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ABSTRACT

This paper examines the impact of ICT on competitiveness, innovation and environment in the glass, ceramics and cement concrete industry. The results show that use of ICT seems to favor innovation and competitiveness. As for the effect on the environment, the use of some ICT helps to reduce emissions, whereas others increase them.

KEYWORDS

ICT, competitiveness, innovation, environment.

INTRODUCTION AND LITERATURE REVIEW

In the last years, the economic and social structure has undergone some important changes, especially because of the introduction of Information and Communication Technology (ICT). As the years go by, ICTs, born in the military world, have spread to every economic activity (Vilaseca et al., 2006). Nowadays, ICT has become the fundamental pillar of the knowledge economy and draws great interest to overcome many of the drawbacks of conventional systems and to save money and/or time (Takahashi et al., 2004).

ICTs have as their main features the application of knowledge, and at the same time, they generate new knowledge (known as “third industrial revolution”). This has caused ICT to take on a main role in the economy transformation process as well as constituting a vital source of competitiveness for enterprises. Therefore, ICT has a great potential for sustainable

development (Hilty et al., 2006). All these circumstances have caused ICT to receive great attention in management literature.

Most ICT research has focused on analyzing the determinants of his adoption. Taking into account the determinants of ICT adoption, the factors analyzed in previous literature can be classified into three groups: factors related to the company staff who are going to use ICT, factors related to the characteristics of the company and factors related to the environment in which the company operates.

Regarding the characteristics a company staff, the literature has focused on analyzing how the level of studies of the individuals and their ages affect the adoption of the practices, but they have not yielded significant results. Some articles have shown that the higher the educational level of employees, the higher the degree of adoption and use of ICT (Bayo and Lera, 2007). However, some studies have found that the level of education does not have any effect on the adoption of ICT. The reason to account for this fact is that workers with high educational levels show more aptitude to take advantage efficiently of the know-how of the company and to translate the tacit knowledge into innovation (Vilaseca et al., 2006).

The second group of factors refers to enterprise features. The fact that the company operates in domestic or international markets, as well as the fact that the company is multinational, the economic sector of activity, etc., are factors that affect the adoption of ICT. Thus, previous studies have found that the presence of the company in international markets promotes the adoption of ICT, as does being part of a multinational company (Bayo and Lera, 2007). Regarding the activity sector, there are no differences in the degree of ICT adoption between

the manufacturing and the services sectors, but their use is smaller in agriculture and building sectors (Bayo and Lera, 2007). As regards the effect that the size of companies has on adoption and use of ICT, opposite results exist depending on how size is measured. While measuring the size of a company by the number of employees has shown that the bigger the size, the lower its degree of adoption of ICT. Measuring size as that of the establishments, size has a positive effect on the above mentioned adoption (Bayo and Lera, 2007).

The third group of factors that the literature has shown to have an effect on the adoption and use of ICT are the factors related to the environment in which the company operates. In this group factors related to the national culture of the country, to the legal system, to the economic factor and factors related to the degree of competitiveness which the companies must face are included. Competitive pressure is an important determinant in adoption of ICT (Gattignon and Robertson, 1989). In relation to cultural factors, previous studies have shown that power distance and uncertainty avoidance are barriers opposing the adoption of ICT, having a negative impact. Other factors that affect ICT adoption negatively are poverty or limited economic development (Baliamoune, 2003; Mwesige, 2003), owing principally to the large investment that ICT introduction entails. Civil liberties of a country, as well as political rights also determine ICT adoption.

In the last years, numerous studies have focused on analyzing how adoption of ICT affects companies. More specifically, they have studied whether investments in ICT and their use affect in a significant way the growth in the output of companies. When it comes to considering the effects of ICT on the companies, we can differentiate two types of studies: the ones related to productivity and those related to the environment.

The studies that analyze the effect of ICT on productivity, are themselves subdivided into two: those that analyze the direct effect on productivity and those that analyze the indirect effect on productivity through the impact that ICT has in other areas of the company.

A degree of consensus does not exist as to the effect that ICT has on productivity of companies. While some authors argue that ICT can have a negative impact due to the fact that the great investment effort in ICT and the high rate of capital depreciation of already installed ICTs is not compensated by earnings in productivity, other authors argue and prove that the higher, not only adoption but also use of ICT, the higher the productivity of the companies (Lehr and Lichtenberg, 1999; Gilchrist et al., 2001; Greenan et al., 2001; Gretton et al., 2004; Mas and Quesada, 2005).

The indirect effects that ICT has on the productivity of companies are basically due to the effects that ICT has on the organization of work in the companies and to the complementary investments that the company should make on investing in ICT (Milgrom and Roberts, 1990). In this regard, previous studies show that a correlation exists among ICT use, the introduction of new practices in the workplace and the growth of productivity in the manufacturing sector of the USA (Black and Lynch, 1996, 2001, 2004).

