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ROLE OF BIG DATA IN OPEN INNOVATION PRACTICES: THE CASE OF SERBIAN ICT INDUSTRY

Uloga velikih podataka u praksi otvorenih inovacija - primer srpske IKT industrije

Abstract

Big data is the term for data sets that are characterized by great volume, variety, velocity, veracity, and which are very hard or impossible to capture, manage, store, and analyze with traditional data management tools. By engaging in open innovation practices companies interact with producers, suppliers, customers, competitors, academics, consultants, other companies, which enables them to collect large amounts of data from a variety of sources with greater frequency. Open innovation concept requires techniques and technologies with the ability to integrate, process and analyze both external and internal data sources and translate them into value. The aim of this paper is to show the role and importance of big data concept for companies which are pursuing open innovation practices with a special focus on Serbian information and communication industry (ICT).

The results indicate that big data is becoming a reality within the Serbian ICT companies as 91% of surveyed companies responded that they have big data initiative planned or in progress. The primary data issues that drive investment in big data include the possibilities of analyzing data from diverse sources and analyzing new data types, which indicates that big data in surveyed companies is not about volume, but variety and velocity. Engaging in open innovation practices allows companies to gather real-time data, unstructured data, higher quality data, and more granular data and transform them into fact-based decisions in order to achieve higher quality products and services and more efficient operations.

Big data concept is still in early development phase in surveyed ICT companies, with clear signs of increased awareness of its importance for competitive advantage.

Key words: *information and communication technology, big data, analytics, open innovation, partnership, organizational change*

Sažetak

Big data (veliki podaci) predstavlja termin kojim se opisuju podaci čiji obim, raznovrsnost, struktura i brzina generisanja prevazilaze mogućnosti tradicionalnih baza podataka i softvera za njihovo prikupljanje, obradu, upravljanje i analiziranje. Primenom praksi otvorenih inovacija kompanije stupaju u partnerske odnose sa proizvođačima, dobavljačima, konkurentima, akademskom zajednicom, konsultantima, drugim kompanijama i prikupljaju velike količine podataka iz različitih izvora sa znatno većom frenkventnošću. Koncept otvorenih inovacija zahteva primenu tehnika i tehnologija koje poseduju mogućnosti integrisanja, obrade i analiziranja eksternih i internih izvora podataka i njihovog transformisanja u vrednost. Cilj rada je da ukaže na značaj i ulogu *big data* koncepta prilikom stupanja u prakse otvorenih inovacija, na primeru kompanija iz informaciono-komunikacione industrije u Srbiji.

Rezultati pokazuju da je *big data* realnost u srpskim IKT kompanijama i da u 91% anketiranih kompanija postoje *big data* inicijative koje su u toku ili su planirane. Ključni razlozi za primenu *big data* tehnologija su mogućnosti da se analiziraju potpuno novi tipovi i izvori podataka, što ukazuje da *big data* nije primarno uzrokovan veličinom podataka, već njihovom raznovrsnošću i strukturom. Stupanjem u prakse otvorenih inovacija kompanije prikupljaju nestrukturirane, relevantnije i detaljnije podatke u realnom vremenu i transformišu ih u odluke kojima će poboljšati kvalitet proizvoda i usluga i povećati efikasnost poslovnih procesa.

Big data koncept je još uvek u ranim fazama razvoja u anketiranim IKT kompanijama, ali postoje jasni indikatori da među ovim kompanijama postoji svest o značaju *big data* za sticanje konkurentske prednosti.

Ključne reči: *informaciono-komunikaciona tehnologija, veliki podaci, analitika, otvorene inovacije, partnerstva, organizaciona promena*

Introduction

The evolution of information technology has led to big data and ability to monetize innovative ideas. Also, today there cannot be found a company that is big enough, strong enough and smart enough to stay competitive focusing only on its own knowledge and resources. The mixture of big data techniques, technologies and philosophy with open innovation practices will transform the way enterprises run their businesses. Companies are establishing various forms of partnership in order to stay alive and achieve agile business processes that allow them to adapt quickly to evolving markets, customer needs, policies and regulations. Big data, as a means of leveraging unique insights about customers, products, and operations gives companies the opportunity to optimize key business processes and uncover new opportunities for competitive advantage. Big data is placed at the center of disruptive technologies that could have economically disruptive impact until 2025 [29].

The aim of this paper is to show the role and importance of big data for companies which are pursuing open innovation practices. Additionally, in this paper we will deal with the analysis of the Serbian information and communication industry (ICT) and try to answer the following questions: Which open innovation practices are the most frequently used in Serbian ICT companies? Do they have need for big data, and which data are important to them? What are the primary benefits from big data? Which factors are critical to successful business adoption of big data? In order to answer the imposed research questions, we used theoretical and empirical approaches. The theoretical approach is based on critical evaluation of existing literature by analysis, synthesis, deduction and induction while the empirical approach is based on the results collected from survey.

The paper is organized as follows. *The first part* of the paper highlights the importance of innovation economics doctrine and treatment of knowledge as endogenous variable. Companies have become aware that they can no longer stay competitive on their own, which caused a shift from closed innovation toward open innovation concept. *The second part* of the paper deals with big data as disruptive technology and analytics that has swept into every industry showing its importance in analyzing and making value of the data collected through open innovation practices. *The third part* of the paper is based on the research of big data and open innovation practices in companies in Serbian ICT industry and discussion of research findings.

