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External Knowledge Sourcing and Innovation Processes in Modern Economic Environment

Abstract

In an open and digital economy where ICTs, global networks and innovation systems play a key economic role, knowledge used by companies is increasingly gathered using different external sources. Rapidly changing technology enables companies to use new ways to innovate. New innovation processes permit companies to reduce risk and the costs of innovation. New paradigms, called open innovation and co-innovation, allow organizations to remain innovative in a rapidly changing environment. The objectives of this paper are: to provide a better understanding of open innovation and co-innovation paradigms and to suggest instruments for organizations to benefit from co-innovation ecosystem.

Internet empowered ICT tools can be the first step for an organization to initiate implementation of a digital strategy. To gain incremental, tacit, organizational knowledge or marketing skills, a new innovation strategy should involve networking through social networks and virtual communities. Digitalization of innovation activities constitutes a new important role for innovation networks and ecosystems, including global innovation networks, as knowledge and technology are no longer owned by a single firm or country. This paper attempts to prepare the theoretical background, for empirical studies on the impact of new innovation processes on company innovation and their competitive advantages. The study is descriptive and analytical, building on the theory and empirical results of previous studies on new, digital innovation models.

Keywords: external knowledge, innovation management, innovation process, co-innovation, open innovation

JEL: L17, M11, M21

Introduction

In non-globalized and non-networked economy, companies' knowledge-sourcing decision faced two simple choices, either to create knowledge internally, or transfer technology through trade in capital goods or intellectual property rights. Technological revolution and digitalization influenced innovation processes models and cooperation structure. In an open economy, where global networks and innovation systems play important economic role, technologies implemented in companies are increasingly created using different external knowledge sources. New models of innovation processes enable companies to reduce both risk and costs of innovation.

The objectives of this paper are: to identify sources of external knowledge, provide better understanding of open innovation and co-innovation paradigm, indicate instruments which could be implemented by organizations to benefit from co-innovation ecosystem. This paper also provides the theoretical background for empirical studies on the impact of new innovation processes on companies' innovation and their competitive advantages.

To meet these objectives the literature on innovation economics and innovation management was reviewed. Our study has a descriptive and analytical nature, as it builds on the theory and empirical results of previous studies a new digital innovation models. Using this methodology we hope to contribute to a better understanding of modern innovation management process in the age of digital transformation.

In the first part of the paper we present the basic terminology connected with innovation management and a literature review on the relationship between external knowledge and innovation in organizations. In the second part, we analyze different approaches to external knowledge sources and examine how innovation process models have changed over time. In the third part, we focus on the characteristics of open-innovation and co-innovation models as well as knowledge sourcing processes used in those models. The fourth part includes a description of modern tools for collaboration and networking in a co-innovation environment. In this section, we show how organizations can use ICTs to influence their innovation processes. The paper ends with a summary and conclusions.

External Knowledge and Innovation. Terminology and Literature Review

According to the literature, innovation and technical changes are main determinants of economic growth [Solow, 1957, pp. 312–320]. Du Plessis states that innovation is the creation of new knowledge and ideas to facilitate new business outcomes, aimed at improving internal business processes and structures and to create market driven products and services [2007, p. 3]. Innovation is connected with change and organizations use it to influence an environment or in response to changing environments [Damanpour, 1991]. Innovation can be described as new knowledge implemented on the market. Without new knowledge innovation cannot be created. Consequently, issues like knowledge-capital, innovation process, and innovation management are very important research topics.

Knowledge-capital is necessary for innovation. It also determines the effectiveness of innovation process. Knowledge-capital is described as a set of information and knowledge produced, acquired and used in the value creation process [Laperche, Liu, 2013]. The process of creating knowledge is usually costly in terms of time and money. In a dynamic and competitive economic environment, internal resources are not sufficient to create knowledge, effectively making external knowledge sourcing a crucial process in modern organizations. External knowledge sources enable firms to cope with such changes as shorter product life cycles and increasing R&D costs [Porter, Stern, 2001, pp. 28–43].

The innovation process model is a theoretical concept that is useful to analyze the sources, flows and implementation of knowledge in organizations. Innovation is the result of a process whose phases form cycles, called the technique development cycles. Such a cycle lasts from the initial expenditure on research to completion and implementation (end of expenditure) [Jasiński, 1997, pp. 13–26]. This definition implies that the innovation process starts with an ideation stage, which involves mining knowledge sources for new products or processes, and continues to a product development and commercialization stage. The new knowledge acquired by the organization may not have a technological character. Instead, influencing skills, organizational and marketing knowledge can lead to innovation. External knowledge can be applied not just to generate new products but also to improve existing ones. The concept of ambidextrous organizations stresses that organizations need to simultaneously develop exploratory/radical and exploitative/incremental innovations, to meet the needs of emerging customers or markets [Benner, Tushman, 2002, 2003].

The relationship between innovation and the use of external sources of knowledge has been well-researched. Literature confirms that suppliers and customers' engagement in the innovation facilitate innovation [von Hippel, 1998, p. 4] and further influence development and profiting from innovations [Calantone, Stanko, 2007]. External knowledge and information help companies grow in rapidly changing business environments.

