Exploring Information and Communications Technology Adoption in Enterprises and its Impact on Innovation Performance of European Countries

*Mirjana PEJIĆ BACH**

Abstract

This article analyses whether there are differences in information and communications technology (ICT) adoption among enterprises in European countries (full EU members, candidate and other countries) according to the ranking of countries at the Innovation Union Scoreboard (IUS) list. According to the results, countries from different innovation level groups differ according to: (1) adoption of the internal processes support within information systems, (2) adoption of e-Commerce and CRM, and (3) adoption of broadband and LAN. Since the Digital Agenda goals are oriented primarily towards closing the digital gap among individuals, the EU should also address active fostering of ICT adoption in enterprises in order to further improve their innovative capacity.

Keywords: *ICT adoption; innovation; digital divide; European Union; Digital Agenda; Innovation Union Scoreboard*

JEL Classification: O31, O32, Q55, N74, O14, L86

1. Introduction

Information and communication technologies (ICT) change educational, working and leisure activities in the modern society, and have a significant impact on how business is done. A widespread adoption of ICT enables innovation and thus fosters growth and productivity (Oliner and Sichel, 2002; Gust and Marquez, 2004; Van Ark and Piatowski, 2004; Peri, 2005). The term *ICT* has been used as a joint term for a variety of technological applications that range from basic technologies such as hardware, software, and telecommunications to more advanced electronic information resources such as the World Wide Web and communication channels such as social networks (Selwyn, 2004; Toivonen

* Mirjana PEJIĆ BACH, Faculty of Economics & Business, University of Zagreb, Department of Informatics, Trg J. F. Kenndyja 6, 10000 Zagreb, Croatia; e-mail: mpejic@efzg.hr

et al., 2009). Although the emergence of first computers was followed by the fear of technology, in the meantime our attitude towards technology has changed completely and we are accepting it widely. Broadband has become widespread and 95% of Europeans had access to a fixed broadband connection in 2011, the mobile Internet has grown to 217 mobile broadband subscriptions, 68% of Europeans in 2011 regularly used Internet, and e-Government has been widely accepted in a number of European countries (EC, 2009a). The adoption of ICT today has the same radical impact as the education had on the economic growth a century ago (Sianesi and Van Reenen, 2003). Still, the digital divide is an important issue that has been explored both on the national and an individual level (Vehovar et al., 2006; Çilan, 2007), but also among enterprises (Forman, 2005; Galliano, Roux and Soulie, 2011), and within the notion of sustainable development (Pejić Bach, 2014).

Research on adoption of ICT in enterprises seeks to explore why enterprises adopt ICT at different pace and what the impact of ICT adoption on the enterprises' performance is (Forman and Goldfarb, 2006; Khuong, 2011). Antonelli (2003) and James (2003) explore how developing countries can use ICT to catch up with developed countries. A number of studies focus on the influence of ICT adoption on the increase in productivity. Van Ark and Piatkowski (2004) found out that ICT has three effects on the productivity: the effect of rapid technological progress in the ICT-producing industry on the total factor productivity growth, the effect of ICT investment on labour productivity, and the effect of economy-wide use of ICT on the total productivity growth through creating knowledge spillovers. This result leads us to the implicit conclusion that an ICT adoption fosters innovations in the three different fields: (1) ICT products and services itself, (2) ICT adoption in organizations, and (3) ICT adoption in formal and informal education. However, Jorgenson, Ho and Stiroh (2008) traced the evolution of the influence of ICT adoption on the productivity increase to the mid 1990s and found out that the ICT started influencing productivity noticeably only after the massive ICT investment boom of the late 1990s. Therefore, the research indicates that ICT adoption influences productivity but through diverse channels and not with the same intensity during the adoption phases.

Innovation has also been recognized as an important source of growth in the enterprises, and the direct impact of ICT on innovation has also been explored by a number of researchers. Milan and Zelli (2002) analysed the impact of ICT on the generation, diffusion and the use on new knowledge and found out a positive impact. Pilat (2004) emphasizes that a greater use of ICT contributes to a more rapid innovation pace. Koellinger (2008) analysed the impact of the adoption of Internet-based technologies, and found out that firms that rely on

Internet-enabled innovations are likely to experience at least the same level of growth as firms that rely on non-Internet-enabled innovations. The impact of ICT adoption on innovation has been examined by Ollo-López and Aramendía--Muneta (2012). Using data on the sample of glass, ceramic and cements/ concrete industry, they determined which ICT seems to favour innovation and competitiveness. However, the same authors find out that a higher level of innovations does not automatically lead to a higher level of profitability, which is not totally surprising taking into account the product life cycle theory (Rink and Swan, 1979). Exploring a selection of enterprises in OECD countries, Spiezia (2011) found contradictory results indicating that ICT acts as an enabler of innovation but not that ICT adoption increases the ability to innovate. Research on the influence of ICT adoption on the innovation is growing, examining in what way ICT enables innovations and whether it and how increases the enterprises' capacity to innovate products, processes, organization and marketing. However, not all instances of the research point to the same direction, and partial studies rely only on the narrow definitions of ICT adoption. There is an obvious lack of studies that would provide the big picture on the impact of ICT adoption on the innovation activities. More comprehensive research should be conducted in this area exploring both data on the national and the enterprises' level in order to assess whether and how the level of ICT adoption influences innovation.

This paper employs the exploring approach focusing on the level of ICT adoption in the EU member and candidate countries. Using the Innovation Union Scoreboard (IUS) country ranking list (EC, 2012), we explore the differences among different groups of countries (innovation leaders and followers, moderate and modest innovators) according to the level of ICT adoption. We define ICT adoption measures within the benchmarking framework for developments in the information society that consists of four groups of indicators (EC, 2009a): (1) internal processes IT support; (2) integration with customers/suppliers and supply chain management (SCM); (3) Internet of things; (4) e-Commerce and customers relations management (CRM), and (5) infrastructure provided by availability of fixed broadband access and LAN/Intranet/extranet. Differences among groups of countries according to their level of ICT adoption and their innovation performance were investigated. We have found out that countries whose enterprises more often support the internal process with ICT, also adopt e-Commerce and CRM more often, adopt broadband and LAN more often and also have better innovation performance. Also, it has been investigated which areas of ICT adoption are the most important contributors to the innovation performance of countries. The results of our analysis indicate that the Digital Agenda goals (EC, 2010a) should be enhanced by fostering ICT adoption in enterprises in order to improve the innovativeness of the countries to the greater extent.

This paper is organized as follows: Section 2 opens up the issue of differences in innovation performance among European countries. Section 3 explores developments in the information society within European countries. Section 4 investigates previous research on the linkage between adoption of ICT and innovativeness in enterprises. Methodology and data are presented in Section 5; results are described in Section 6; and last Section concludes.

2. Innovation across European Countries

Innovation can be defined as a complex phenomenon that comprises both technical and non-technical changes and product and process innovations (Anderson and King, 1993; Totterdell et al., 2002; Škrinjar et al., 2010). Technical changes refer to, for instance new products and new production methods, and non-technical changes refer to, for instance new markets, new approaches to target customers, new segmentations. Product and process changes could not be firmly divided and often occur together.

Innovation has been pointed out by Porter (1990) as one of the three pillars of global competitiveness, together with continuous improvement and change, and has been used as one of the main predictors of long-term survival of organizations (Ancona and Caldwell, 1987). Innovation, as well as ICT adoption, has been one of the goals for Europe 2020 (EC, 2010c).

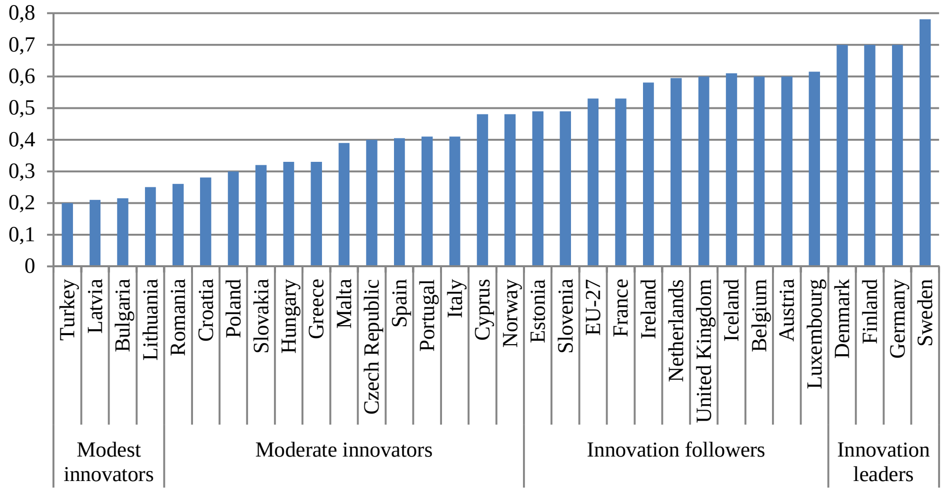
Europe 2020 Innovation Union presents a comparative evaluation of the innovation performance of the EU-27 member countries as well of candidate countries and other European countries (EC, 2012). The Innovation Union Scoreboard contains innovation indicators for the EU-27 member states and Croatia, Iceland, the Former Yugoslav Republic of Macedonia, Norway, Serbia, Switzerland and Turkey.