ICT also influences the flexibility that companies have to adapt to the contingencies of the markets, enabling accommodating their offer to the needs of the market (Vilaseca et al., 2006). This has become especially relevant in the last years, as due to globalization companies are facing meaningful challenges originated by the increase of competitiveness in

the markets, the appearance of new products and the higher expectations of consumers.

Summarizing, ICT seems to have a positive effect on productivity, directly as well as indirectly, depending on the sectors analyzed (Gordon, 2000; Gilchrist et al., 2001; Devaraj and Kohli, 2003; Gretton et al., 2004). On the whole the investments in ICT contribute to the growth of productivity on an enterprise level, through the direct effects derived from the intensification of the capital, as well as to the overall effect on the factor contributing to productivity. ICT contributes to innovation in the business and at the same time, to the organization's riches. So, in line with the prevailing views in the economy, technology, in comparison with the accumulation of the physical and human capital, is what counts most when it comes to explaining the differences in revenues and growth among countries. (Easterly, 2001).

Regarding the impact that ICT has on the environment, consistent results do not exist, due to the fact that this aspect, up to not a very long time ago, has barely been explored.

A priori, ICT seems to be counterproductive for the environment because the use of ICT implies energy consumption. However, as Romm (2002) highlights in his work, contrary to a popular myth propagated by Mark Mills and Peter Hubes, ICT seems to have a great potential to support a sustainable development as the growth in ICT was linked to reductions in energy intensity. The effects that ICT has on the environment are divided into three types (Hilty et al., 2006). Primary effects due to the physical existence of ICT, such as the environmental impact of its production and use, as well as recycling of the hardware that makes up ICT (Idowu and Awodele, 2010). Secondary effects, namely the indirect effects ICT has on the

environment owing to the power that they have to change productive processes, resulting in a modification in the impact that they have on the environment, increasing the above mentioned impact or diminishing it. Tertiary effects, effects on the environment of the medium or long-term adaptation of behavior (e.g. consumption patterns) or economic structures due to the stable availability of ICT and the services it provides.

According to the conclusions of the European Council in Gothenburg, reviewed in the Spring European Council in March 2002 (Hilty et al., 2006), the indicators of the environment to measure its own sustainability are: greenhouse gas emissions, energy intensity of the economy, volume of transport to gross domestic product, modal split of transport, urban air quality, municipal solid waste landfilled or incinerated.

Taking all that has been mentioned above into consideration, the aim of this paper is to analyze the impact that the adoption and use of ICT has on managerial output. More specifically, it will analyze its effects on productivity of a company, as well as on its degree of innovation and on the environment.

DATA AND METHODOLOGY

E-Business Watch Survey

The data used for the empirical part of this study come from the E-Business Watch Survey of 2009, launched by the Commission and the Sectoral e-Business Watch. The main objective of the survey is to provide an overview of the use of ICT and e-business in enterprises in six European countries (France, Germany, Italy, Spain and United Kingdom). The survey, carried out using computer-aided telephone interview technology, targeted heads of IT/DEP

departments or seniors members of IT/DP departments or their managers. The sample was carried out among firms from the glass, ceramics and cement industries. We consider the sectors interviewed very relevant for the study of the impact of ICT on the environment, given that these industries produce the most energy and pollution, and because they represent one of the main sector in which automation process was carry out; e.g., paper-based and manually processed correspondents with business partners had been substituted by electronic data exchanges.

The questionnaire provides information about various aspects related to ICT as well as the companies themselves. More specifically, it provides information about the use of ICT systems and e-business software, automated data exchange with suppliers and customers, innovation activity and the role of ICT, ICT skills requirements, ICT investments, energy efficiency and emissions.

The sample of the survey is made up of firms that employ at least ten people and which make used computers. It has been stratified randomly from the population in each of the six countries. Samples were drawn locally by fieldwork organizations based on official statistical records and widely recognized business directories.

The fieldwork was carried out in March 2009 and the final sample includes 676 firms, which represents around 12% of firms contacted.

Dependent variables

The dependent variables make reference to three different aspects related to firm outcomes: competition, innovation and environmental emissions.

In order to assess competition, we use two variables. The first is a dummy variable that measures whether e-business has an influence on competition in the sector in which the firm operates. The second variable measures on a one (rather decreased) to three (significantly increased) scale to what extend competition has changed due to e-business.

As far as innovation was concerned, we also used two variables. A dummy variable which measures whether in the course of the past twelve months the company has launched any new or substantially improved product or services (product innovation) and the other one refers to whether the firm has introduced any new or significantly improved internal process (process innovation).

Environmental emissions were measured through one variable. This measures on a one (little potential) to three (high potential) scale the potential of ICT systems for reducing greenhouse gas emissions in the industry.