Research shows that external sources of information are essential for effective innovation activity. Firms that implement open innovation and use different information sources have a greater capacity to generate innovation [Levitt, March, 1988; Gomez, Salazar, Vargas, 2016; Svetina, Prodan, 2008; Lee, Huh, 2016; Grant, 1996]. Despite the wide range of potential benefits, the positive external knowledge effect depends on proper knowledge absorption. External knowledge implementation process is neither easy nor automatic. The effectiveness of external knowledge use depends on organizational knowledge capacities, defined as “firm’s critical capabilities of managing internal and external knowledge, which include: inventive, absorptive, transformative, connective, innovative and desorptive capacities” [Lichtenthaler, 2009]. Among those capabilities, absorptive capability is the most frequently researched and recognized. Absorptive capacity is defined as the ability of a firm to recognize the value of external information, assimilate it and apply it to commercial ends [Cohen, Lvinthal, 1990]. The strategy of external knowledge use should be consistent with organizational resources and long-term goals. It is important for firms to use external knowledge sources according to their internal capabilities [Cohen, Lvinthal, 1990]. It is not the knowledge acquisition but effective implementation that can bring positive results for organizations. The positive impact of external knowledge on innovation and competitiveness depends also on the balance between a firm’s reliance on external sources and in-house R&D activity. Research confirms that beyond a specific threshold, a greater share of external R&D activities reduces a firm’s innovative performance. The greater a firm’s R&D capacity, the more noticeable the substitution effect [Berchicci, 2013]. In addition, when firm’s knowledge is relatively tacit, external contracting is more viable, due to the lower threat of knowledge outflow to the contractor [External sources of knowledge..., 2001].

External Knowledge Sources and the Evolution of Innovation Process Models

Modern organizations need external knowledge to innovate and compete. There are many different forms and sources of knowledge as well as channels to acquire it, and quantifying this process is challenging. In this research we identify the most important and commonly used sources of external knowledge based on selected literature. The OECD methodology [OECD; Science, Technology and Industry Scoreboard, 2015] presents a wide range of external knowledge sources, divided into three groups: The first group (market sources) includes: suppliers of equipment, materials, components or software, clients or customers, competitors or other enterprises in the same sector and consultants, commercial labs or private R&D institutes. The second group (institutional sources) includes: universities or other higher education and government or public research institutions. The

third group (collaboration) involves active participation in joint innovation projects with other organizations, jointly implemented innovations with customers and suppliers, as well as partnerships with other organizations – and excludes contracting-out of innovation.

Eurostat methodology [Eurostat, Innovation Statistics], on which official EU statistics are based, considers the following sources of external information: suppliers of equipment, materials, components or software within the enterprise or enterprise group, clients or customers from the private sector, conferences, trade fairs, exhibitions, competitors or other enterprises in the sector, scientific journals and trade/technical publications, consultants or commercial labs institutes, professional and industry associations, clients or customers from the public sector, government, universities, and private or public research institutes.

Research conducted by the Spanish Technological Innovation Panel (PITEC), managed by the Spanish National Institute of Statistics emphasizes the importance of such external sources as: materials, suppliers of equipment, components or software, customers, competitors or other enterprises in the sector, consultants, commercial labs or private R&D institutes, and universities or other higher education institutions. According to the methodology used by Svetina and Prodan [2008], external knowledge sources are: interactions with clients and/or suppliers cooperation with other companies, public institutions and research centers, local government, semi-public institutions, industry associations, consultants, trade unions and private research centers (analyzed in three dimensions: local, national, international). Further, Tidd and Trewhella view external sources as suppliers and customers, contract research, licensing, alliances, and universities [1997].

Table 1 lists, the main external knowledge sources, developed and adopted in OECD methodology (with limited, mostly semantic, changes) and national statistical sources, as well as empirical scientific research.

TABLE 1. Sources of external knowledge according to different methodologies (OECD methodology is presented as a benchmark)

OECD	Eurostat	A. C. Svetina and I. Prodan	Spanish National Institute of Statistics	J. Tidd and M. Trewhella
suppliers of equipment, materials, components or software	+	+	+	+
clients or customers	+	+	+	+
competitors or other enterprises within the same sector	+	+	+	+(alliances/ licensing)
consultants	+	+	+	-
commercial labs or private R&D institutes	+	+	+	+(contract research)

OECD	Eurostat	A.C. Svetina and I. Prodan	Spanish National Institute of Statistics	J. Tidd and M. Trehwella
universities or other higher education institutions and government or public research institutes	+	+	+	+
active participation in joint innovation projects with other organizations	-	-	-	-
-	conferences, trade fairs, exhibitions	-	-	-
-	scientific journals and trade/technical publications	-	-	-
-	professional and industry associations	-	-	-

S o u r c e : own elaboration, based on documents mentioned in this section.

This approach to research on external knowledge omits sources associated with the dynamic growth of information and communication technologies (ICTs), including those associated with online/virtual communities. The traditional approach does, however, help counteract some ambiguities when, for example, customers, suppliers or other companies are key elements of online communities and platforms. Considering them a separate channel could result in double-counting. Consequently, instruments such as the Internet, online communities, and platforms (including crowdsourcing) are better characterized as mechanisms to access knowledge, instead of traditional, external knowledge sources. To be effective in the digital economy traditional channels of knowledge transfer need to be supported with ICTs empowered tools. Table 2 presents relations between traditional and digital mechanisms for external knowledge acquisition.

