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ICT, Innovation and Productivity: Evidence from Eastern European Manufacturing Firms

Aleksandra Skorupinska (**askorupinska@uoc.edu**)
Internet Interdisciplinary Institute (IN3)
Open University of Catalonia (UOC)

Joan Torrent-Sellens (jtorrent@uoc.edu)
Economics and Business Studies and Internet Interdisciplinary Institute (IN3)
Open University of Catalonia (UOC)

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Internet Interdisciplinary Institute (IN3)
http://www.in3.uoc.edu
Edifici MediaTIC
c/ Roc Boronat, 117
08018 Barcelona
Espanya
Tel. 93 4505200

Universitat Oberta de Catalunya (UOC)
http://www.uoc.edu/
Av. Tibidabo, 39-43
08035 Barcelona
Espanya
Tel. 93 253 23 00

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Aleksandra Skorupinska (askorupinska@uoc.edu)
Internet Interdisciplinary Institute (IN3)
Open University of Catalonia (UOC)

Joan Torrent-Sellens (jtorrent@uoc.edu)
Economics and Business Studies and Internet Interdisciplinary Institute (IN3)
Open University of Catalonia (UOC)

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Abstract

Main motivation behind this study is to evaluate relations between ICT, management practices, innovation, human capital and organizational changes in sample of manufacturing enterprises from Eastern European countries. Using data from Management, Organization and Innovation (MOI) Survey 2009 for a representative sample of 444 firms from Bulgaria, Poland, Romania, Serbia and Ukraine and using ordinary least squares and structural equation modelling econometric techniques we examined direct and indirect determinants of labour productivity.

Main finding that have emerged from the study is that cost for employees is the main determinant of labour productivity. In addition, the casual relationship between ICT and its complementarities and productivity, has been established indirectly. Mainly, by the enterprise workers ICT use. The results of the investigation bridge the gap of insufficient academic research about Eastern European countries extend existing research on firm-level labour productivity determinants and enable to compare the results at the international framework.

Keywords

Eastern European Countries, Firm-level Productivity, Information and Communication Technologies (ICT), Innovation, Manufacturing Industries

Introduction

The widespread use of Information and Communication Technologies (ICT) is one of the main distinguishing features of today's economic activity (Jovanovic and Rousseau, 2005; Jorgenson and Vu, 2007). The reason for this is twofold: first, their direct contribution to increased productivity and economic growth and second, their indirect contribution resulting from the generation of complementary innovations that improve economy's Total Factor Productivity (TFP) (Pilat, 2006; Jorgenson et al., 2011; Ceccobelli et al., 2012). From the perspective of the impact analysis of ICT investment on productivity and economic growth, empirical evidence shows that: 1) the rates of return on digital investment are relatively much higher than those on investment in other physical components; 2) the reason for this is that digital investment and use often go hand in hand with other endeavours, usually human capital improvement and organisational and institutional change (Bresnahan et al., 2002; Arvanitis, 2005). Indeed, the transformative impact of digital investment and use on the productivity and economic growth becomes more evident through co-innovation processes. The transition countries of Eastern Europe (EE) face considerable challenges in adapting their economies to compete effectively in regional and global markets. It is a key issue to find a path to increase their productivity, adapt the structure of their economy to global-knowledge competition, to promote co-innovation and develop new goods and services that respond to changing domestic and international demand. Thus, the impact of digital technological change and their co-innovation processes on productivity is an important aspect for the region's economic performance.

Main motivation behind this study is to evaluate relations between ICT, management practices, innovation, human capital and organizational changes in sample of manufacturing enterprises from Eastern European countries. The main questions behind this study are: 1) Does existence of new co-innovation productivity sources (usage of ICT, workplace organization and human capital) affect manufacturing enterprises performance in Eastern European countries? 2) What are interrelationships between those complementary factors? 3) What are the differences between Eastern European manufacturing enterprises?

The reminder of this paper is organised as follows. Section 1 presents a survey from the empirical literature about the relationships between ICT, innovation and firm productivity. Section 2 describes the data. Section 3 reports the OLS and SEM models and the empirical findings, and Section 4 provides conclusions and policy implications based on those findings.

1. Literature review: ICT, Innovation and Firm Productivity

Much effort was put into research to understand the so called Solow Paradox concerning the limited evidence of a positive productivity impact of the ICT (Jorgenson and Stiroh, 1999). The importance of ICT is a much debated question with extensive literature focused on explaining and understanding their role in economic growth, productivity and efficiency. Significant progress has been noted since 1990 in the analysis of ICT and productivity. Most empirical studies have been performed at the microeconomic firm and industry level examining their relationship with economic growth and productivity. At macroeconomic level fewer studies have been conducted because of a shortage of datasets related especially to ICT investment and usage and other relevant national characteristics.

Firm-level analysis complements the analysis at the macro-level and enables researches to better understand ICT diffusion effects and especially to more adequately reflect those quality changes brought about by ICT. Regarding the relation between ICT and productivity at the firm-level there are findings that ICT alone is not enough affect for productivity. Ignoring other complementarities may bias the analysis and overestimate the effect on ICT on productivity. Significant changes within the firm structure, such as a shift in the employment structure from low to high skills, the diffusion of ICT and a redesign of a firms workplace organization, can be observed over the last years and present new challenges for companies. Many authors pointed out importance of these interrelated changes as a shift towards a 'new firm paradigm', which they characterized using different labels: from a 'mechanistic' to an 'organic' firm structure (Burns and Stalker, 1994), from the 'mass production model' to the 'flexible multiproduct firm' (Milgrom and Roberts, 1990), or from a 'tailoristic' to a 'holistic' organization of work (Lindbeck and Snower, 2000). Potential of ICT will not be realized without business model changes and increase of human capital and ICT skills (Bresnahan et al., 2002; Arvanitis, 2005). The main results that the international empirical evidence has suggested in relation to the new co-innovative sources of firm productivity are presented in this section (Torrent and Ficapal, 2010; Díaz et al., 2013). The results are presented by country and date of publication, with special attention to the Eastern European countries.

