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Innovation, knowledge and information management in supply chains

Mariusz Szuster, Maciej Szymczak

ABSTRACT
In this study the question of innovation and information management in supply chain is addressed. We assume that innovation and information management are interrelated in supply chains and that the relationship is crucial for their success on the market. Considerable attention was given to the issue of outsourcing which is now a commonplace in supply chain management. In particular, we examined how approaches to managing information and knowledge in the supply chain differ according to ICT outsourcing. The deduction is based on a data set of 426 companies located in Poland, representing a variety of industry sectors. Two stages of the research were realised. The rationale behind this was to identify enterprises that utilise a well-developed system of information and knowledge management to determine the scope of possible in-depth analyses. This helped to receive valuable responses. We find what information and knowledge management is mainly driven by. We show the similarities and differences in information and knowledge management between entities that use ICT outsourcing and those that do not. We discuss the research results and draw conclusions.

KEY WORDS
innovation management; information management; supply chain management

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Corresponding authors:

Mariusz Szuster
Poznań University
of Economics and Business
Faculty of International
Business and Economics

e-mail: mariusz.szuster@ue.poznan.pl

Maciej Szymczak
Poznań University
of Economics and Business
Faculty of International
Business and Economics

e-mail: maciej.szymczak@ue.poznan.pl

Introduction

The phenomenon of innovation is widely recognised by managers as well as by researchers. Innovation is defined as a change in the company that is characterised by the following features: „relative advantage, compatibility, complexity and observability" (Rogers, 1995) or as: „an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003). Innovation is viewed as a worthwhile source of advantage and of competitiveness for companies, oriented to improve company's performance (Pietrobelli & Rabellotti, 2011; Rabelo & Hughes Speller, 2005; Chen & Jaw, 2009; Berghman et al., 2013). Innovation is a major issue for companies and their innovation capacity is an important condition for their success (Fagerberg & Verspagen, 2009) or their survival (Drucker, 1985). To meet many challenging requirements, companies must find new sources of competitiveness and engage in the process of knowledge and innovation creation. They need to develop strategically aligned capabilities not only within the company itself, but also among the other organisations. Firms have to look beyond their organisational boundaries and evaluate how the resources and capabilities of other organisations may be utilised to create new exceptional value (Soosay et al., 2008).

The basic classification of innovation presents product, process, service, and organisation innovation (Baregheh et al., 2009). Process innovation which is the basic focus of this paper, means new methods of performing firm activities, which have lower costs

and higher efficiency or generate new revenue, having also a positive impact on profitability (Arvanitis et al., 2013). Most innovations follow the same organisational diffusion process. This process ushers the adopting organisation from first realizing a perceived need for innovation, all the way through the embedding of the chosen innovation into the organisation's governance structure and work processes (Rogers, 2003). Ulusoy (2003) provided a list of possible meanings of innovation, by identifying the following ones: the renewal and enlargements of the range of products and services; the establishment of new methods of production, supply, and distribution; and the introduction of changes in management, work organisation, and the working conditions and skills of the workforce.

Innovations can either be incremental or radical (Ageron et al., 2013). Radical innovations require implementing completely new knowledge that renders obsolete the existing knowledge. On the contrary, incremental innovations introduce minor changes and adaptations (Brettel et al., 2011). Thus, innovation does not need to be something completely new and never experienced by companies in the actual world, but rather something that a particular company has not used in the past and that it decides to develop and set up for the future (Ageron et al., 2013).

In the context of supply chain management, Arlbjorn et al. (2011) defined supply chain innovation (SCI) as „a change (incremental or radical) within the supply chain (SC) network, SC technology, or SC processes (or combination of those) that can take place in a company function, within a company, in an industry or in a SC in order to enhance new value creation". Many ideas such as cross-docking, containerization, and even green reverse logistics are technological innovations that have been discussed in the supply chain literature (Grawe, 2009; Hazen et al., 2012). Electronic data interchange (EDI) is an information technology used to exchange data across organisations (Germain & Droge, 1995) that is addressed as a technological innovation in a variety of past SCM studies (Ahmad & Schroeder, 2001; Narayanan et al., 2009). ICT can help a company to put in place a radical new value chain that can deliver value to the customer in an innovative and economical way (Markides & Anderson, 2006).