Improved access to external knowledge and new forms of collaboration in organizations influences changes in innovation and knowledge management, as well as innovation modeling structures. It is worth considering research on five generations of innovation models [Rothwell, 1994]. The first and second generations are simple linear models, which can either take market pull or technology push variants. The third generation is a coupling model, recognizing interaction and feedback loops between market needs and research and the development sector (state of science and technology). It focuses on integration of the two above-mentioned generations. The fourth generation is called the parallel (interactive) model. It concentrates on internal firm integration with key customers and suppliers, and also includes external linkages and alliances. The fifth generation innovation model characterizes system integration and extensive networking, flexible and customized response, and continuous innovation. In that model, strategically directed integration within external agencies is critical. Networking, used extensively in that model, relies

on a sophisticated electronic toolkit in design and development activities. The literature also describes a sixth generation model in which a company's capability to acquire new knowledge is the most important element. Simultaneous interactions and continuous improvement are keys to expanding innovation.

TABLE 2. The comparison and relations between traditional and digital mechanisms for external knowledge acquisition

External knowledge source	Traditional mechanism for acquisition of knowledge	Digital mechanism for acquisition of knowledge
Suppliers of equipment, materials, components or software	Formal agreements, discussions, conferences participation	Platforms, online communities
Clients or customers	Feedbacks, marketing research	Platforms, online communities
Competitors or other enterprises in the same sector	Corporate venturing, clusters, discussions, conferences participation	Platforms, online communities
Consultants	Formal agreement	Online communities
Commercial labs or private R&D institutes	Formal agreement	Platforms
Universities or other higher education institutions and government or public research institutes	Formal agreement	Platforms
Active participation in joint innovation projects with other organizations	Formal agreement	Online communities
Conferences, trade fairs, exhibitions	Active, formal participation	Webinars, teleconferences
Scientific journals and trade/technical publications	Trade	Online access
Professional and industry associations, semi-public institutions such as chambers of commerce, industry associations, trade unions	Active formal participation	Online communities,

Source: own elaboration, based on literature used to prepare that paper.

Other classifications of innovation models were developed by Lee, Olson, Trimi [2012, p. 822]. Those authors believe that the innovation process has undergone evolutionary steps during the past three decades, and have indicated four different models: closed innovation, collaborative innovation, open-innovation, and co-innovation. The level of openness is a distinctive feature in this classification regime. The closed innovation process corresponds to first, second and third generation of innovation modeling, according to Rothwell. The fourth generation should be classified as collaborative innovation model, which leads

to value creation. This model relies on a co-development method with a selected partner, for example, a supplier (table 2), and is mainly bilateral and based on a formal agreement.

In addition, Marinova and Philimore [2003] further examined innovation models, relying on Rothwell's typology. Their first-generation model is a black box model, which claims that the innovation process itself is not important. Second and third generation models correspond to the linear, coupling and interactive models in Rothwell's classification. These three first generation models should be classified as closed models. The three remaining models correspond to an open innovation paradigm and will be discussed in the next section of this paper.

The innovation model classifications presented above suggest important changes in the innovation creation process. Key differences include the extent and form of external relations. Interdependencies between different classifications are presented in table 3, below, where the Rothwell classification is presented as a benchmark.

**TABLE 3. The comparison of different approaches to innovation models
(Rothwell classification is presented as a benchmark)**

Lee et al.	Rothwell	Marinova and Phillimore
x	x	The black box model (1 generation)
Closed innovation	1 generation	Linear model (2 generation)
Closed innovation	2 generation	Linear model (2 generation)
Closed innovation	3 generation (coupling model)	Interactive model (3 generation)
Collaborative innovation	4 generation (parallel/integrated/ interactive model)	Interactive model (3 generation)
Open innovation	5 generation (networking model)	System model (4 generation)
Co-innovation	x	Evolutionary model (5 generation)
x	x	Innovative milieu (6 generation)

S o u r c e : own elaboration, based on publications mentioned in this section.

Open Innovation and Co-innovation as Modern Approaches to Knowledge Sourcing Processes

Openness is necessary to acquire external knowledge, to share knowledge, to overcome challenges and increase profitability. The developments and trends such as globalization, increased technology intensity, technology fusions, new business models, and knowledge leveraging make open innovation model more appropriate [Gassmann, 2006]. Open innovation models consider the integration of both internal and external sources of knowledge into the innovation process. According to this approach, firms need to evaluate all internal and external resources [Chesbrough, 2003]. Open innovation is based on a multi-agent relationship where internal R&D is complemented by a Connect and Develop function [Lee, Olson, Trimi, 2012]. Traditionally, these forms of relationships include: alliances, joint-ventures, and joint development centers. They tend to be formalized, relying on long term contracts. The basic idea of open innovation is to build a world-class value chain through a new innovation ecosystem where various complements are part of regional innovation process [Cooke, 2002]. Porter's cluster theory is considered a local and regional development tool [Swords, 2013] as clusters affect national and international competitiveness. Research on clusters provide knowledge on modes that companies, institutions, and government can influence innovativeness and enhance competitiveness [Porter, 1998].