Several groups of indicators have been measured in order to assess innovation performance of the countries examined: (1) Enablers: Human resources, Research systems and Finance and support; (2) Activities: Investments, linkages & entrepreneurship and Intellectual assets, and (3) Outputs: Innovators and Economic effects. In total, there are 24 indicators that measure the effectiveness of national research innovation systems (EC, 2012), and the data has been sourced mainly from Eurostat and in other cases from other relevant data sources (e.g. Thompson Scientific). Based on those indicators the average performance is measured using the composite statistic Summary Innovation Index, which has been calculated for the period from 2003 onwards.

The Summary Innovation Index has been calculated as a composite indicator based on data for 24 indicators. Its maximum value is 1 and minimum value is 0. The average performance in a particular year reflects the performance for the change in the previous year compared to the year before. Therefore, the Summary Innovation Index for 2011 reflects performance in 2009/2010 (Figure 1).

F i g u r e 1

Summary Innovation Index for 2011 Calculated for EU Member States, other European Countries and Candidate Countries



Source: Author, based on EC (2012).

Figure 2 contains historical representation of the countries according to their ranking based on the Innovation Scoreboard methodology. The first group of countries includes innovation leaders, and this group of countries has decreased in number losing the United Kingdom in 2010. The second group of countries includes innovation followers, and in this group of countries, there have been numerous changes, especially after 2009 when a number of countries joined this group (e.g. Slovenia, Estonia, Cyprus) as a result of the increase in innovation performance. The third group of countries includes moderate innovators and it also increased after 2008 when e.g. Hungary, Poland and Lithuania joined the group. The fourth group of countries includes modest innovators, and it decreased in size after 2009, and its members in all of the examined years were Romania, Lithuania, Bulgaria, Latvia and Turkey. However, when examining how countries changed their innovation performance groups, one should take into account that the methodology has been changed since 2010.

F i g u r e 2

Historical Representation of Countries According to their Ranking Based on the Innovation Scoreboard Methodology

2007	2008	2009	2010	2011
Switzerland Sweden Denmark Germany Finland United Kingdom	Switzerland Sweden Denmark Germany Finland United Kingdom	Switzerland Sweden Germany Denmark Finland United Kingdom	Switzerland Sweden Germany Finland Denmark	Switzerland Sweden Denmark Germany Finland
Luxembourg Belgium Austria Ireland Netherlands Iceland France	Luxembourg Belgium Ireland Austria Netherlands France	Luxembourg Austria Belgium Netherlands Iceland Ireland France Slovenia Estonia Cyprus	Luxembourg Austria Belgium Iceland United Kingdom Netherlands Ireland France Slovenia Estonia Cyprus	Belgium United Kingdom Iceland Netherlands Luxembourg Austria Ireland France Slovenia Cyprus Estonia
Norway Slovenia Cyprus Italy Czech Republic Spain Estonia	Iceland Cyprus Norway Slovenia Italy Estonia Czech Republic Spain Portugal Greece	Norway Italy Portugal Spain Czech Republic Malta Greece Hungary Slovakia Poland Lithuania	Norway Italy Portugal Spain Czech Republic Malta Greece Hungary Slovakia Poland Croatia	Norway Italy Portugal Czech Republic Spain Hungary Greece Croatia Slovakia Poland
Portugal Greece Hungary Slovakia Malta Poland Lithuania Croatia Romania Latvia Turkey Bulgaria	Hungary Malta Slovakia Poland Lithuania Croatia Romania Latvia Bulgaria Turkey	Croatia Romania Latvia Bulgaria Turkey	Romania Lithuania Bulgaria Latvia Turkey	Malta Romania Lithuania Bulgaria Latvia Turkey

Note: The order of countries reflects the ranking of countries within particular groups.

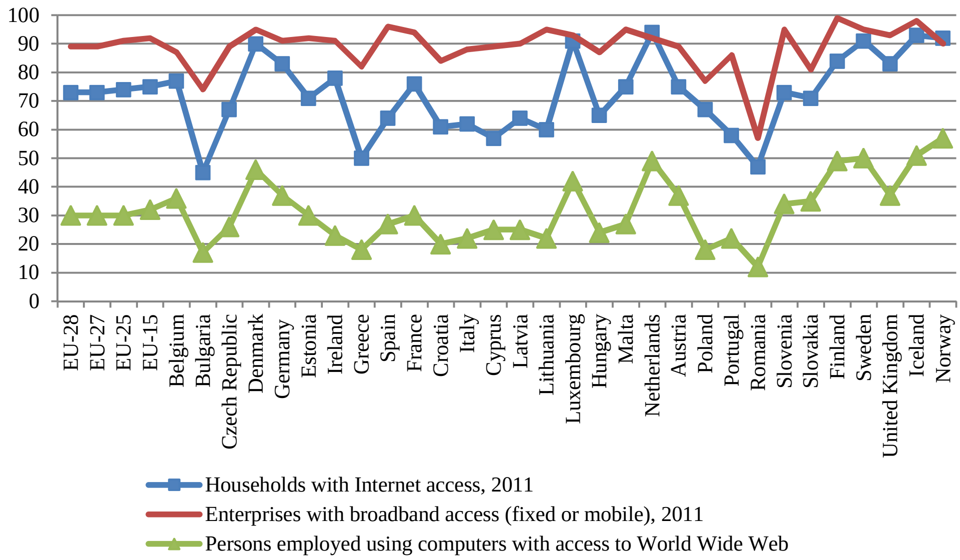
Source: Author, adapted from EC (2008; 2009b; 2010a; 2011; 2012).

3. Development of the Information Society in European Countries

Although adoption of ICT has increased rapidly, there are still great differences among countries and groups of users. Figure 2 represents the percentage of households that had Internet access in 2011, and the percentage of enterprises that had broadband access in 2011. Adoption of ICT has attained the highest level of coverage in enterprises. In the EU-27 countries, 85% of enterprises in 2011 had broadband access (fixed or mobile). However, differences among countries are large, with the Netherlands and Sweden where 91% of enterprises have broadband access on one side, and Bulgaria, Latvia and Romania where 62%, 68% and 52% of the enterprises have broadband access, respectively. The average percentage of households having Internet access in EU-27 countries is 70% with the adoption pattern following almost completely adoption in enterprises, while countries with the highest level of adoption in enterprises are also leaders in adoption in households. However, the ratio of employees that use personal computers with access to the World Wide Web is surprisingly low, comprising only 43% of EU-27 countries on average. Only in the United Kingdom the coverage of both enterprises and employees with Internet access is approximately the same.

Figure 3

Households with Internet Access and Enterprises with Broadband Access (Fixed or Mobile), Persons Employed Using Computers with Access to WWW (percentage, 2011)



Source: Author, based <http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database>.

The information society has been recognized by the European Union as one of the important leverages for attaining the goals of the Europe 2020 Strategy (EC, 2010b). One of the seven flagship initiatives of this strategy is the Digital Agenda that sets out to increase the ICT adoption. The European Union regularly measures a number of indicators important for its development. The 2011 – 2015 Benchmarking Digital Europe Framework sets out which indicators have to be measured regarding the development of information society. Table 1 represents the summary of the Benchmarking Digital Europe indicators (EC, 2009a), which are grouped into five areas: ICT sector, broadband and connectivity, ICT usage by households and individuals, ICT adoption in enterprises, and e-Public services.