Most of the firm-level studies were focused on highly-developed countries. The empirical study for the United States (Bresnahan et al., 2002) formulated and confirmed new theory of skill-biased technical change. The authors have shown the evidence of positive correlation of ICT use and investment, workplace organization and skilled labour which have affected productivity. Moreover, it concluded that with growing spread and access to ICT, the investment in complementarities is crucial, particularly in skilled labour. Brynjolfsson and Hitt (2003) identified a set of new organisational practices in firms (freedom of information and communication, decision-making rights, performance-related incentives, and investment in education and

training) that, together with digital innovation, are determinants in the explanation of productivity growth. Furthermore taking the United States into consideration, there are studies from Black and Lynch (2001, 2004) of manufacturing establishments showing that productivity growth during 1990s has a source in workplace organization changes and innovations (employee involvement, team work, incentive pay and decision-making autonomy) along with diffusion of computers.

Investigations conducted in other countries followed the path of analysis initiated in the United States. Gretton et al. (2004) found interactions between ICT use and human capital, history of innovation, use of advanced business practices and intensity of organisational restructuring and its positive influence on productivity in a sample of Australian firms. Grimes et al. (2012) have confirmed a very significant transversal impact of broadband Internet use on firm productivity in New Zealand. Additionally, effects are consistent across urban versus rural locations and across high versus low knowledge intensive sectors. Analysis of panel data from for British and French firms (Caroli and Van Reenen, 2001) revealed that skilled workers adapt more easily to changes in organization. Having the above in mind, the authors presented empirical evidence of relationship between workplace innovation and human capital, and its influence on productivity. Another comparative study of Swiss and Greek firms (Arvanitis and Loukis, 2009) shows positive effects of physical capital, ICT, human capital and new organizational practices on labour productivity. However, Swiss firms are more efficient in combining and implementing those factors, while in the Greeks firms physical capital still plays crucial role in relation to labour productivity. Research for the Catalan firms (Torrent-Sellens and Ficapal-Cusí, 2010) confirmed role of new co-innovative sources in technology and knowledge-intensive firms. Among the remaining 80% of firms no evidence was found to show any impact of those sources. In Japan, Miyazaki et al. (2012) have classified ICT applications into four stages of sophistication (non-performing ICT assets, section-wide system applications, company-wide system applications and inter-corporate system applications) and found that the impact of ICT on firm productivity increases with a successive stage of ICT use sophistication. In Germany, a set of studies (Hempell, 2005; Hempell and Zwick, 2008) based on several time samples of its industry's firms also confirmed the existence of relationships of dependence between labour productivity and digital technology and organisational innovation processes. Authors found out that ICT fosters product and process innovations by facilitating employee participation and communication and ICT investment is most productive in firms with experience from earlier innovations. In recent work Hall et al. (2012) examine the firm-level relationships between product, process, and organizational innovations, productivity, research and development (R&D) and ICT, using data on manufacturing enterprises from Italy. They find that R&D and ICT are both strongly associated with innovation and productivity, with ICT investment being more important for productivity. ICT and R&D contribute to productivity both directly and indirectly through the innovation equation, but they are neither complements nor substitutes. However, individually both appear to have large impacts on productivity, suggesting some underinvestment in these activities by Italian firms.

Although the transition of Eastern European economies from centrally planned economy to market driven system occurred more than two decades ago and now those countries actively participate in the global economic community publications on ICT in transition economies are sparse (Roztocki and Weistroffer, 2011). Following Roztocki and Weistroffer (2008, 2011) there are several explanations of this scarcity of published research. Firstly, lack of funding for this type of research. Therefore much of the published research dealing with ICT in transition economies has been carried out by researchers employed at institutions in developed countries. However, the transition economies that have joined the EU now can get more founds and more research maybe expected from those countries in the future. Secondly, in the communist period research was directed to other disciplines than ICT, such as physics and chemistry. Moreover, the effect of many administrative structures and procedures that were instituted in the past still remain. Furthermore, reforms have been concentrated on economic changes rather than academics, with existing structures at many higher universities still inhibiting research productivity.

First publications concerning Eastern European countries evaluated the impact of ICT on growth at the aggregate level. Van Ark and Piatkowski (2004) compare productivity performance of 10 Central and Eastern European countries (CEE) and EU-15 countries during 1990s examining productivity and income convergence hypothesis. Their investigation gives more support to the convergence hypothesis. Besides, they show that ICT capital in the CEE countries has contributed as much to labour productivity growth as in the EU-15 countries and that ICT capital depending on itself has not been an important source of convergence. They emphasize the importance of consistent progress in economic, institutional and regulatory environment, the creation of modern institutions, implementation of market oriented policy reforms, increase in innovation and improvements in the quality of human capital. There are some pioneers of firm-level analysis as Stare et al. (2006) who explored a link between ICT and the performance of service firms in Slovenia. They confirmed positive impact of ICT use on productivity, however due to absence of data on complementary expenditures for training and organizational change the results might overestimate the impact of ICT.

Table 1 summarises the main results for a broad set of studies. Most of international empirical evidence has confirmed the complementarities of new co-innovative firm productivity sources: ICT investment and usage, human capital and new forms of work organization. However, more empirical studies are still needed in this field. Eastern European countries are clearly marked by sacristy of studies on ICT and complementarities and productivity.

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Table 1: Literature Review Summary

Authors	Region	Time period	Key results
Macroeconomic literature			
Van Ark & Piatkowski (2004)	CEE-10 & EU-15	1989-2002	Support of convergence hypothesis of CEE countries to EU-15 countries. Emphasis on complementarities to ICT investment.
Microeconomic (firm-level) literature			
Caroli & Van Reenen (2001)	United Kingdom & France	1984,1990, 1992, 1996	Skilled workers more easily adapt to changes in organization. Evidence of relationship between workplace innovation and human capital and their influence on productivity.
Bresnahan & Brynjolfsson & Hitt (2002)	United States	1987-1994	Positive correlation of ICT, workplace organization and skilled labour which have affected productivity.
Brynjolfsson & Hitt (2003)	United States	1987-1994	Set of new organisational practices in firms together with digital innovation, are determinants in the explanation of productivity growth.
Black & Lynch (2001, 2004)	United States	1987-1993, 1997	ICT together with workplace organization have significant and positive impact on productivity.
Gretton & Gali & Parham (2004)	Australia	1994-1998	Interactions between ICT use and human capital, innovation, business practices and organisational restructuring.
Hempell (2005)	Germany	1994-1999	ICT investment is linked innovation and is most productive in firms with experience from earlier innovations.
Hempell & Zwick (2008)	Germany	2002-2004	ICT fosters product and process innovations by facilitating employee participation and communication.
Stare & Jaklic & Kotnik (2006)	Slovenia	1996-2002	Positive impact of ICT use on productivity.
Arvanitis & Loukis (2009)	Switzerland & Greece	2005	Positive effects for physical capital, ICT, human capital and new organizational practices on labour productivity.
Torrent & Ficapal (2010)	Spain (Catalonia)	2003	No relevant impact of ICT use in 80% of firms. Significant delay in the implementation of the co-innovative productivity sources in Catalonia.
Grimes & Ren & Stevens (2012)	New Zealand	2005-2006	Broadband adoption boosts firm productivity.
Miyazaki & Idota & Miyoshi (2012)	Japan	2006	Impact of ICT on firm productivity increases with a successive stage of ICT use sophistication.
Hall & Lotti & Mairesse (2012)	Italy	1995-2006	R&D and ICT are associated with innovation and productivity. They contribute to productivity both directly and indirectly through the innovation equation.

