a parallel investment in associated resources. These resources are usually intangible and related to the requirements of new professional skills and new organisational methods that guarantee the efficient use of these technologies.

Finally, it is important to point out the evidence that the effective use of productive ICT factors requires an organisational adaptation for their efficient use; that is, a cultural change at all levels of the organisation. These adjustments are neither automatic nor immediate; therefore they can only become patent if they are instituted over time periods that go beyond the short term. The explanation for this gradual modification of different organisational models can be found in the postulations of organisational models based on learning, according to which the introduction of digital technologies into organisations generally implies a period of approach, learning and trial of its more efficient uses for a specific productive activity. Thus, everything seems to indicate that a clear sequence of the possible ICT relationships with the business productivity rate is outlined. It can be synthesized in the following process: initially the company should invest in ICT in order to improve the efficiency of the productive factors; secondly, investment should be spent on learning about the efficient and effective use of these technologies. Finally, the company's organisational structure should be adapted to the new productive reality.

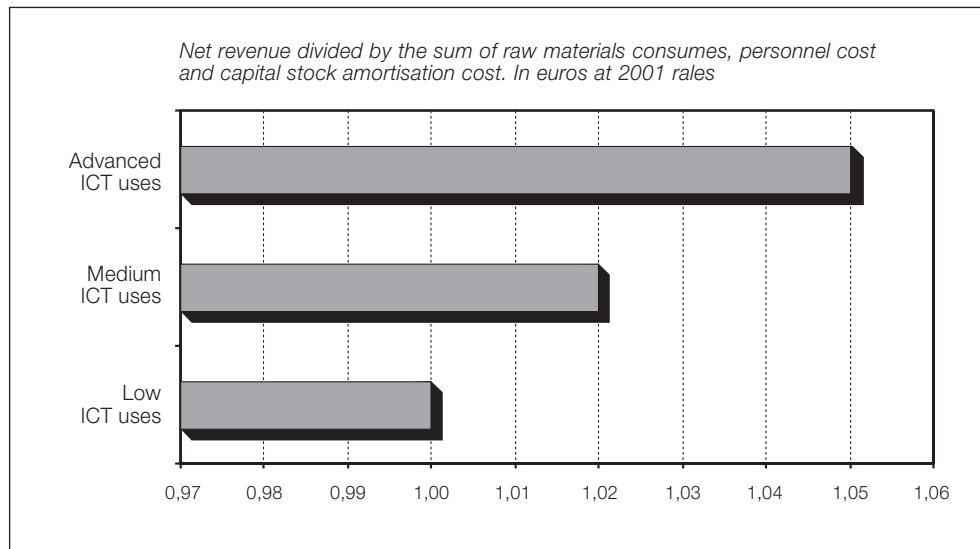
Therefore, we adopt short term productivity as an approach to the company's potential to obtain profits. We analyse ICT effects on the behaviour of product per unit produced in

28. In fact, several studies, basically in the USA, highlight the statistically significant relationship between short and long term output growth and investment in digital technologies. See Brynjolfsson and Hitt (1993: 2003), Bresnahan, Brynjolfsson and Hitt (1999) and Hitt (1999).

29. Brynjolfsson and Hitt (2003).

Catalan business through its uses and the Internet equipment. With this objective, we focus on two differentiated ways of measuring the productivity index: the total factors productivity, considered as the relationship between the output level and the level of the inputs labour, capital, materials consumes and outsourced services. The second measure is the company's gross added value per employee, considered as the added value generated in the company per labour unit. The first productivity indicator is used to analyse the incidence of ICT and the Internet equipment on all Catalan business, whereas the second indicator is used to contrast ICT effects on the different activity sectors and company sizes. The use of this latter work productivity measuring tool allows a greater degree of homogeneity when evaluating the productivity in activity sectors which by nature are heterogeneous.

Figure 42. Total factors productivity and ICT uses of Catalan companies



Source: own creation.

From the perspective of all Catalan companies it can be confirmed that there is a statistically significant positive relationship between ICT uses, company Internet equipment and productivity gains. In fact, as Catalan firms intensify the use of the ICT in its production activity, the productivity derived from the combined use of the different production factors increases considerably. This rising behaviour goes from a relationship of 1 point in companies with low ICT uses to 1.02 points in companies with medium ICT uses, and finally, it reaches 1.05 points in companies with advanced ICT uses. Therefore we possess partial but sufficient evidence to affirm that ICT use in the productive process improves the efficiency of the Catalan business activity due to both its direct incidence on generation of outputs and its indirect effect on other productive factors.

Jordi Vilaseca / Joan Torrent

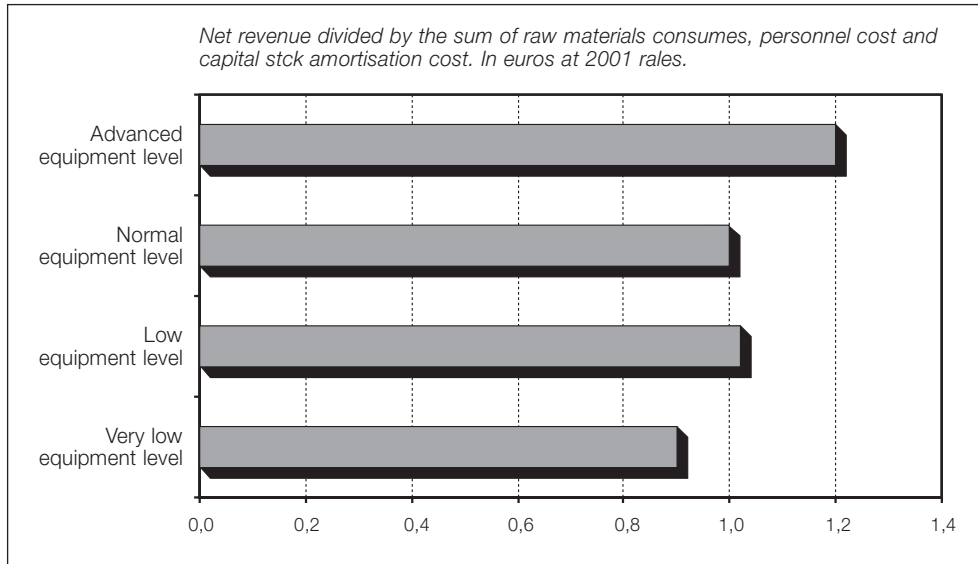
If we break down the partial incidence of investment and the use of Internet equipment of Catalan firms to analyse the behaviour of the total factors productivity, we can confirm, as we did with ICT uses, a global increasing tendency of the productivity index as investment and the use of this equipment intensify. However, certain intermediate points in this tendency should be stressed. Benefits from productivity decrease when the company goes from a low level of Internet equipment use (with a productivity index of 1.02 points) to a normal level (with an index of 1 point). On the one hand, this circumstance is due to the investment requirements derived from a new stage of technological change (it should be remembered here that the difference between the two levels lies in that the normal level has Internet connection and website, while the low level has only access to an Internet connection). On the other hand, the reason is the need of an adaptation and corporate learning period to reach an efficient use of these resources. However, once the company has made the leap from a low level to a normal level of Internet equipment, the data analysed show that important synergies are produced with highly significant growing returns when the company goes from a normal level to an advanced investment and equipment use level (with an index of 1.2 points). Those companies having a very low level of Internet equipment show the lowest productivity index: a value of 0.9 points.

To complete this initial level of analysis, we would like to check whether cultural and organisational change required by investment and ICT use to guarantee its efficient contribution to the productive activity has a partial direct effect on the total factors productivity. Indeed, the data analysed show there is a positive relationship between the organisational change in Catalan firms and the gains in productivity. In fact, companies that state not having made any change to their organisation have a productivity index of 1 point, below the 1.04 points achieved by companies that have carried out any kind of change. This empirical evidence reinforces the premise according to which the productive use of the ICT must go accompanied by an organisational change, usually subsequent and manifested in new ways of organizing the company's productive activity.

The second level of our analysis leads us to contrast the relationship types existing between the level of ICT uses, the level of Internet equipment and its uses, and the productivity of Catalan firms, which is measured through the gross added value (GAV) per employee according to the activity sector and company size. We will explain the results of the analysis in an isolated form and we will study the industry separately from the services. That is due to the significant productive differences and output measurements these two sectors reflect, in accordance with the differentiated nature of the business activities they group.

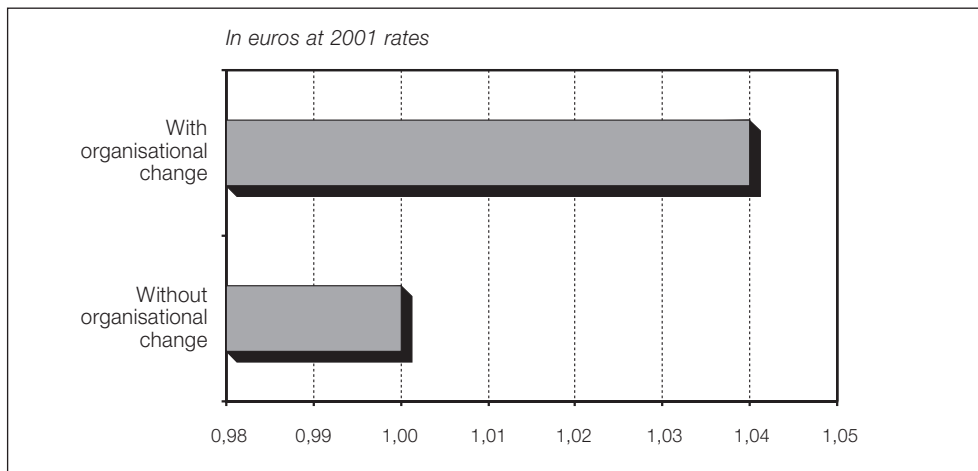
In accordance with the effect of ICT use levels on productivity gains, it should be stressed that in all the industrial sub-sectors with the exception of the medium technology industry there is a significant increase in the productivity index, when companies turn from a medium to an advanced ICT use level. Therefore, in general terms, we can state that in the industrial scope ICT use shows a positive incidence on the scope of productive efficiency.

Figure 43. Total factors productivity and Internet equipment in Catalan companies



Source: own creation.

Figure 44. Total factors productivity and organisational change in Catalan companies



Source: own creation.

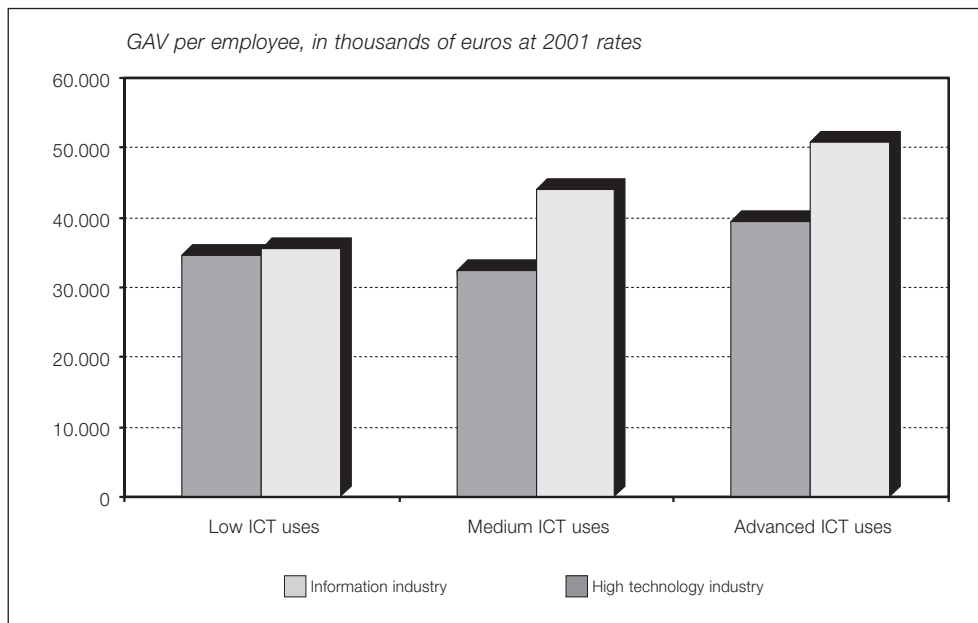
The effects on productivity derived from the transition from low levels to advanced ICT use levels present three differentiated behaviour patterns. In industries with a high technological level —the high technology industry and the information industry— a positive relationship can be seen between intensification in ICT use and productivity gains. This relation-

Jordi Vilaseca / Joan Torrent

ship partly can be attributed to the greater ability of employees to adapt to a higher level of technological uses. However, it should be stressed that in the case of the information industry, the passage from a low use level to a medium use level implies a small loss in productivity. Probably this is due to the learning effect, which is the most important skill that this leap in ICT use intensity requires. In the medium technology industry the intermediate effects are different. The most significant gains in productivity appear when passing from a low use level to a medium use level, with no possibility to maintain the synergic effects on productivity when turning to an advanced use stage. Finally, the low technology industry has its productivity diluted in the transition from a low to a medium use level. However, it achieves an efficiency increase in the productive application of factors when intensifies the use from consolidated medium uses and goes to an advanced ICT use scenario.

Like in the industrial sector, regarding the analysis of the investment incidence and Internet equipment uses on the productivity value, it should be noted that there is a tendency to increase the company's productivity as equipment level and equipment use increase. This increase is especially significant in the transition from a normal equipment level to an advanced level, with the single exception of the low technology industry. It can therefore be affirmed that in general terms the effort in investment intensification and Internet equipment use in the Catalan industry is compensated by significant increases in productivity.