The definitions of these dependent variables and their descriptive statistics by country are reported in Table 1. The data summarized in Table 1 show the existence of variations in the use of new work practices across countries.

Table 1. Definition and mean of the dependent variables by countries

		Germany	Spain	France	Italy	UK	Poland
Influence ICT on competition	Obs	177	116	80	92	62	114
	No	68.93%	65.52%	90.00%	79.35%	75.81%	56.14%
	Yes	31.07%	34.48%	10.00%	20.65%	24.19%	43.86%
Competition increase	Obs	47	36	8	16	14	38
	Rather decreased	6.38%	19.44%	12.50%	18.75%	21.43%	13.16%
	Somewhat increased	76.60%	75.00%	37.50%	56.25%	71.43%	81.58%
	Significantly increased	17.02%	5.56%	50.00%	25.00%	7.14%	5.26%
Product innovation	Obs	180	123	85	100	62	120
	No	63.89%	63.41%	78.82%	60.00%	64.52%	52.50%
	Yes	36.11%	36.59%	21.18%	40.00%	35.48%	47.50%
Process innovation	Obs	177	123	86	101	64	118
	No	59.89%	55.28%	75.58%	61.39%	59.38%	33.05%
	Yes	40.11%	44.72%	24.42%	38.61%	40.63%	66.95%
ICT monitor greenhouse	Obs	176	121	82	85	60	115
	No	59.89%	55.28%	75.58%	61.39%	59.38%	33.05%
	Yes	3.98%	12.40%	2.44%	11.76%	1.67%	6.96%
ICT reduces greenhouse	Obs	164	112	57	80	56	103
	little potential	75.61%	55.36%	70.18%	72.50%	64.29%	47.57%
	medium potential	20.73%	34.82%	26.32%	18.75%	30.36%	39.81%
	high potential	3.66%	9.82%	3.51%	8.75%	5.36%	12.62%

Independent variables

The independent variables make reference to Information and Communication Technologies (ICT). By means of dummy variables we take into account whether the firm's survey use different ICTs.

The survey provides specific information about the usage of ICT in companies. Firms answer question referring to whether they have access to the internet, to a Local Area Network (LAN) and to a Wireless LAN.

The survey also yields information about the use of specific software systems to support any of the following e-business and manufacturing processes: Enterprise Resource Planning (ERP), Supply Chain Management system (SCM), Customer Relationship Management

(CRM), Supplier Relationship Management, Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM).

The last group of ICT is related to different technologies or media to communicate with other people. The variables measure whether firms use Radio Frequency Identification Technologies (RFID), communicate with supplier through EDI connection and make use of e-invoicing that is sending or receiving invoices electronically.

Table 2 summarizes the use of one of the above ICT across countries.

Control variables

A series of control variables that, according to previous literature, influence the impact of ICT on productivity, as well as in other firm outcomes, are included. These variables capture firm characteristics. Mainly, firm size, industry, market in which the firm operates and export share.

Methodology

Through the use of the STATA 10 software, probit models were estimated for binary dependent variables, while ordered probit models were used when the dependent variables were an ordered scale. It also worth mentioning that condition indices and variance inflation factors show values below the usual thresholds of 30 and 5, respectively (Judge et al., 1985), indicating that multicollinearity is not a problem in our models.

Table 2. Independent variables by countries

		Germany	Spain	France	Italy	UK	Poland
Internet	Obs	18	125	86	101	64	120
	No	0.00%	0.00%	2.33%	0.00%	1.56%	0.83%
	Yes	100.00%	100.00%	97.67%	100.00%	98.44%	99.17%
Local area network	Obs	177	123	86	100	63	116
	No	11.86%	8.13%	16.28%	11.00%	22.22%	25.00%
	Yes	88.14%	91.87%	83.72%	89.00%	77.78%	75.00%
Wireless LAN	Obs	179	123	86	101	62	116
	No	54.75%	47.15%	68.60%	67.33%	58.06%	54.31%
	Yes	45.25%	52.85%	31.40%	32.67%	41.94%	45.69%
ERP	Obs	173	120	78	100	61	12
	No	67.63%	54.17%	69.23%	73.00%	90.16%	60.00%
	Yes	32.37%	45.83%	30.77%	27.00%	9.84%	40.00%
SCM	Obs	177	122	81	100	63	120
	No	92.66%	68.85%	91.36%	85.00%	95.24%	87.50%
	Yes	7.34%	31.15%	8.64%	15.00%	4.76%	12.50%
CRM	Obs	1	124	82	99	63	120
	No	75.14%	66.13%	82.93%	78.79%	84.13%	76.67%
	Yes	24.86%	33.87%	17.07%	21.21%	15.87%	23.33%
SRM	Obs	179	123	82	98	63	117
	No	92.74%	72.36%	89.02%	86.73%	98.41%	89.74%
	Yes	7.26%	27.64%	10.98%	13.27%	1.59%	10.26%
CAD	Obs	179	123	84	97	64	12
	No	49.16%	60.16%	64.29%	51.55%	56.25%	54.17%
	Yes	50.84%	39.84%	35.71%	48.45%	43.75%	45.83%
CAM	Obs	178	123	84	96	62	119
	No	83.15%	66.67%	76.19%	92.71%	95.16%	82.35%
	Yes	16.85%	33.33%	23.81%	7.29%	4.84%	17.65%
RFID technology	Obs	176	125	83	99	58	115
	No	96.02%	91.20%	96.39%	97.98%	100.00%	98.26%
	Yes	3.98%	8.80%	3.61%	2.02%	0.00%	1.74%
EDI connections	Obs	177	108	86	98	61	109
	No	84.18%	79.63%	72.09%	82.65%	80.33%	83.49%
	Yes	15.82%	20.37%	27.91%	17.35%	19.67%	16.51%
E-invoicing	Obs	180	124	83	101	63	118
	No	80.00%	73.39%	81.93%	31.68%	63.49%	64.41%
	Yes	20.00%	26.61%	18.07%	68.32%	36.51%	35.59%