Source: Own elaboration.

2. Data

Our empirical descriptive and econometric analysis is based on data from Management, Organization and Innovation (MOI) Survey 2009, a joint initiative of the European Bank for Reconstruction and Development (EBRD) and the World Bank Group. The MOI survey was undertaken for the first time in 2008-2009, covering 1870 manufacturing establishments with between 50 and 5000 employees from 10 Eastern European countries: Belarus, Bulgaria, Kazakhstan, Lithuania, Poland, Romania, Russia, Serbia, Ukraine, Uzbekistan, and Germany as a developed country benchmark

and India as a developing country benchmark. MOI interviews were conducted face-to-face with by the interviewers recruited by local survey companies and took place between October 2008 and April 2010. The interviews were conducted with managers endured on average 50 minutes. The response rate was 44 percent. The questionnaire comprised seven sections organised by topic. The first asked questions about the characteristics of the firm, such as legal status, ownership and number of years in operation. This was followed by sections on management practices, organisation of the firm, innovation and R&D, degree of competition and labour. The MOI questionnaire was developed and tested in two pilot surveys prior to its implementation in the field. Two main objectives of the sample is measure and compare management practices across the countries and to conduct firm performance analysis focusing on determining how management practises affect productivity and job creation in manufacturing. MOI survey was used to determine if quality of management practices is positively associated with various measures of firm performance in Eastern European countries (Bloom et al., 2012; Schweiger and Friebel, 2013). The Survey uses a standardized survey instrument and a uniform sampling methodology to minimize measurement error and generate a sample representative of the manufacturing sectors in each country. Data are comparable across the countries and the sample seize is large enough to conduct statistically robust analysis with levels of precision at minimum 7.5% precision for 90% confidence intervals (EBRD and World Bank, 2008).

Data from MOI survey was complemented by firm performance data (balance sheets and income and loss statement) from Bureau van Dijk's Orbis database. Given that the output variables from Bureau van Dijk's Orbis database are not available for all countries and also for all firms in the country, we run the risk that results are driven by specific country. Performance data: the operating revenue and cost of employees are winsored at 1% to limit the impact of outliers on the result (this means that all the data below the 0.5th percentile are set to 0.5th percentile and all the data above the 99.5th percentile are set to 99.5th percentile as in Bloom et al. (2012)).

For the present study, we have included 444 complete cases from five Eastern European countries: 95 from Bulgaria, 41 from Poland, 84 from Romania, 110 from Serbia and 114 firms from Ukraine. Other countries were excluded from analysis due to lack of financial data in 2008 data available. Those firms operate mainly (55% of firms) in low and medium-low technology industries (mostly food, textiles, fabricated metal products). 17% of firms are medium-high and high technology industries (machinery and equipment, electronics and chemicals). We not have data to which industry belong 126 remaining firms. The companies in the sample are medium-size manufacturing firms and have on average 207 employees. Table 2 gives summary statistics of variables of interests and additional data to conceptualize.

Table 2: Summary statistic

	Total	Bulgaria	Poland	Romania	Serbia	Ukraine
Average firm productivity	47.26	37.66	136.48	39.84	54.51	21.66
Average cost of employee	6.61	4.12	14.89	6.12	9.41	3.37
Firms with Internet access (% of total)	90.00	96.00	100.00	96.00	80.00	87.00
ICT usage (% of empl. using computer)	23.33	20.53	32.61	14.52	20.11	31.92
Firms with patents (% of total)	31.00	34.00	29.00	20.00	21.00	47.00
Firms with product innovation (% of total)	64.00	63.00	80.00	61.00	60.00	65.00
Education (% of empl. with univ. degree)	19.78	18.15	15.97	14.92	12.53	33.08
Quality of management[1]	0.00	0.10	0.02	-0.05	-0.06	0.00
Average number of employees	207.65	152.89	222.12	188.88	188.99	279.92
GDP per capita. PPP (current Int $)	-	13.62	18.80	14.64	11.09	6.31
Manufacturing value added (% of GDP)	-	15.40	18.49	21.55	16.32	17.81
Country population (million)	-	7.59	38.15	21.48	7.32	46.05
Number of firms in sample	444.00	95.00	41.00	84.00	110.00	114.00

1. Construction of indicator quality of management is explained in the section OLS estimation.
Source: Own elaboration. Orbis database, MOI survey and World Bank World Development Indicators (2009).

Most countries of Eastern Europe during the transition form a command to market economy have involved restructuring and reallocating resources to foster great efficiency in resource use. Despite of significant growth of service sector after transition in those countries manufacturing sector still contributes significantly to GDP. Manufacturing value added as a share of GDP ranged from 15 percent for Bulgaria to 21 percent in Romania. There is significant gap between Poland and other EE countries in labour productivity, measured as a company's turnover in 2008 divided by the number of full-time employees. Considering this indicator on the average the firms from the leader Poland have more than two and half times higher productivity than Serbia and more than three times higher than as well EU countries Bulgaria and Romania. Regarding ICT indicators, on average 80% manufacturing enterprises in Serbia have high-speed Internet connection, where in Poland all companies are connected. Moreover, in Polish and Ukrainian manufacturing firms on average than 32% of employees regularly uses personal computers for their job, when in Romania less than 15% and in Bulgaria and Serbia 20%. Regarding other dimension of productivity sources, innovation, Polish manufacturing enterprises are leading, as 80% of firms introduced new product or service, as in other countries it was 60% of firms. In addition, strong patent protection, which preserves new innovation, is associated with higher levels of total factor productivity. As well, patents can be used as a measure of the output of innovation. Patents are registered in almost half Ukrainian companies, than fallowed by Bulgaria 34% and Poland 29%. Moreover, the importance of human capital is much higher in knowledge economy than in industrial economy in used sample the highest share of employees with university degree is in Ukraine 33% of total and in rest of the countries varies from 12% to 20%. Lastly, in our analysis we

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included quality of management, which is important with implementation of ICT. On average the management practices are better in Bulgaria, and followed by Poland and Ukraine.