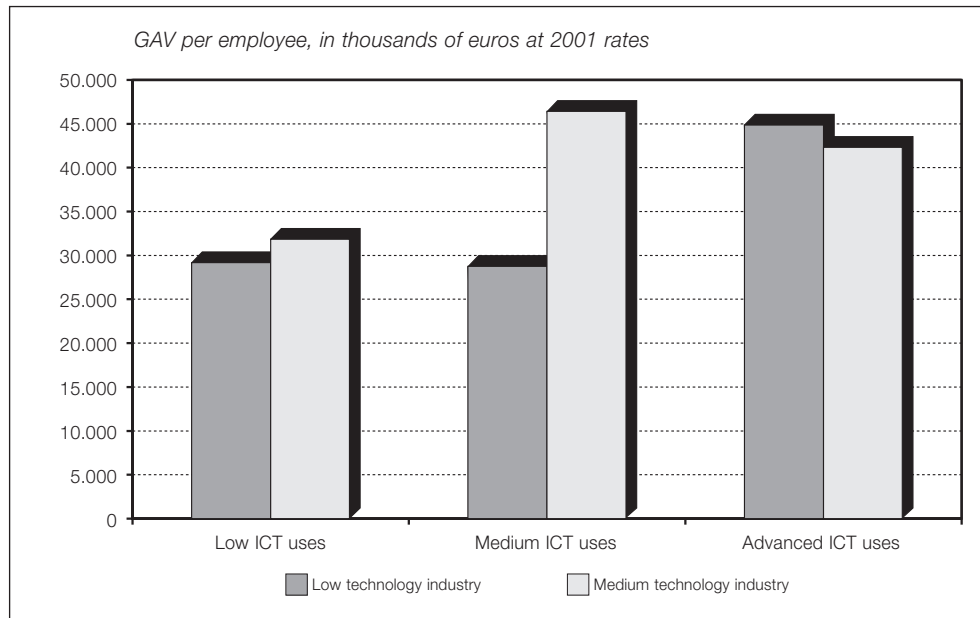
Figure 45. Labour productivity in the information industry and in the high technology industry in Catalonia and ICT uses



Source: own creation.

Observation of the broken down analysis of this upward trend in different industries reveals a series of differentiated features. In the information industry there is a decrease in business productivity when passing from a low equipment level to a medium level. It is due to the fact that this leap concentrates the most significant investment and the most extreme adaptation requirements, which clearly become profitable in the upper stage of more advanced equipment levels. The high technology industry shows this point of adaptation and consequent descent in the productivity index at a moment prior to the technological capitalisation process. It specifically occurs in the transition from a very low equipment level to a low level, thus obtaining incremental gains as the level increases and enters into more advanced stages.

Figure 46. Labour productivity in medium and low technology industries in Catalonia and ICT uses



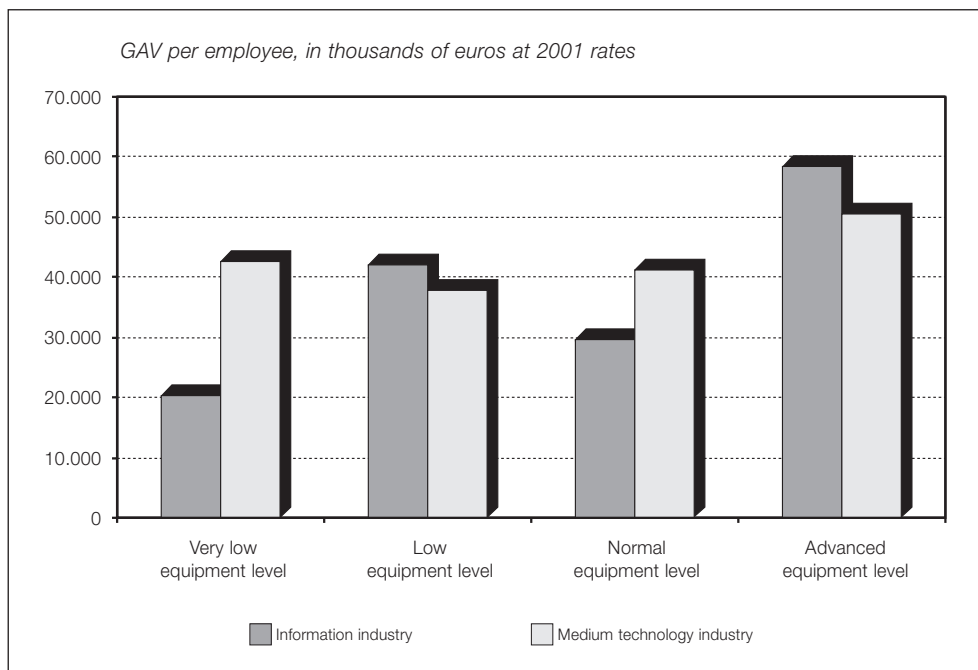
Source: own creation.

At this point it is worth mentioning the behaviour of the medium technology industry. It shows a sustained growth of the productivity index as Internet equipment levels increase, as well as the highest increase of the whole industry when passing from normal to advanced levels. Therefore, it can be stated that companies of this industry achieve more adequately the cost-profit balance in the short term, derived from the use of the Internet in the productive activity. This industry has shown that the better capacity to achieve a more efficient behaviour of its productive factors is partly explained by the fact that the necessary infrastructure investment for developing the business activity is more moderate in the medium technology industry than in the high technology industry or in the information industry. Lastly,

Jordi Vilaseca / Joan Torrent

the behaviour of productivity in the low technology industry should be stressed. This industry shows decreasing values when going from a very low to a low equipment level and in the transition from a normal to a high level. This means that the relative cost of investment and the necessary organisational adaptation to transcend these levels is higher in this industry than in other industries.

Figure 47. Labour productivity in the information industry and in the high technology industry in Catalonia and Internet equipment



Source: own creation.

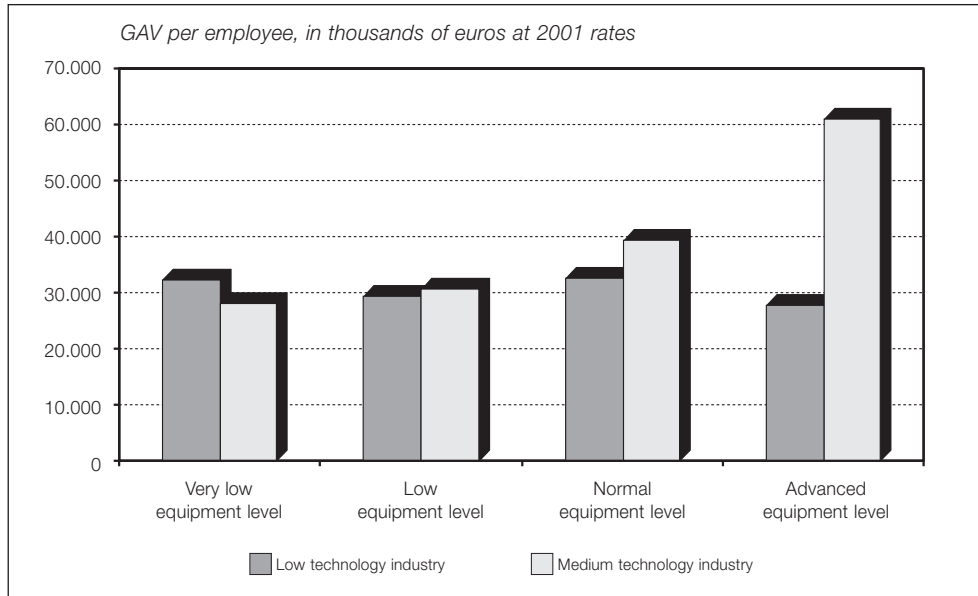
A specific behaviour pattern can be noticed when only considering the services sector. On the one hand, and from the analysis of the effect of ICT use on business productivity values, it can be seen that the most intensive knowledge services do not show relevant productivity gains respect the evolution of the ICT use level when passing from a low to a normal ICT use level. The cause of this situation can be found in the very nature of this service typology, where a slight impact of this use intensification in the business activity can be appreciated. However, in the transition from a normal to an advanced use level there is a clear negative impact on the short term labour productivity values. It is due to two complementary effects. Firstly, the opportunity cost can be attributed to the need to match personnel skills to direct effects on production efficiency. Secondly, the substitution effect of pro-

ductive factors (labour for technology) seems to have a negative incidence on the short term output value. On the other hand, from the data obtained we can observe a positive relationship between ICT use intensity and productivity values in the less intensive knowledge services. Therefore, it is confirmed that a less qualified labour force associated to a lower wage level permits great productivity returns in the short term. Instead, productivity behaviour due to the effect of Internet equipment and uses reveals a differentiated behaviour compared to the case of ICT uses. In this case the analysis reveals a positive tendency towards an increase in the tertiary productivity index as Internet equipment levels increase. Furthermore, this growing dynamics does not follow a homogeneous pattern. On the one hand, the data obtained confirm the productive efficiency in the short term in the less intensive knowledge services, with a practically sustained growth of the productivity index as equipment levels increase. On the other hand, it shows that the opportunity cost of investment and organisational adaptation to the increasing Internet equipment in the intensive knowledge services is produced in the transition from a low to a normal level. This fact implies a clear labour productivity downturn once the company has the Internet and creates a website. However, this fall is importantly profitable in the next phase of the digital impact: the broadband Internet connection. In this step the productivity of the intensive knowledge services increases highly significantly.

Likewise, the analysis by company size introduces a number of results which should be emphasized. Initially, if we consider the incidence of ICT uses on productivity values according to the company size, three differentiated tendencies can be confirmed: Firstly, intensification of ICT productive uses in micro-companies shows a negative relationship with the productivity index. Thus we observe a progressive and notable reduction of this value in the transition from a low to a normal use level. Reasonably, this fact deserves two explanations: the relative cost of ICT use intensity is relatively high in smaller companies and needs to be accompanied with a contribution of the human factor, which often requires of specific skills of a higher wage level. Secondly, it is understood that small and medium-sized enterprises report growing productivity gains as they increase their ICT use level. It denotes these companies possess a productive structure capacity that permits to reach increasing efficiency levels in the short term. Thirdly, the data show that the structure of large companies breaks the rising tendency of the productivity in the most advanced strata. It occurs when going from low to medium ICT use levels, due to the impact of the significant associated cost of investment and organisational adaptation.

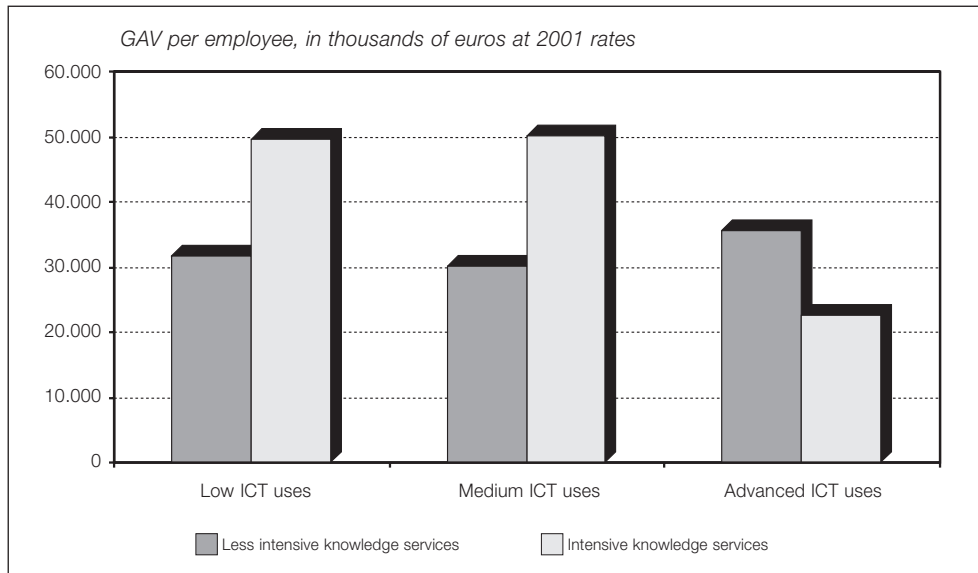
Jordi Vilaseca / Joan Torrent

Figure 48. Labour productivity in medium and low technology industries in Catalonia and Internet equipment



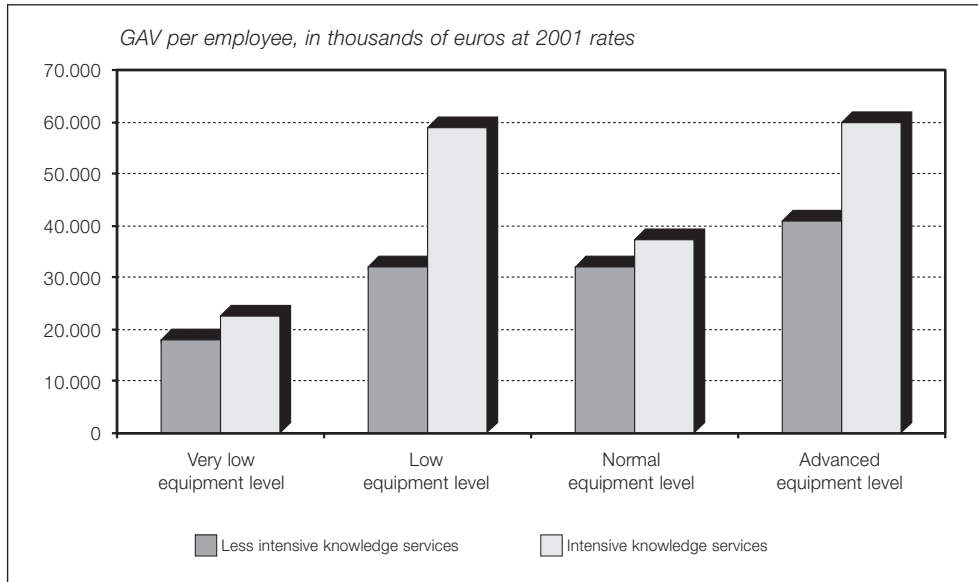
Source: own creation.