RESULTS

This section is structured as follows: first, the basic characteristics of the sample are described; then, the effects of ICT on firm outcomes are analyzed using multivariate analysis techniques.

Sample characteristics

Table 1 and 2 present the mean descriptive of the dependent and independent variables. It is clear that there is a wide range of differences as well on firm outcomes as on ICT adoption among countries.

Although managers or persons in charge of the ICT think that ICT has a great degree of influence on the competitiveness of the sector in Poland, only 10% of person of those who answered the survey in France claimed that they have some influence. On the other hand, 50% of interviewed French people think that ICT increases competition, while the figures for this same item are very low in Spain and Poland. As regards innovation, differences among countries are lowers. In all countries analyzed, except France, more than 35% of interviewees said that they had launched any new product or services during the last year and also that they had introduced any process innovation. Regarding the impact of ICT on the reduction of greenhouse effect, the percentage of people that think that ICT has a small impact on environment is greater than 50% in all countries, except for Poland. In this country, however, the percentage of people who think that ICT have a great impact on reduction of emissions to the environment is the highest with 12.62%.

Concerning the dependent variables, we can see that about 100% of the sample in all the countries have access to the Internet in their firm and about 80% shave a LAN. The percentage of people that said who have a wireless LAN is a bit lower, on average around 40%, while there are some differences among countries. As to the use of specific software and

in contrary to what we expected, the country that on average use more on specific software systems is Spain, while the country that use least on average uses the least specific software systems is the United Kingdom. The software systems more used in all countries is CAD, while the less adopted is SCM.

With respect to the ICT used to communicate with people, we can see that RFID technologies are very little adopted, being the degree of use in the United Kingdom inexistent. The degree of adoption of EDI connection varies between 15.82% and 27.81%, corresponding these degrees to Germany and France respectively. Finally, the last technology of communication analyzed is e-invoicing. The use of e-invoicing is very high in Italy 68.32%, being around 35% in Poland and the United Kingdom and around 20% on Germany, Spain and France.

ICT effect on firms outcomes

By means of multivariate analysis, this study will analyze the effect that the use of ICT has on the competitiveness of companies, as well an on innovation processes and on the environment. More specifically, provided that in all the cases the dependent variables were dummies, probit models have been estimated with the use of the STATA 10 software. On the whole, it has been proved that the use of diverse ICT does not seem to have any effect on the level of competitiveness of companies.

However, the use of ICT seems to favor innovation in the companies, considering it as launching new products / services to the market, as well as improving or introducing new processes. As to the effect on the environment, it has been verified that while the use of some ICT, as for example Internet, help to reduce emissions to the environment, the use of others,

mainly related to the productive processes, such as the use of CRM, contributes to their increase.

Table 3 present a model framework to analyze the effect that ICT has on the competitiveness of companies, as well an on innovation processes and on the environment.

As is clear from the table, the first two models analyze the effect that ICT has on firm competitiveness. We find that while LAN does not have any effect on the increase of competitiveness, the use of wireless LAN increases it. The different specific software systems analyzed have no effect on competitiveness, (except for CAM which seems to have some positive effects on e-business competition), while the technologies that serve to communicate people have different effects. People interviewed think that RFID technologies and EDI connections and e-invoicing have some influence on e-business competitiveness, while EDI connections decrease competition itself.

Concerning innovation, we find that ICT has different effects on product innovation and on process innovation. The use of LAN and Wireless LAN has no effect on innovation. The use of a specific software system related to design, CAD, has a positive effect on the launching of new product, and the use of this software system and the use or an ERP have positive effects on the introduction of a process innovation. Only the use of services online has positive effects on the introduction of process innovation.