This concept, as well as national innovation and global innovation systems, are theoretical underpinnings more relevant from a macroeconomic than an innovation management perspective. However, as indicated by the fourth and sixth generation models, the economic environment influences dynamics of innovation process. Open innovation based on outside knowledge provides the opportunity to share knowledge with external partners, increasing the number of institutions involved in that processes.

Openness is a part of digital economy², as knowledge can be accessed and managed using ICTs. That ability has influenced further developments in the innovation process. The new global business environment is characterized by permanently networked interdependent entities. In this world, innovation models can be seen as a platform where different ideas and complex projects are developed and solved, permitting easy and competitive value creation. In the literature that process is called co-innovation. The core of co-innovation includes engagement, co-creation, and a compelling experience for value creation. Co-innovation is open to the world platform primarily in marketing and commercial activities (as opposed to R&D). In the process of co-innovation collective intelligence and crowdsourcing are possible through formal channels and social networks. The key element of innovation is to provide a compelling experience with network effects for value creation. [Lee, Olson, Trimi, 2012, p. 818]. The goal of co-innovation is to build value, not only through new technologies, but also through finding and accessing new markets, (implementation of blue ocean strategy). It means that co-innovating leads not only to product innovation,

but also to process, organizational and marketing innovations. This approach influences strategies used to implement external knowledge and gain competitive and innovative advantage. Co-innovation uses different methods for bringing together various groups of experts, enabling the use of collective intelligence. Instruments that enable co-innovation are mainly based on ICTs, and include the internet, computers, mobile phones, smartphones, tablets, smart devices, and beacons. These devices enable unlimited access to new knowledge in real-time, and easy networking. To implement a co-innovation model in innovation processes firms are forming new business approaches, i.e., where virtual communities connect and develop ideas, products, and technologies. The meaning and the process of value creation is rapidly shifting from a product and firm-centric view to personalized consumer experiences. Informed, networked, empowered, and active consumers are increasingly co-creating such value [Prahalad, Ramaswamy, 2004].

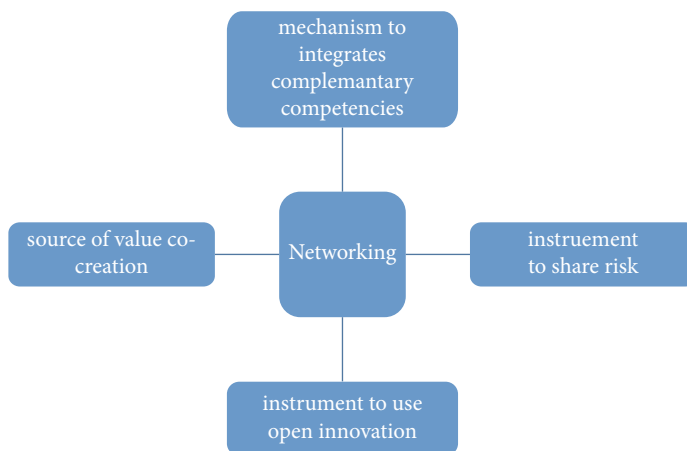
OECD methodology indicates three strategies used in an open innovation environment. The first is partnerships with external parties (alliances, joint ventures, joint development, etc.), the second is the acquisition or sale of knowledge (contract R&D, purchasing, licensing), and the third is corporate venturing (equity investments in university spin-offs or venture capital investment funds) [OECD, *Open innovation...*, 2008, p. 11] All these strategies are formal in nature. Consequently, this co-innovation model should be considered as a new, different paradigm, mainly because of its specific channels for acquiring knowledge and external knowledge implementation. The co-innovation model is based on new knowledge co-creation and not outsourcing, as is the case in other models.

Modern Tools for Collaboration and Networking in a Co-innovation Environment

Networking enhancing creation and transfer of knowledge and technology rely on tacit knowledge access. Investments in different forms of mutual learning and other forms of collaboration are associated with increased patenting [Fagerberg et al., 2005, p. 73], adding to the positive impact of networking on innovation. According to Tidd et al. [2001, p. 232] the collaboration process should lead to acquisition of new skills or competencies rather than technology or products. There is an important difference between acquiring the skills of a partner and gaining access to them. Access is possible through contracting or licensing. Internalization of a partner's skills requires closer contact, made possible through joint-ventures or strategic alliances. That kind of formal network, supported with informal collaboration, tends to bring new value to organizations. The concept of innovation networks, as a new hybrid form of organization, became an important topic for research. This research shows that networks are appropriate where the benefits of co-specialization, sharing of joint infrastructure and standards, and other network externalities outweigh the

costs of network governance [Tidd et al., 2001, pp. 214–215]. Organizations with broader networks are exposed to more experiences, different competencies, and opportunities [Beckman, Haunschild, 2002]. A number of empirical studies on the relationship between networks and innovation focus on formal, mainly bilateral contracts, indicating a strong positive relationship between alliance formation and innovation [Fagerberg et al., 2005, pp. 60–70]. The impact of informal relations was first researched by von Hippel [1989], who analyzed the relationship between engineers in rival firms, focusing on the impact of membership in professional communities on productivity. In addition, Brown and Duguid developed a concept known as the network of practice [2001]. Modern researches on networking concentrate on networking facilitated by internet and multiparty networking including open software communities. Romero and Molina [2011] mentioned strategic networks such as collaborative networked organizations (CNOs) and virtual customer communities (VCCs), which inspired the creation of values in co-creation and co-innovation processes. Networking has many important functions, which enable innovation in a digital environment, mainly through open and co-innovation model implementation. It is not just a mechanism helping to integrate, manage and implement competencies of a crowd and create value. It also helps minimize risk of innovation (see Figure 1).