Figure 49. Labour productivity in services in Catalonia and ICT uses



Source: own creation.

Figure 50. Labour productivity in services in Catalonia and Internet equipment

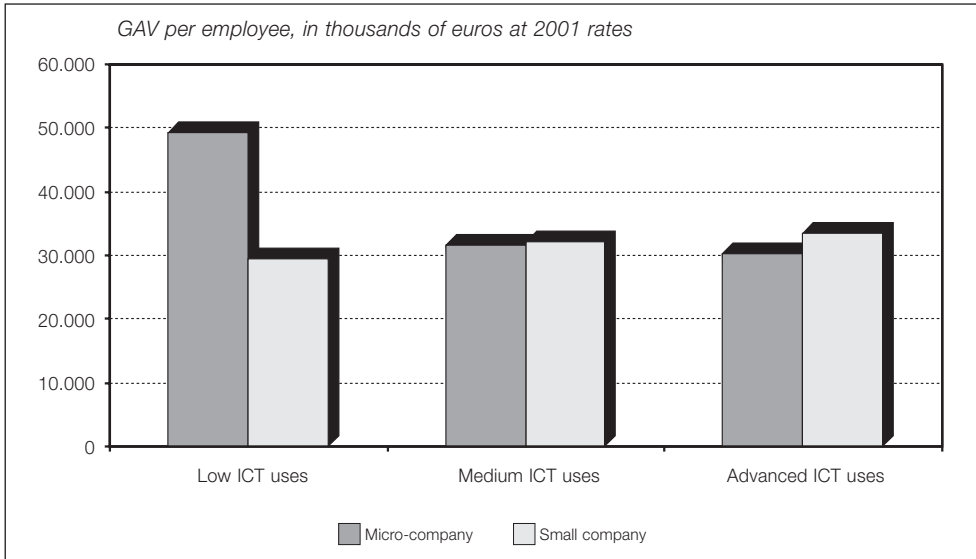


Source: own creation.

Lastly, the study of the effect of Internet uses and equipment on the productivity index according to company size reveals that there is a positive relationship between equipment levels and productivity gains in the different company sizes considered, even though there is no clear link between size and the intensity of the relationship of these variables. In fact, it should be stressed that micro-companies, after having overcome the negative impact on productivity of the necessary investment to go from a low to a normal level, obtain the highest growth in this indicator that even easily surpasses the results reported by large companies. We would also point out that the data available reveal that productivity gains in large companies begin to be sustained from a low level of Internet uses and equipment and that there is not any company of this size with no Internet connection.

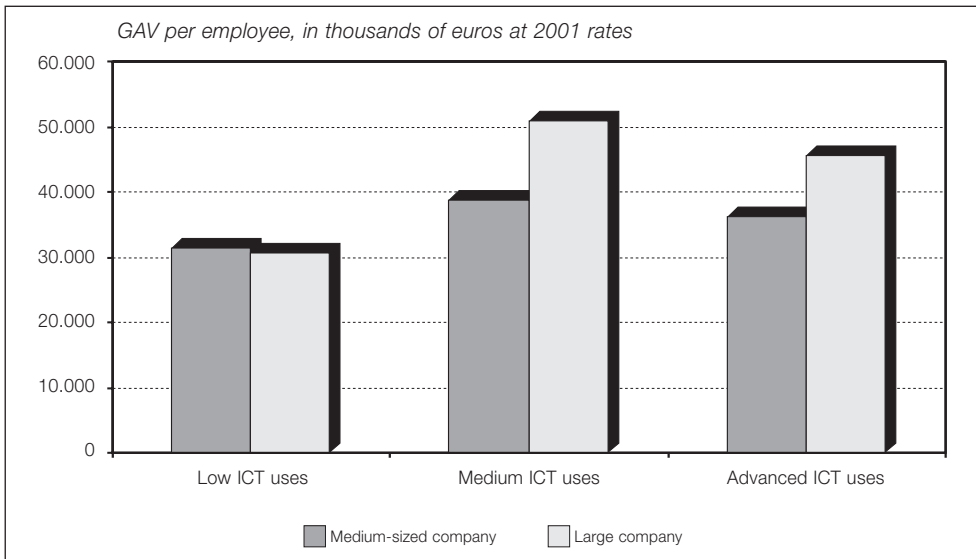
Jordi Vilaseca / Joan Torrent

Figure 51. Labour productivity in Catalan companies and ICT uses, by size (micro-companies and small companies)



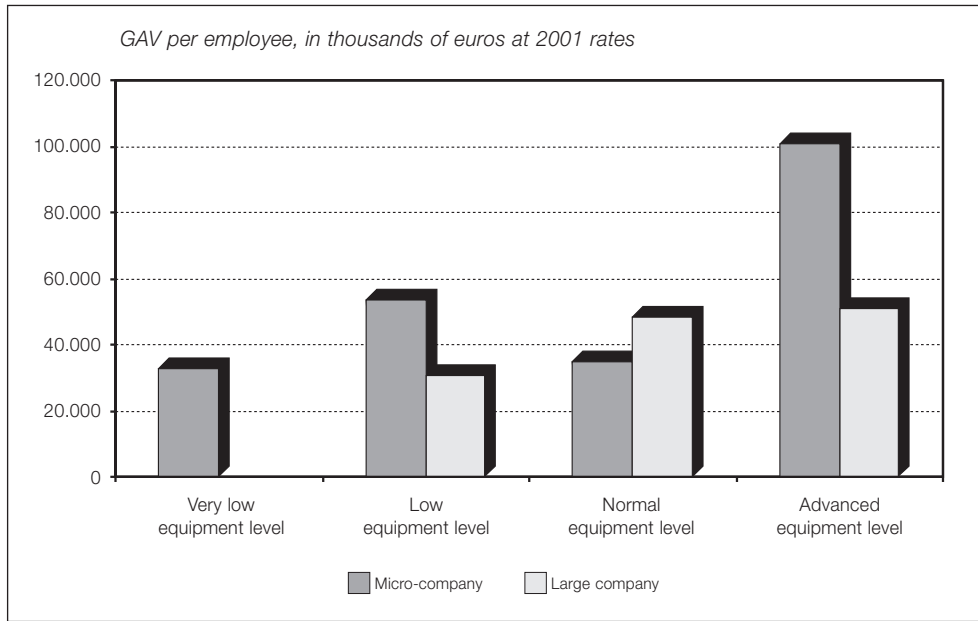
Source: own creation.

Figure 52. Labour productivity in Catalan companies and ICT uses, by size (medium-sized and large companies)



Source: own creation.

Figure 53. Labour productivity in Catalan companies and Internet equipment, by size (micro-companies and large companies)



Source: own creation.

3

CONCLUSION: TECHNOLOGICAL CHANGE AND BUSINESS ACTIVITY IN CATALONIA

Currently, two powerful agents for change affect Catalan business: globalisation and digital technologies. Spatial and temporal enlargement of markets has altered significantly production, distribution, exchange and consumer schemes in the Catalan economy, which progressively enters into a transition process towards a global and knowledge-based economy. The company is doubtlessly one of the economic agents that in recent years have undergone more transformations. Here we summarise them from the consolidation of two concepts: the network firm and the e-business. The network firm is a strategic and organisational business activity model based on the network decentralisation of all its business lines. This model surpasses the organisational models consolidated in the eighties, based on a network of companies. At the same time it stands for a transformation of the business functioning towards a differently configured system in which work is done in network and the value chain is significantly diluted. However, this new strategic and organisational model would not be possible without a powerful technological tool. Therefore, ICT make electronic business possible; that is, they are the necessary condition (the sufficient condition is cultural change) for doing business in another form: through computers and telecommunications networks. Thus, e-business does not only embrace all the new productive activities that have emerged around ICT productive uses, but traditional productive activities also add value to digital technology uses, even though in different intensity.

Therefore, it is important to point out that the relationship between profound changes in demand and productive schemes, derived from growing worldwide economic integration, and the use of information and communication technologies as a tool for adding value to a production to which increasing doses of knowledge are required, is not unidirectional. We would not comprehend globalisation without its foremost infrastructure: ICT. However, neither can we understand business use of digital technologies without reference to its prime objective: gaining market share. Therefore, the implications are much more complex than in a simple unidirectional relationship.

It is clear then that the analysis of Catalan firms' transformations linked to ICT uses cannot be isolated either from the most fundamental processes it overlaps with or from the structure and configuration of the economic agent to be studied. In other words, the strategic, organisational and productive changes in Catalan business associated to ICT uses cannot be interpreted in all their complexity without an analysis of the principal engine of this transformation: the globalisation of the economic activity. Nevertheless, we have to bear in mind that Catalan firms have certain pronounced defining features that certainly condition

Jordi Vilaseca / Joan Torrent

the transition towards the knowledge economy. Specifically, this has been the methodological path of the research we are now concluding: to describe and characterise the current state of Catalan companies, especially concerning the impact of its process of internationalisation; to study the equipment level and the main uses of the ICT and to explain the transformations of each value element of the business activity. Furthermore, we have made a step forward in this research with the aim of answering, on behalf of Catalans, the open questions raised in national and international research about the new business economy. This research provides evidence of the impact of ICT uses on the four main aspects of any productive activity. That is, the two productive factors (capital and labour), the incorporation of technical change and the results of its organisational and productive practice.

At the dawn of the 21st century, Catalan firms were in a halfway transitional period between the consolidation of a new type of economy, basing its functioning on the use of growing amounts of knowledge, and the maintenance of their traditional organisational and productive structures within the industrial economy and services. At first sight there is nothing further from the global knowledge economy than an economic activity still highly focused on itself and barely open to external influences. In accordance with the data obtained, less than 10% (7.9%) of Catalan companies sell more than a third of their production outside Spain. Furthermore, there is a very weak presence of establishments outside Spain (3.4%) and a low internationalisation degree of direct and indirect work (only 2.1% of companies have executives from other parts of the European Union, while 4.7% of companies have employees from Latin America, 4.0% from Europe and 2.8% from Africa, to quote the most representative figures).

We can indicate that internationalisation is much more commonly present in the interaction of Catalan companies with their immediate external agents. Indeed, the data obtained confirm the dynamism and the complexity of the Catalan business environment. Catalan companies operate in markets with a high level of competitive intensity: out of those that state knowing their competitors, a large number (43.9%) also affirm having over twenty competitors (17.6% of Catalan companies even indicate they have 100 or more than 100 competitors). Additionally, the data obtained show that Catalan companies compete both locally and globally. In fact, 92% of companies affirm having Catalan competitors, but 44.4% state having competitors in the rest of the Spanish state, 28.3% in the rest of the European Union and a significant 20.9% in the rest of the world. Catalan companies interact simultaneously with an average of 72 suppliers. Furthermore, the geographical dispersion of these suppliers is quite high. The 94.7% of companies state they have Catalan suppliers, but 65.2% are also supplied by other parts of the Spanish state, 37.9% by the European Union and almost twenty percent (19.6%) of Catalan companies have suppliers in other parts of the world. The average number of customers of the Catalan company is around three thousand. Even though the sales percentages in Catalonia rise to 76.8%, Catalan companies' customers are geographically dispersed. The 94.9% of these companies state they have customers in Catalonia, 43.7% in other parts of Spain, 18.5% in the rest of the European Union and 11% in other parts of the world.

ICTs and transformations in Catalan companies

In fact, both the degree of internationalisation and digital technology uses in Catalan firms depend to a great extent on its structure and characteristics. The Catalan business sector is characterised by small size (over 88% of Catalan companies have less than five employees), a considerable diversification of the business lines (only 7.9% of companies concentrate their activity with one or more business lines belonging to the same sector as their main activity) and a high geographical concentration of their activity (80% of Catalan companies have their head office in the metropolitan area of Barcelona). Furthermore, most of the Catalan productive landscape is made up of family companies possessing a single establishment; therefore over 90% of the business capital of Catalan companies has its origin in Catalonia. By sectors, 52% of Catalan companies are situated in the less intensive knowledge services, followed by a less than 20% of companies in the intensive knowledge services and 17.5% of companies in the low technology industry. However, it stands out the comparative low number of companies in the information industry (6.3%), medium technology industry (2.9%) and high technology industry (1.7%).

Yet, there are also powerful business groups in Catalonia. These are large companies that do business outside the country (28.1% of large companies' capital comes from abroad, compared to a very low percentage, 8.5%, from other parts of Spain). These companies, more intensive in knowledge use, are also those that in general show a higher degree of internationalisation of their activities, a higher use level of ICT tools and more advanced Internet equipment. Production in short customised series is gaining ground in Catalan companies' offers, as well as the degree of international interaction as pressure increases for global competition. Finally, expectations for the immediate future in the business world are moderately favourable to the creation of new employment (more than a third of Catalan companies foresee increasing their staff in the next two years and another additional half consider that the slowing down of the cycle will not be accompanied by adjustments in employee numbers), especially among activities more intensive in technology and knowledge and in the majority of large companies as well. Nevertheless, the scarcity of trained and specialised labour has become a strategic challenge for the development potential of the Catalan companies.