As concerns environmental emissions, we find that while some ICT has an impact on the reduction of greenhouse, others increase energy efficiency. Having a LAN in the firm

increases energy efficiency, but has no effect on reducing the greenhouse effect. Two of the specific software systems analyzed have effects on greenhouse reduction, but they have opposite impacts. While the use of SCM reduces greenhouse effect, the use of CRM increases it. As to the effect of specific software systems on energy efficiency, we find that the use of an ERP and of SCM increase energy efficiency whereas the use of CRM decreases energy efficiency. Finally, we find that the use of RFID technologies reduce greenhouse, effect emission, while the use of e-invoicing has the opposite effect.

CONCLUSIONS

On the whole, we find that the use of diverse ICTs does not seem to have any effect on the level of competitiveness of firms. However, the use of ICT seems to favor innovation in the companies, considering it as launching new products or services as well improving or introducing new processes, which increase the level of competitiveness in the enterprise. Regarding its effect on the environment, it has been found that while the use of some ICT reduces greenhouse effect and increase energy efficiency, positive effects for the environment, others have the opposite effect; they increase greenhouse effect and do not increase energy efficiency.

Table 3. Probit and ordered probit results of the influence of ICT on competition, innovation and environment.

	Influence e-business Competition		Competition Increase		Product Innovation		Process Innovation		ICT Reduces Greenhouse		ICT Increase Energy Efficiency	
Local area network	0.200	*(0.207)*	0.313	*(0.439)*	0.077	*(0.189)*	0.099	*(0.187)*	0.226	*(0.193)*	0.596***	*(0.189)*
Wireless LAN	0.010	*(0.140)*	0.549*	*(0.286)*	0.144	*(0.127)*	0.073	*(0.130)*	0.191	*(0.130)*	0.090	*(0.120)*
ERP	-0.052	*(0.163)*	-0.235	*(0.308)*	0.022	*(0.151)*	0.433***	*(0.152)*	0.142	*(0.153)*	0.450***	*(0.142)*
SCM	0.250	*(0.234)*	-0.385	*(0.368)*	-0.158	*(0.227)*	-0.229	*(0.233)*	0.400*	*(0.211)*	0.025	*(0.205)*
CRM	0.023	*(0.177)*	0.148	*(0.309)*	0.129	*(0.165)*	0.088	*(0.172)*	-0.338*	*(0.173)*	-0.434***	*(0.159)*
SRM	0.202	*(0.250)*	0.329	*(0.398)*	0.241	*(0.238)*	0.177	*(0.245)*	0.168	*(0.242)*	0.485**	*(0.228)*
CAD	-0.216	*(0.147)*	0.207	*(0.266)*	0.312**	*(0.131)*	0.280**	*(0.133)*	0.030	*(0.133)*	0.104	*(0.123)*
CAM	0.402**	*(0.178)*	-0.299	*(0.314)*	-0.075	*(0.167)*	0.263	*(0.172)*	-0.264	*(0.171)*	0.051	*(0.154)*
RFID technologies	0.773**	*(0.367)*	-0.417	*(0.478)*	0.350	*(0.331)*	0.130	*(0.348)*	0.774**	*(0.313)*	0.432	*(0.304)*
EDI connections	0.635***	*(0.170)*	-0.542*	*(0.285)*	0.201	*(0.158)*	0.062	*(0.161)*	0.054	*(0.160)*	-0.204	*(0.154)*
E-invoicing	0.306*	*(0.159)*	0.050	*(0.271)*	-0.013	*(0.150)*	-0.066	*(0.152)*	-0.453***	*(0.155)*	0.021	*(0.142)*
Services online	0.078	*(0.150)*	0.426	*(0.314)*	0.202	*(0.136)*	0.312**	*(0.138)*	0.000	*(0.138)*	-0.037	*(0.128)*
Employ ICT practitioners	0.289*	*(0.157)*	-0.128	*(0.279)*	0.126	*(0.149)*	0.550***	*(0.152)*	0.276*	*(0.145)*	0.125	*(0.138)*
Energy save	0.126	*(0.157)*	-0.294	*(0.287)*	0.170	*(0.148)*	0.229	*(0.151)*	0.731***	*(0.143)*	0.737***	*(0.136)*
Regional market	-0.324	*(0.265)*	0.917**	*(0.448)*	-0.362	*(0.252)*	-0.541**	*(0.268)*	0.195	*(0.256)*	0.145	*(0.234)*
Country market	-0.192	*(0.243)*	0.863**	*(0.400)*	-0.185	*(0.229)*	-0.390	*(0.245)*	0.218	*(0.235)*	0.081	*(0.214)*
Share exports	0.000	*(0.004)*	0.004	*(0.007)*	-0.003	*(0.004)*	-0.005	*(0.004)*	0.003	*(0.004)*	0.000	*(0.004)*
Glass	0.272	*(0.182)*	0.596*	*(0.319)*	0.079	*(0.166)*	0.158	*(0.171)*	0.048	*(0.168)*	0.070	*(0.153)*
Ceramics	0.391**	*(0.176)*	0.345	*(0.326)*	0.337**	*(0.161)*	0.007	*(0.169)*	-0.067	*(0.165)*	0.208	*(0.152)*
Size	0.000	*(0.000)*	0.000	*(0.001)*	0.000	*(0.000)*	0.000	*(0.000)*	0.000	*(0.000)*	0.000	*(0.000)*
_cons	-1.233***	*(0.372)*			-0.763**	*(0.345*	-0.712**	*(0.357)*				
N	503		128		520		518		464		472	
log-likelihood	-257.615		-86.772		-308.014		-291.822		-340.951		-407.780	
R2	24.71%		27.43%		14.93%		27.98%		18.91%		21.26%	