T a b l e 1

Summary of the Benchmarking Digital Europe Indicators (EC, 2009a)

ICT Adoption area	**Indicators**
ICT sector	Share, growth, productivity level and productivity growth in the ICT sector Size and nominal growth of ICT markets R&D expenditures by the ICT sector as % of GDP, BERD, value added Imports and exports of ICT goods and services
Broadband and connectivity	Broadband coverage: % of population reached Broadband prices and number of subscriptions per 100 inhabitants % of households and enterprises with Internet access (fixed and mobile) % of persons employed with Internet access provided at work (fixed and mobile)
ICT usage by households and individuals	% of individuals using Internet Various activities via Internet (personal communication, use of entertain-ment, access to information, civic and political participation, creativity, learning, e-health, e-banking, e-Commerce, professional life, e-skills and e-inclusion)
ICT adoption in enterprises	Internal processes ICT support Integration with customers/suppliers and SCM Key technologies for the Internet of things e-Commerce, CRM
e-Public services	Online availability of basic e-Public services % of individuals using e-Public services % of enterprises using e-Public services

Source: Author, adapted from EC (2009a).

The 2011 – 2015 Benchmarking Digital Europe indicators presented in Table 1 aim at measuring the digital divide both between and within countries of the European Union. Data is broken down for enterprises based on their size and NACE Rev. 1 and Rev. 2 industry levels and for individuals based on age, gender, education and employment. In addition, for some indicators data have been collected at the NUTS 2 regional level.

Presumptions of the Digital Agenda are that: efficiency gains in the production of ICTs will influence the economic growth and the falling of prices of ICT goods and services, while decreasing prices will stimulate investment in ICTs by individuals, business and the public sector, which will increase adoption of ICT that contributes to the sustainable growth of the economy, the public sector efficiency and the quality of life. The Digital Agenda goals focus mainly on individuals, public services and infrastructure. ICT adoption in enterprises has been present to a lower extent, and with its goals targeting online buying and selling. However, the impact of ICT adoption in enterprises is also important for innovation, being one of the drivers for the economic growth and development (Porter, 1990), although the big differences exist between particular ICT solutions regarding their impact to innovation (Koellinger, 2008; Delina, Tkac and Janke, 2012).

4. ICT Adoption in Enterprises as an Agent for Innovative Activities

The Benchmarking Digital Europe Framework (EC, 2009a) sets out indicators that measure ICT adoption in enterprises clustered in four groups: (1) internal processes support by ICT, (2) integration with customers/suppliers and SCM, (3) key technologies for the Internet of things, and (4) e-Commerce and CRM usage. Research that explores the relation between ICT adoption and innovative activities will be examined from this perspective.

4.1. Internal Processes ICT Support

Internal processes ICT support within the Benchmarking Digital Europe Framework refers to adoption of Enterprise Resource Planning (ERP) software packages to share information between different functional areas that enable sharing information within an enterprise electronically, especially on sales or on purchase (EC, 2009a). Other information systems, such as knowledge systems and decision support systems are also considered.

Most of the research that investigates the relation between internal processes and the innovation level in enterprises focuses on the implementation of the ERP system. Srivardhana and Pawlowski (2007) explored this relationship within the framework of absorptive capacity (Zahra and George, 2002), and their results indicated that ERP systems both enable and constrain the business process innovation. Madapusi and D'Souza (2012) found out that the ERP system implementation influences operational performance aspects in different ways and with different intensity, and found out that innovativeness of enterprises could even be decreased due to the standardized nature of ERP modules. However, Newell et al. (2003) discovered that the combined implementation of ERP and the knowledge system can foster efficiency and innovation within the firm. Chen and Huang (2009) used the regression analysis to investigate the relationship between strategic human resource practices and the knowledge management capacity for innovation performance of enterprises, and found a positive relationship. Cho and Chang (2008) found out that resistance towards the new sales force automation system decreased innovativeness of employees. Therefore, ICT support to internal processes can have both a negative and a positive impact on innovativeness in enterprises.

4.2. Integration with Customers/Suppliers and SCM

Integration with customers/suppliers and SCM within the Benchmarking Digital Europe Framework refers to electronically exchanging business documents with suppliers and customers, electronically exchanging information on SCM and receiving/sending e-invoices.

Evidence on fostering innovation through collaboration with customers and suppliers has been explored by a number of researchers. Nieto and Santamaria (2007) clearly prove that collaboration with suppliers, clients and research organizations positively influences the novelty of product innovation, while the strongest positive impact stems from collaboration with different types of partners within collaborative networks. The same conclusion has been attained by Tarafdar and Gordon (2007). These results prove previous research results that indicated that the collaboration can enhance the synergistic effect of various knowledge and expertise within the collaborative network (Zakaria, Amelinckx and Wilemon, 2004), and ICT adoption seems even to enhance this effect. In addition, collaboration with suppliers seems to increase innovativeness of firms that implement ERP systems (Watanabe and Hobo, 2004), which is in contradiction with the research conducted by Srivardhana and Pawlowski (2007). On the other side, Wu (2012) explores the impact of strategic alliances on innovations and founds out that a positive effect of technological collaboration can be decreased in highly competitive markets.

The SCM impact on innovations is also the subject of several research articles. Kim (2000) focuses on the balance needed in the increase in profitability for both a manufacturer and a supplier in order to foster innovation in the supply chain management system. Ulusoy (2003) explored the supply chain and innovation management on the sample of Turkish manufacturing firms, and established that the product differentiation also advances various areas of the supply chain as well as innovation management. Bello, Lohtia and Sangtani (2004) state that complex institutional arrangements typical for supply chain management systems could also increase reluctance of enterprises to innovate. However, Lin, Wang and Yu (2010) and Mikalef (2014) found out that value co-creation and value constellation in such systems could serve as drivers of innovation.

4.3. Key Technologies for Internet of Things

Key technologies for Internet of things within the Benchmarking Digital Europe Framework refer to usage of Radio Frequency Identification (RFID) technology.

RFID technology has been implemented to a rare extent in enterprises, but the level of adoption should be positively impacted by taking into account strategic value and influence to enterprises' performance including innovation (Tajima, 2007). Roh, Kunnathur and Tarafdar (2009) name innovation as one of the expected RFID benefits that can provide an organization with a competitive advantage. Also, Bunduchi, Weisshaar and Smart (2011) demonstrated that RFID implementation is connected with the increase in innovativeness in enterprises. However, this effect is more evident in more mature phases of implementation, while in early phases costs predominate (capital, development and direct implementation costs). Dominguez-Péry, Ageron and Neubert (2011) propose a framework that could be used for supporting service innovation in an IT-driven case for RFID technology.

4.4. E-Commerce and Customers Relations Management

E-Commerce and Customers Relations Management within the Benchmarking Digital Europe Framework refers to having website with e-Commerce functions, using software applications for managing information about clients, such as CRM, and selling and purchasing by e-Commerce.

Xu, Sharma and Hackney (2005) base their exploration on the Web service innovation on the rationale that the existing enterprise process integration technologies are not able to resolve the problems connected with e-Business practices that increase both in volume and in complexity. Koellinger (2008) also finds that the Internet-based technologies were significant factors that enabled innovation in 2003.

The World Wide Web has itself been the greatest leverage of disruptive innovation (Keller and Hüsig, 2009) with Google and Facebook being the most famous and most influential representatives of this phenomenon. Laffey (2007) also points out that the use of the text advertisement connected with a search topic (paid search) was the key driver to the recent changes at the World Wide Web. The World Wide Web can also help innovators trough the e-Government services that could serve as relevant resources during the service innovation process (Wu et al., 2010).

Wu and Hisa (2004) examined the impact of e-Commerce and m-Commerce innovating applications to stakeholders (Internet service providers, e-Commerce and m-Commerce companies, customers and business partners) and found out that the impact is radical only on e-Commerce and m-Commerce enterprises and Internet service providers. The question that also emerges is how to attract customers to use new, fast-appearing innovations, such as social networks. Hung, Chou and Dong (2011) found out that individuals with a particular search behaviour are more apt to try new innovative services, especially connected with social networks. The World Wide Web also fosters other completely new forms of innovation such as Open Innovation within an Enterprise 2.0 context (Carbone et al., 2012).

CRM fosters innovation because it facilitates receiving important information from customers that are a source of new ideas for products and processes, especially if customers are actively engaged in the process (Ngo and Cass, 2012). At the same time, CRM can be successfully implemented only if the top management supports innovations (Özgener and İraz, 2006). Chen and Tsou (2012) investigated the relationship between ICT adoption, service process innovation and performance gains through customer service, and found out that customer service can be an important intermediary for ICT adoption and service process innovations influencing the enterprises' performance. The same authors found out that ICT adoption supported service process innovation.

The findings of the previous research on ICT adoption as leverage for innovative activities are controversial. Some of the research show that ICT adoption can foster innovation and these findings are especially present in the field of e-Commerce, CRM, RFID and integration with customers/suppliers. On the other hand, ERP and SCM systems could both facilitate and inhibit innovations, especially in the field of business process innovation.