FIGURE 1. Networking functions

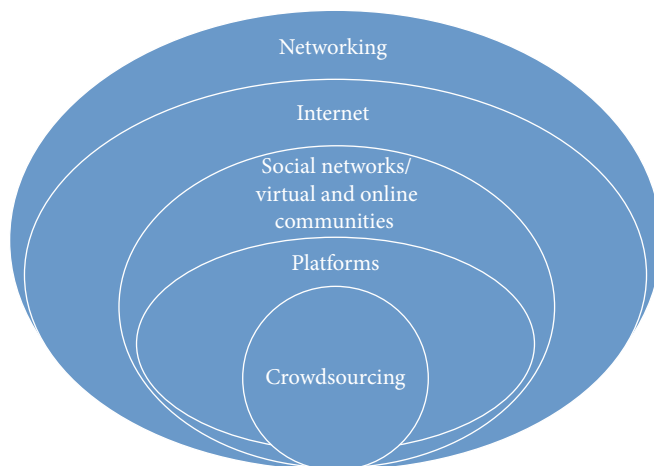


S o u r c e : own elaboration, based on: Romero D., Molina A., Collaborative networked organizations and customer communities: value co-creation and co-innovation in the networking era. *Production Planning and Control*, 2001, 22 (5-6), pp. 447–472.

In today's economic environment, the development of a firm's knowledge-capital relies primarily on cooperation among other large and small companies and/or public institutions and consumers. In a digital world, the construction of the knowledge-capital takes place in innovation networks [Laperche, Liu, 2013, p. 1]. Under this co-innovation

model paradigm, new value is created through multilateral networking, which helps firms use external knowledge effectively by managing links among partners, institutions, and consumers. The Internet has made knowledge creation and diffusion much more community-oriented, accessible, and less expensive. Using the internet, consumers exchange information, knowledge and opportunities to transform innovative ideas into new products. To be effective such processes need effective management. Networking is needed among interdependent group of entities possessing complementary resources. Inter-organizational cooperation influencing the innovation process needs to set clearly defined goals, which are publicly announced using designated platforms. The relationships between networking tools are presented in Figure 2 below. The more specific instrument used to acquire or gather knowledge, the more explicit and appropriate the knowledge that is acquired.

FIGURE 2. Interdependencies between different ICTs empowered tools for knowledge acquisition



Source: own elaboration.

In a digital economy, online communities are critical to connect users and business [Reducing the risk of failure..., 2016]. Social networks and virtual communities are also essential for understanding current changes in the business environment, which forces companies to work faster and operate globally. On the one hand, online communities are a source of knowledge that is comprised of the knowledge and opinions from particular members of the community. On the other hand online communities allow to set a strategy for future action, that emerges from the process of web analysis. Social networks are defined as web-based services that allow individuals to construct a public or semi-public profile within a bounded system, create a list of users with whom they share connections, and

view and share a list of those connections within the system [Boyd, Ellison, 2007, p. 211]. Social networks facilitate and enhance learning, creativity, collaboration, and knowledge creation, which can be shared with others [Garrigos et al., 2011]. Virtual communities are defined as technology-supported cyberspace, focusing on the communication and interaction of its participants, which build relationships among members, generate specific knowledge enabling participants to perform common functions, and collectively learn and build knowledge [Lin et al., 2008].

Channels used to acquire knowledge from the cyber crowd include internet, digital platforms connecting organizations, partners, consumers, media and other users. These platforms facilitate the acquisition and creation of knowledge in a special ecosystem supporting innovation, where all interested in specific activities can be integrated. Social networking sites also constitute such platforms. There are internal (company-specific), and external (industry-wide) platforms. From the co-innovation perspective, external (industry) platforms are more important. Platforms are the instruments that enable the communication with other firms and create business specific ecosystems. Platforms also enable the creation of complementary products, services, and technologies, and also cause network effects, which increase the value of platforms for users [Gawer, Cusumano, 2014]. This combined impact of the internet, digital technologies and platforms exists when two user groups (typically, a producer and consumer) generate network value for each other, resulting in mutual benefits that drive demand-side economies of scale. The network effects of platforms, with the biggest amount of connected users and transactions, drive value creation and scale [Accenture, Technology Vision, 2016, p. 7]. Intermediary platforms appear in different areas of the modern economy (where not only R&D platforms and open innovation software function) but also communities of innovators and creators; marketing, design and idea platforms, collective intelligence and prediction platforms, HR and freelancers platforms, and intermediary open innovation services [Board of Innovation, available at: boardofinnovations.com].