*** p<0.01; **p<0.05; *p<0.1

Countries are included as control variables.

Standard deviation in brackets.

REFERENCES

Baliamoune-Lutz, M. (2003). An analysis of the determinants and effects of ICT diffusion in developing countries. Information Technology for Development, 10, 151-169.

Bayo-Moriones, A., & Lera-López, F. (2007). A firm-level analysis of determinants of ICT adoption in Spain. Technovation, 27, 352-366.

Black, S.E., & Lynch, L.M. (1996). Human capital investments and productivity. American Economic Review, 86 (2), 263-7. The Economic Journal, 114 (493), 97-116.

Black, S.E., & Lynch, L.M. (2001). How to compete: the impact of workplace practices and information technology on productivity. Review of Economics and Statistics, 83 (3), 434-445.

Black, S.E., & Lynch, L.M. (2004). What's driving the new economy? The benefits of workplace innovation. The Economic Journal, 114 (493), 97-116.

Devaraj, S., 6 Kohli, R. (2003). Performance Impacts of Information Technology: is Actual Usage the Missing Link?. Management Science, 49 (3), 273-289.

Easterly, W. (2001). The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics. MIT Press, Cambridge, Ma.

Gattignon, H., & Robertson, T.S. (1989). Technology diffusion: an empirical test of competitive effects. Journal of Marketing, 53 (1), 35-49.

Gilchrist, S., Gurbaxani, V., & Town, R. (2001). PCs and the Productivity Revolution. Working Paper, Center for Research on Information Technology and Organizations, University of California, Irvine.

Gordon, R. J. (2000). Does the "New Economy" Measure up to the Great Inventions of the Past?. Journal of Economic Perspectives, 14 (4). 49-74.

Greenan, N., Mairesse, J., & Topio-Bensaid, A. (2001). Information Technology and Research and Development Impacts on Productivity and Skills: Looking for Correlations on French Firm-level Data, in: Pohjola, M. (Ed.) Information Technology, Productivity and Economic Growth: International Evidence and Implications for Economic Development. Cambridge, Oxford University Press, 119-148.

Gretton, P., Gali, J., & Parham, D. (2004). The effects of ICTs and complementary innovations on Australian productivity growth. In: OECD (Ed.), The Economic Impact of ICT. Measurement, Evidence and Implication. OECD, Paris, pp. 105-130.

Hilty, L.M., Arnfalk, P., Erdmann, L., Goodman, J., Lehmann, M., & Wäger, P.A. (2006). The relevance of information and communication technologies for environmental sustainability – A prospective simulation study. Environmental Modelling & Software, 21, 1618-1629.

Idowu, S.A & Awodele, O. A. (2010). Information and Communication Technology (ICT) Revolution: Its Environmental Impact and Sustainable Development. International Journal on Computer Science and Engineering, 2, 30-35.

Lehr, B. & Lichtenberg, F. (1999). Information Technology and Its Impact on Productivity: Firm-Level Evidence from Government and Private Data Sources. The Canadian Journal of Economics, 32 (2), 335-362.

Mas, M.; & Quesada, J. (dirs) (2005). Las Nuevas Tecnologías y el Crecimiento Económico en España. Bilbao, Fundación BBVA.

Milgrom, P. & Roberts, J. (1990). The economics of modern manufacturing: Technology, strategy and organization. American Economic Review, 80, 511-528.

Mwesige, P.G. (2003). Cyber elites: a survey of Internet Café users in Uganda. Telematics and Informatics, 21, 83-101.

Room, J. (2002). The internet and the new energy economy. Resources Conservation & Recycling, 36, 197-210.

Takahashi, K.I., Tatemichi, H., Tanaka, T., Nishi, S., & Kunioka, T. (2004). Environmental impact of information and communication technologies including rebound effects. International Symposium on Electronics and the Environment (ISEE'04), pp. 13-16

Vilaseca, J., Torrent, J.; Lladós, J.; & Garay, L. (2006). El impacto de las TIC en la empresa turística: el caso de Cataluña. UOC, Working Paper Series, WP06-003.