3. Empirical results

3.1. OLS estimation

Methodology for estimation of co-innovative sources of firm productivity is an extension of well-established traditional growth and productivity accounting approach, based on Solow growth model (Solow, 1957) and its extension by Jorgenson and Griliches (1967). The co-innovation productivity sources are incorporated in the efficiency component (Total Factor Productivity, TFP). This is an important contribution because, in the analysis of the determinants of firm productivity, indicators of ICT use, work organisation or human capital can be used. This allows for the use of explanatory elements that go beyond pure investment, which contemplate the management and effective transformation of business activity. For example, in the case of ICT, investment in such technologies is not an automatic determinant of efficiency improvements. For improvements to made, ICT goods and services must be used effectively by a firm's value elements, which entail the need to capture indicators of use.

In order to examine labour productivity sources in Eastern European manufacturing enterprises, we used as dependant variables: cost of employees, ICT usage and infrastructure, product innovation, patents, human capital and organization. Firm production function of Cobb-Douglas type takes form:

$$Y_i = A_i K_i^{\alpha} L_i^{\beta} I_i^{\gamma} \quad (1)$$

Where, for any given firm *i*, *Y* is level of turn over; *A* is production efficiency (total factor productivity); *K* is input of physical capital; *L* is input of labour; *I* is input of intermediate production costs. Coefficients α, β and γ represent the elasticities of physical capital, labour and intermediate production costs over the level of firm turnover.

Indeed, in keeping with the usual literature (Bresnahan et al., 2002; Arvanitis, 2005; Timmer et al., 2010), innovative sources of productivity are incorporated into the production efficiency indicator. This element shows the effects of firm innovation that

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are not associated directly with factors of production. Thus, the indicator of efficiency A_i takes the following functional form:

$$A_i=\exp(\delta_0+\delta_1 ICTU_i+\delta_2 ICTI_i+\delta_3 INNOV_i+\delta_4 PATENT_i+\delta_5 EDU_i+\delta_6 ORG_i) \quad (2)$$

After logarithm transformation of equation 1 and incorporating production efficiency indicator model innovative sources of productivity takes form:

$$\ln Y_i-\ln L_i=\beta_0+\beta_1(\ln K_i-\ln L_i)+\beta_2 ICTU_i+\beta_3 ICTI_i+\beta_4 INNOV_i+\beta_5 PATENT_i+\beta_6 EDU_i+\beta_7 ORG_i+\varepsilon_i \quad (3)$$

Where, β_0 (constant) incorporates the logarithmic difference of intermediate costs per worker, β_i for i=1…7, represents the elasticities (coefficients) of the explanatory components of firm productivity and ε_i is estimation error.

Finally, the labour productivity function of manufacturing enterprises from Eastern European countries which would be estimated by ordinary least squares method takes following form:

$$LP_i=\beta_0+\beta_1 LUC_i+\beta_2 ICTU_i+\beta_3 ICTI_i+\beta_4 INNOV_i+\beta_5 PATENT_i+\beta_6 EDU_i+\beta_7 ORG_i+\varepsilon_i \quad (4)$$

Regarding the specific indicators and variables used in the estimation, the following comments need to be made. The dependent variable, firm labour productivity (LP), has been approximated by the logarithm of turnover divided by the number of full-time employees.

Considering the independent variables, the procedure described below has been followed. Firstly, it should be noted that the logarithmic difference between intermediate production costs and full-time employees, which is required for the conversion of the turnover indicator into added value, has been incorporated into the constant of the model to be estimated. Secondly, the effect of physical productive capital on firm productivity has been captured by the logarithmic difference between cost of employees and the number of full-time employees (LUC). Cost of employees is important component of productive physical capital and what is worth mentioning this indicator partially captures investment in human capital. Thirdly, the set of independent variables represents ICT and its complementarities. Regarding ICT, we included two variables ICTU and ICTI. First variable (ICTU) represents ICT usage in the company and is a percentage of firm employees that regularly use personal computers in their jobs. Second variable ICTI is indicator of ICT infrastructure takes two values: 1 when firm has a high-speed Internet connection on its premises and 0 otherwise. With the aim of showing firm's innovatory dynamics we used two dummy variables. Product innovation (INNOV) which takes value 1 when firm has introduced new products or services in the last three years and 0 otherwise. Further, variable PATENT which is 1 when firm has any patents registered abroad or at home and 0 otherwise. Moreover,

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we have one indicator of human capital, variable EDU which is a percentage of firm full-time employees (including production and non-production workers) with a university degree. Lastly, variable ORG is indicator of quality of management. To compose this indicator we fallowed procedure used in Bloom et al. (2012). Management practices were grouped into four areas: operations, monitoring, targets and incentives. The operations question focused on how the establishment handled a process problem, such as machinery breakdown. The monitoring questions covered collection, monitoring, revision and use of production performance indicators. The targets question focused on the time-scale of production targets and the incentives questions covered promotion criteria, practices for addressing poor employee performance and rewarding production target achievement. As the scaling varied across management practices, the scores were converted to z-scores by normalizing each practice (i.e. each question) to mean zero and standard deviation one. To avoid putting the most emphasis on the monitoring aspect of management practices (which had the most underlying questions), an unweighted average was first calculated across z-scores for a particular area of the four management practices. Further, an unweighted average was then taken across the scores for the four practices and then it was normalized. This means that the average management practices across all firms in all countries in the sample are equal to zero, and the actual management practices of the firm deviate from zero either to the left ('bad' practices) or to the right ('good' practices).