5. Data and Methodology

Our main research question is whether there is a significant difference between particular innovative countries groups according to different aspects of ICT adoption. The second research question is whether information on ICT adoption in enterprises should become one of the milestones of the European Union Digital Agenda, in addition to measures that are oriented mainly toward individuals, households and public institutions.

Since European countries will be compared in terms of ICT adoption, the five group indicators from the Benchmarking Digital Europe Framework enhanced by infrastructure indicators, available in Eurostat, have been employed for investigation. Indicators are presented in Table 2: (1) Internal process ICT support (indicators IP1-IP3); (2) Integration with customers/suppliers & SCM (indicators IC1-IC3); (3) Key technologies for Internet of things (RFID indicator); (4) e-Commerce & CRM (indicators ECOM1-ECOM5), and (5) Infrastructure (indicators INFR1-INFR2). Since presented indicators have been measured only since 2010 in most of the cases, the year 2010 has been used as the year for examining relationships in question. The only exception is RFID adoption and adoption of websites that provide online ordering or reservation. Both indicators have lots of missing data for 2010, and therefore data for 2011 have been used for the analysis, since there is little difference between those two years due to the slow pace of RFID adoption (Spekman and Sweeney II., 2006; Pedroso, Zwicker and de Souza, 2009).

Table 2

Selected Indicators from the Benchmarking Digital Europe Framework

Adoption dimensions	**ICT adoption indicators**	**Variable explanations**
Internal process ICT support (2010)	IP1	Enterprises which have ERP software package to share information between different functional areas
	IP2	Enterprises which electronically share information on sales or on purchases with the software used for any internal function
	IP3	Enterprises which electronically share information within the enterprise
Integration with customers/ suppliers & SCM (2010)	ICS1	Enterprises using automated data exchange with other ICT systems outside the own enterprise
	ICS2	Enterprises which electronically share information suitable for automatic processing with external business partners or on the SCM with suppliers or customers
	ICS3	Enterprises sending and/or receiving e-invoices
Key technologies for Internet of things (2011)	RFID	Enterprises using Radio Frequency Identification (RFID) technologies
e-Commerce & CRM (ECOM1-2011; ECOM2-ECOM5-2010)	ECOM1	Enterprises with the website providing online ordering or reservation or booking, e.g. shopping cart
	ECOM2	Enterprises using software solutions such as Customer Relationship Management (CRM)
	ECOM3	Enterprises' turnover from e-Commerce as % of total turnover
	ECOM4	Enterprises having received orders via computer-mediated networks
	ECOM5	Enterprises having purchased via computer-mediated networks
Infrastructure (2010)	INFR1	Enterprises with Internet connection: fixed broadband access
	INFR2	Enterprises using LAN and Intranet or extranet in reference year

Source: Author, indicator definitions available from Eurostat.

Table 3 contains the mean values for ICT adoption indicators according to innovation performance country groups. ICT adoption is measured in % of enterprises that used particular technology in 2010, except for RFID and website providing online ordering/reservation/booking, that both refer to 2011. The year

2010 has been selected for the analysis since for that year data on ICT adoption indicators have been collected for the first time since the Benchmarking Digital Europe Framework was adopted (EC, 2010a).

T a b l e 3

Mean Values for ICT Adoption Indicators (% of enterprises) According to Innovation Performance Country Groups in 2010, and Exceptionally 2011 for RFID (in %)

Adoption dimensions	ICT adoption indicators	Innovation performance country groups				Total
		Leaders	Followers	Moderate	Modest	
Internal process ICT support (2010)	IP1	30.3	19.4	19.5	12.8	19.8
	IP2	45.3	46. 7	46.5	33.8	44.4
	IP3	60.3	54.3	53.1	41.0	52.5
Integration with customers/suppliers & SCM (2010)	IS1	51.0	45.9	44.8	43.4	45.8
	IS2	51.0	42.5	47.8	45.2	45.9
	IS3	34.8	26.5	27.8	31.0	28.7
Key technologies for Internet of things (2011)	RFID	5.0	3.7	4.4	3.6	4.1
e-Commerce & CRM (ECOM1-2011; ECOM2-ECOM5-2010)	ECOM1	23.8	18.2	17.1	12.8	17.6
	ECOM2	35.8	25.0	22.2	19.2	24.5
	ECOM3	17.8	13.6	11.8	5.6	12.2
	ECOM4	24.3	17.2	15.6	9.4	16.3
	ECOM5	60.0	38.3	29.5	15.2	34.2
Infrastructure (2010)	INFR1	88.3	87.0	81.1	68.6	82.1
	INFR2	45.5	37.4	33.4	33.2	36.3

Note: Data is missing for the following variables and countries – RFID and ECOM1 (Iceland, Turkey), ECOM3 (Greece, Luxembourg, Malta).

Source: Author, calculated based on Eurostat data.

Mean values are calculated for the following groups of countries according to their innovation performance ranking in 2010, presented in Figure 2. Innovation leaders in 2010 were: Switzerland, Sweden, Germany, Finland and Denmark. Innovation followers in 2010 were: Luxembourg, Austria, Belgium, Iceland, the United Kingdom, the Netherlands, Ireland, France, Slovenia, Estonia and Cyprus. Moderate innovators in 2010 were: Norway, Italy, Portugal, Spain, the Czech Republic, Malta, Greece, Hungary, Slovakia, Poland and Croatia. Modest innovators in 2010 were: Romania, Lithuania, Bulgaria, Latvia and Turkey. Since data for Switzerland is not available in Eurostat, we examine the total number of 31 countries.

The highest level of adoption is present in the group of Infrastructure indicators. The average fixed broadband access usage in enterprises for all of the countries examined is 82.1%. Innovation leaders and followers are above the average, but moderate and modest innovators are lower according to the fixed broadband access usage in enterprises. The same pattern is present for all of the other indicators indicating that there are differences in the level of ICT adoption according to innovation performance country groups in 2010.

In this study, we explore the level of ICT adoption in European countries by using indicators (EC, 2009a) oriented towards IT support of internal processes, integration with customers/suppliers and SCM Internet of things; (4) e-Commerce and CRM, and (5) broadband and LAN/intranet/extranet access. By using MANOVA we explore if the level of ICT adoption is different in four groups of countries ranked according to their innovation performance (innovation leaders and followers, and moderate and modest innovators). As a result of MANOVA, it has been revealed that there has been a digital gap between innovation performance country groups according to the level of ICT adoption in their enterprises. The ANOVA analysis uncovered that discriminating ICT indicators belong to the following areas of ICT adoption: Internal ICT support, e-Commerce and CRM, and infrastructure (broadband and LAN/intranet/extranet). As a result of the post-hoc analysis it has been proved that the biggest difference in the level of ICT adoption is between two sub-groups of countries: innovation leaders-followers and modest/moderate innovators. The stepwise discriminant analysis has been conducted in order to test which ICT adoption indicators contribute the most to the difference among European countries according to their innovation performance, and two indicators have been found significant: ECOM5 (Enterprises having purchased via computer-mediated networks), and INFR1 (Enterprises having fixed broadband access to the Internet). Those two indicators are not listed as the Digital Agenda targets.

The paper aims at answering following research questions: (i) RQ1: Do countries from different innovative ranking groups also differ according to the level of ICT adoption in enterprises?; (ii) RQ2: Which innovation ranking groups are different according to the level of ICT adoption in enterprises?, and (iii) RQ3: Which ICT adoption aspects are the most significant in creating differences between innovative country groups?

In order to answer RQ1, MANOVA method was used in order to asses if there is statistically significant difference among innovation performance country groups according to overall impact of ICT adoption indicators. ANOVA method was used in order to test if there is statistically significant difference among innovation performance country groups according to specific ICT adoption indicators.

In order to answer RQ2, Tukey post hoc tests was be applied in order to assess which particular innovative country groups differ (innovation leaders and followers, moderate and modest innovators) according to different aspects of ICT adoption (internal processes support by ICT, integration with customers/suppliers and SCM, key technologies for the Internet of things, e-Commerce and CRM usage, and network infrastructure).

In order to answer RQ3, the discriminant stepwise analysis will be applied in order to determine which ICT adoption aspects are the most significant in creating differences between innovative country groups.

6. Results

Results of the paper are presented in the following manner. First, since the MANOVA and the discriminant analysis have been deployed, assumptions for both methods have been tested. Second, the MANOVA and the ANOVA analysis have been conducted. Third, post hoc analyses have been carried out. Finally, discriminant analyses have been applied to the variables examined.

6.1. Assumptions Achievement

The MANOVA and the discriminant analysis are computationally very similar and common assumptions apply: sample size, normal distribution, homogeneity of variances/covariances and outliers.