At the start of the knowledge economy we have analysed the ICT equipment and use levels for the diverse value elements in the Catalan firms. In broad terms, we saw that Catalan business is digitally well equipped, although the level of ICT use penetration could be improved. However, we also showed that approximately one third of Catalan companies, basically medium-sized and large companies, and the most intensive sectors of technology or knowledge use, reflect normal or advanced digital use intensity. Likewise, it should be stressed that 91% of Catalan companies have an Internet connection, 87.4% have access to e-mail, while 46.1% have website, 21.7% purchase on the Internet and 11% sell via the Internet. Yet, a highly significant number of Catalan companies make an insufficient use of the ICT in the areas of operations, marketing and organisation and human resources. The 73.4% of Catalan companies do not plan production (or their services offer) using ICT. The 75.7% do not have access to an external technological planning system with suppliers or distributors. A 77.6% of companies do not have integrated systems for obtaining and managing the infor-

Jordi Vilaseca / Joan Torrent

mation they generate with their customers, and therefore, they make insufficient use of the ICT in their marketing area. Finally, in terms of organisation and human resources, only 15.4% of companies make what could be qualified as sufficient use of basic equipment (compared to 84.6% of companies that do not use it); meaning that they use accounting and invoicing systems, wage payment or else internal communications systems. And just 6.5% make a more complex use of the ICT, which implies using them in at least two of the following systems: data management and information exploitation, executive information systems or enterprise resource planning. However, by sectors, it is clear that the high technology industry and the less intensive knowledge services lead the way in terms of sufficient uses. Instead, by size, the vast majority of large companies make sufficient use of ICT in all operational elements (77.8% of companies plan production and 55.6% do so for suppliers and distributors), for marketing (55.6%), and for organisation and human resources (77.8%)

Bearing in mind the ICT uses among companies in each area of the value chain, it can be concluded that the level of ICT business uses can be improved. The 71.7% of Catalan companies reflect an insufficient ICT use. This insufficiency is clearly seen through the lack of any technological system in any operations area (production and suppliers/distributors), marketing and organisation and human resources (basic and complex); it is also seen when the technological system is only used in one of the five areas. In terms of average uses, 24.2% of all companies have systems for two or three of the five areas. Finally, 4.1% of Catalan companies have systems for four or five of the value elements mentioned (advanced uses). Here and as it also occurs with Internet equipment, the data obtained clearly show significant differences between activity branches and company size. In terms of production sectors, it should be pointed out that, even if in all these activities the low uses of technology systems exceed the two third parts of the total sample of the surveyed companies, we can observe certain relevant differences. In fact, the two sectors that show the lowest ICT uses are the high technology industry and the less intensive knowledge services, with 68.6% and 65.5% of companies respectively. Therefore, penetration of medium and advanced ICT uses is more relevant, especially in the high technology industry (with 22.9% of companies reporting medium uses and 8.6% of companies reporting high ICT uses). The services intensive in the use of knowledge follow the information industry when regarding the application of advanced ICT uses (5.7% of Catalan companies). By size, companies with less than ten employees generally reflect low ICT uses (between 73.3% and 75.2%). A significant percentage of small companies with over ten employees (32.9%) and medium-sized companies (41.1%) make a medium use of ICT in their organisation. Large companies can be highlighted because in general they report medium and advanced uses (44.4% of large companies show this use typology).

Finally, in reference to attitudes associated to ICT use, it is worth commenting that 89.2% of companies think that ICT use and implementation transforms their business activity. These transformations of the business activity eventually imply, to a certain extent, the perception of increases in productivity, competitiveness, profits and individual relationships. Even though we are at an initial stage, the fact that there is a generalised extended use of

basic ICT (such as e-mail or an Internet connection), and taking into account the main advantages these uses generate, it makes one think of a progressive increase in transformations leading to organise the firm in network, both internally and externally. In fact, bearing in mind the main ICT business uses, which are basically employed to provide support to the infrastructure element of the value chain (44.4% of Catalan firms use ICT in management, administration and accounting tasks, 29.3% to obtain information, 27.4% to communicate with suppliers and customers and 23.4% to communicate generally) it is not surprising that, at this initial use stage, increases in business efficiency are recorded. Especially, this reality co-exists with close to 15% of additional companies that consider ICT as their basic business tool and are in an upper state of implementation. Lastly and with significant difference, the most common reason for not applying ICT productively to the company's value elements is that the firms do not consider it necessary, a fact that confirms the cultural change as one of the main requirements to consolidate the network firm.

To analyse more closely the real impact of ICT uses we have also analysed the transformations of each of the value elements of the business activity. From the strategic perspective we indicated that the Catalan business environment is dynamic and complex. With such a framework it is not surprising that the majority of Catalan companies focused on a strategy of differentiating their product/service (86.5%). This differentiation is especially fundamental in quality (40.7%) and in the offer of products or specific services to each customer type (25.8%). However, around 10% of companies still apply a strategy of cost leadership. In spite of the fact that we cannot confirm that the Catalan companies have overcome the classic dichotomy between differentiation and cost strategies, we can state that companies that apply a differentiation strategy are also concerned to control their costs, as shown by the fact that half of Catalan companies apply some internal cost system. In the same way, Catalan companies reflect a clear concern for quality. For this reason, the vast majority of firms adopt quality control systems for their products or services (76.3%) and/or their processes (67.5%). Nevertheless, they show less inclination to certify their quality control systems (26.6%). Finally, we can also state that Catalan companies consider the strategic process as a continual process of adopting strategic decisions, applying these strategies, controlling and reviewing this strategic process and reformulating their strategy. In that respect, almost all Catalan companies have redefined their strategic objectives at some stage. The most frequent reasons for this redefinition are the need to adapt to market changes (in more than 75% of companies) and the need to introduce improvements into their products and services offer.

From the perspective of the organisation of the business activity, the data obtained confirm that some Catalan small and medium-sized enterprises show a significant degree of flexibility. The 83.7% of companies have between one and three departments. The average number of departments is 1.8 and the average number of employees at an operative level is 8.5. In that respect, it can also be confirmed a certain degree of orientation of the productive activity in Catalan business towards process. Therefore, 28.9% of companies are organised by processes, 31.2% have introduced innovations of an organisational nature, 48.9% use

Jordi Vilaseca / Joan Torrent

flexible and adaptable work teams on business lines and the average speed in adapting the productive technology to the demand changes is 6.6 (on a scale from 0 to 10). Furthermore, 46.7% of industrial companies offer unitary orders, and 47.8% of service companies accept customised orders from the customer.

As far as infrastructure activity is concerned and in terms of the investment and financing cycle dynamics of the business activity, the data obtained suggest that ICT affect the speed of execution in such a way that Catalan companies have the perception that ICT enable them to finance themselves and to invest faster than ever (43.2%). The most direct consequence of this situation is a higher degree of rotation both in the application of resources in the form of investments and in making these investments profitable. The dynamic nature of the company's capitalisation process implies the inherent need to study the patrimonial structure. In this framework and in terms of the financial structure, it should be stressed that Catalan firms are mainly financed with external resources, which implies an important level of indebtedness. In spite of this composition of the financial structure, the data show that Catalan business is capable enough to meet its payment obligations within the established periods.

In terms of business investment it is important to point out a series of aspects associated to both structure and functionality of the investments Catalan companies make. We observed that a highly significant part of the available resources were set aside for financing the productive activity (up to 91.9% of the total) in detriment of the financial activity. In that respect it is worth stressing that by sector it seems to be a positive trend between investment in ICT infrastructure and the degree of financial activity within the total business activity. In this area, it is also important to note that one fifth of the investment in productive infrastructure in Catalan firms is concentrated on the acquisition of intangible factors. The study of the company's productive activity through its cost structure has also revealed a series of results to be mentioned. Firstly, less than half of annual costs in Catalan business are fixed costs. This circumstance indicates a certain general capacity for flexibility of the productive structure in terms of costs, via the conversion of fixed costs into variable costs. Secondly, we can state that more than half of total annual business costs are direct costs. Additionally, the data reveal a certain trend to generate more indirect costs as investment in ICT infrastructure increases. Thirdly, regarding the use of information systems for business costs management, the data reveal that over half of Catalan companies have implemented some type of cost system.

ICT use as a means of innovation is a widely accepted strategy in the Catalan business world. In the last two years almost half of Catalan companies (46.3%) have introduced innovations supported by these technologies. Therefore, it can be affirmed that a significant part of the business world has accepted that ICT are a competitive advantage and a strategic differentiation factor regarding to competition. The strategic use of these technologies to support innovation processes is not homogeneous, but it is much more widely disseminated among larger companies and among economic activities that use knowledge more intensively as a production factor. Over a wide area of the Catalan business landscape, the presence of ICT in innovation processes is not developed enough. Therefore, despite the fact

that we can speak of moderate use intensity, this research results enable us to infer that these technologies influence significantly on business innovation processes. In particular, they confirm that ICT affect the determiners, the behaviour and the nature of innovation.

Furthermore, one should bear in mind that business innovation is a complex process depending both on internal company factors and others linked to the environment in which it operates. The particularities of Catalan business reality, with a productive structure characterised by the great predominance of smaller companies, mean that innovations are generally the result of either new knowledge and technology assimilation from outside, or largely informal and internal company processes that lead more to continual and incremental improvements rather than to radical changes in their scientific and technical knowledge stock. Consequently, the nature of the productive network means that, within the Catalan innovation system, both environmental features and the particularities of internal company innovation processes are highly important. This fact has direct consequences on the potential to generate endogenous innovations and the capacity to assimilate new external technologies and knowledge and it also conditions the content of innovation support policies.

Without large formal R+D+I structures at company level (only present in 16.4% of companies) and without an extremely favourable specialisation in highly intense technological activities, ICT are favouring the increase of new knowledge throughout the productive world. In this scenario, their use has affected the company's capacity to develop more complex innovations and to favour company's interactions with its own environment. On the one hand, these technologies stimulate and make innovation more sophisticated, both if it is the result of systematised and highly formalised processes or the result of less formal processes. This has principally been the case of the high technology and the information industries and the case of large companies in general. More than half of companies with over 100 employees and more than 40% of companies in the information industry have used ICT to innovate either in product or in process. On the other hand, they promote knowledge dissemination from outside. This has principally been the case of service companies and industrial companies using the new technologies less intensively, as well as the case of smaller companies in general. Almost half of innovations carried out using ICT by companies with less than 5 employees and by service companies have received external support.

One of the main consequences of ICT use is the reduction of the barriers to innovation, since their use fosters company interactions with its environment and with whoever can supply new knowledge and technology. This is especially relevant in those Catalan companies with a more limited potential to begin continuous and endogen innovation projects. The immense majority of companies located in Catalonia (73.8%) sees this driving effect of ICT on innovation. Nevertheless, not all companies have carried out innovations with the support of these technologies, a sign of the persistence of other obstacles. These falling barriers have been accompanied by the stimulating effect that ICT have had on cooperation between companies and institutions to develop innovation projects, especially in smaller companies and in less intensive knowledge activities. Over 20% of Catalan companies with less than 20 employees have cooperated to make innovations. Therefore, the network effect induced by

Jordi Vilaseca / Joan Torrent

these technologies is clear revealed. For this reason, in the case of small companies, the creation of cooperative networks compensates the absence of formal R+D+I structures within the company.

The increasing cooperation between suppliers and customers means that innovative Catalan companies modify their company model so as to develop more complex and sustainable competitive strategies. They are based on the improvement in product and service designs and features, a higher productive flexibility, a faster response to changes in demand and a strategic interaction with customers. In that respect, it does not appear that ICT have substantially modified the geographic limits of cooperation, but instead, ICT have increased the dynamism of the interactions already carried out in company's surroundings. Almost three quarters of cooperation experiences in conducting innovations (72.2%) have been carried out between economic agents within Catalonia. In this way, the importance of local cooperation has been revitalized by ICT use as an innovation means, in favouring existing interactions between companies and their immediate environment.

However, ICT use also affects the nature of innovations. In general, the use of these technologies has been preferentially aimed at stimulating innovations that optimise company's competitive factors. Innovation based on ICT means that companies develop more complex, interactive, interdependent innovation processes, linked to the dominant competitive strategy. It is clear then that ICT have been present in almost half the product innovations carried out by Catalan companies and have allowed a third of Catalan companies to be innovative in their productive process. Specifically, almost 65% of Catalan companies that have carried out product innovations through the use of the ICT have introduced new products or services into the market. The 40% of innovative companies have improved features on product and service ranges introducing new technology and 18% have introduced new raw material. Furthermore, the combination of the different innovation typologies permits us to infer that ICT use has enabled Catalan companies to become more innovative in constantly renewing their processes and products or services, as well as developing more complex innovation processes that fulfil the objective of achieving continual improvements in the value chain and which correspond to more sophisticated competitive strategies.

It is obvious the potential of ICT as an innovative tool in Catalan companies, both regarding its use as an innovation means in itself and its use as a means for overcoming obstacles to innovation. However, these positive effects should not distract us from the fact that innovation continues to be a strategic challenge for the entire Catalan economy. Most of the production network of the country is out of the intensive utilisation of these technologies. There is still a substantial critical mass of service companies and, especially, of industrial companies of medium and low technological intensity that do not introduce innovations continuously. Even though they recognise the positive effects of ICT use, the potential of the country's innovative system in many companies is conditioned by non-proactive and non-strategic behaviours.

When it comes to human resources in Catalan business activity, from the data obtained we can see that labour relations are built upon the basis of a job with a contract of indefinite

length. Yet, there is also another reality: almost the 20% of jobs are temporary contracts or self-employed work. As for the typical working day, the data obtained show that in Catalan business 90.6% of employees work fulltime and 9.5% of employees work part-time. Regarding to the average gross annual wage, the Catalan average is situated at 17,846 euros. By sector, we can see higher degrees of contractual and hourly flexibility, as well as better wage levels in the more intensive knowledge and technology sectors: the intensive knowledge services (20,279 euros) and the high technology industry (18,956 euros) are the two production sectors leading the wage rate in the Catalan economy. Furthermore, digital technologies open new possibilities in personnel management within the organisation. Despite all this, we have contrasted that Catalan companies make a limited use of these technologies: 83.8% of Catalan firms do not use ICT to cover vacant job positions, while 93.6% of Catalan business organisations do not have mechanisms for professional evaluation using ICT. Moreover, we have also confirmed that a good number of companies (over 40%) do not allow employees to use the Internet for personal interactions.