3.1.1. Results OLS estimation

The results obtained by estimation of ordinary least squares for the productivity of manufacturing establishments in Eastern European countries are presented in Table 3. We estimated the model for all countries and with sample division for every country: Bulgaria, Poland, Romania, Serbia and Ukraine. All estimated models are significant (p-value= 0.000) and level of adjustment (adjusted R^2) varies from 43% to 69%.
Regarding the coefficients of the determinants of the labour productivity variable representing physical capital (LUC) ($p<0.001$) is significant and as expected have positive sign. For whole sample (EE) ICT infrastructure ($\beta=0.497$, $p<0.001$), patents ($\beta=0.149$, $p<0.1$) and quality of management ($\beta=0.181$, $p<0.001$) are considered to be important determinants of productivity. In sample of Bulgarian firms two variables are significant: ICTI ($\beta=0.778$, $p<0.1$) and ORG ($\beta=0.215$, $p<0.05$). Furthermore, in Poland and Serbia only one variable appeared to be relevant: education ($\beta=0.017$, $p<0.05$) and ICT infrastructure ($\beta=0.604$, $p<0.05$), respectively. In Romania two indicators of firm innovation: INNOV ($\beta=0.537$, $p<0.01$) and PATENT ($\beta=0.446$, $p<0.05$), and EDU ($\beta=0.011$, $p<0.1$) are significant positively affecting productivity. Lastly, in manufacturing firms from Ukraine existence of patents ($\beta=0.245$, $p<0.1$) and indicator of good organization practices ($\beta=0.189$, $p<0.05$) are relevant factors for labour productivity. Estimated models show that different variables influence productivity depending of the country. However, the results are disappointing, regarding that only

few of six considered explanatory variables of ICT and it complementarities turned out to be significant. Besides we have tried to include in the model relations of complementarity (co-innovation), by including of interactions of ICT, education, innovation, organization, but they were not relevant for the firm productivity.

Table 3: Influence of ICT and complementarities on labour productivity: Cross-country comparison

	EE	Bulgaria	Poland	Romania	Serbia	Ukraine
(Intercept)	**1.054*** **	**0.951** **	0.190	0.806	**0.678** **	**1.535*** **
LUC	**0.909*** **	**1.019*** **	**1.477*** **	**0.834*** **	**0.996*** **	**0.740*** **
ICTU	0.002	0.007	0.000	0.003	0.003	−0.002
ICTI	**0.487*** **	**0.758** *	-	0.384	**0.604** **	0.229
INNOV	0.138	−0.134	0.045	**0.537*** **	0.077	0.175
PATENT	0.149*	0.308	0.047	**0.446** **	−0.074	**0.245** *
EDU	0.002	−0.001	**0.017** **	**0.011** *	0.007	0.000
ORG	**0.181*** **	**0.215** **	0.117	0.130	0.127	**0.189*** **
R^2	0.527	0.531	0.735	0.505	0.475	0.461
Adj. R^2	0.520	0.493	0.688	0.459	0.439	0.425
Num. obs.	444	95	41	84	110	114

***p<0.01, **p<0.05, *p<0.1

Note: In Poland variable ICTI is not relevant, because all firms in the sample have Internet connection.

Source: Own elaboration. Orbis database and MOI survey.

3.2. SEM estimation

Presence of relations of complementarity (co-innovation) was not found using ordinary least squares analysis. As so, we introduced the casual effects of interaction between factors of productivity into analysis. We aim to use structural equation modelling with observed variables and measurement errors to identify indirect effect of ICT and its complementarities.

Structural equation modelling is a very general and powerful multivariate analysis technique that includes specialized versions of a number of other analysis methods as special cases. The model is a set of linear equations, which can combine various kinds of models such as: regression models, systems of simultaneous equations, factor analysis and path analysis. This model enables to estimate the factors explaining differences in productivity between firms, besides to infer relations between independent variables. Implication of this methodology to explain productivity sources in manufacturing enterprises from Eastern European countries let to establish better explanatory model because of usage of multi-equation system. Furthermore, this method enables to introduce specific measurement errors to each of the variables.

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That improves parameters specification, in meaning of being unbiased and consistent and having lower variance.

As in the previous part we have used data from MOI survey. 444 complete cases from Eastern European countries include: 95 from Bulgaria, 41 from Poland, 84 from Romania, 110 from Serbia and 114 firms from Ukraine. Variables are approximated as in OLS estimation. In the model eleven hypotheses are tested, which are identified in international literature. The direct explanatory factors of labour productivity of Eastern European manufacturing enterprises are: cost of employees, ICT infrastructure, ICT usage, organization and patenting. The firm productivity is higher, when the costs of employees are higher (H_1). H_1 is related to a firm's capacity to increase turnover per worker through economies of learning, scale, reach and scope. Further, we have two hypotheses related to ICT. The productivity is higher when more workers regularly use computers in the jobs (H_2) and when company has high-speed Internet connection (H_3). Moreover, better organization (quality of management) (H_4) in the company can be explanation of higher productivity. Lastly regarding direct influence on labour productivity we stated H_5 that presence of patents positively affects productivity. Afterwards, we have established six hypotheses related to indirect factors of productivity and their interrelationships. H_6 and H_7 postulate that in firms with innovative practices (new product or service introduction, or obtaining a patent), ICT use needs increase. Next examined hypothesis is: that higher level of human capital the greater presence of use of technology during their tasks (H_8). Last hypothesis (H_9) related to ICT usage, is casual relationship, the better ICT infrastructure the higher ICT usage in the company. Furthermore, we examine relationship of education and patents with H_{10}: higher level of human capital in the company boosts innovation activities. Lastly, H_{11} is that better organization and management in the company improves ICT infrastructure development.

Formally and simplifying the formulation considered earlier, the SEM model represented by the following system of equations (equation (5)) with observed variables and measurement errors is to be estimated.

$$\begin{pmatrix} LP \\ ICTU \\ PATENT \\ ICTI \end{pmatrix} = \begin{pmatrix} \beta_{10} \\ \beta_{20} \\ \beta_{30} \\ \beta_{40} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14} & \beta_{15} & 0 & 0 \\ 0 & 0 & \beta_{23} & 0 & \beta_{25} & \beta_{26} & \beta_{27} \\ 0 & 0 & 0 & 0 & 0 & 0 & \beta_{37} \\ 0 & 0 & 0 & \beta_{44} & 0 & 0 & 0 \end{pmatrix} * \begin{pmatrix} LUC \\ ICTU \\ ICTI \\ ORG \\ PATENT \\ INNOV \\ EDU \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \end{pmatrix} \quad (5)$$

Model shows direct and indirect factors that explain labour productivity in manufacturing enterprises firm Eastern European. First equation is related to the direct explanatory factors of labour productivity (LP) and includes hypotheses 1-5. Second equation is related to the indirect explanatory factors of the ICT usage of employees and includes hypotheses 6-9. Third equation is related to the indirect explanatory factor