To improve processes realized in an uncertain environment, a communication and coordination between all members of innovative supplier chain has to be well prepared. The innovative supply chain is characterised by increased amount of data and information, channel integration and advances in information and communication technologies (ICT). Lavastre et al. (2011) defined innovative supply chain practice as a set of methods and tools that are previously inexistent in companies and/or their subsidiaries that will be generated, developed and deployed within supply chains to tackle different supply chain issues such as quality, costs and lead-time. Innovations can rely on logistics network reconfiguration, outsourcing of many functions or ISs development. Thanks to these innovative supply chain practices, companies can create value for their customers and improve their competitiveness and the performance of the whole supply chain (Chan & Qi, 2003). Richey et al. (2005) stated that supply chain and logistics innovation should improve a firm's market effectiveness and internal cost efficiency. Moreover, there is a positive relationship between logistics innovation and development of a competitive advantage (Grawe, 2009).

There are three areas (presented in the Fig. 1) of innovative supply chain (Ageron et al., 2013):

1. Operational processes that embody the execution of tasks and constitute the „doing of business". They are often associated with short-term actions. Operational processes are part of their inter-organisational practices, companies are increasingly developing control tools and methods to enhance management. Stock reduction has long been a major issue and recently, companies have started to face new challenges that require new methods and new organisational arrangements between supply chain actors. Emergence of new supply chain practices such as consignment stock signals the existence of these new challenges. Operational and managerial processes are inextricably linked.
2. Managerial processes or the management of supply chain flows. Management processes are strategic activities associated with administration and control of resources. They are frequently long-term. Supplier selection processes, supply chain business unit strategy conception, standardization of supply chain processes, and so on are elements constituting SCM, given that they modify the organisational scope of supply chains and the relationships established between all the partners of the company. Thanks to coordinated management of suppliers and customers,

companies may improve their performance.

3. Information systems and information technologies (IS/IT). They are an important issue for companies as they create new organisational configurations like supply chain networks (Mentzer et al., 2000). IS/IT reduce the geographical and cultural distance between supply chain partners who are increasingly distant and exigent. Moreover, partners can be managed simultaneously, thus increasing supply chain reactivity. Among the major inter-organisational IS, companies frequently develop enterprise resource planning (ERP), warehouse management system and transportation management system.

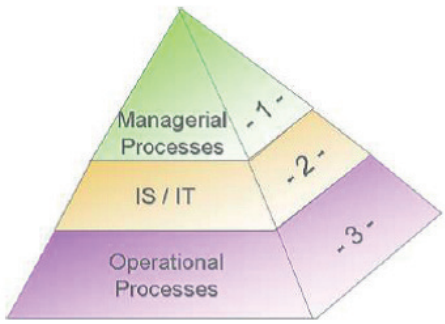

Fig. 1. Innovative supply chain practices levels
Source: (Ageron et al., 2013, p. 267).

But in spite of this consideration, the academic literature specifically focused on SCI is still poor as well as empirical studies about this topic (Caniato et al., 2013). Furthermore, empirical firm-level studies of the effect of ICT on innovation performance focus on the „hard" ICT capital (mainly on ICT equipment) and neglect the role of the „soft" ICT capital (for example ICT knowledge and skills), though its importance for the exploitation of the potential of the hard ICT capital has been widely recognized in information systems (IS) research (Wade & Hulland, 2004; Ravichandran & Lertwongsatien, 2005; Liang et al., 2010). The literature on innovation in a supply chain context mainly addresses product development (Ageron et al., 2013). Some research has been conducted on innovation in SCM in the context of logistics service providers (Selviaridis & Spring, 2007; Little, 2007). Under the combined pressures of cost, lead time and quality, and with the goal of improving supply chain performance, suppliers, producers and customers attempt to construct and develop innovative inter-organisational relationships (Ageron et al., 2013). Bello et al. (2004) observed that innovations in SCM rely on information systems and information technologies (ISs/ITs) developments associated with new logistics methods. Roy et al. (2004) argue that two main factors influence innovation: internal factors related to inter-firm relationships (commitment, IT adoption, trust, and so on) and factors external to inter-firm relationships (demand stability, network connections, and so on). These opinions are very interesting as they highlight that innovations can either be internal to the innovating companies or external and related to the whole supply chain.