The sample size allows for unequal sample sizes which is not a case with the data examined. The maximum of independent variables is $n - 2$, with n being the sample size. Therefore, in our data, we could have the maximum of 29 (31 – 2) independent variables. Since we have 14 independent variables this could be considered acceptable.

The normal distribution for all of the independent variables has been examined by the use of the Kolmogorov-Smirnov test (Appendix 1). Only three variables have been proved at the 1% significance level to have non-normal distribution (RFID, ECOM1 and INFR1), and two variables have been proved at the 10% significance level to have non-normal distribution (IP2 and IP3). However, since most of the variables are normally distributed, the non-normality is caused by skewness and not outliers, and results of the MANOVA and the discriminant analysis could be considered reliable (Tabachnick and Fidell, 1996).

Homogeneity of variances/covariances has been tested by the Box's M test that tests the null hypothesis of equal population covariance matrices. The test revealed at the 5% level that population covariance matrices are not equal for ICT adoption indicators examined ($F = 1.342$; p-value = 0.013). Since the Box's M test is sensitive to non-normality of the variables, the Levene's Test of Equality of Error Variances has also been used (Appendix 2) testing the null hypothesis that the error variance of the dependent variable is equal across the groups. Since the test proved that this is true for all of the variables except for IS3 and INFR1, taking into account the Box's M test, we could conclude that homogeneity of variances is at the acceptable level.

Outliers have been examined by the use of Box-Plot graphs, and only two countries (Bulgaria and Romania) have been outliers for the indicator INFR1. Therefore, those countries have been left out of the analysis.

6.2. MANOVA and ANOVA Analysis

In order to examine if the differences in mean values for ICT adoption indicators (% of enterprises) according to innovation performance country groups in 2010 are statistically significant MANOVA has been conducted. Missing values for the data in Table 3 have been replaced by the value of the same variable and the same country from the previous year, thus following the *Last value carried forward* approach (Gelman and Hill, 2006).

Four statistics have been observed in order to examine MANOVA results (Table 4). The most used test is Wilks' Lambda, and we shall use it for this study. Since it is statistically significant at the 5% level (Wilks' Lambda = 0.049; p-value = 0.032), we can conclude that ICT adoption indicators are statistically different among countries of different innovation performance levels. However, this conclusion is based on the overall impact of ICT adoption indicator, and further analysis of the impact of particular ICT adoption will be conducted using ANOVA analysis.

T a b l e 4

Results of MANOVA Tests for Overall Difference among Innovation Performance Country Groups According to ICT Adoption Indicators

	Value	**Sig.**
Pillai's Trace	1.726	0.072*
Wilks' Lambda	0.049	0.032**
Hotelling's Trace	6.833	0.013**
Roy's Largest Root	5.073	0.001***

* Statistically significant at 10% level. ** Statistically significant at 5% level. *** Statistically significant at 1% level.

Source: Own calculation.

The ANOVA tests have been conducted in order to test for which particular ICT adoption indicators there are statistically significant differences among countries of a different innovation performance level. Table 5 presents the results of the ANOVA test. It has been proved that all of the Internal process ICT support indicators are significantly different among countries of different innovation performance levels at the 5% level (IP1 and IP3) or at the 10% level (IP2). Also, e-Commerce and CRM indicators are statistically different among countries of different innovation performance levels at the 1% level (ECOM5), the 5% level (ECOM2 and ECOM3) or at the 10% level (ECOM4). Both infrastructure indicators are statistically different among countries of different innovation performance levels, INFR1 at the 1% level, and INFR2 at the 10% level. Which particular country groups differ among each other according to the level of ICT adoption in enterprises will be tested in the next step by using post hoc tests. From the results presented, we can conclude that the following group of ICT adoption indicators differ among innovation performance country groups: Internal process ICT support, e-Commerce & CRM, and Infrastructure. On the other hand, integration with customers/suppliers & SCM and RFID do not differ among innovation performance country groups. Such conclusion could be the result of the fact that enterprises across EU-27 countries still rarely use RFID, and also integration with customers/suppliers & SCM, since both are examples of higly-advanced technologies, that are still not widely used (Spekman and Sweeney II., 2006; Pedroso, Zwicker and de Souza, 2009; Closs, Speier and Meacham, 2011).

Table 5

Results of Anova Tests for ICT Adoption Indicators among Innovation Performance Country Groups

Adoption dimensions	ICT adoption indicators	F-test	Sig.
Internal process ICT support (2010)	IP1	3.893	0.020**
	IP2	2.410	0.089*
	IP3	3.063	0.045**
Integration with customers/suppliers & SCM (2010)	IS1	0.215	0.885
	IS2	0.481	0.698
	IS3	0.452	0.718
Key technologies for Internet of things (2011)	RFID	0.522	0.671
e-Commerce & CRM (2010)	ECOM1	1.884	0.156
	ECOM2	3.139	0.042**
	ECOM3	4.335	0.013**
	ECOM4	2.883	0.054*
	ECOM5	10.055	0.000***
Infrastructure (2010)	INFR1	6.153	0.003***
	INFR2	2.840	0.057*

* Statistically significant at 10% level. ** Statistically significant at 5% level. *** Statistically significant at 1% level.

Source: Own calculation.

6.3. Post hoc Analysis

The post hoc analysis has been deployed in order to test for which particular innovation performance country groups are adoption dimensions statistically different. For this purpose, the post hoc Tukey honest significant difference (HSD) multiple comparison is used. Only those pairs that are statistically different at least at the 10% level are reported in the table (20 pairs). Mean difference in % between groups is also presented in the table. We can observe that in most of the cases the biggest difference occurs between innovation leaders and modest innovators (8 pairs), then between innovation followers and modest innovators (5 pairs). A smaller number of pairs is present among the following combinations: innovation leaders and moderate innovators (3 pairs), innovation leaders and innovation followers (2 pairs), and moderate and modest innovators (2 pairs). We can conclude that innovation leaders are the fastest group in utilizing ICT for innovation, and that other countries are lagging behind. This conclusion indicates that the gap in development among EU-27 countries will remain the same or even increase, if strong action will not be conducted in order to increase ICT adoption in enterprises.

T a b l e 6

Multiple Comparisons of Groups (Tukey HSD)

Adoption dimension	ICT adoption indicators	Pairs of innovation performance country groups with statistically different means (at 10% or lower)	Mean difference (%)	Sig.
Internal process ICT support (2010)	IP1	Leaders – Followers Leaders – Modest	10.9 17.5	0.094* 0.011***
	IP2	Moderate – Modest Followers – Modest	12.9 12.8	0.086* 0.092*
	IP3	Leaders – Modest Followers – Modest	19.3 13.3	0.040** 0.095*
e-Commerce & CRM (2010)	ECOM2	Leaders – Moderate Leaders – Modest	13.6 16.6	0.057* 0.039**
	ECOM3	Leaders – Modest Followers – Modest	12.2 7.9	0.010** 0.044**
	ECOM4	Leaders – Modest	14.9	0.035**
	ECOM5	Leaders – Followers Leaders – Moderate Leaders – Modest Followers – Modest	21.7 30.6 44.8 23.1	0.033** 0.002*** 0.000*** 0.012**
Infrastructure (2010)	INFR1	Leaders – Modest Followers – Modest Moderate – Modest	19.7 18.4 12.5	0.010** 0.002*** 0.052*
	INFR2	Leaders – Moderate Leaders – Modest	12.1 12.3	0.051* 0.099*

* Statistically significant at 10% level. ** Statistically significant at 5% level. *** Statistically significant at 1% level.

Source: Own calculation.

6.4. Stepwise Discriminant Analysis

In order to test which ICT adoption indicators contribute the most to the innovation performance of the European countries, the stepwise discriminant analysis has been deployed (Hair et al., 2009).

The dependent variable for the discriminant analysis has been formed as a binominal variable that consists of two possible values: (1) innovation leaders and followers, and (2) modest and moderate innovators. The reason for taking into account the binominal variable instead of a four-level variable is that the post hoc test revealed that the biggest difference is among those two subgroups. All of the ICT adoption indicators have been used as independent variables. Wilks' Lambda has been calculated in order to test the statistical significance of the discriminant function and it has been proved that it is statistically significant at the 1% level (Lambda = 0.620; Chi-square = 13.386; p-value = 0.001).

As the result of the stepwise discriminant analysis, ECOM5 (Enterprises having purchased via computer-mediated networks), and INFR1 (Enterprises having fixed broadband access to the Internet) are discriminating countries according to their innovation performance (innovation leaders and followers; moderate and modest innovators). None of those two indicators have been listed as the Digital Agenda targets.