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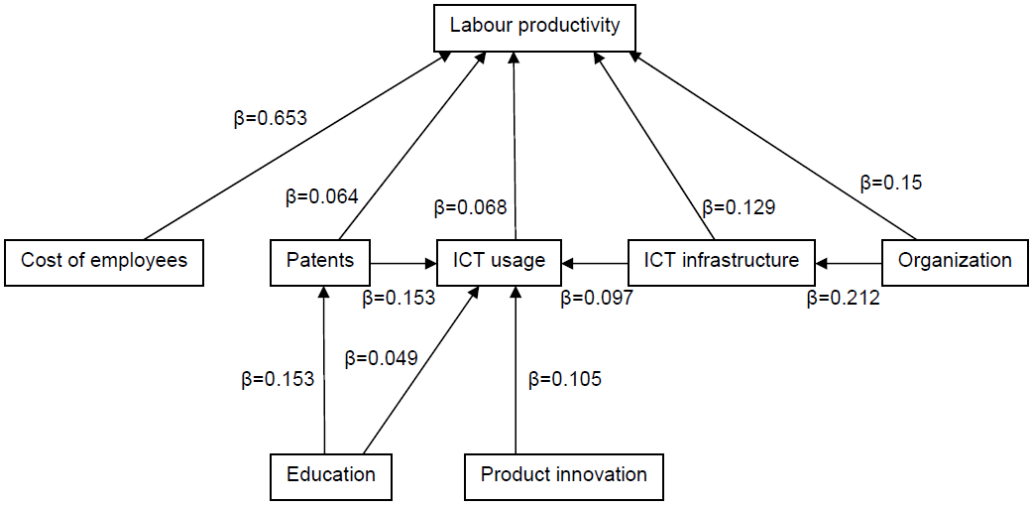
of the innovation indicator PATENT and includes hypothesis 10. Finally, fourth equation is related to the indirect explanatory factor of ICT infrastructure and includes hypothesis 11.

3.2.1. Results SEM estimation

Results of structural equation model estimation for manufacturing enterprises from Eastern Europe are presented in Figure 1 and Table 4. Figure 1 is a path diagram with hypotheses and standard coefficients estimated. Table 4 shows SEM results and goodness of fit statistics.

Figure 1: SEM model results



Source: Own elaboration. Orbis database and MOI survey.

Firstly, it should be noted that, proposed in the literature fit indices (Hu and Bentler, 1999; Hooper et al., 2008; Kline, 2011) suggest that the model is valid and represents the data fairly (CFI=0.973, NFI=0.952, IFI=0.974, TLI=0.937, SRMR=0.041). In addition, the value of CMIN/DF=2.162, below 3, and the value of RMSEA=0.051, below 0.06 proof adequate fit of the developed model. Secondly, the SEM model estimation shows that variables which were insignificant in OLS, become significant with more complex model which includes interrelationships between variables. As well model shows that variables which represented innovation and human capital have indirect effect on labour productivity by ICT usage. Furthermore, ICT infrastructure has both direct and indirect by ICT usage. Moreover, quality of management has as well both effects and the indirect effect is by ICT infrastructure.

In addition, it is confirmed that all coefficients obtained are significant and the direction of relations are as expected. The SEM model estimation shows that variables

which were insignificant in OLS, become significant with more complex model which includes interrelationships between variables. In the third place, it should be noted that the main direct determinant of labour productivity in Eastern European manufacturing enterprises is cost of full-time employees (Hypothesis 1: β=0.653, p=0.000). It is followed by quality of management (H_4: β=0.15, p=0.000), ICT infrastructure (H_3: β=0.068, p=0.000), ICT usage (H_2: β=0.068, p=0.047) and presence of patents (H_5: β=0.064, p=0.058).

Furthermore, set of indirect determinants of productivity is confirmed. Firstly, variables which represented innovation: INNOV (H_6: β=0.105, p=0.011) and PATENT (H_7: β=0.153, p=0.000), human capital (H_8: β=0.049, p=0.000) and ICT infrastructure (H_9: β=0.097, p=0.02) by relation with ICT usage. Another indirect impact on productivity is established by the human capital on the presence of patents (H_{10}: β=0.153, p=0.001). Moreover, variable ORG has indirect effect by affecting ICT infrastructure (H_{11}: β=0.212, p=0.000).

Table 4: Results of structural equations model (n=444)

Explained variable	Explanatory variable	*H*	Coefficients	Std. Coefficients	Std. Error	Critical Ratio	P-value
LP	LUC	H_1	0.904	0.653	0.046	19.651	0.000
LP	ICTU	H_2	0.003	0.068	0.002	1.983	0.047
LP	ICTI	H_3	0.517	0.129	0.137	3.769	0.000
LP	ORG	H_4	0.180	0.150	0.041	4.424	0.000
LP	PATENT	H_5	0.168	0.064	0.088	1.898	0.058
ICTU	INNOV	H_6	5.086	0.105	2.001	2.541	0.011
ICTU	PATENT	H_7	7.743	0.153	2.127	3.641	0.000
ICTU	EDU	H_8	0.498	0.426	0.049	10.219	0.000
ICTU	ICTI	H_9	7.625	0.097	3.264	2.336	0.020
PATENT	EDU	H_{10}	0.004	0.153	0.001	3.248	0.001
ICTI	ORG	H_{11}	0.064	0.212	0.014	4.612	0.000

Model fit statistics: CMIN= 25.94; DF=12; CMIN/DF=2.126; P-value=0.011; CFI=0.973; NFI=0.952; IFI= 0.974; TLI=0.937; RMSEA=0.051; SRMR=0.041

Source: Own elaboration. Orbis database and MOI survey.

4. Conclusion

In the last years variety of international research has demonstrated the existence of co-innovative sources of firm productivity. Precisely, complementarity between ICT usage and investment, innovation, human capital and work organization. Using Management, Organization and Innovation (MOI) Survey 2009 data for representative sample of manufacturing enterprises from Eastern European countries: Bulgaria, Poland, Romania, Serbia and Ukraine, we analysed the determinants of firm labour

productivity. We aim to extend existing literature by new empirical evidence for manufacturing enterprises from Eastern European countries. Ordinary least squares was used to identify factors explaining levels of labour productivity and enable cross-country comparison. Moreover, developed and tested structural equation model add evidence to direct and indirect determinants of labour productivity.

In OLS is our estimation of extended growth model by ICT and its complementarities. In the line with Solow grow model, labour productivity is explained by physical capital which is represented by cost of full-time employee by worker. Models for country sub-samples show that depending on the country different factors appear to be significant, mainly ICT infrastructure and management quality.