2. Innovation, knowledge and the learning process

There is a strong relation between innovation and knowledge absorbing. The literature on Knowledge Based View (KBV) associates knowledge with superior firm performance, considering knowledge as the most important strategic resource and the fundamental basis for innovation capability and competitive advantage (Yazdanparast et al., 2010). Especially knowledge used in process improvements leads to superior organisational performance (Panayides & So, 2005; Richey et al., 2005). Knowledge was also recognized as an organisational resource that influences logistics innovation (Grawe, 2009; Chapman et al., 2003). KBV also supports the relationship between innovation and competitive advantage by emphasizing that the ability of a firm to integrate and apply its acquired knowledge (in the form of more relevant and/or innovative offerings) is a critical factor in achieving competitive advantage (Matusik & Hill, 1998). Due to this point of view the main factor that allows the firm to succeed is the knowledge of what the firm does, how it is done, and why it is done that way (Zack, 2003). Knowledge in organisations is related to structures and processes of the organisation (Davenport & Prusak, 1998). Organisations tend to use knowledge in explicit form, which is easy to store and transmit through language (Rantapuska & Ihanainen, 2008). To be successful, it is necessary for firms to absorb internal and external knowledge, combine them, create new knowledge capabilities and apply the knowledge (Cohen & Levinthal, 1990). Firms' knowledge capability (technological and organisational), is important driver of innovation. Firms that invest in building

this capability are likely to induce further innovation (Baumol, 2002). Firms build capabilities by reflecting on the value of the work performed and applying integrative principles that allow multiple processes to be synchronised (Soosay & Sloan, 2005).

The literature about innovation has widely addressed the contribution of dynamic capabilities to enable successful innovations (Eisenhardt & Martin, 2000; Gebauer, 2011). Dynamic capability theory is well suited to organisational innovation, not being specifically related to a single technology and being easily related to the development of new processes, systems and business models (Lawson & Samson, 2001). Dynamic capabilities are defined by Teece and Pisano (1994) as „a subset of the competences which allow the firm to create new products and processes and respond to changing market circumstances". Verona (1999) distinguished dynamic capabilities on the basis of the type of knowledge they contain (that is functional capabilities to allow technical knowledge; integrative capabilities to absorb knowledge from external sources; innovation capability to mould and manage multiple capabilities). Caniato et al. (2013) suppose that the identification of the roles of dynamic capabilities for SCI has still to be studied.

The helping tool is the framework for creation of innovation, new knowledge capabilities and consequently new value and the prospective competitive advantage. It consists of three phases (Yazdanparast et al., 2010):

- the learning phase (knowledge absorbing),
- the innovation and execution phase,
- the outcomes phase – gaining new value and the prospective competitive advantage.

In the learning phase the key factors are interactions (also based on communication) designed to encourage learning between the members of supply chain. In the second and third phase (innovation, execution and outcome), the utilization of the knowledge acquired in the learning phase leads to design and implement innovative solutions and to gain a competitive advantage. The innovations developed through this process influence the performance of the firm in terms of quality, efficiency and effectiveness (Yazdanparast et al., 2010).

Dickson (1992) suggests that firms that do the best are those firms that learn most quickly in a dynamic and evolving competitive market. Learning is a capability that enables other capabilities such as collaboration, agility (Christopher, 2000), flexibility (Fawcett et al., 1996; Morash & Clinton, 1997), and innovation (Flint et al., 2008), all of which are important for building competitive advantage.

The learning process may be divided into four stages (Yazdanparast et al., 2010):

- information acquisition,
- information dissemination,
- shared interpretation,
- organisational memory.