Table 7 presents classification results of the stepwise discriminant analysis. The correct classification rate is calculated to be 77.4%. In order to estimate whether this particular discrimination rate is valid or not, the maximum chance criterion has been used. The maximum chance criterion is calculated using the group with the maximum number of cases as a base group. In our study, two groups are almost the same size. The group of innovation leaders and followers contains 15 countries, and group of moderate and modest innovators contains 16 countries. Thus, the maximum change criteria is 16/(16 + 15) = 0.52. Hair et al. (2009) depict that, in order to have a valid classification rate, the correct classification rate should be higher than the maximum change calculated. In Table 7, the correct classification rate is 77.4%, which is higher than the calculated maximum change of 52%, which leads us to the conclusion that the classification is successful.

Table 7

Summary Table of Classification

Original		**Predicted group membership**		**Total**
		Innovation leaders and followers	Moderate and modest innovators	
Count	Leaders and Followers	12	4	15
	Moderate and Modest	3	12	16
Percent (%)	Leaders and Followers	75.0	25.0	100.0
	Moderate and Modest	20.0	80.0	100.0

Note: 77.4% of original grouped cases correctly classified.

Source: Own calculation.

Table 8

Country Classification According to the IUS Ranking and the Stepwise Discriminant Analysis (in %)

Countries	**Stepwise discriminant analysis probabilities of group membership to**		**Actual group (IUS ranking)**	**Predicted group (stepwise discriminant analysis)**
	Moderate/Modest (MM) group	Leaders/Followers (LF) group		
Belgium	14	86	LF	LF
Bulgaria	98	2	MM	MM
Czech Republic	43	57	MM	LF
Denmark	7	93	LF	LF
Germany	10	90	LF	LF
Estonia	62	38	LF	MM
Ireland	31	69	LF	LF
Greece	86	14	MM	MM
Spain	42	58	MM	LF
France	43	57	LF	LF
Italy	47	53	MM	LF
Cyprus	61	39	LF	MM
Latvia	94	6	MM	MM
Lithuania	70	30	MM	MM
Luxembourg	19	81	LF	LF
Hungary	69	31	MM	MM
Malta	53	47	MM	MM
Netherlands	22	78	LF	LF
Austria	38	62	LF	LF
Poland	94	6	MM	MM
Portugal	63	37	MM	MM
Romania	99	1	MM	MM
Slovenia	62	38	LF	MM
Slovakia	89	11	MM	MM
Finland	18	82	LF	LF
Sweden	5	95	LF	LF
United Kingdom	15	85	LF	LF
Iceland	35	65	LF	LF
Norway	9	91	MM	LF
Croatia	69	31	MM	MM
Turkey	70	30	MM	MM

Source: Own calculation.

Table 8 presents actual and predicted groups of European countries. The following countries have not been properly classified: the Czech Republic, Estonia, Slovenia, Cyprus, Span, Italy and Norway. However, for most of those countries the probability of group membership to both groups is approximately 60 : 40, with the exception of Norway, which was wrongly classified within the leaders – followers group with the probability of 91%.

Conclusions

In this study, we explore the level of ICT adoption in European countries by using indicators (EC, 2009a) oriented towards IT support of internal processes, integration with customers/suppliers and SCM Internet of things;

(4) e-Commerce and CRM, and (5) broadband and LAN/Intranet/extranet access. The research revealed following answers to research questions.

By using MANOVA we explore if the level of ICT adoption is different in four groups of countries ranked according to their innovation performance (innovation leaders and followers, and moderate and modest innovators). As a result of MANOVA, it has been revealed that there has been a digital gap between innovation performance country groups according to the level of ICT adoption in their enterprises. The ANOVA analysis uncovered that discriminating ICT indicators belong to the following areas of ICT adoption: Internal ICT support, e-Commerce and CRM, and infrastructure (broadband and LAN/intranet/extranet). Therefore, we conclude that countries from different innovative ranking groups also differ according to the level of ICT adoption in enterprises, thus giving the positive answer to RQ1. As a result of the post hoc analysis it has been proved that the biggest difference in the level of ICT adoption is between two subgroups of countries: innovation leaders – followers and modest/moderate innovators, thus giving the positive answer to RQ2. Finally, the stepwise discriminant analysis has been conducted in order to test which ICT adoption indicators contribute the most to the difference among European countries according to their innovation performance, and two indicators have been found significant: ECOM5 (Enterprises having purchased via computer-mediated networks), and INFR1 (Enterprises having fixed broadband access to the Internet), thus giving the positive answer to RQ3.

Some of the results needs further clarification. At first sight it may seem surprising that adoption of purchasing via computer-mediated networks is an important indicator for discriminating countries according to their innovation performance. However, this indicator could be used as a proxy for using e-Commerce as a decreasing cost factor (Rabinovich, Knemeyer and Mayer, 2007), which is especially important since, due to the process of globalization, in the few last decades production has moved to countries with lower costs (Mahutga and Smith, 2011). This is especially important in the time of crises when e-Commerce has been proved to be an efficient leverage for escaping from recession (Savrul and Kılıç, 2011). Broadband adoption has also been proved as one of the important contributors to the economic growth (Holt and Jamison, 2009).

The Digital Agenda is one of the seven flagship initiatives of the Europe 2020 Strategy, with the goal to increase the level of ICT adoption. The goals of the Digital Agenda focus on Broadband targets, Digital singe market and Digital inclusion, while ICT adoption in enterprises has not been given a strong emphasis. However, based on the results of our study, we could suggest incorporating more e-Commerce indicators and broadband adoption indicators in enterprises into the Digital Agenda targets, especially taking into account the fact that less than half of employees in European countries use personal computers that have access to the World Wide Web at their workplaces. Possible activities for encouragement of ICT adoption in enterprises should also be proposed for e-Commerce activities and broadband access in enterprises.

The focus of previous research in this area was primarily on ICT adoption impact on the innovation activities at the enterprise level, taking into account a limited sample of countries and industries and at the same time examining usually only one form of ICT, for instance ERP systems. Furthermore, none of the research focused on the level of ICT adoption among enterprises in countries ranked according to their innovation performance. As a proxy for innovation performance of countries, the IUS ranking, which clusters countries into four groups (innovation leaders and followers, moderate and modest innovators) has been used. Therefore, the contribution of this study stems from the fact that this is one of the first researches that explore the existence of a relationship between the ICT adoption among enterprises and the ranking of countries according to their innovation performance.

Limitations of this study stems from following sources. First, availability of the data was incomplete. For some indicators a large number of data were missing, and one year ahead data was used for the analysis. When a small number of data was missing, the 'last value carried forward approach' was used. Second, our analysis was conducted only for 2010 (and for 2011 for some indicators of ICT adoption in enterprises). Therefore, only one year has been chosen for the analysis, but this is due to the fact that the observed indicators have been collected in 2010 for the first time since the Benchmarking Digital Europe Framework was adopted (EC, 2010a). Third, limited metrics was used for measuring both the enterprise digital divide and innovation performance of the countries. Literature review suggests many different metrics for measuring ICT adoption in enterprises, as well as there are many approaches to measuring innovative performance of the countries. On the other side, metrics for ICT adoption are not available for all of the countries and all of the years for European countries. Fourth, our analysis is exploratory in its nature and did not try to find any casual relationships between ICT adoption in enterprises and innovative performance of countries. For such approach different more comprehensive data sources should be used, and a different approach should be deployed using dependent variables and its regressors. This is also a possible future venue for other research on this subject. Nevertheless, this study provides a significant insight into the level of ICT adoption in enterprises and its possible influence on innovation performance of European countries. Finally, while taking account the results of this research it should be understood that ICT adoption is part of innovation performance. Hence, our opinion is that the findings of the study might be useful in making decisions regarding supporting ICT adoption in the EU and other countries.

References

ANCONA, D. – CALDWELL, D. (1987): Management Issues Facing New Product Teams in High Technology Companies. In: LEWIN, D., LIPSKY, D. and SOKEL, D. (eds): Advances in Industrial and Labor Relations, Vol. 4, pp. 191 – 221. Greenwich, CT: JAI Press.

ANDERSON, N. R. – KING, N. (1993): Innovation in Organizations. International Review of Industrial and Organizational Psychology, *8*, No. 2, pp. 1 – 34.

ANTONELLI, C. (2003): The Digital Divide: Understanding the Economics of New Information and Communication Technology in the Global Economy. Information Economics and Policy, *15*, No. 5, pp. 173 – 199.