Having analysed the support elements of the value chain, below we focus on the transformations of its basic elements: the operations area, the marketing area and after-sales service. As far as operations are concerned, it is worth noting that 26.6% of Catalan companies make a sufficient use of the ICT in this activity. This use increases in production planning activities or in the services offer, which highlights the different stages a company goes through during the process of integrating its supply chain. The initial integration must be carried out internally so as to later integrate both suppliers and distributors. In that respect, the data obtained confirm that ICT use in operations is greater at an internal than at an external level. In fact, one of the main priorities of Catalan firms is the adaptation to a changing global demand which, in production terms, means affirming the need to develop flexible production schemes. Therefore, we can confirm that the A-type product portfolio is wider and wider (over a third of Catalan industries offer between two and five references to the market). This fact indicates that 80% of company sales are no longer achieved with a single product/service. Changing consumer demands does not only affect the product/service range in itself, but also the product/service delivery aspect in terms of delivery at the time and place of the customer's choice. In order to accomplish these two latter requirements, Catalan firms increasingly trust in using information and communication technologies in their relationship with their distributors, thereby ensuring the diminishing of sales numbers affected by distribution incidences. The data obtained show clearly that technological and working flexibility in Catalan firms is high (6.6 and 7.8 points, on average, on a scale from 0 to 10).

In terms of the marketing area it can be noted that the representative Catalan company makes significant use of ICT in this value area. Almost all companies have file systems through which they register and manage the data obtained from their customers. Some companies even have access to advanced information systems of CRM type (Customer Relationship Management) that allow them to obtain and manage customer information and integrate it into other company information systems (22.3%). These systems, combined with occasional use of formal market research studies, make it possible for Catalan companies to

Jordi Vilaseca / Joan Torrent

quickly obtain, accumulate and analyse large volumes of information. However, it is more significant that this information provides these companies a deep knowledge and a wide understanding of the current and future customer needs. ICT are additionally used to design and generate new products (45% of companies making product innovations use digital technologies). Likewise, Catalan firms know how to take advantage of business opportunities in a segmented market and to detect homogeneous groups of potential buyers. By launching a wider market segmentation strategy (54%) and taking it to its ultimate extreme, Catalan firms are showing themselves that they are able to establish differentiated marketing strategies for each targeted segment. It is carried out by adapting or personalising the variables of the mix variables such as price, distribution or communication and developing a personalised customer attention service. Lastly, it can be affirmed that Catalan firms are performing an increasing part of its economic activity through the Internet. Even though the data recorded are not as significant as those for United States companies or other countries in Europe, they show certain dynamism in the Catalan business community within the network environment (12.4% of Catalan companies carry out electronic commerce on the Internet). Regarding B2C electronic commerce, the penetration index in Catalan companies is not insignificant: 11% of companies, 7.1% of total sales and an average business figure per company of 102,000 euros. On the other hand, B2B electronic commerce has a higher implementation level in Catalan companies than the aimed at final consumers. This occurs not only because more companies are doing it (21.7%) but also because a larger business share is recorded (19.7% of total purchases and an average business figure per company of 207,000 euros).

Finally, we contrasted the impact of the ICT use and the Internet equipment with the four priority elements of the business activity: capital, labour, innovation and organisational and productive practices. In terms of digital impact on the business activity capitalisation process, we confirmed that the Internet equipment level as well as the ICT use level in Catalan firms affects the speed of the flow of the financial resources. In that respect, it should be highlighted that companies with a very low investment level in Internet equipment and its uses (almost 50% of companies in this segment) believe that ICT have a direct effect on the speed of the cycle. This effect is clearly revealed when the company goes from a low to a normal equipment level. This perception of ICT incidence is diluted in the more advanced stages, where the integration of this aspect affects all areas of the productive activity. From the perspective of patrimonial structure, two extremely important results should be highlighted regarding the configuration of a balanced financial structure. Firstly, the wage costs of external financial resources (the cost of financing) decrease progressively as investment in Internet equipment and its uses increase. Indeed, financing costs moves from percentages around 20% in low Internet equipment levels to under the 2% in advanced equipment levels. Furthermore, this transition is especially important when passing from a very low to a low level. Secondly, the greater ICT use intensity, the lesser the company's need for access to liquid funds for debt payment. The treasury percentage significantly decreases as ICT intensity increases. Lastly, regarding the economic structure of the business patrimony and above other considerations, it should be considered the effect of the ICT

on the composition of Catalan business investment, as there is a positive relationship between ICT use levels and an increasing use of intangible assets in the productive activity. This increase is especially significant in the transition from a medium ICT to an advanced ICT use level. Indeed, the participation in intangible fixed assets over the total fixed assets drops to under 25% with medium ICT uses and rises to over 35% with advanced uses.

Regarding the digital impact on labour relations we wanted to test the causality between ICT use and labour. Our starting point was the considerable relative distance between wages in intensive Internet use sectors and non-intensive sectors. In fact, wages in companies with advanced Internet equipment show a rising deviation compared to the average Catalan company wage of close to 10%. On the contrary, the falling deviation of wages in companies with very low Internet equipment levels is close to 25%. Furthermore, in Catalan firms is also obvious the double causality between wages and productivity explained by international empirical evidence. However, this double effect is determined by a set of elements without which feedback either increases or is weakened. These factors are the Internet equipment, the digital technology intensity and the employee training (face-to-face and e-learning). In terms of the first implication: for every increase in productivity per employee, the average wage in Catalan companies increases twelve tens. Regarding the second implication, the wage impact on the productivity through e-training is clearly positive, and it grows in sectors with technological or knowledge use intensity. Instead, the impact on face-to-face training is negative. Secondly, the impact of wages on total productivity through face-to-face training is positive for low ICT uses, although it decreases according to technological and knowledge use intensity.

ICT uses as an innovation means foster the network organisation of Catalan companies, as these technologies partially reduce the obstacles to innovation and make interactions within the company and with its environment more efficient, so that they stimulate the innovative dynamism and allow the development of more sophisticated and interdependent innovation processes. The results obtained confirm the close relationship between a medium and a high degree of ICT uses, more advanced Internet equipment levels and more innovative behaviour. In fact, 57.8% of companies that have an advanced ICT use level and 84.3% of companies with an advanced Internet equipment level are innovators (66.7% in the case of medium ICT use and 60.7% in the case of normal Internet equipment). We also see that organisational change is more intensive in the most innovative companies, and at the same time we can verify the strategic role of training. On the one hand, companies with better qualified employees tend to innovate constantly (62% of companies with university-qualified employees are innovative). On the other hand, continuous training within the company is a key aspect for innovative dynamism (67.5% of companies with employees in continuous face-to-face training programmes are innovators). Furthermore, innovative companies make use of e-learning (more than 90% of companies with employees in continuous training programmes or tailor-sized e-learning programmes are innovators). Lastly, innovative companies are characterised by the development of more complex competitive strategies with higher potential for differentiation (79.3 and 69.7% of companies that differentiate by trade-

Jordi Vilaseca / Joan Torrent

mark or technology are innovative). Consequently, they also show more advanced internationalisation degrees (65.5% of highly internationalised companies are innovative), higher productivity (the total factors productivity of highly innovative companies is situated at around 47%, above the non-innovative company), and finally, higher assets rotation and higher profitability.

Lastly, we saw the effect of the ICT productive use and Internet equipment levels on the business productivity. The results obtained in Catalan firms highlight a clear increase in the total factors productivity as ICT uses increase as well as the amount of Internet equipment. Actually, total factors productivity in companies with advanced ICT uses is situated at 1.05 points, clearly higher than the companies with low ICT uses (1 point). Additionally, we also observed that the total factors productivity in Catalan companies increases with organisational change. In an approach by sectors we have seen that ICT use intensity becomes a crucial element in explaining labour productivity increases in both industry and services. Especially we have seen two clearly differentiated trends. The information industry, the high technology industry and the intensive knowledge services show a sustained trend of productivity gains throughout the entire sequence of possible uses (from low to medium uses and from medium to advanced uses). On the contrary, low and medium technology industries and less intensive knowledge services do not show this uniform trend. As far as Internet equipment is concerned, the data obtained confirm a double stage of productivity gains as a result of its implementation, especially in intensive technology and knowledge use sectors. Indeed, we see two states of efficiency increases. The first is achieved when transitioning from a very low Internet equipment level to a low level (that is, the setting up of an Internet connection), and the other is achieved in the transition from normal to advanced equipment levels (that is, moving from narrow-band to broadband). Between these extremes, or rather in moving from Internet connection to website, this rising trend in labour productivity increases is broken, as a result of the application and adaptation costs that this new technological state requires. Finally, the analysis of the company size once again shows a positive significant relationship between business size and ICT use efficiency. However, it has not been the case when it comes for the implications for the labour productivity of Internet equipment, which show a wider and more extended incidence to all sectors, although reflecting relatively high values in micro-companies.

BIBLIOGRAPHY

- ÁLVAREZ PINILLA, A. (2001). *La medición de la eficiencia y la productividad*. Madrid: Pirámide (Economía y Empresa).
- ANDREWS, K. (1977). *El concepto de estrategia de la empresa*. Pamplona: EUNSA.
- ANGELES, R. (2000). 'Revisiting the role of Internet-EDI in the current electronic commerce scene'. *Logistics Information Management*. Vol. 13, no. 1, p. 45-57.
- ANTONELLI, C. (1997). 'New Information Technology and the Knowledge-Based Economy. The Italian Evidence'. *Review of Industrial Organization*. No. 12, p. 593-607.
- ANTONELLI, C. (2001). *The Microeconomics of Technological Systems*. Oxford, New York: Oxford University Press.
- ANTONELLI, C.; GEUNA, A.; STEINMUELLER, E. (2000). 'Information and communication technologies and the production, distribution and use of knowledge'. *International Journal of Technology Management*. Vol. 20, no. 1-2, p. 72-94.
- ARGANDOÑA, A. (2001). 'La Nueva Economía y el crecimiento económico'. *Revista del Instituto de Estudios Económicos*. Vol. 1 and 2, p. 191-210.
- ARTHUR, W.B. (1994). *Increasing Returns and Path Dependence in the Economy*. Ann Arbor: The University of Michigan Press.
- ARTUS, P. (2001). *La nouvelle économie*. Paris: Éditions La Découverte.
- ATKESON, A.; KEHOE, P.J. (2001). 'The Transition to a New Economy after the Second Industrial Revolution'. Cambridge (Massachusetts). (NBER working paper; 8676). <<http://www.nber.org/papers/w8676>>
- ÁVILA, G.; R. PAMPILLÓN (2001). 'Nueva Economía, tecnologías de la información y crecimiento económico'. *Revista del Instituto de Estudios Económicos*. No. 1 and 2, p. 211-251.
- BAI, CH.; YUEN, CH. (ed.) (2003). *Technology and the New Economy*. Cambridge, Londres: The MIT Press.
- BAILY, M.N.; LAWRENCE, R.Z. (2001). 'Do we have a new e-economy?'. Cambridge (Massachusetts). (NBER working paper; 8243). <<http://www.nber.org/papers/w8243>>
- BANEGAS, J. (2003). *La nueva economía en España. Las TIC, la productividad y el crecimiento económico*. Madrid: Alianza Editorial.
- BARNEY, J.B. (1986). 'Strategic factor markets: Expectations, luck and business strategy'. *Management Science*. No. 32, p. 1234-1241.
- BAUMOL, W.J. (2002). *The Free Market Innovation Machine. Analyzing the Growth Miracle of Capitalism*. Princeton, Oxford: Princeton University Press.
- BENAVIDES, C.A. (1998). *Tecnología, innovación y empresa*. Madrid: Pirámide (Empresa y Gestión).

Jordi Vilaseca / Joan Torrent

- BESANKO, D.; DRANOVE, D.; SHANLEY, M. (2000). *Economics of Strategy*. New York: John Wiley & Sons.
- BLATTBERG, R.C.; DEIGHTON, J. (1991). 'Interactive Marketing: Exploiting the Age of Addressability'. *Sloan Management Review*. Vol. 33, no. 1, p. 5-14.
- BOHN, R.E. (1994). 'Measuring and Managing Technological Knowledge'. *Sloan Management Review*. P. 61-73.
- BOISSOT, M. (1998). *Knowledge Assets. Securing Competitive Advantage in the Information Economy*. Oxford, New York: Oxford University Press.
- BOWERSOX, D.J.; DOHERTY, P.J. (1995). 'Logistics paradigms: the impact of information technology'. *Journal of Business Logistics*. Vol. 16, no. 1, p. 65-80.
- BRESNAHAN, T.F.; BRYNJOLFSSON, E.; HITT, L.M. (1999). 'Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-Level Evidence'. Cambridge (Massachusetts). (NBER working paper; 7136).
<<http://www.nber.org/papers/w7136>>
- BROOKING, A. (1997). *El capital intelectual: el principal activo de las empresas del tercer milenio*. Barcelona: Paid s.
- BRYNJOLFSSON, E. (1996). 'The Contribution of Information Technology to Consumer Welfare'. *Information Systems Research*. No. 8, p. 281-300.
- BRYNJOLFSSON, E.; HITT, L.M. (1998). Information Technology and Organizational Design: Evidence from Micro Data. (MIT Sloan Working Papers).
- BRYNJOLFSSON, E.; HITT, L.M. (2000a). 'Computing Productivity: Firm-level Evidence' Cambridge (Massachusetts). (MIT Working Paper)
<<http://ebusiness.mit.edu/erik>>
- BRYNJOLFSSON, E.; HITT, L.M. (2000b). 'Beyond Computation: Information Technology, Organizational Transformation and Business Performance'. A: *The Puzzling Relations Between Computer and the Economy*. Cambridge (Massachusetts): MIT Press.
- BRYNJOLFSSON, E.; HITT, L.; YANG, S. (2000). 'Intangible Assets: How the Interaction of Computers and Organization Structure Affects Stock Markets Valuations'. Cambridge, (Massachusetts). (MIT Working Paper).
<<http://ebusiness.mit.edu/erik>>
- BRYNJOLFSSON, E.; KAHIN, B. (2000). *Understanding the Digital Economy*. Cambridge (Massachusetts): MIT Press.
- BRYNJOLFSSON, E.; RENSHAW, A.; VAN ALSTYNE, M. (1997). 'The Matrix of Change - A Tool for Business Process Reengineering, *Sloan Management Review*. P g. 37-54.
- BUENO, E. (2002). 'Globalizaci n, sociedad red y competencia. Hacia un nuevo modelo de empresa'. *Revista de Econom a Mundial*. No. 7, p. 23-37.
- BUENO, E. (1998). 'El capital intangible como clave estrat gica en la competencia actual'. *Bolet n de Estudios Econ micos*. Vol. LII, no. 164, p. 207-229.
- CABRAL, L. (1997). *Econom a Industrial*. Madrid: McGraw-Hill.
- CANALS, J. (2001). 'La estrategia de la empresa en la era de Internet'. *Informaci n Comercial Espa ola*. No. 793, p. 57-75.