Learning was defined as the process of absorbing, involving, and integrating external and internal knowledge resources (Grant, 1996). This term may be also defined as the ability to integrate and utilize pieces of knowledge. Learning from new members of supply chain or firms from outside this structure, who have specific and utilitarian knowledge, the company did not previously have, may provide new insights into strategy, choice of managerial tools, supply chain organisation and relationships within the whole structure. Flint et al. (2008) found that supply chain learning leads to logistics innovation. Thus, to gain competitive advantage, managers need to create opportunities for absorbing, involving, and integrating external knowledge resources with internal knowledge resources and apply the resultant learning to the production of goods and services (Grant, 1996).

Also, ICT have the potential to support and enhance significantly the collection and management of innovation-related knowledge, the innovation production and the external innovation collaborations, increasing the productivity of firms' innovation creation processes (Thomke, 2006). It has been widely recognized that information and communication technologies (ICT) have a great potential not only to improve the efficiency of the established business processes of firms, through which their usual products and services are produced, but also to facilitate and drive innovations both in their processes, and in the products and services (Arvanitis et al., 2013). Reduction of information processing and transfer costs offer huge capabilities and opportunities for radical innovations in the organisational processes, new product and services development. The emergence and growing penetration of ICT lead to the gradual realization of its great potential not only to improve the efficiency of established business processes of firms, through which their usual products and services are produced, but also to facilitate and drive important innovations in their processes, and also in their products and services (Arvanitis et al., 2013). Finally, there is

another more recent theoretical research stream dealing with the potential of ICT to increase the productivity of firms' research and development (R&D) and innovation creation processes, which can result in higher innovation performance (Thomke, 2006; Dodgson et al., 2006; Kafouros, 2006; Gordon et al., 2008; Kleis et al., 2012). This theoretical literature concludes that ICT can significantly help improving the collection, management and exchange of innovation-related knowledge. They enable firms to easily and rapidly share knowledge assets. Furthermore, ICT allow a better communication and exchange of knowledge among firm's employees from different functions and disciplines, and this facilitates the combination of scientific and operational knowledge from different domains, which according to the relevant literature (Rogers, 2003; Nerkar & Paruchuri, 2005) is of critical importance for innovation. The application of ICT provide the required links for effective research partner monitoring and information sharing, as well as reduce the transaction costs of working with multiple innovation partners (Arvanitis et al., 2013).

3. Information and knowledge management in supply chains

Development and implementation of innovation requires proactive information and knowledge management within the organisation. Similar requirements concern transfer of innovation in the supply chain except that in this case information and knowledge management needs to be coordinated within a complex business system consisting of many various entities. Information and knowledge are closely related to each other. In a broader context R. L. Ackoff (1989) distinguishes five categories with data, information, knowledge and understanding relating to the past, and wisdom dealing with the future. Data is raw. Information is data that has been given meaning. Knowledge is the collection of information suitable for occasion. Understanding is essential to generate new knowledge and reflects the learning process. Wisdom goes far beyond understanding and gives understanding about what used to be given no understanding so far. This is why the transition from data to information, to knowledge, and finally to wisdom is essential to be innovative. The ICT investment is basically a learning process in which decision makers creates and distribute knowledge at organisational and individual levels (Rantapuska & Ihanainen, 2008).

The need to have high quality knowledge and great wisdom manifests itself in the fact that the information is sought in increasingly larger data sets now. Analysts are looking for new methods and applications of data analysis, because these previously known become insufficient. The term 'big data' has been coined to express the scale of the problem. Collecting and processing big data is particularly challenging in the supply chain, but the potential for its use is huge and untapped so far (Marciniak & Szymczak, 2015).