BELLO, D. C. – LOHTIA, R. – SANGTANI, V. (2004): An Institutional Analysis of Supply Chain Innovations in Global Marketing Channels. Industrial Marketing Management, *33*, No. 1, pp. 57 – 64.

BUNDUSHI, R. – WEISSHAAR, C. – SMART, A. U. (2011): Mapping the Benefits and Costs Associated with Process Innovation: The Case of RFID Adoption. Technovation, *31*, No. 9, pp. 505 – 521.

CARBONE, F. – CONTRERAS, J. – HERNÁNDEZ, J. Z. – GOMEZ-PEREZ, J. M. (2012): Open Innovation in an Enterprise 3.0 Framework: Three Case Studies. Expert Systems with Applications, *39*, No. 10, pp. 8929 – 8939.

CHEN, C.-J. – HUANG, J. W. (2009): Strategic Human Resource Practices and Innovation Performance – The Mediating Role of Knowledge Management Capacity. Journal of Business Research, *62*, No. 1, pp. 104 – 114.

CHEN, J.-S. – TSOU, H.-T. (2012): Performance Effects of IT Capability, Service Process Innovation, and the Mediating Role of Customer Service. Journal of Engineering and Technology Management, *29*, No. 1, pp. 71 – 94.

CHO, S. D. – CHANG, D. R. (2008): Salesperson’s Innovation Resistance and Job Satisfaction in Intra-organizational Diffusion of Sales Force Automation Technologies: The Case of South Korea. Industrial Marketing Management, *37*, No. 7, pp. 841 – 847.

ÇILAN, C. A. – BOLAT, B. A. – COȘKUN, E. (2007): Analyzing Digital Divide within and between Member and Candidate Countries of European Union. Government Information Quarterly, *26*, No. 1, pp. 98 – 105.

CLOSS, D. J. – SPEIER, C. – MEACHAM, N. (2011): Sustainability to Support End-to-end Value Chains: The Role of Supply Chain Management. Journal of the Academy of Marketing Science, *39*, No. 1, pp. 101 – 116.

DELINA, R. – TKAC, M. – JANKE, F. (2012): Trust Building Electronic Services as a Crucial Self-regulation Feature of Digital Business Ecosystems. [Online.] Journal of Systems Integration, *3*, No. 2, pp. 29 – 38. Available at: <http://www.si-journal.org>.

DOMINGUEZ-PÉRY, C. – AGERON, B. – NEUBERT, G. (2011): A Service Science Framework to Enhance Value Creation in Service Innovation Projects. [An RFID Case Study.] International Journal of Production Economics, *141*, No. 2. Available online December 29, 2011.

EC (2008): European Innovation Scoreboard (EIS) 2007. Available at: <http://www.proinno-europe.eu/ metrics>.

EC (2009a): i2010 High Level Group. Brussels: European Commission.

EC (2009b): European Innovation Scoreboard (EIS) 2008. Available at: <http://www.proinno-europe.eu/metrics>.

EC (2010a): A Digital Agenda for Europe. Brussels: European Commission.

EC (2010b): European Innovation Scoreboard (EIS) 2009. Available at: <http://www.proinno-europe.eu/metrics>.

EC (2010c): EUROPE 2020 – A Strategy for Smart, Sustainable and Inclusive Growth – 2020. Brussels: European Commission.

EC (2010d): Europe’s Digital Competitiveness Report. Brussels: European Commission.

EC (2011): European Innovation Scoreboard (EIS) 2010. Available at: <http://www.proinno-europe.eu/metrics>.

EC (2012): European Union Innovation Scoreboard 2011. Journal of Systems Integration, *3*, pp. 29 – 38. Available at: <http://www.proinno-europe.eu/metrics>. Feature of Digital Business Ecosystems.

FORMAN, C. (2005): The Corporate Digital Divide: Determinants of Internet Adoption. Management Science, *51*, No. 4, pp. 641 – 654.

FORMAN, C. – GOLDFARB, A. (2006): Information and Communication Technology Diffusion to Businesses. In: HENDERSHOTT, T. (ed.): Handbooks in Information Systems, Vol. 1: Economics and Information Systems, pp. 1 – 52. Amsterdam: Elsevier.

GALLIANO, D. – ROUX, P. – SOULIE, N. (2011): ICT Intensity of Use and the Geography of Firms. Environment and Planning, *43*, No. 1, pp. 67 – 86.

GELMAN, A. – HILL, J. (2006): Data Analysis Using Regression and Multilevel/Hierarchical Models. Cambridge, UK: Cambridge University Press.

GUST, C. – MARQUEZ, J. (2004): International Comparisons of Productivity Growth: The Role of Information Technology and Regulatory Practices. Labour Economics, *11*, No. 1, pp. 33 – 58.

HAIR, J. F. – BLACK, W. C. – BABIN, J. B. – ANDERSON, R. E. (2009): Multivariate Data Analysis. 7th Edition. Upper Saddle River: Prentice Hall.

HOLT, L. – JAMISON, M. (2009): Broadband and Contributions to Economic Growth: Lessons from the US Experience. Telecommunications Policy, *33*, No. 10, pp. 575 – 581.

HUNG, C.-L. – CHOU, J. C.-L. – DONG, T.-P. (2011): Innovations and Communication Through Innovative Users: An Exploratory Mechanism of Social Networking Website. International Journal of Information Management, *31*, No. 4, pp. 317 – 326.

JAMES, J. (2003): Bridging the Global Digital Divide. Cheltenham, UK: Edward Elgar.

JORGENSON, D. W. – HO, M. S. – STIROH, K. J. (2008): A Retrospective Look at the US Productivity Resurgence. Journal of Economic Perspectives, *22*, No. 1, pp. 3 – 24.

KELLER, A. – HÜSIG, S. (2009): Ex ante Identification of Disruptive Innovations in the Software Industry Applied to Web Applications: The Case of Microsoft’s vs. Google's Office Applications. Technological Forecasting and Social Change, *76*, No. 8, pp. 1044 – 1054.

KHUONG, M. V. (2011): ICT as a Source of Economic Growth in the Information Age: Empirical Evidence from the 1996 – 2005 Period. Telecommunications Policy, *35*, No. 4, pp. 357 – 372.

KIM, B. (2000): Coordinating an Innovation in Supply chain Management. European Journal of Operational Research, *123*, No. 3, pp. 568 – 584.

KOELLINGER, P. (2008): The Relationship between Technology, Innovation, and Firm Performance – Empirical Evidence from E-Business in Europe. Research Policy, *37*, No. 8, pp. 1317 – 1328.

LAFFEY, D. (2007): Paid Search: The Innovation that Changed the Web. Business Horizons, *50*, No. 3, pp. 211 – 218.

LIN, Y. – WANG, Y. – YU, C. (2010): Investigating the Drivers of the Innovation in Channel Integration and Supply Chain Performance: A Strategy Orientated Perspective. International Journal of Production Economics, *127*, No. 2, pp. 320 – 332.

MADAPUSI, A. – D’SOUZA, D. (2012): The Influence of ERP System Implementation on the Operational Performance of an Organization. International Journal of Information Management, *32*, No. 1, pp. 24 – 34.

MAHTUGA, M. C. – SMITH, D. A. (2011): Globalization, the Structure of the World Economy and Economic Development. Social Science Research, *40*, No. 1, pp. 257 – 272.

MIKALEF, P. – PATELI, A. – BATENGURG, R. – Van de WETERING, R. (2014): Business Alignment in the Procurement Domain: A Study of Antecedents and Determinants of Supply Chain Performance. International Journal of Information Systems and Project Management, *2*, No. 1, 2014, pp. 43 – 59.

MILAN, C. – ZELLI, A. (2002): The Contribution of ICT to Production Efficiency in Italy: Firm--Level Evidence Using Data Envelopment Analysis and Econometric Estimations [STI Working Paper 2002/13.] Paris: OECD.

NEWELL, S. S. – HUANG, J. C. – GALLIERS, R. D. – PAN, S. L. (2003): Implementing Enterprise Resource Planning and Knowledge Management Systems in Tandem: Fostering Efficiency and Innovation Complementarity. Information and Organization, *13*, No. 1, pp. 25 – 52.

NGO, L. V. – O'CASS, A. (2012): Innovation and Business Success: The Mediating Role of Customer Participation. Journal of Business Research, *66*, No. 8, pp. 1134 – 1142.

NIETO, M. J. – SANTAMARÍA, L. (2007): The Importance of Diverse Collaborative Networks for the Novelty of Product Innovation. Technovation, *27*, No. 6, pp. 367 – 377.