- CARNOY, M. (2000). *El trabajo flexible en la era de la información*. Madrid: Alianza editorial.
- CASTELLS, M. (1997). *La era de la información: Economía, sociedad y cultura. Volumen I: La Sociedad Red*. 2a. ed. 2000. Madrid: Alianza Editorial.
- CASTELLS, M. (2001). *La galaxia Internet. Reflexiones sobre Internet, empresa y sociedad*. Madrid: Editorial Plaza&Janés.
- CASTELLS, M. (2002). 'Tecnologías de la Información y la Comunicación y Desarrollo Global'. *Revista de Economía Mundial*. No. 7, p. 91-107.
- CASTELLS, M.; DÍAZ DE ISLA, M.I. (2001). 'Diffusion and Uses of Internet in Catalonia and in Spain. A Commented Summary of Available Evidence, as of 2001'. Barcelona: UOC. (PIC working paper series; 1201).
<<http://www.uoc.edu/in3/dt/20012/index.html>>
- CASTELLS, M.; HIMANEN, P. (2001). *The Finnish Model of the Information Society*. Helsinki: Sitra (Sitra Reports series 17).
- CASTELLS, M.; TUBELLA, I.; SANCHO, T. [et al.] (2002). *La Societat Xarxa a Catalunya. Informe de recerca I* [online article]. Barcelona: Universitat Oberta de Barcelona.
<<http://www.uoc.edu/in3/pic/cat/pic1.html>>
- CETTE, G.; MAIRESSE, J.; KOCOGLU, M. (2000). *The diffusion on information and communication technologies in France. Measurement and contribution to economic growth and productivity*. Paris: INSEE (Economie et Statistique). Pàg. 339-340.
- CHANDLER, A. (1962). *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. Cambridge (Massachusetts): The MIT Press.
- CHRISTOPHER, M. (1998). *Relationships and alliances: Embracing the era of network competition, Strategic Supply Chain Management*. Regne Unit: John Gattorna, Gower Press.
- CLAYCOMB, C.; DROGE, C.; GERMAIN, R. (2001). 'Applied process knowledge and market performance: the moderating effect of environmental uncertainty'. *Journal of Knowledge Management*. Vol. 5, no. 3, p. 264-278.
- COLECCHIA, A.; SCHREYER, P. (2001). 'ICT Investment and Economic Growth in the 1990s: Is the United States a Unique Case?. A comparative study of nine OCDE Countries'. Paris: OECD. (STI Working Papers; 2001/7).
<http://www.oecd.org/dsti/sti/prod/sti_wp.htm>
- COLET, E. (1998). *Sistemes d'informació. Reptes per a les organitzacions*. Barcelona: Proa.
- CORIAT, B. (1995). 'Variety, Routines and Networks: The Metamorphosis of Fordist Firms'. *Industrial and Corporate Change*. Vol. 4, no. 1, p. 205-227.
- CORTADA, J.W. (ed.) (1998). *Rise of the Knowledge Worker*. Boston, Oxford: Butterworth and Heinemann (Resources for the Knowledge-based Economy).
- CORTADA, J.W.; HARGRAVES, T.S. (2000). *La era del trabajo en redes*. Oxford, New York: Oxford University Press.
- CRAFTS, N. (2000). 'The Solow Productivity Paradox in Historical Perspective'. A: *Long-Term Trends in the World Economy* (Desembre: Copenhagen) [consultation document]. Copenhagen: University of Copenhagen.
- CUESTA, F. (1998). *La empresa virtual*. Madrid: McGraw-Hill.

Jordi Vilaseca / Joan Torrent

- DAVID, P.A. (1990). 'The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox'. *American Economic Review, Papers and Proceedings*. No. 80, p. 355-361.
- DAVID, P.A. (1993). 'Knowledge, Property and the System Dynamics of Technological Change'. A: *Proceedings of the World Bank Annual Conference on Development Economics*. Washington D.C.
- DAVID, P.A. (2000). 'Understanding Digital Technology's Evolution and the Path of Measured Productivity Growth: Present and Future in the Mirror of the Past'. A: *Understanding the Digital Economy*. Cambridge (Massachusetts): MIT Press.
- DE LA FUENTE, Á. (1992). 'Histoire d'A: Crecimiento y Progreso Técnico'. *Investigaciones Económicas*. Vol. XVI, no. 3, p. 331-391.
- DE LA FUENTE, Á. (1995). 'Inversión, catch-up tecnológico y convergencia real'. *Papeles de Economía Española*. No. 63, p. 18-34.
- DE LA FUENTE, Á. (1998). 'Innovación tecnológica y crecimiento económico'. Madrid: Fundación COTEC (Studies Collection no. 11).
- DE LONG, B. (2001). 'A Historical Perspective on the New Economy'. A: *Montreal New Economy Conference*. (Juny: Montreal) [online conference].
<<http://www.econ161.berkeley.edu>>
- DE MASI, P. (2000). 'Does the Pickup in Productivity Growth Mean That There is a 'New Economy?'. A: *United States of America: Selected Issues*. Washington D.C.: Fons Monetari Internacional. (IMF Staff Country Report; 00/112).
- DEPARTAMENT D'ECONOMIA I FINANCES (2002). *Informe anual de l'empresa catalana 2001. Anàlisi detallada 2000*. Barcelona: Generalitat de Catalunya.
- DEPARTMENT OF TRADE AND INDUSTRY (DTI) (1998). 'Our Competitive Future building the Knowledge driven economy' [online article]. Londres: Secretary of State for Trade and Industry.
<<http://www.dti.gov.uk/comp/competitive>>
- DOSI, G. (2001). *Innovation, Organization and Economic Dynamics, Selected Essays*. Chentelham (Regne Unit), Northampton (Massachusetts): Edward Elgar.
- DOSI, G.; FREEMAN, C.; NELSON, R. (ed.) [et al.] (1988). *Technical Change and Economic Theory*. Londres, New York: Pinter Publishers.
- DRUCKER, P.F. (1946). *Concept of Corporation*. New York: John Day.
- DRUCKER, P.F. (1993). *Post-Capitalist Society*. New York: HarperCollins Publishers.
- DRUCKER, P.F. (2000). *El management del siglo XXI. Los desafíos de un mundo sin fronteras*. Barcelona: Edhasa.
- DURSI (2003). *Enquesta sobre la penetració de les TIC a les empreses de més de 10 o més ocupats* [online article]. Barcelona: DURSI.
<http://dursi.gencat.net/pdf/si/observatori/np_TIC_empreses_2002.pdf>
- E-BUSINESS W@TCH (2003). *The European e-Business Report 2002/2003. A portrait of e-business in 15 sectors of the UE Economy* [online article]. Brussels: European Commission. Entreprise Director General.
<<http://www.ebusiness-watch.org/marketwatch/resources.htm>>

- ECONOMIC PLANNING AGENCY (2000). *The Effect of IT (Information Technology) on Productivity: In search of Japan's 'New Economy'*. Tòquio: Economic Planning Agency.
- THE ECONOMIST (2000). 'Untangling e-economics' [online article]. [Consultation date: 23 september 2000].
<<http://www.economist.com>>
- EDVINSSON, L.; MALONE, M.S. (1999). *El capital intelectual*. Barcelona: Ediciones Gestión 2000.
- EICHENGREEN, B. (1999). *Towards a New International Financial Architecture. The Practical Post-Asia Agenda*. Washington: Institute for International Economics.
- EICHENGREEN, B. (2003). *Capital Flows and Crises*. Cambridge, Massachusetts: MIT Press.
- EUROPEAN COMMISSION (2001). *Cuadro de Indicadores de la Innovación 2001*. Luxemburg: Publications Office of the European Communities.
- EUROPEAN COMMISSION (2002). Flash Eurobarometre 116 'e-Commerce'. *Economic and Financial Affairs Directorate* [online article]. Brussels: European Commission.
<http://europa.eu.int/comm/public_opinion/flash/fl116_en.pdf>
- EUROSTAT (2001a). *Information Society Indicators*. Brussels: European Commission.
- EUROSTAT (2001b). *Information Society Statistics*. Luxemburg: Publications Office of the European Communities.
- EUROSTAT (2001c). 'The European Community Survey on E-commerce: First Results'. *Information Newsletter*. No. 1, Luxemburg: Eurostat.
- EUROSTAT (2002a). *Statistics on the Information Society in Europe. Date 1990-2002*. Brussels: European Commission.
- EUROSTAT (2002b). *Information Society Statistics. Date 1996-2001*. Brussels: European Commission.
- EUROSTAT (2002c). *European Business. Facts and Figures. Date 1990-2000*. Brussels: European Commission.
- EUSTACE, C. (2000). *The Intangible Economy. Impact and Policy Issues*. Report of the European High Level Expert Group on the Intangible Economy. Brusel.les: Comissió Europea.
- FAYOL, H. (1961). *Administración industrial y general*. México D.F.: Herrero Hermanos.
- FELDSTEIN, M. (2003). 'Why is Productivity Growth Faster?'. Cambridge (Massachusetts). (NBER working paper; 9530).
<<http://www.nber.org/papers/w9530>>
- FERRATÉ, G. (2002). 'Tecnología, educación y sociedad. Nuevos retos formativos para el siglo XXI'. *Revista de Economía Mundial*. No. 7, p. 13-22.
- FORAY, D. (2000). *L'économie de la connaissance*. Paris: Éditions La Découverte.
- FORAY D.; LUNDVALL, B-A. (1996). 'The Knowledge-Based Economy: From the Economics of Knowledge to the Learning Economy'. A: *Employment and Growth in the Knowledge-based Economy*. Paris: OCDE.
- FREEMAN, R. (2002). 'The Labour Market in the New Information Economy'. Cambridge (Massachusetts). (NBER working paper; 9254).
<<http://www.nber.org/papers/w9254>>

Jordi Vilaseca / Joan Torrent

- FREEMAN, C.; PÉREZ, C. (1988). 'Structural Crises of Adjustment, Business Cycles and Investment Behaviour'. A: *Technical Change and Economic Theory*. Londres, New York: Pinter Publishers.
- FRENCH, W.L.; BELL, C.H. (1981). *Organizational Development: Behavioral Science Interventions for Organizational Improvement*. Nova Jersey: Prentice Hall.
- FUNDACIÓN AUNA (2002). *eEspaña 2002. Informe anual sobre el desarrollo de la Sociedad de la Información en España*. Madrid: Fundación AUNA.
- GALLOUJ, F. (2002). *Innovation in the Service Economy. The New Wealth of Nations*. Cheltenham (Regne Unit), Northampton (Massachusetts): Edward Elgar.
- GARBER, P. (2000). *Famous First Bubbles: the Fundamentals of Early Mania*. Cambridge (Massachusetts): MIT Press.
- GORDON, R.J. (1999). 'Has the 'New Economy' Rendered the Productivity Slowdown Obsolete?'. Northwestern University.
- GORDON, R.J. (2000). 'Does the 'New Economy' Measure Up the Great Inventions of the Past?'. *Journal of Economic Perspectives*. No. 14, p. 49-74.
- GORDON, R.J. (2003). 'Hi-tech Innovation and Productivity Growth: Does Supply Create Its Own Demand?'. Cambridge (Massachusetts). (NBER working paper; 9437).
<<http://www.nber.org/papers/w9437>>
- GREENAN, H.; L'HORTY, Y.; MAIRESSE, J. (ed.) (2002). *Productivity, Inequality, and the Digital Economy. A Transatlantic perspective*. Cambridge, London: The MIT Press.
- GREENSPAN, A. (1999). 'Information, productivity, and capital investment'. *The Business Council* [online article]. Boca Raton (Florida).
<<http://www.federalreserve.gov/boarddocs/speeches/1999/199910282.htm>>
- GREENSPAN, A. (2000a). 'Technological Innovation and the Economy'. *White House Conference on the New Economy* [online article]. Washington D.C.
<<http://www.federalreserve.gov/boarddocs/speeches/2000/20000405.htm>>
- GREENSPAN, A. (2000b). 'Structural Changes in the economy and financial markets'. *America's Community Bankers Conference: Business Strategies for Bottom Line Results* [online article]. New York.
<<http://www.federalreserve.gov/boarddocs/speeches/2000/20001205.htm>>
- GREENSPAN, A. (2001). 'The Growing need for skills in the 21st century'. *US Department of Labor 21st Century Workforce Summit* [online article]. Washington, D.C.
<<http://www.federalreserve.gov/boarddocs/speeches/2001/20010620/default.htm>>
- GRILICHES, Z. (1994). 'Productivity, R&D, and the Data Constraint'. *American Economic Review*. No. 84, p. 1-23.
- GRILICHES, Z. (1995a). Comments on Measurement Issues in Relating IT Expenditures to Productivity Growth'. *Economics of Innovation and New Technology*. No. 3, p. 317-321.
- GRILICHES, Z. (1995b). 'Academic Research Underlying Industrial Innovations: Sources, Characteristics, and Financing'. *The Review of Economics and Statistics*. Vol. 77 (1), p. 55-65.
- GRÖNROOS, C. (2000). 'Relationship Marketing: Interaction, Dialogue and Value'. *Revista Europea de Dirección y Economía de la Empresa*. Vol. 9 (3), p. 13-24.