Table

Table 1. Definition and mean of the dependent variables by countries

		Germany	Spain	France	Italy	UK	Poland
Influence ICT on competition	Obs	177	116	80	92	62	114
	No	68.93%	65.52%	90.00%	79.35%	75.81%	56.14%
	Yes	31.07%	34.48%	10.00%	20.65%	24.19%	43.86%
Competition increase	Obs	47	36	8	16	14	38
	Rather decreased	6.38%	19.44%	12.50%	18.75%	21.43%	13.16%
	Somewhat increased	76.60%	75.00%	37.50%	56.25%	71.43%	81.58%
	Significantly increased	17.02%	5.56%	50.00%	25.00%	7.14%	5.26%
Product innovation	Obs	180	123	85	100	62	120
	No	63.89%	63.41%	78.82%	60.00%	64.52%	52.50%
	Yes	36.11%	36.59%	21.18%	40.00%	35.48%	47.50%
Process innovation	Obs	177	123	86	101	64	118
	No	59.89%	55.28%	75.58%	61.39%	59.38%	33.05%
	Yes	40.11%	44.72%	24.42%	38.61%	40.63%	66.95%
ICT monitor greenhouse	Obs	176	121	82	85	60	115
	No	59.89%	55.28%	75.58%	61.39%	59.38%	33.05%
	Yes	3.98%	12.40%	2.44%	11.76%	1.67%	6.96%
ICT reduces greenhouse	Obs	164	112	57	80	56	103
	little potential	75.61%	55.36%	70.18%	72.50%	64.29%	47.57%
	medium potential	20.73%	34.82%	26.32%	18.75%	30.36%	39.81%
	high potential	3.66%	9.82%	3.51%	8.75%	5.36%	12.62%

Table 2. Independent variables by countries

		Germany	Spain	France	Italy	UK	Poland
Internet	Obs	18	125	86	101	64	120
	No	0.00%	0.00%	2.33%	0.00%	1.56%	0.83%
	Yes	100.00%	100.00%	97.67%	100.00%	98.44%	99.17%
Local area network	Obs	177	123	86	100	63	116
	No	11.86%	8.13%	16.28%	11.00%	22.22%	25.00%
	Yes	88.14%	91.87%	83.72%	89.00%	77.78%	75.00%
Wireless LAN	Obs	179	123	86	101	62	116
	No	54.75%	47.15%	68.60%	67.33%	58.06%	54.31%
	Yes	45.25%	52.85%	31.40%	32.67%	41.94%	45.69%
ERP	Obs	173	120	78	100	61	12

	No	67.63%	54.17%	69.23%	73.00%	90.16%	60.00%
	Yes	32.37%	45.83%	30.77%	27.00%	9.84%	40.00%
SCM	Obs	177	122	81	100	63	120
	No	92.66%	68.85%	91.36%	85.00%	95.24%	87.50%
	Yes	7.34%	31.15%	8.64%	15.00%	4.76%	12.50%
CRM	Obs	1	124	82	99	63	120
	No	75.14%	66.13%	82.93%	78.79%	84.13%	76.67%
	Yes	24.86%	33.87%	17.07%	21.21%	15.87%	23.33%
SRM	Obs	179	123	82	98	63	117
	No	92.74%	72.36%	89.02%	86.73%	98.41%	89.74%
	Yes	7.26%	27.64%	10.98%	13.27%	1.59%	10.26%
CAD	Obs	179	123	84	97	64	12
	No	49.16%	60.16%	64.29%	51.55%	56.25%	54.17%
	Yes	50.84%	39.84%	35.71%	48.45%	43.75%	45.83%
CAM	Obs	178	123	84	96	62	119
	No	83.15%	66.67%	76.19%	92.71%	95.16%	82.35%
	Yes	16.85%	33.33%	23.81%	7.29%	4.84%	17.65%
RFID technology	Obs	176	125	83	99	58	115
	No	96.02%	91.20%	96.39%	97.98%	100.00%	98.26%
	Yes	3.98%	8.80%	3.61%	2.02%	0.00%	1.74%
EDI connections	Obs	177	108	86	98	61	109
	No	84.18%	79.63%	72.09%	82.65%	80.33%	83.49%
	Yes	15.82%	20.37%	27.91%	17.35%	19.67%	16.51%
E-invoicing	Obs	180	124	83	101	63	118
	No	80.00%	73.39%	81.93%	31.68%	63.49%	64.41%
	Yes	20.00%	26.61%	18.07%	68.32%	36.51%	35.59%

Table 3. Probit and ordered probit results of the influence of ICT on competition, innovation and environment.