However, the results of OLS estimation have not allowed any casual relationships to be established for the explanation of labour productivity in Eastern European manufacturing firms. With the aim of adding the evidence on the direct and indirect determinants of productivity we developed and tested structural equation model with observed variables and measurement errors. The results of SEM estimation show that the casual relationship between ICT and its complementarities and productivity, has been established both directly and indirectly. As was in the case of OLS model the main determinant of firm productivity is cost of full-time employee by worker. In this respect, it was found that productivity is basically associated with labour quality. Lower direct effects have indicators of ICT usage and infrastructure, management quality and patents. Furthermore, we identified set of indirect effects. Firstly, variable ICT usage of workers in the enterprise is affected by patents, education, presence of innovation, quality of management and ICT infrastructure. Second indirect effect on labour productivity is established from education to obtained patents. Lastly, quality of management is significant for ICT infrastructure in the enterprise.

The obtained results have some policy implications. First, it is important to emphasize the need to coordinate efforts in the joint promotion of ICT use, with innovation activities, organizational changes and human capital improvement. For example, partial public policies to promote ICT use or ICT investment, without considering the other ICT complementarities which affect labour productivity, may not produce the desired effects. Moreover, due to indirect effects on labour productivity, companies which invest in human capital for example by internal training, increase ICT usage and then productivity. In addition, promotion of innovation activities not only has direct effect, but also can raise ICT usage. All in all, enterprises in which ICT investment go by hand with other determinants of productivity will be better off than those which just invest in one of the factors.

The main limitation of this research is relatively small sample of enterprises included in the MOI survey database and high number of missing financial data. We have in mind existing disparities in labour productivity caused by firm heterogeneity across countries and across industries. It implies that more factors influence labour productivity which we could not have taken into consideration. However, such a discussion is out of scope of current research. Regarding importance of this topic

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especially for transition economies there is a need for more data including: more countries, improving indicators, collecting data from service enterprises and small and medium enterprises. This study has a preliminary character and suggests further research lines for transition economies.

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Bibliographic references

Arvanitis, S. (2005). Computerization, workplace organization, skilled labour and firm productivity: Evidence for the Swiss business sector. *Economics of Innovation and New Technology*, 14(4):225–249.

Arvanitis, S. and Loukis, E. N. (2009). Information and communication technologies, human capital, workplace organization and labour productivity: A comparative study based on firm-level data for Greece and Switzerland. *Information Economics and Policy*, 21(1):43–61.

Black, S. E. and Lynch, L. M. (2001). How to Compete: The Impact of Workplace Practices and Information Technology on Productivity. *The Review of Economics and Statistics*, 83(3):434–445.

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

Bloom, N., Schweiger, H., and Van Reenen, J. (2012). The land that lean manufacturing forgot? Management practices in transition countries. *Economics of Transition*, 20(4):593–635.

Bresnahan, T. F., Brynjolfsson, E., and Hitt, L. M. (2002). Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm- Level Evidence. *The Quarterly Journal of Economics*, 117(1):339–376.

Brynjolfsson, E. and Hitt, L. M. (2003). Computing Productivity: Firm-Level Evidence. *The Review of Economics and Statistics*, 85(4):793–808.

Burns, T. and Stalker, G. (1994). The Management of Innovation. Oxford University Press, Oxford, 3 edition.

Caroli, E. and Van Reenen, J. (2001). Skill-Biased Organizational Change? Evidence from a Panel of British and French Establishments. *The Quarterly Journal of Economics*, 116(4):1449–1492.

Ceccobelli, M., Gitto, S., and Mancuso, P. (2012). ICT capital and labour productivity growth: A non-parametric analysis of 14 OECD countries. *Telecommunications Policy*, 36(4):282–292.

Díaz-Chao, A., Ficapal-Cusí, P. And Torrent-Sellens, J. (2013). ICT, innovation, wages and labour productivity. New evidence from small local firms. *Revista de Estudios Empresariales*, 2(segunda época):20-45.

EBRD and World Bank (2008). Management, Organisation and Innovation (MOI) survey: Sampling Methodology.

EBRD and World Bank (2010). Management, Organisation and Innovation (MOI) survey.

Gretton, P., Gali, J., and Parham, D. (2004). The effects of ICTs and complementary innovations on Australian productivity growth. In *The Economic Impact of ICT: Measurment, Evidence and Implications*, pages 105–130., Paris. OECD.

Grimes, A., Ren, C., and Stevens, P. (2012). The need for speed: impacts of internet connectivity on firm productivity. *Journal of Productivity Analysis*, 37(2):187–201.

Hall, B. H., Lotti, F., and Mairesse, J. (2012). Evidence on the Impact of R&D and ICT Investment on Innovation and Productivity in Italian Firms. *Economics of Innovation and New Technology*, (0):1–29.

Hempell, T. (2005). Does experience matter? Innovations and the productivity of information and communication technologies in German services. *Economics of Innovation and New Technology*, 14(4):277–303.

Hempell, T. and Zwick, T. (2008). New Technology, Work Organisation, and Innovation. *Economics of Innovation and New Technology*, 17(4):331–354.

Hooper, D., Coughlan, J., and Mullen, M. (2008). Structural Equation Modelling : Guidelines for Determining Model Fit. *Journal of Business Research Methods*, 6(1):53–60.

Hu, L.-t. and Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, 6(1):1–55.

Jorgenson, D. W. and Griliches, Z. (1967). The Explanation of Change Productivity. *The Review of Economics and Studies*, 34(3):249–283.

Jorgenson, D. W., Ho, M. S., and Samuels, J. D. (2011). Information technology and US productivity growth: evidence from a prototype industry production account. *Journal of Productivity Analysis*, 36(2):159–175.

Jorgenson, D. W. and Stiroh, K. J. (1999). Information Technology and Growth. *American Economic Review*, 89(2):109–115.

Jorgenson, D. W. and Vu, K. (2007). Information Technology and the World Growth Resurgence. *German Economic Review*, 8(2):125–145.

Jovanovic, B. and Rousseau, P. L. (2005). General purpose technologies. In Aghion, P. and Durlauf, S. N., editors, *Handbook of economic growth*, volume 1, pages 1181–1224. Elsevier, Amsterdam.

Kline, R. B. (2011). *Principles and practice of structural equation modeling*. Guilford Press, New York, third edition.