Information and knowledge management is gaining importance and managerial attention in the face of business process outsourcing and offshoring. Outsourcing of several kinds of activity, for example outsourcing of research and development, ICT,

Tab. 1. Similarities and differences in the field of information and knowledge management in the surveyed companies

	Companies not using ICT outsourcing	Companies using ICT outsourcing
Key area of information management	Data mining	Decision support and expert systems
Most commonly used tools	CRM EDI	CRM EDI
Preferred data processing model in the future	Workflow management	Workflow management SOA/SOC Cloud computing
Knowledge creation	Collectively with closest partners	Collectively with closest partners
Rationale behind co-operation in knowledge creation	Knowledge resources Risk of mistakes Range of proven ready-to-use solutions	Technology advancement Lower new product development cost Range of proven ready-to-use solutions

logistics service, manufacturing of goods, semi-products or components, is making contemporary supply chains more and more knowledge-based. The pressure to outsource processes and functions seems to be growing and this phenomenon is undoubtedly gaining momentum. Members of supply chains create competitive advantage by assembling resources (both internal and external, domestic or foreign) that have to work together. Vargo and Lusch (2004) identified operand and operant resources (operant resources are employed to act on operand resources). Operand resources are defined as those resources on which an operation or act is performed to produce an effect, they are static and require more dynamic operant resources (such as technology and know-how) to make them useful. Thus organizations may develop competences and capabilities through fundamental knowledge and skills, that is operant resources. These resources, such as embedded knowledge and skills, can manifest themselves as core competencies, capabilities, and organizational processes, which are vital to the creation of innovation, value and the competitive advantage (Vargo & Lusch, 2004). Thus, to gain competitive advantage, the integration of external knowledge resources with internal knowledge resources seems to be necessary. Organization's ability to assemble, integrate, and deploy these resources depends strongly on ICT system efficiency and management's ability to consolidate technologies and skills of members of a particular supply chain. Consolidated knowledge, information and skills facilitate quicker adaptation to changing opportunities. Currently business process outsourcing and offshoring certainly benefit from dynamic development in communications and computer systems on the other hand, which eliminated the issue of distance, marginalised cultural differences and removed obstacles to trade in services. The findings of the 2009 Fourteenth Annual Third-Party Logistics Study indicate that the key success factors for good relationships between members of supply chain are transparency and good communication (Langley & Capgemini, 2009).

4. Research methods and preliminary findings

Therefore, it became important to establish priorities and reveal good practices for information and knowledge management in supply chains practising outsourcing and offshoring. It was one of the objectives of the research project no. 4232/B/H03/2011/40, conducted from January to October 2012, financed by the National Science Centre, Poland. The first stage of research was focused on the recognition of the „soft" managerial issues and approaches used within particular enterprises being members of various supply chains. An important thread of the research concerned the information and knowledge management. The research involved carrying out a questionnaire survey of manufacturing companies located in Poland. In total, 426 companies were researched at the preliminary stage of the study. At the final detailed stage of the study 139 responses (CATI and direct interviews) were analysed.

On this basis we could formulate specific recommendations for information and knowledge management (Szymczak, 2013) as they form preliminary findings of the research:

- information management should adapt to a business model based on business process outsourcing and offshoring. Operation under new business model drives significant changes within the dependent information system and forces a new approach to information management. Its inherent feature should be flexibility that is a key component of defining how successful enterprises are run under these conditions. Availability of the state-of-the-art group work platforms that boost effectiveness in dispersed environments and streamline work on large projects that involve various units – company's own and/or partners – in different locations worldwide goes in-line with these requirements;
- companies that outsource and offshore processes should think about the implementation of more advanced, preferably innovative information management solutions. Analysed companies exhibit a comprehensive approach to information management in general and perform analysis in all the most important areas of their operation. The research shows that companies use many state of the art solutions in the field and many of them successfully adopted adequate information management models for supply chains. They should review the solutions and models once in a while however, due to the rapid development of ICT. From the supply chain management perspective especially cloud computing and software agents should be considered as well as workflow management software. As claimed by

T. L. Friedman (2005), it is mainly software which supports and automates workflow management and group work that has become a tool to ensure effective company operations in the offshore model. W. van der Aalst and K. van Hee (2002) perceive these systems as the last (as for now) stage of developing information systems supporting business processes, in which the main emphasis has been placed on decentralising information system support for tasks performed and „discharging" them from the supervision of only a single autonomous application;