OLINER, S. D. – SICHEL, D. (2002): Information Technology and Productivity: Where are We Now and Where Are We Going? Federal Reserve Bank of Atlanta Review, *87*, No. 1, pp. 15 – 44.

OLLO-LÓPEZ, A. – ARAMENDÍA-MUNETA, E. (2012): ICT Impact on Competitiveness, Innovation and Environment. Telematics and Informatics, *29*, No. 2, pp. 204 – 210.

ÖZGENER, Ş. – İRAZ, R. (2006): Customer Relationship Management in Small-medium Enterprises: The Case of Turkish Tourism Industry. Tourism Management, *27*, No. 6, pp. 1356 – 1363.

PEDROSO, M. C. – ZWICKER, R. – DE SOUZA, C. A. (2009): RFID Adoption: Framework and Survey in Large Brazilian Companies. Industrial Management & Data Systems, *109*, No. 7, pp. 877 – 897.

PEJIĆ BACH, M. – ZOROJA, J. – MERKAČ-SKOK, M. (2014): Social Responsibility in Tourism: System Archetypes Approach. Kybernetes, *43*, No. 3/4, pp. 587 – 600.

PERI, G. (2005): Determinants of Knowledge Flows and their Effect on Innovation. Review of Economics and Statistics, *87*, No. 2, pp. 308 – 322.

PILAT, D. (2004): Introduction and Summary in the Economic Impact of ICT Measurement. Evidence and Implications. Paris: OECD.

PORTER, M. E. (1990): The Competitive Advantage of Nations. New York: Free Press.

RABINOVICH, E. – KNEMEYER, M. A. – MAYER, C. M. (2007): Why do Internet Commerce Firms Incorporate Logistics Service Providers in Their Distribution Channels? The Role of Transaction Costs and Network Strength. Journal of Operations Management, *25*, No. 3, pp. 661 – 681.

RINK, R. D. – SWAN, J. E. (1979): Product Life Cycle Research: A Literature Review. Journal of Business Research, *7*, No. 3, pp. 219 – 242.

ROH, J. J. – KUNNATHUR, A. – TARAFDAR, M. (2009): Classification of RFID Adoption: An Expected Benefits Approach. Information & Management, *46*, No. 6, pp. 357 – 363.

SAVRUL, M. – KILIÇ, C. (2011): E-Commerce as an Alternative Strategy in Recovery from the Recession. Procedia – Social and Behavioral Sciences, *24*, No. 1, pp. 247 – 259.

SELWYN, N. (2004): Reconsidering Political and Popular Understandings of the Digital Divide. New Media & Society, *6*, No. 3, pp. 341 – 362.

SIANESI, B. – Van REENEN, J. (2003): The Returns to Education: Macroeconomics. Journal of Economic Surveys, *17*, No. 2, pp. 157 – 200.

SPEKMAN, R. E. – SWEENEY II, P. J. (2006): RFID: From Concept to Implementation. International Journal of Physical Distribution & Logistics Management, *36*, No. 10, pp. 736 – 754.

SPEZIA, V (2011): Are ICT Users More Innovative? An Analysis of ICT-enabled Innovation in OECD Firms. OECD Journal: Economies Studies, *2011*, No. 1, pp. 1 – 21.

SRIVARDHANA, T. – PAWLOWSKI, S. D. (2007): ERP Systems as an Enabler of Sustained Business Process Innovation: A Knowledge-based View. Journal of Strategic Information Systems, *16*, No. 1, pp. 51 – 69.

ŠKRINJAR, R. – BOSILJ VUKŠIĆ. V. – INDIHAR ŠTEMBERGER, M. (2010): Adoption of Business Process Orientation Practices: Slovenian and Croatian Survey. Business Systems Research, *1*, No. 1 – 2, pp. 5 – 19.

TABACHNICK, B. G. – FIDELL, L. S. (1996): Using Multivariate Statistics. New York: Harper Collins College Publishers.

TAJIMA, M. (2007): Strategic Value of RFID in Supply Chain Management. Journal of Purchasing and Supply Management, *13*, No. 4, pp. 261 – 273.

TARAFDAR, M. – GORDON, S. R. (2007): Understanding the Influence of Information Systems Competencies on Process Innovation: A Resource-based View. Journal of Strategic Information Systems, *16*, No. 4, pp. 353 – 392.

TOIVONEN, R. – KOVANEN, L. – KIVELÄ, M. – ONNELA, J. – SARAMÄKI, J. – KASKI, K. (2009): A Comparative Study of Social Network Models: Network Evolution Models and Nodal Attribute Models. Social Networks, *31*, No. 4, pp. 240 – 254.

TOTTERDELL, P. – LEACH, D. – BIRDI, K. – CLEGG, C. – WALL, T. (2002): An Investigation of the Contents and Consequences of Major Organizational Innovations. International Journal of Innovation Management, *6*, No. 4, pp. 343 – 368.

ULUSOY, G. (2003): An Assessment of Supply Chain and Innovation Management Practices in the Manufacturing Industries in Turkey. International Journal of Production Economics, *86*, No. 3, pp. 251 – 270

Van ARK, B. – PIATKOWSKI, M. (2004): Productivity, Innovation and ICT in Old and New Europe. Groningen Research Memorandum (GD-69). Groningen: Groningen Growth and Development Centre.

VEHOVAR, V. – SICHERL, P. – HÜSING, T. – DOLNICAR, V. (2006): Methodological Challenges of Digital Divide Measurements. The Information Society, *22*, No. 5, pp. 279 – 290.

WATANABE, C. – HOBO, M. (2004): Creating a Firm Self-propagating Function for Advanced Innovation-oriented Projects: Lessons from ERP. Technovation, *24*, No. 6, pp. 467 – 481.

WU, J.-H. – HISA, T.-L. (2004): Analysis of E-Commerce Innovation and Impact: A Hypercube Model. Electronic Commerce Research and Applications, *3*, No. 4, pp. 389 – 404.

WU, M. J. – LIN, Y. – LIU, F. – HSIAO, S. (2010): Overcoming Service Innovation Bottlenecks Using Web 2.0. Expert Systems with Applications, *37*, No. 11, pp. 7373 – 7379.

WU, J. (2012): Technological Collaboration in Product Innovation: The Role of Market Competition and Sectoral Technological Intensity. Research Policy, *41*, No. 2, pp. 489 – 496.

XU, H. – SHARMA, S. K. – HACKNEY, R. (2005): Web Services Innovation Research: Towards a Dual-core Model. International Journal of Information Management, *25*, No. 4, pp. 321 – 334.

ZAHRA, S. A. – GEORGE, G. (2002): Absorptive Capacity: A Review, Reconceptualization, and Extension. Academy of Management Journal, *27*, No. 2, pp. 185 – 203.

ZAKARIA, N. – AMELINCKX, A. – WILEMON, D. (2004): Working Together Apart? Building a Knowledge-sharing Culture for Global Virtual Teams. Creativity and Innovation Management, *13*, No. 1, pp. 15 – 29.

A p p e n d i x 1

Kolmogorov-Smirnov Test for Normal Distribution Calculated for ICT Adoption Indicators

ICT adoption indicators	Kolmogorov-Smirnov		
	Statistic	df	Sig.
IP1	0.109	31	0.200
IP2	0.156	31	0.052*
IP3	0.150	31	0.075*
IS1	0.104	31	0.200
IS2	0.106	31	0.200
IS3	0.121	31	0.200
RFID	0.225	31	0.000***
ECOM1	0.191	31	0.006***
ECOM2	0.141	31	0.120
ECOM3	0.107	31	0.200
ECOM4	0.132	31	0.181
ECOM5	0.143	31	0.105
INFR1	0.212	31	0.001***
INFR2	0.128	31	0.200

* Statistically significant at 10% level. *** Statistically significant at 1% level.

Source: Own calculation.

A p p e n d i x 2

Levene's Test of Equality of Error Variances(a)

ICT adoption indicators	F	df1	df2	Sig.
IP1	1.022	3	27	0.398
IP2	0.283	3	27	0.837
IP3	1.571	3	27	0.219
IS1	2.288	3	27	0.101
IS2	1.782	3	27	0.174
IS3	2.382	3	27	0.092*
RFID	0.744	3	27	0.535
ECOM1	0.766	3	27	0.523
ECOM2	0.595	3	27	0.623
ECOM3	1.542	3	27	0.226
ECOM4	1.248	3	27	0.312
ECOM5	0.641	3	27	0.595
INFR1	4.039	3	27	0.017**
INFR2	1.983	3	27	0.140

* Statistically significant at 10% level. ** Statistically significant at 5% level.

Source: Own calculation.