Lindbeck, A. and Snower, D. J. (2000). Multitask Learning and the Reorganization of Work: From Tayloristic to Holistic Organization. *Journal of Labor Economics*, 18(3):353–376.

Milgrom, P. and Roberts, J. (1990). The Economics of Modern Manufacturing: Technology, Strategy and Organization. *The American Economic Review*, 80(3):511–528.

Miyazaki, S., Idota, H., and Miyoshi, H. (2012). Corporate productivity and the stages of ICT development. Information *Technology and Management*, 13(1):17–26.

Orbis database (2012). Bureau van Dijk. [Online]. Available at: https://orbis.bvdep.com (Accessed: August 2008).

Pilat, D. (2006). The impacts of ICT on productivity growth: Perspectives from the aggregate, industry and firm level. In Mas, M. and Schreyer, P., editors, *Growth, capital and new technologies*, pages 113–147. Fundación BBVA, Bilbao.

Roztocki, N. and Weistroffer, H. R. (2008). Information Technology in Transition Economies. *Journal of Global Information Technology Management*, 11(4):2–9.

Roztocki, N. and Weistroffer, H. R. (2011). From the Special Issue Editors: Information Technology in Transition Economies. *Information Systems Management*, 28(3):188–191.

Schweiger, H. and Friebel, G. (2013). Management Quality, Ownership, Firm Performance and Market Pressure in Russia. *Open Economies Review*, 24(4):763–788.

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

Stare, M., Jaklič, A., and Kotnik, P. (2006). Exploiting ICT Potential in Service Firms in Transition Economies. *The Service Industries Journal*, 26(3):287–302.

Timmer, M. P., Inklaar, R., and O'Mahony, M. (2010). *Economic growth in Europe: A comparative industry perspective*. Cambridge University Press.

Torrent-Sellens, J. and Ficapal-Cusí, P. (2010). TIC, co-innovación y productividad empresarial: evidencia empírica para Cataluña y comparación internacional de resultados. *Revista de Economía Mundial*, 26:203–233.

Torrent-Sellens, J. and Ficapal-Cusí, P. (2010). ¿Nuevas fuentes co-innovadoras de la productividad empresarial? *Innovar*, 20(38):111-124.

Van Ark, B. and Piatkowski, M. (2004). Productivity, innovation and ICT in Old and New Europe. *International Economics and Economic Policy*, 1(2-3):215–246.

World Bank (2013). World Development Indicators (2009). Washington, DC: World Bank.

Resumen

La motivación principal de la investigación es evaluar las relaciones entre las TIC, las prácticas de gestión empresarial, la innovación, el capital humano y los cambios organizativos en las empresas manufactureras de los países de Europa del Este. Utilizando la base de datos Management, Organization and Innovation (MOI) Survey 2009 para una muestra de 444 empresas de Bulgaria, Polonia, Rumania, Serbia y Ucrania y dos técnicas econométricas: mínimos cuadrados ordinarios y modelos de ecuaciones estructurales hemos examinado los determinantes, directos e indirectos, de la productividad empresarial del trabajo.

La primera conclusión de la investigación es que el coste laboral de los trabajadores es el principal determinante de la productividad del trabajo. En segundo lugar, la investigación también pone de relieve que relación causal entre las TIC, sus complementariedades y la productividad se establece de manera indirecta. Principalmente a través del uso TIC por parte de los trabajadores en la empresa. Estos resultados aportan nueva evidencia para los países de Europa del Este, extienden la investigación sobre los determinantes de la productividad empresarial y permiten comparar tendencias en el contexto internacional.

Palabras clave

Europa del Este, Productividad del trabajo, Tecnologías de la Información y la Comunicación (TIC), Innovación, Industrias manufactureras

Resum

La motivació principal de la investigación es l'anàlisi de les relacions entre les TIC, les pràctiques de gestió empresarial, la innovació, el capital humà i els canvis organitzatius de les empreses manufactureres dels països de l'Europa de l'Est. Utilitzant la base de dades Management, Organization and Innovation (MOI) Survey 2009 per a una mostra de 444 empreses de Bulgària, Polònia, Romania, Sèrbia i Ucraïna i dues tècniques economètriques: mínims quadrats ordinaris i sistemes d'equacions estructurals, hem examinat els determinants, directes i indirectes, de la productivitat empresarial del treball.

La primera conclusió de la investigació és que el cost laboral dels treballadors és el principal determinant de la productivitat del treball. En segon lloc, la investigació també posa de manifest que la relació causal entre les TIC, les seves complementarietats, i la productivitat s'estableix de manera indirecta. Principalment, a través dels usos TIC per part dels treballadors de l'empresa. Aquests resultats aporten nova evidència per als països de l'Europa de l'Est, estenen la investigació sobre els determinants de la productivitat empresarial i permeten comparar tendències en el context internacional.

Paraules clau:

Europa de l'Est, Productivitat del treball, Tecnologies d'Informació i Comunicació (TIC), Innovació, Indústries manufactureres

Aleksandra Skorupinska
askorupinska@uoc.edu
Doctoral program in Knowledge and Information Society
Internet Interdisciplinary Institute (IN3), Open University of Catalonia (Spain)

Aleksandra Skorupinska is a PhD student in Knowledge and Information Society Doctoral program at IN3 and is carrying out her research under the direction of Dr. Joan Torrent-Sellens. She holds Master in Computer Science and Econometric from Faculty of Economic Sciences at University of Warsaw. She is a member of the interdisciplinary research group on ICTs (i2TIC) at IN3 (UOC). Her research interests include productivity, ICT and innovation in Eastern European countries and econometric modelling.

Joan Torrent-Sellens
jtorrent@uoc.edu

Economics and Business Studies and Internet Interdisciplinary Institute (IN3)
Open University of Catalonia (Spain)

Dr. Joan Torrent-Sellens (http://i2tic.net/en/people/joan-torrent-sellens/) is BsC in Economics and MsC in Applied Economics by the Universitat Autònoma de Barcelona, and PhD in Information and Knowledge Society by the Universitat Oberta de Catalunya. Actually, he is the director of Open University of Catalonia (UOC) Business School and the director of interdisciplinary research group on ICT, i2TIC (http://i2TIC.net). I2TIC is a research group attached to the Internet Interdisciplinary Institute (http://in3.uoc.edu). Dr. Torrent-Sellens specializes in the analysis of ICT, productivity and growth; the knowledge economy, the knowledge work and the network firm, subject on which he has published 10 books and 20 articles in indexed journals.