Platform value also stems from their role in enabling crowdsourcing, when applied as an instrument to source completely new knowledge addressing new problems. Crowdsourcing is a new concept and it is connected to many practices. Crowdsourcing may be connected with any type of internet-based collaborative activity, such as co-creation or user innovation [Estelles-Arolas, Gonzalez-Ladron-de-Guevara, 2012]. It is also defined as an online, distributed problem-solving and production model [Brabham, 2010] or an activity wherein the company assumes functions once performed by employees and outsources them to an undefined (and generally large) network of people. This process typically takes a form of an open call, performed by individuals or collaborative groups [Callaghan, 2016].

The literature shows that the interaction between absorptive capacity and network position has significant, positive effects on business innovation and performance. Tsai [2001] argue that networking is an effective way to facilitate open innovation among SMEs [Lee

et al., 2010]. There is also evidence that network partnership is primarily used for activities such as data collection and only used in a limited capacity strategy and decision-making [Heger, Boman, 2014]. Research confirms that for relatively small organizations, it is difficult to network with bigger, influential partners, or use crowdsourcing competitions. Small and medium enterprises (SMEs) which lack resources, do not maintain effective networks, often limiting themselves to networks necessary for co-innovation. It is worth noting the important role of state, public organization and intermediaries to transform companies in such an open environment [Hossain, 2015, p. 10]. Horizontal collaborative networks are essential for the expansion of knowledge in companies and open innovation and social networks enable that process [McAdam et al., 2014].

Summary and Conclusions

Open innovation and co-innovation involve unlimited access to external knowledge as the key element of an innovation strategy in today's economy. Models differ in terms of the forms for acquiring knowledge, external relation characteristics and the kinds of innovation, which are specific to each innovation model's implementation. The synthetic comparison of the closed, open and co-innovation models is presented below in table 4.

TABLE 4. The comparison of the concepts of closed, open and co-innovation models

Innovation model	Closed/ collaborative	Open	Co-innovation
Knowledge transfer channel	Trade/ formal agreement	Trade/ formal agreement	Networking/ online communities/ platforms
Kind of innovation which is mainly generated as an effect of specific innovation model's implementation	Product/ process innovation	Product/ process/ organizational innovation	Product/ process/ marketing/ organizational innovation
Form of relation with external partners	Bilateral/ formal	Multilateral/ formal	Multilateral/ informal

Source: own elaboration.

The development of new innovation models leads to important conclusions for organizations and economic policy. Companies' key resource in the digital economy is knowledge. Openness and co-innovation, which enable time and cost saving in acquiring knowledge, therefore need to be a critical part of a company's business strategy. In addition, human capital management should play an important role in innovation strategy, allowing effective new knowledge implementation. Priorities of modern companies should contain such elements as development of IT competencies, open culture, and diversity.

Most organizations need digital transformation to effectively access external knowledge, and that message that should be part of their business strategy. Internet tools described in this paper can be used as the first steps in digitalization and empowerment of the innovation process. The knowledge needed by a particular organization should determine the digital tools required. If an organization works in high-tech sector, where intellectual property rights play an important role, in order to acquire new, technological knowledge, it needs to turn to traditional technology transfer channels, supported by networking dedicated communities or crowdsourcing platforms. To gain incremental, tacit, organizational knowledge or marketing skills, networking through social networks and virtual communities should be included in an innovation strategy. Digitalization of innovation activities implies an important role for innovation networks and ecosystems, including global innovation networks. New innovation models are consistent with a lean innovation approach, which concentrates on rapid identification, development and testing of minimally viable products, and is also considered a more efficient learning process. Rapid technology development resulting in increasing R&D spending is insufficient to remain competitive. There is a critical role for proper network management and analytics, especially as most of digital instruments used to gain new knowledge (such as crowdsourcing), are costly when used for evaluation or data analytics.

Notes

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² The digital economy is the share of total economic output derived from a number of broad "digital" inputs. These digital inputs include digital skills, digital equipment (hardware, software and communications equipment) and intermediate digital goods and services used in production. Such broad measures reflect the foundations of the digital economy., Digital disruption: The growth multiplier – Accenture, 2016, available at: https://www.accenture.com/_acnmedia/PDF-4/Accenture-Strategy-Digital-Disruption-Growth-Multiplier.pdf, accessed: February 10, 2017.

References

- Accenture Technology Vision 2016, available at: https://www.accenture.com/fr-fr/_acnmedia/PDF-2/Accenture-Platform-Economy-Technology-Vision-2016-france.pdf, accessed: September 20, 2016.
- Beckman, C.M., Haunschild, P.R. (2002), Network learning: The effects of partners' heterogeneity of experience on corporate acquisitions. *Administrative Science Quarterly*, Vol. 47, No. 1, pp. 92–124.