	Influence e-business Competition		Competition Increase		Product Innovation		Process Innovation		ICT Reduces Greenhouse		ICT Increase Energy Efficiency	
Local area network	0.200	*(0.207)*	0.313	*(0.439)*	0.077	*(0.189)*	0.099	*(0.187)*	0.226	*(0.193)*	0.596***	*(0.189)*
Wireless LAN	0.010	*(0.140)*	0.549*	*(0.286)*	0.144	*(0.127)*	0.073	*(0.130)*	0.191	*(0.130)*	0.090	*(0.120)*
ERP	-0.052	*(0.163)*	-0.235	*(0.308)*	0.022	*(0.151)*	0.433***	*(0.152)*	0.142	*(0.153)*	0.450***	*(0.142)*
SCM	0.250	*(0.234)*	-0.385	*(0.368)*	-0.158	*(0.227)*	-0.229	*(0.233)*	0.400*	*(0.211)*	0.025	*(0.205)*
CRM	0.023	*(0.177)*	0.148	*(0.309)*	0.129	*(0.165)*	0.088	*(0.172)*	-0.338*	*(0.173)*	-0.434***	*(0.159)*
SRM	0.202	*(0.250)*	0.329	*(0.398)*	0.241	*(0.238)*	0.177	*(0.245)*	0.168	*(0.242)*	0.485**	*(0.228)*
CAD	-0.216	*(0.147)*	0.207	*(0.266)*	0.312**	*(0.131)*	0.280**	*(0.133)*	0.030	*(0.133)*	0.104	*(0.123)*
CAM	0.402**	*(0.178)*	-0.299	*(0.314)*	-0.075	*(0.167)*	0.263	*(0.172)*	-0.264	*(0.171)*	0.051	*(0.154)*
RFID technologies	0.773**	*(0.367)*	-0.417	*(0.478)*	0.350	*(0.331)*	0.130	*(0.348)*	0.774**	*(0.313)*	0.432	*(0.304)*
EDI connections	0.635***	*(0.170)*	-0.542*	*(0.285)*	0.201	*(0.158)*	0.062	*(0.161)*	0.054	*(0.160)*	-0.204	*(0.154)*
E-invoicing	0.306*	*(0.159)*	0.050	*(0.271)*	-0.013	*(0.150)*	-0.066	*(0.152)*	-0.453***	*(0.155)*	0.021	*(0.142)*
Services online	0.078	*(0.150)*	0.426	*(0.314)*	0.202	*(0.136)*	0.312**	*(0.138)*	0.000	*(0.138)*	-0.037	*(0.128)*
Employ ICT practitioners	0.289*	*(0.157)*	-0.128	*(0.279)*	0.126	*(0.149)*	0.550***	*(0.152)*	0.276*	*(0.145)*	0.125	*(0.138)*
Energy save	0.126	*(0.157)*	-0.294	*(0.287)*	0.170	*(0.148)*	0.229	*(0.151)*	0.731***	*(0.143)*	0.737***	*(0.136)*
Regional market	-0.324	*(0.265)*	0.917**	*(0.448)*	-0.362	*(0.252)*	-0.541**	*(0.268)*	0.195	*(0.256)*	0.145	*(0.234)*
Country market	-0.192	*(0.243)*	0.863**	*(0.400)*	-0.185	*(0.229)*	-0.390	*(0.245)*	0.218	*(0.235)*	0.081	*(0.214)*
Share exports	0.000	*(0.004)*	0.004	*(0.007)*	-0.003	*(0.004)*	-0.005	*(0.004)*	0.003	*(0.004)*	0.000	*(0.004)*
Glass	0.272	*(0.182)*	0.596*	*(0.319)*	0.079	*(0.166)*	0.158	*(0.171)*	0.048	*(0.168)*	0.070	*(0.153)*
Ceramics	0.391**	*(0.176)*	0.345	*(0.326)*	0.337**	*(0.161)*	0.007	*(0.169)*	-0.067	*(0.165)*	0.208	*(0.152)*
Size	0.000	*(0.000)*	0.000	*(0.001)*	0.000	*(0.000)*	0.000	*(0.000)*	0.000	*(0.000)*	0.000	*(0.000)*
_cons	-1.233***	*(0.372)*			-0.763**	*(0.345*	-0.712**	*(0.357)*				
N	503		128		520		518		464		472	
log-likelihood	-257.615		-86.772		-308.014		-291.822		-340.951		-407.780	
R2	24.71%		27.43%		14.93%		27.98%		18.91%		21.26%	

*** p<0.01; **p<0.05; *p<0.1

Countries are included as control variables.

Standard deviation in brackets.

We examine the ICT impact on competitiveness, innovation and environment in the glass, ceramics and cement concrete industry. We use data from the E-Business Watch Survey of 2009. We conclude that ICT use favors innovation and competitiveness and helps to reduce emissions.