- there is no way towards supply chain's excellence without collective knowledge management. The study showed that collective knowledge management is the domain of companies whose supply chains are at the highest maturity levels. Maturity means operational excellence and the ability to respond to market conditions in a manner that allows to gain and sustain competitive edge. In the contemporary supply chain management more and more non-routine tasks are undertaken. Neither algorithms nor procedures but knowledge itself is needed for them to be properly executed. For supply chains substantial knowledge resources is a must to achieve performance excellence. Generating knowledge at the level of a specific business unit or at corporate level may not be sufficient in today's business environment. Significant knowledge resources exist outside the organisation. To reach for them collaboration may involve the closest partners in the supply chain. This is a good point to start from before a larger network of partners is created.

5. Research results

There are a lot of available information and knowledge management models, methods and tools, such as: data mining (sometimes called knowledge discovery), query & reporting, online analytical processing (OLAP), decision support, knowledge-based and expert systems, customer and supplier relationship management systems (CRM, SRM), warehouse management systems (WMS), supply chain management systems (SCM), cloud computing, service oriented architecture and computing (SOA/SOC), workflow management systems to name the most important ones. They fit into the business information system alongside the widespread enterprise resource planning (ERP) systems, electronic data interchange (EDI) or automatic identification and data collection (AIDC) or mobile technologies.

The general trend towards outsourcing (both inshore and offshore outsourcing) is also subject to ICT. Not all companies surveyed exhibit practice in the field. Thus may be of interest a juxtaposition of results showing whether and how the approach to the information and knowledge management varies depending on whether the company uses outsourcing in the field of ICT or not. Only some of the 139 companies surveyed responded to additional detailed questions concerning ICT and knowledge management and entered next stage of research. In this regard 50 companies were examined and have been taken into consideration in the analysis herein.

Among these companies there are 26 that use ICT outsourcing (52%). Others do not. Both subordinate information and knowledge management mainly to distribution management and sales (76% in case of companies using ICT outsourcing and 58% in the other group). In the case of companies that do not use ICT outsourcing, the focus is also on manufacturing management (54%). One can say that information management is bended to suit the supply chain on the outbound side of a company. Still, it remains more obvious in companies that use ICT outsourcing. Tab. 1 shows the similarities and differences in information and knowledge management. They include issues that were the subject of detailed questions in the research survey.

Differences occur in the context of key area of information management. Companies that do not use ICT outsourcing as a key area in this regard primarily consider data mining (19.2%). Those practising ICT outsourcing pointed out decision support systems and expert (28.6%). This probably results from the fact that data mining is one of the most commonly outsourced areas in the field of information management. If a company itself does not practice data mining, it rather focuses on more advanced activities related to increasing operational effectiveness and performance. They include computer-aided decision making. Advanced tools in this area are just decision support and expert systems. Such systems – often highly individualized and tailored specifically to the needs of a business entity – are installed at the company premises and used on-site in the relevant areas of decision-making. Usually

they are not subject to outsourcing.

In both groups companies most commonly used tools such as CRM and EDI and their use is a little bit more characteristic for companies that do not outsource ICT – 14,3% vs. 19,2% of respondents. This may suggest that companies using ICT outsourcing have no need to use CRM software on their own, because they purchase services for the management of data coming from sales and customers. Striking is, however, a much higher rate of EDI utilization in companies not practicing ICT outsourcing. This popular tool is used by almost every business entity today with the possible exception of only small local businesses. This research result means that companies using outsourcing in the field of ICT also outsource EDI communication (Web EDI/Lite EDI). This result is not surprising if one considers that among the surveyed entities there were many small and medium size companies. They usually do not want to invest in EDI infrastructure deciding on the mediation of specialized operators. EDI communication is then performed through a standard Web browser.

The surveyed companies represent a common view relating to the preferred data processing model in the future, that would be preferred for supply chains. In both groups a large representation of businesses indicates workflow management in this regard. Enterprises using ICT outsourcing additionally mention SOA/SOC and cloud computing. This is probably the experience of those entities. It is hard to use ICT outsourcing services not benefiting from SOA/SOC and cloud computing models. Especially the latter has been doing a sensation lately. In addition, it should be noted that the indications of the respondents do not conflict. Workflow management tools are transferred to the SOA/SOC and cloud computing model. This will probably be the model of collaboration in a distributed business environment, which is the supply chain.