- Benner, M.J., Tushman, M.L. (2003), Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of Management Review*, Vol. 28, No. 2, pp. 238–256.
- Benner, M.J., Tushman, M.L. (2002), Process management and technological innovation: a longitudinal study of the photography and paint industries. *Administrative Science Quarterly*, Vol. 47, No. 4, pp. 676–706.
- Berchicci, L. (2013), Towards an open R&D system: Internal R&D investment, external knowledge acquisition and innovative performance. *Research Policy*, Vol. 42, pp. 117–127.
- Birkinshaw, J., Fey, C.F. (2001), External sources of knowledge and performance in R&D organizations. External sources of knowledge and performance in R&D organizations, available at: <http://facultyresearch.london.edu/docs/SIM03.pdf>, accessed: September 23, 2016.
- Board of Innovation, available at: www.boardofinnovations.com, accessed: September 20, 2016.
- Boyd, D.M., Ellison, N.B. (2007), Social Network Sites: Definition, History, and Scholarship. *Journal of Computer-Mediated Communication*, Vol. 13, No. 1, pp. 210–230.
- Brabham, D.C. (2010), Crowdsourcing as a model for problem solving: leveraging the collective intelligence of online communities for public good, Doctoral dissertation, The University of Utah,
- Brown, J.S., Duguid, P. (2001), Knowledge and organization: A social-practice perspective. *Organization science*, Vol. 12, No. 2, pp. 198–213.
- Brunswick, S., Vanhaverbeke, W. (2014), Open Innovation in Small and Medium-Sized Enterprises (SMEs): External knowledge sourcing strategies and internal organizational facilitators. *Journal of Small Business Management*, Vol. 53, No. 4, pp. 1241–1263.
- Calantone, R.J., Stanko, M.A. (2007), Drivers of Outsourced Innovation: An Exploratory Study. *Journal of Product Innovation Management*, Vol. 24, No.3.
- Callaghan, C.W. (2016), Disaster management, crowdsourced R&D and probabilistic innovation theory: Toward real time disaster response capability. *International Journal of Disaster Risk Reduction*, Vol. 17, pp. 238–250.
- Callaghan, C.W. (2015), Crowdsourced 'R&D' and medical research. *British Medical Bulletin*, Vol. 115, No. 1, pp. 67–76.
- Chesborough, H. (2003), Open Innovation: The new imperative for creating and profiting from technology, Harvard Business School Press, Boston.
- Cohen, W.M., Levinthal, D.A. (1990), Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, pp. 128–152.
- Colombo, M.G., Piva, E., Rossi-Lamastra, C., (2014), Open innovation and within-industry diversification in small and medium enterprises: The case of open source software firms. *Research Policy*, 2014, Vol. 43, No. 5, pp. 891–902.
- Cooke, P. (2002), Regional innovation systems. *The Journal of Technology Transfer*, No. 27, Vol. 1, pp. 133–145.
- Damanpour, F. (1991), Organizational innovation: A meta-analysis of effects of determinants and moderators. *Academy of Management Journal*, No. 34, Vol. 3, pp. 555–590.
- Du Plessis, M. (2007), The role of knowledge management in innovation. *Journal of Knowledge Management*, Vol. 11, No. 4, pp. 20–29.
- Estellés-Arolas, E., González-Ladrón-De-Guevara, F. (2012), Towards an integrated crowdsourcing definition. *Journal of Information Science*, Vol. 38, No. 2, pp. 189–200.
- Fagerberg, J., Mowery, D., Nelson, R. (2005), The Oxford Handbook of Innovation, Oxford University Press.
- Garrigos, F., Gil, I., Narangajavana, Y., The impact of social networks in the competitiveness of the firms, in: Beckford, A.B., Larsen, J.P. (eds.) (2011), *Competitiveness: Psychology, Production, Impact and Global Trends*. Nova Science Publishers, Inc. Hauppauge.