- GUPTA, U. (ed.) (2000). *Done Deals. Venture Capitalists Tell their Stories*. Boston: Harvard Business School Press.
- G-7 FINANCE MINISTERS (2000). 'Impact of the IT Revolution on the Economy and Finance'. *Report from G7 Finance Ministers to the Heads of State and Government*. (Fukuoka).
- HAACKER, M.; MORSINK, J. (2001). 'You Say You Want a Revolution: Information Technology and Growth'. *IMF Research Department*. Washington: Fons Monetari Internacional.
- HALL, R. (1989). 'The Management of Intellectual Assets: A New Corporate Perspective'. *Journal of General Management*. Vol. 15, no. 1, p. 53-68.
- HARRISON, B. (1997). *Lean and Mean. The Changing Landscape of Corporate Power in the Age of Flexibility*. New York: The Guildford Press.
- HATCHUEL, A.; WEIL, B. (1995). *Experts in Organizations: A Knowledge-based Perspective on Organisational Change*. Berlin, New York: Walter de Gruyter.
- HOFFMAN, D.L.; NOVAK, T.P. (1996). 'Marketing in Hypermedia Computer-Mediated Environments: Conceptual Foundations'. *Journal of Marketing*. Vol. 60 (3), p. 50-69.
- IDESCAT (2000). *L'estad stica oficial sobre la implantaci  de les TIC i sobre la recerca a Catalunya*. Barcelona: IDESCAT.
- IDESCAT (2003a). *Equipament i  s de les TIC a l'empresa catalana* [online article]. Barcelona: IDESCAT.
<<http://www.idescat.es/scripts/dce.dll?TC=3&ID=6205>>
- IDESCAT (2003b). *Equipament i  s de les TIC a la PIME catalana* [online article]. Barcelona: IDESCAT.
<<http://www.idescat.es/scripts/dce.dll?TC=3&ID=6206>>
- IMF (2001). 'The Information Technology Revolution'. A: *World Economic Outlook October 2001. World Economic and Financial Surveys* [online article]. Washington D.C.: International Monetary Fund.
<<http://www.imf.org/external/pubs/ft/weo/2001/02>>
- INE (2002). *El Directorio Central de Empresas (DIRCE)*. Resultados Estadisticos 2002. Tom I. Madrid: INE (Datos de Empresas).
- INSTITUTO DE ESTUDIOS ECONOMICOS (2001). *La sociedad de la informaci  en Espa a*. Madrid. No. 1 and 2.
- JOHNSON, R.A.; FREEMON, E.K.; ROSENZWEIG, J.E. (1961). 'Designing Management Systems'. *Management Systems*. New York.
- JOHNSON, G.; SCHOLLES, K. (1996). *Direcci  Estrat gica. An lisis de la estrategia de las organizaciones*. Madrid: Prentice Hall.
- JORGENSEN, D.W.; STIROH, K.J. (2001). 'Information Technology and the US Economy'. *American Economic Review*. No. 91, p. 1-32.
- KOHLI, A.K.; JAWORSKI, B.J. (1990). 'Market Orientation: The Construct, Research Propositions and Managerial Implications.' *Journal of Marketing*. Vol. 54 (4), p. 1-18.
- KOTLER, P. (1999). *El marketing seg n Kotler. C mo crear, ganar y dominar los mercados*. Barcelona: Paid s Ib rica.
- KRANZBERG, M. (1985). 'The information age: evolution or revolution?'. A: Bruce R. Guile

Jordi Vilaseca / Joan Torrent

- (ed.). *Information Technologies and Social Transformation*. Washington D.C.: National Academy of Engineering.
- LANDEFELD, J.S.; FRAUMENI, B.M. (2001). 'Measuring the New Economy'. *Survey of Current Business* [online article]. Pàg. 23-40.
<<http://www.bea.doc.gov/bea/ARTICLES/2001/03march/0301mne.pdf>>
- LANGLOIS, R.N.; ROBERTSON, P.L. (1995). *Firms, Markets and Economic Change. A Dynamic Theory of Business Institutions*. London: Routledge.
- LLADÓS, J. (2001). 'Ha aprofitat la indústria catalana la revolució tecnològica dels noranta?' [online article]. UOC.
<<http://www.uoc.edu/web/cat/art/uoc/llados1201/llados1201.html>>
- LÓPEZ, A.; PULIDO, A. (2001). 'Penetración de las TIC y crecimiento económico'. *Revista del Instituto de Estudios Económicos*. No. 1 and 2, p. 252-300.
- LUCAS, H.C.JR. (1999). *Information Technology and the Productivity Paradox. Assessing the Value of Investing in IT*. Oxford, New York: Oxford University Press.
- LUCAS, R.E.JR. (1988). 'On the Mechanics of Economic Development'. *Journal of Monetary Economics*. No. 22, p. 3-42.
- LUCAS, R.E.JR. (2002). *Lectures on Economic Growth*. Cambridge, London: Harvard University Press.
- LUNDVALL, B-A. (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publishers.
- LUNDVALL, B-A. (2002). 'Estados-nación, capital social y desarrollo económico. Un enfoque sistémico de la creación de conocimiento y aprendizaje en la economía global'. *Revista de Economía Mundial*. No. 7, p. 69-90.
- LUNDVALL, B-A.; JOHNSON, B. (1994). 'The Learning Economy'. *Journal of Industry Studies*. Vol. 1, no. 2, p. 23-42.
- MAGRETA, J. (2001). *La administración en la nueva economía. Nuevas Perspectivas*. Oxford, New York: Oxford University Press.
- MAHMOUD, M.; QUIGLEY, J.V. (1994). 'The utility of information systems: views of CEOs and Information System Executives'. *Industrial Management & Data Systems*. Vol. 94, no. 5, p. 25-29.
- MAIRESSE, J.; CETTE, G.; KOCOGLU, Y. (2000). 'Les technologies de l'information et la communication en France: diffusion et contribution a la croissance'. *Économie et Statistique* [online article]. Paris. No. 339-340, p. 117-146.
<http://www.insee.fr/fr/nom_def_met/colloques/acn/colloque_9/ES339E.pdf>
- MANDEL, M. (2000). *The Coming Internet Depression*. New York: Basic Books.
- MCCLELLAN, J.E.; DORN, H. (1999). *Science and Technology in World History: An Introduction*. Baltimore, London: The Johns Hopkins University Press.
- MESEGUER, A.; RODRÍGUEZ, I. (2002). *Situació i perspectives del comerç electrònic a Espanya: una anàlisi a partir del volum del negoci electrònic* [document de treball en línia]. UOC. (IN3 Working Paper Series; WP02-004).
<<http://www.uoc.edu/in3/dt/20003/index.html>>

- MILANA, C.; ZELI, A. (2002). *The Contribution of ICT to Production Efficiency in Italy: Firm-level Evidence Using Data Envelopment Analysis and Econometric Estimations*. Paris: OCDE. (STI working paper; 2002/13).
<<http://www.oecd.org/dataoecd/23/40/1956116.pdf>>
- MILGROM, P.; ROBERTS, J. (1993). *Economía, organización y gestión de la empresa*. Barcelona: Ariel.
- MINTZBERG, H. (1984). *La estructuración de las organizaciones*. Barcelona: Ariel.
- MINTZBERG, H. (1991). *Mintzberg y la Dirección*. Madrid: Díaz de Santos.
- MINTZBERG, H.; VAN DER HEYDEN, L. (1999). 'Organigraphs: Drawing How Companies Really Work'. *Harvard Business Review*. Pàg. 87-94.
- MOKYR, J. (1990). *The Level of Riches: Technological Creativity and Economic Progress*. New York: Oxford University Press.
- MOLERO, J. (coord.) (2000). *Competencia global y cambio tecnológico*. Madrid: Ediciones Pirámide.
- NARVER, J.C.; SLATER, S.F. (1990): 'The Effects of a Market Orientation on Business Profitability'. *Journal of Marketing*. No. 54, p. 20-35.
- NAVAS, J.E. (1994). *Organización de la Empresa y Nuevas Tecnologías*. Madrid: Pirámide.
- NEEF, D. (ed.) (1998). *The Knowledge Economy*. Boston, Oxford: Butterworth and Heinemann (Resources for the Knowledge-based Economy).
- NEEF, D.; SIESFELD, G.A.; CEFOLA, J. (ed.) (1998). *The Economic Impact of Knowledge*. Boston, Oxford: Butterworth and Heinemann (Resources for the Knowledge-based Economy).
- NEGROPONTE, N. (1995). *Being Digital*. New York: Alfred A. Knopf.
- NONAKA, I. (1991). 'The Knowledge Creating Company'. *Harvard Business Review*. Pàg. 28-47.
- NONAKA, I.; BYOSIERE, P. (2000). 'La creación de conocimiento regional: un proceso de desarrollo social'. A: *Las Sociedades del Conocimiento*. Bilbao: Ediciones PMP (Cluster Conocimiento).
- NONAKA I.; TAKEUCHI, H. (1999). *La organización creadora de conocimiento*. Oxford, New York: Oxford University Press.
- NORDHAUS, W.D. (2001). 'Productivity Growth and the New Economy'. Cambridge (Massachusetts). (NBER working paper; 8096).
<<http://www.nber.org/papers/w8096>>
- NORTON, R.D. (2001). *Creating a New Economy. The Entrepreneur and the US Resurgence*. Cheltenham (United Kingdom), Northampton (Massachusetts): Edward Elgar.
- OCDE (2001a). *Communications Outlook 2001*. Paris: OCDE.
- OCDE (2001b). *Science, Technology and Industry Outlook. Drivers of Growth: Information, Technology, Innovation and Entrepreneurship. Special Edition 2001*. Paris: OCDE (Science and Innovation).
- OCDE (2001c). *OCDE Science, Technology and Industry Scoreboard. Towards a Knowledge-Based Economy*. Paris: OCDE (Science and Innovation).
- OCDE (2001d). *OECD Productivity Manual: A Guide to the Measurement of Industry-level*

Jordi Vilaseca / Joan Torrent

- and Aggregate Productivity Growth* [online article]. Paris: OCDE.
<<http://www.oecd.org/dataoecd/59/29/2352458.pdf>>
- OCDE (2002a). *OECD Science, Technology and Industry Outlook*. Paris: OCDE (Science and Innovation).
- OCDE (2002b). *OECD Information Technology Outlook. ICTs and the Information Economy*. Paris: OECD.
- OCDE (2003a). *Seizing the Benefits of ICT in a Digital Economy*. Paris: OECD [Ministerial Meeting of the Council of the OECD in 2003].
- OCDE (2003b). *Consumers in the Online Marketplace: The OECD Guidelines Three Years Later*. Paris: OCDE [report by the Committee of Consumer Policy on the directives for the protection of consumers in e-commerce matters].
- OLINER, S. D.; SICHEL, D.E. (2000). 'The Resurgence of Growth in the Late 1990s: Is Information Technology the Story'. *Journal of Economic Perspectives*. No. 14, p. 3-22.
- OSTERMAN, P. (2000). 'Work Reorganization in an Era of Restructuring: Trends in Diffusion and Effects on Employee Welfare'. *Industrial and Labor Relations Review*. Vol. 53, no. 2, p. 179-196.
- OSTERMAN, P.; KOCHAN, T.A.; LOCKE, R.M. [et al.] (2002). *Working in America. A Blueprint for the New Labor Market*. Cambridge (Massachusetts): The MIT Press.
- P REZ, C. (2002). *Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages*. Cheltenham (Regne Unit), Northampton (Massachusetts): Edward Elgar Publishing.
- PILAT, D.; LEE, F.C. (2001). 'Productivity Growth in ICT-Producing and ICT-Using Industries. A Source of Growth Differentials in the OCDE?'. Paris: OECD. (STI Working Papers; 2001/4).
- PIORE, M.J.; SABEL, C.F. (1990). *La segunda ruptura industrial*. Madrid: Alianza.
- POHJOLA, M. (2001). *Information Technology, Productivity, and Economic Growth. International Evidence and Implications for Economic Development*. Oxford, New York: Oxford University Press.
- POLANYI, M. (1958/1978). *Personal Knowledge*. London, New York: Routledge and Kegan Paul.
- POON, S.; JOSEPH, M. (2000). 'Product characteristics and Internet commerce benefit among small business'. *Journal of Product & Brand Management*. Vol. 9 (1), p. 21-34.
- PORTER, M. (1985). *Competitive Advantage. Creating and Sustaining Superior Performance*. New York: The Free Press.
- PORTER, M. (2001). 'Strategy and the Internet'. *Harvard Business Review*. P. 62-78.
- PORTER, M.E.; STERN, S. (2000). 'Measuring the 'Ideas' Production Function: Evidence from International Patent Output'. Cambridge (Massachusetts). (NBER working paper; 7891).
<<http://www.nber.org/papers/w7891>>
- RICKETTS, M. (2002). *The Economics of Business Enterprise. An Introduction to Economic Organisation and the Theory of the Firm*. 3a. ed. Cheltenham (Regne Unit), Northampton (Massachusetts): Edward Elgar Publishing.