The study proved that significant knowledge resources exist outside the organisation. The largest share of surveyed companies (32%) was in favour of cooperation within the supply chain in this area. This cooperation usually does not go beyond the circle of first tier suppliers and customers but it usually gives a head start to broaden the relationships. Only 8% of respondents admitted to working as part of a much wider business network. In the field of knowledge management the study showed no difference between the entities involved in the outsourcing of ICT and others.

Collective creation of knowledge in all surveyed companies was associated with new product development (besides many other reasons). In the case of companies using IT outsourcing 70% of them believe that in the case of product design, development or utilization of outside resources produces better results than using internal resources.

This shows the importance they attach to new product development and the pursuit of innovation in the product range. Companies recognized that it is primarily where they need to use knowledge. The study revealed differences between companies in terms of direct rationale behind co-operation in the field of knowledge creation. Companies not using ICT outsourcing want to create knowledge collectively mainly because of the size and value of knowledge resources their partners have (54,5%). Those using ICT outsourcing as the main reason indicate access to technological advances (50%). This can be interpreted twofold. Either these companies are definitely technologically oriented, or based on their own R&D capacity, they are not able to develop products or services that have a clear innovative or technological advantage. Another reason for co-operation in this group of companies is lower new product cost (37,5%) while companies that do not practice ICT outsourcing as the second reason indicate the desire to avoid mistakes and accompanying risk (45,5%). Among the most important reasons for co-operation in knowledge creation companies representing both groups indicate unanimously access to a wide range of ready-to-use solutions that have been tested already by the partner and whose quality has been confirmed on the market.

The study showed that new product development is usually the domain of companies' own research and development department. This is the case in most of the surveyed companies (72%). New products are result of a collaboration with external research centres within 18% of surveyed companies, and this group is dominated by companies using ICT outsourcing. Independent new product development forces investment in ICT. This usually means a big investment effort as it represents the need to purchase highly specialised computer equipment and software. These are, for example, drawing and painting software, CAD/CAM applications, modelling and rendering software, product simulation software, range imaging sensors, 3D printers. These tools provide a starting point to sketch, draw and paint a designer's vision with emulation of real life materials,

develop digital models, thoroughly review them together with stakeholders to get better control over project outcomes, then develop a prototype, assess its features and capabilities, and finally deliver great products.

Conclusions

It's beyond doubt that a high level of process innovation and a quick cycle of new product development can make it possible to satisfy customers' needs in a short time. In the supply chain it can be achieved through a collaboration with external entities. In this kind of collaborative approach effective communication is a must. This is why investments in ICT or ICT outsourcing (or an appropriate arrangement of both) have the potential to streamline the creation of innovation and its transfer throughout the supply chain. ICT is becoming an increasingly important infrastructure of innovation due to the gradual move from the „internal innovation" point of view in which firms generate internally ideas for innovative products, processes and services, to a new „open innovation" view in which they then develop, produce, distribute and sell them. In this view internal and external capabilities, skills and knowledge (from employees, suppliers, customers, outsourcees, research institutions and so on) are combined in order to create better innovations in a shorter time and promote them throughout the supply chain in order for it to gain extra value and competitive advantage. The research results highlight that innovations in various fields (ICT, knowledge management, new product development) can either be internal to a company or external and related to the whole supply chain.

Innovations based on ICT aim to increase collaborative relationships between supply chain partners. Close collaboration between them is crucial in terms of knowledge creation and transfer. The results prove that significant knowledge resources exist outside the organisation. All surveyed companies declared that internal resources are more valuable only if it comes to knowledge of the industry and of customer expectations. This indicates the importance of the experience gained. The study shows that if a company is open to cooperation in the ICT area, it is usually more open to cooperation in other areas. This means that ICT outsourcing can lever co-operation, networking capabilities and relationship creation ability in the supply chain, which is the base for further innovative development and implementation of innovative solutions in the future.

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