- Gassmann, O., Kausch, Ch., Enkel, E. (2010), Negative Side Effect of Customer Integration The final version of this manuscript is published in International. *Journal of Technology Management*, Vol. 50, No. 1, pp. 43–63.
- Gassmann, O. (2006), Opening up the innovation process: towards an agenda, “R&D Management”, Vol. 36, No. 3.
- Gawer, A., Cusumano, M.A. (2014), Industry platforms and ecosystem innovation. *Journal of Product Innovation Management*, Vol. 31, No. 3, pp. 417–433.
- Gómez, J., Salazar, I., Vargas, P. (2016), Sources of Information as Determinants of Product and Process Innovation. *PLoS One*, Vol. 11, No. 4.
- Grant, R.M. (1996), Toward a knowledge-based theory of the firm. *Strategic Management Journal*, Vol. 17, No. S2, pp. 109–122.
- Heger, T., Boman, M. (2014), Networked foresight. The case of EIT ICT Labs. *Technological Forecasting and Social Change*, Vol. 101, pp. 147–164.
- Hemert, P, Nijkamp, P, Masurel, E. (2013), From innovation to commercialization through networks and agglomerations: analysis of sources of innovation, innovation capabilities and performance of Dutch SMEs. *The Annals of Regional Science*, Vol. 50, No. 2, pp. 425–452.
- von Hippel, E. (1988), *The Sources of Innovation*, Oxford University Press, New York, Oxford.
- Hossain, M. (2015), A review of literature on open innovation in small and medium-sized enterprises. *Journal of Global Entrepreneurship Research*, Vol. 5, No.1.
- Jasiński, A.H. (1997), *Innowacje i polityka innowacyjna*, Białystok: Wydawnictwo Uniwersytetu w Białymstoku, pp. 13–26.
- Laperche, B., Liu Z. (2013), SMEs and knowledge-capital formation in innovation networks: a review of literature. *Journal of Innovation and Entrepreneurship*, Vol. 2, No. 12.
- Laursen, K., Salter, A.J. (2014), The paradox of openness: Appropriability, external search and collaboration. *Research Policy*, Vol. 43, No. 5, pp. 867–878.
- Lee, J., Huh, M.G. (2016), How does external knowledge source influence product innovation in Korean firms? *Journal of Applied Business Research*, Vol. 32, No. 2.
- Lee, S., Park, G., Yoon, B., Park, J. (2010), Open innovation in SMEs. An intermediated network model. *Research Policy*, Vol. 39, No. 2, pp. 290–300.
- Lee, S.M., Olson, D.L., Trimi, S. (2012), Co-innovation: convergenomics, collaboration, and co-creation for organizational values. *Management Decision*, Vol. 50, No. 5, pp. 817–831.
- Lee, S.M., Olson, D.L., Trimi, S. (2010), The impact of convergence on organizational innovation. *Organizational Dynamics*, Vol. 39, No. 3, pp. 218–225.
- Levitt, B., March, J.G. (1988), Organizational learning. *Annual Review of Sociology*, No. 14, pp. 319–340.
- Lin, F.R., Lin, S.C., Huang, T.P. (2008), Knowledge sharing and creation in a teachers’ professional virtual community. *Computers & Education*, Vol. 50, No. 3, pp. 742–756.
- Lundvall, B.A., *National systems of innovation: An analytical framework*, Pinter, London, 1992.
- Marinova, D., Phillimore, J. (2003), Models of innovation, *The international handbook on innovation*, 1., in: Shavinina, L.V. (ed.), Elsevier.
- McAdam, M., McAdam, R., Dunn, A., McCall, C. (2014), Development of small and medium-sized enterprise horizontal innovation networks: UK agri-food sector study. *International Small Business Journal*, Vol. 32, No. 7, pp. 830–853.
- Nelson, R.R. (2008), *National innovation systems: a comparative analysis*, Oxford University Press, Oxford, 1993.
- OECD, *Open Innovation in Global Networks*, Executive Summary, available at: <http://www.oecd.org/sti/ino/41446671.pdf>, accessed: September 20, 2016.

- Porter, M.E. (1998), Clusters and the New Economics of Competition. *Harvard Business Review*, Issue: November-December.
- Porter, M.E., Stern, S. (2001), Innovation: Location matters. *Sloan Management Review*, Vol. 42, No. 4, pp. 28–43.
- Prahalad, C.K., Ramaswamy, V. (2004), Co-creation experience: the next practice in value creation. *Journal of Interactive Marketing*, Vol. 18, No. 3, pp. 5–14.
- Prahalad, C.K., Ramaswamy, V. (2013), *The Future of Competition: Co-creating Unique Value with Customers*, Harvard Business School Press.
- Ford, S., Aubert, C., Ryckewaert, E. (2016), Reducing the risk of failure in new product development: getting it right at the front end of innovation. A Practice Guide, University of Cambridge Institute for Manufacturing, Great Britain, available at: <http://www.ifm.eng.cam.ac.uk/uploads/Resources/Reports/Reducing-the-risk-of-failure-in-new-product-development-report.pdf>, accessed: September 21, 2016.
- Romero, D., Molina, A. (2011), Collaborative networked organizations and customer communities: value co-creation and co-innovation in the networking era. *Production Planning and Control*, Vol. 22, No. 5–6, pp. 447–472.
- Rothwell R. (1994), Towards the Fifth-generation Innovation Process. *International Marketing Review*, Vol. 11, No. 1, pp. 7–31.
- Solow R.M. (1957), Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics*, Vol. 39, No. 3, pp. 312–320.
- Spithoven, A., Vanhaverbeke, W., Roijakkers, N. (2013), Open innovation practices in SMEs and large enterprises. *Small Business Economics*, Vol. 41, No. 3, pp. 537–562.
- Svetina, A.C., Prodan, I. (2008), How internal and external sources of knowledge contribute to firms' innovation performance. *Managing Global Transitions*, Vol. 6, No. 3, pp. 277–299.
- Swords, J. (2013), Michael Porter's cluster theory as a local and regional development tool: The rise and fall of cluster policy in the UK. *Local Economy*, Vol. 28, No. 4, pp. 369–383.
- Tidd, J., Bessant, J., Pavitt, K. (2001), *Managing Innovation. Integrating technological, market and organizational change*, John Wiley and Sons, LTD.
- Tidd, J., Trehwella, M. (1997), Organizational and technological antecedents for knowledge acquisition. *R&D Management*, Vol. 27, No. 4, pp. 359–375.
- Tsai, W. (2001), Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance. *Academy of Management Journal*, Vol. 44, No. 5, pp. 996–1004.
- von Hippel, E. (1989), Cooperation between rivals: informal know-how trading. *Industrial Dynamics*, pp. 157–175.
- Yan, X., Yu, C.C. (2013), Strengths and weaknesses of Hong Kong's technology and innovation industry with reference to the extended open innovation model. *Journal of Science and Technology Policy in China*, Vol. 4, No. 3, pp. 180–194.