- RODRIGUES, M.J. (ed.) (2002). *The New Knowledge Economy in Europe. A Strategy for International Competitiveness and Social Cohesion*. Cheltenham (United Kingdom), Northampton (Massachusetts): Edward Elgar Publishing.
- RODRÍGUEZ, I. (2000). *Marketing.com. Marketing y comercio electrónico en la sociedad de la información*. Madrid: Editorial Pirámide; Editorial ESIC.
- ROMER, P.M. (1986). 'Increasing Returns and Long-Run Growth'. *Journal of Political Economy*. Vol. 94, no. 5, p. 1002-1037.
- ROMER, P.M. (1989). 'Increasing Returns and New Developments in the Theory of Growth'. Cambridge (Massachusetts). (*NBER working paper 3098*).
- ROMER, P.M. (1994). 'The Origins of Endogenous Growth'. *Journal of Economic Perspectives*. Vol. 8, no. 1, p. 3-22.
- ROSEGGER, G. (1996). *The Economics of Production and Innovation. An industrial perspective*. Boston, Oxford: Butterworth and Heinemann.
- ROSENBERG, N. (1976). *Perspectives on Technology*. London: Cambridge University Press.
- ROSENBERG, N. (1996). 'Uncertainty and Technological Change'. A: *The Mosaic of Economic Growth*. Stanford: Stanford University Press.
- SAINZ, J. (2002). *Nueva Economía en España: Aportación al Crecimiento y Mercados Financieros* [doctoral thesis]. Madrid: Universidad Rey Juan Carlos.
- SALAS FUMÁS, V. (2001). 'La dimensión de la empresa en la economía de la información'. *Papeles de Economía Española*. No. 89/90, p. 2-17.
- SALAS FUMÁS, V. (1987). *Economía de la empresa. Decisiones y organización*. Barcelona: Ariel.
- SCARPETTA S.A.; BASSANINI, A.; PILAT, D. [et al.] (2000). 'Economic Growth in the OECD Area: Recent Trends at the Aggregate and Sectoral levels'. Paris: OECD (OECD Economics Department Working Papers; 248).
<<http://www.oecd.org/dataoecd/25/38/1826375.pdf>>
- SCHREYER, P. (2000). *The Contribution of Information and Communication Technologies to Output Growth*. Paris: OCDE. (STI working paper; 2000/2).
<http://www.oecd.org/dsti/sti/prod/sti_wp.htm>
- SCHUMPETER, J.A. (1934). *The Theory of Economic Development*. New York: Oxford University Press.
- SCHUMPETER, J.A. (1939). *Business cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*. 2 vol. Philadelphia: Porcupine Press.
- SCHUMPETER, J.A. (1942). *Capitalisme, Socialisme i Democràcia*. 2 vol. Barcelona: Edicions 62 (Clàssics del pensament modern).
- SCHUMPETER, J.A. (1954). *Historia del anàlisis econòmic*. Barcelona: Ariel (Ariel Economía).
- SHAPIRO, C.; VARIAN, H.R. (1999). *Information Rules. A Strategic Guide to the Network Economy*. Boston (Massachusetts): Harvard Business School Press.
- SHAW, M.; BLANNING, R.; STRADER, T. [et al.] (ed.) (2000). *Handbook on Electronic Commerce*. Berlin, Heidelberg, New York: Springer.
- SHILLER, R. (1999). *Irrational Exuberance*. New Haven: Yale University Press.

Jordi Vilaseca / Joan Torrent

- SHY, O. (2001). *The Economics of Network Industries*. Cambridge, New York: Cambridge University Press.
- SIDRO, V. (1988). *Gestión tecnológica de la empresa*. Madrid: Instituto de la Pequeña y Mediana Empresa.
- SIMON, H. (1945). *Administrative Behavior*. New York: McMillan.
- SMONLY, W. (2000). *Endogenous Innovations and Knowledge Spillovers. A theoretical and empirical analysis*. Heidelberg: Physica-Verlag (ZEW Economic Studies).
- SOLOW, R.M. (1956). 'A contribution to the Theory of Economic Growth'. *Quarterly Journal of Economics*. Vol. 70, no. 1, p. 65-94.
- SOLOW, R.M. (1957). 'Technical Change and the Agregate Production Function'. *Review of Economics and Statistics*. No. 39, p. 312-320.
- SOLOW, R.M. (ed.) (2001). *Landmark Papers on Economic Growth*. Cheltenham (United Kingdom), Northampton (Massachusetts): Edward Elgar Publishing.
- STEHR, N. (2002). *Knowledge and Economic Conduct. The Social Foundations of the Modern Economy*. Toronto: University of Toronto Press.
- STERN, S.; PORTER, M.E.; FURMAN, J.L. (2000). *The Determinants of National Innovative Capacity*. Cambridge (Massachusetts). (NBER working paper; 7876).
<<http://www.nber.org/papers/w7876>>
- STEVENS, G.C. (1990). 'Successful Supply-Chain Management'. *Management Decision*. Vol. 28, no. 8, p. 25-30.
- STIROH, K.J. (2001). 'Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?' *Staff Report 115*. New York: Federal Reserve of New York.
- TAYLOR, F.W. (1961). *Principios de la administración científica*. México D.F: Herrero Hermanos.
- TERRICABRES, J.M. (1998). *Teoria del coneixement*. Barcelona: UOC.
- TORRENT, J. (2002a). 'L'economia del coneixement a Catalunya: perspectives de futur'. A: RAMON, R.; RUIZ, A. *Catalunya a l'Europa del 2010*. Barcelona: Editorial Mediterrània, p. 167-196.
- TORRENT, J. (2002b). *Innovació tecnològica, creixement econòmic i economia del coneixement. Una aproximació empírica, agregada i internacional a la incorporació del coneixement a l'activitat productiva durant la dècada dels noranta* (doctoral thesis online). Barcelona: UOC.
<<http://www.tdx.cesca.es/TDCat-1213102-162234/>>
- TORRENT, J. (2002c). 'De la Nueva Economía a la Economía del Conocimiento. Hacia la Tercera Revolución Industrial'. *Revista de Economía Mundial*. No. 7, p. 39-68.
- TUGORES, J. (1994). 'Grados de competencia imperfecta, localización industrial y comercio internacional'. *El Trimestre Económico*. Pàg. 585-601.
- TUGORES, J. (1997). *Economía internacional i integració econòmica*. Barcelona: Edicions de la Universitat de Barcelona; McGraw-Hill.
- US DEPARTMENT OF COMMERCE (2002). *Digital Economy 2002. Economics and Statistics Administration* [online article]. Washington DC: US Government Printing Office.
<<http://www.esa.doc.gov/pdf/DE2002r1.pdf>>

- US DEPARTMENT OF LABOR (2002). *Multifactor Productivity Measures for Three-digit SIC Manufacturing Industries, 1990-1999* [online article]. Bureau of Labor Statistics; 956.
<<http://www.bls.gov/mfp/iprmfp02.pdf>>
- VALDALISO, J.M.; LÓPEZ, S. (2000). *Historia económica de la empresa*. Barcelona: Editorial Crítica.
- VAN ARK, B. (2001). *The Renewal of the Old Economy: An International Comparative Perspective*. Paris: OECD. (STI Working Papers; 2001/5).
<http://www.oecd.org/dsti/sti/prod/sti_wp.htm>
- VAN ARK, B., INKLAAR, R.; MCGUCKIN, R. (2002). *Changing Gear. Productivity, ICT and Services Industries: Europe and United States* [research work]. Groningen: Groningen Growth and Development Centre (University of Groningen).
- VIDAL VILLA, J.M. (1990). *Hacia una economía mundial*. Barcelona: Plaza & Janés.
- VIDAL VILLA, J.M. (1996). *Mundialización: 10 tesis y otros artículos*. Barcelona: Editorial Icaria.
- VIDAL VILLA, J.M. (2001). *Fundamentos de economía para la Sociedad de la Información*. Barcelona: UOC [teaching material; doctorate programme on the information and Knowledge Society].
- VILASECA, J. (2000). *Nova economia*. Barcelona: UOC [teaching material; doctorate programme on the information and Knowledge Society].
- VILASECA, J. (2001). 'Economía del Conocimiento' and 'Sociedad del Conocimiento'. A: Diego Guerrero (ed.). *Manual y diccionario de Economía Político-social*. Madrid: Trotta.
- VILASECA, J. (2002). 'Hacia una economía del conocimiento. Introducción'. *Revista de Economía Mundial*. No. 7, p. 3-7.
- VILASECA, J.; CABAÑERO, C.; TORRENT, J. (2002). 'Nova economia i activitat empresarial: de les TIC al canvi cultural' [online article]. Barcelona: UOC.
<<http://www.uoc.edu/web/cat/serveis/observatori/tm/one0402.html>>
- VILASECA, J.; LLADÓS, J.; TORRENT, J. [et al.] (2003). 'Productivity Convergence in Europe?. A Chance for Innovation'. A: *European Innovation. Dynamics, Institutions and Values* [online article]. Roskilde: Roskilde University. No. 8-9.
<<http://www.segera.ruc.dk>>
- VILASECA, J.; TORRENT, J. (2000a). 'La realitat econòmica de la indústria de la informació: cap un model europeu de nova economia?' [online article]. UOC.
<<http://www.uoc.edu/web/cat/serveis/observatori/2000/desembre/temadelmecat/temadelmes.html>>
- VILASECA, J.; TORRENT, J. (2000b). 'Les relacions euro-dòlar: història d'una depreciació retroalimentada' [online article]. UOC.
<<http://www.uoc.edu/web/cat/articulos/euro-dolar.pdf>>
- VILASECA, J.; TORRENT, J. (2001a). 'La ocupación de la economía del conocimiento en España'. *Informe trimestral Infojobs.net* [online article]. Barcelona.
<http://www.uoc.edu/web/esp/articulos/vilaseca/informe0101_esp.html>
- VILASECA, J.; TORRENT, J. (2001b). 'La nova economia: evolució o revolució?. La realitat econòmica de la indústria de la informació'. *Perspectiva Econòmica de Catalunya*. Barcelona: Cambra de Comerç, Indústria i Navegació de Barcelona. No. 211, p. 67-80.

Jordi Vilaseca / Joan Torrent

- VILASECA, J.; TORRENT, J. (2001c). 'La economía del conocimiento en España: una comparación internacional de su desarrollo'. *Carta Económica Regional*. No. 78, p. 34-46.
- VILASECA, J.; TORRENT, J. (2002a), 'Midiendo la economía digital: una aproximación metodológica a un indicador de demanda del sector TIC para EE.UU.'. *Revista de Economía Mundial*. No. 6, p. 159-173.
- VILASECA, J.; TORRENT, J.; CASTILLO, D. (2003b). 'Using Costing Models in Knowledge-based Production. The Case of Spanish Firms' [online conference]. A: *26st Annual Congress European Accounting Association* (2-4 april: Seville).
<<http://www.eaa-online.org/annual/EAA2003/>>
- VILASECA, J.; TORRENT, J.; DÍAZ, A. (2002a). 'La economía del conocimiento: paradigma tecnológico y cambio estructural. Un análisis empírico e internacional para la economía española'. Barcelona: UOC. (IN3 Working Paper Series; WP02-003).
<<http://www.uoc.edu/in3/dt/20007/index.html>>
- VILASECA, J.; TORRENT, J.; DÍAZ, A. (2002b). 'ICTs and the strategic and organizational changes in Catalan business. A review of select evidence for Catalonia, Spain and international data'. Barcelona: UOC. (IN3 Working Paper Series; WP02-001).
<<http://www.uoc.edu/in3/dt/20014/20014.pdf>>
- VILASECA, J.; TORRENT, J.; DÍAZ, A. [et al.] (2002b). 'La evolución del sector TIC en España: una comparación internacional'. *Informe trimestral Infojobs.net* [online article]. Barcelona.
<<http://www.uoc.edu/web/esp/serveis/observatorio/tm/one0202.html>>
- VILASECA, J.; TORRENT, J.; LLADÓS, J. (2001). 'De la economía de la información a la economía del conocimiento: algunas consideraciones conceptuales y distintivas'. *Tendencias*. Vol. II, no. 2, p. 45-63.
- VILASECA, J.; TORRENT, J.; SAINZ, J. (2003). *Fundamentos de Economía para la Sociedad de la Información: Nueva Economía y e-business*. Barcelona: UOC [teaching material; doctorate programme on the information and knowledge society].
- VIVARELLI, M.; PIANTA, M. (2000). *The Employment Impact of Innovation. Evidence and Policy*. London, New York: Routledge.
- VOLCKER, P. (2000). 'A sea of global finance'. A: Hutton, W.; Giddens, A. (ed.). *On the Edge. Living in Global Capitalism*. London: Jonathan Cape.
- WOODWARD, J. (1965). *Industrial Organization: Theory and Practice*. Oxford: Oxford University Press.
- WORLD BANK (2002). *Information and Communication Technologies*. Washington D.C: The World Bank Group.
- YANG, S.; BRYNJOLFSSON, E. (2001). *Intangible Assets and Growth Accounting: evidence from Computer Investments* [online article]. Cambridge (Massachusetts): MIT Working Papers.
<<http://ebusiness.mit.edu/erik>>