Innovation economics doctrine

Eight decades ago, economist *Joseph Schumpeter* (1934) argued that innovation is the main driver of economic development. As evidence from the past identifies innovation as the main driver for companies to prosper, grow and sustain high profits [15], nowadays, there is awareness that a company's long-term competitiveness lies in its ability to innovate. Innovation refers to implementation of new or significantly improved products (physical good or service), processes, new marketing methods, or new organizational methods in business practices, workplace organization, or external relations [31].

Economic doctrine that does not treat knowledge and technology as something that happens outside economic activity is known as "innovation economics" or by a variety of other terms, including "endogenous growth theory", "evolutionary economics", and "neo-Schumpeterian economics" [2]. Instead of treating knowledge and technology as an exogenous factor in the economic model, innovation economics provides an economic framework with clear understanding of how innovation occurs and which intentional activities by economic actors and government are stimulating for innovation.

Innovation economics has at least six key principles [2]:

1. Innovation drives economic growth. In knowledge-based economy innovation is the key factor that drives economic growth, not capital accumulation as claimed by neoclassicalists. This means that the main question is no longer why innovation is important, but instead, how to pursue innovation and how innovation processes can be managed.
2. The primary drivers of economic growth are productive efficiency (the ability of organizations to reorganize production in ways that lead to the largest amount of output with the fewest inputs)

and adaptive efficiency (the ability of economies and institutions to change over time to respond to successive new situations, in part by developing and adopting technological innovations).

3. Innovation and productivity growth take place in the context of institutions: evolving and learning institutions are the key to growth. Innovation is seen as a process that takes place through the interaction and learning of firms, industries, and other organizations. When research in industry is isolated from the rest of the firm there is a great danger for that research to become sterile and unproductive [36, p. 170]. Nowadays, many countries have formulated national innovation systems which represent the "set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store, and transfer the knowledge, skills and artifacts which define new technologies" [26, p. 462].
4. The new knowledge-based economy tends toward change rather than equilibrium. Innovation economists believe that market disequilibrium is responsible not for economic inefficiency but for growth and progress. The entrepreneur who is "endlessly innovative" is a person who constantly irritates the market and keeps it from settling down to a state of equilibrium.
5. Individuals and firms are not rational maximizers. Innovative activity typically involves uncertainty and, as a result, innovative efforts will meet with many failures as well as some great successes.
6. Smart public-private partnerships are the best way to implement policy. Smart public-private partnerships can play a key role in helping non-governmental organizations become more innovative and productive where there are significant market failures limiting their own action.

Since the industrial revolution of the late 18th and early 19th centuries, technology has had a unique role in powering growth and transforming economies [25, p. 1]. Today, more than ever, technology disrupts, replacing older ways of doing business and offsetting old skills, organizational approaches, and routines.

From closed toward open innovation concept

In today's global competition, companies have realized that they cannot innovate alone focusing on their own skills, resources and expertise. Establishment of cross-functional business teams, internal venture capital processes, creation of new business units for research and development (R&D) produced innovations, but their nature were periodic and incremental. Having in mind that continuous and radical innovations are necessary for survival and success in today's global economy, companies have realized that collaboration with other entities is of extraordinary importance for competitive advantage.

In 2003, *Henry Chesbrough*, organizational theorist, professor and executive director of the Center for Open Innovation, coined the term "open innovation" and defined it as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" [7, p. 1]. The key message is that companies should open up their innovation processes and use external as well as internal ideas, creativity, knowledge, and paths to market. They need to use a broad range of sources for innovation activities, such as information and knowledge of producers, suppliers, customers, competitors, academics, consultants, and other companies. As *Koschatzky* stated "firms which do not cooperate and which do not exchange knowledge reduce their knowledge base on a long-term basis and lose the ability to enter into exchange relations with other firms and organizations" [22, p. 6]. Reviewing the literature, it can be found that some innovation modalities have been around a long time such as the specialty labs for customized testing, co-creation, user innovation, and that the other modalities are arising, for example, tech-scouting, crowdsourcing, and public-private partnerships [4, p. 16]. All of these innovation modalities described with variety of names are placed under open innovation umbrella.

Key characteristics that distinguish the open innovation concept among many other concepts in the academic literature are [7, pp. 8-11]:

1. Equal importance given to external knowledge, in comparison to internal knowledge. In open innovation concept external knowledge plays very useful and supplemental role to internal knowledge.
2. The centrality of the business model in converting R&D into commercial value. Companies actively search for genius inside and outside the firm, and inventive output is not restricted by the current business model.
3. As opposed to closed innovation concept where if an R&D project was cancelled nothing was done about it, in open innovation concept projects are evaluated through business model by all partners.
4. Enabling outbound flows of technologies allows firms to let technologies (that lack a clear path to market internally) seek a path to market externally.
5. Useful knowledge is generally believed to be widely distributed and of high quality, and even the most capable R&D organizations need to be well connected to these external sources of knowledge.
6. Proactive role of intellectual property management in open innovation concept enables companies to practice their internal technologies without being blocked or held by external intellectual property.
7. The rise of innovation intermediaries. As innovation becomes a more open process, many companies are specialized to provide information access, and even finance to enable open innovation practices to occur.
8. Development of new and different metrics for assessing the innovation capability and performance. Classical metrics such as the percentage of sales spent on internal R&D, the number of patents produced per dollar of R&D, etc. are abandoned, while the questions of how much R&D is being conducted within the company's supply chain, what percentage of innovation activities originated outside of the company become more important.

The main question for companies is not why it is important to innovate, but how to innovate. In general, there are two types of open innovation practices [9]:

Inbound (outside-in) practices. These practices can increase a company's innovativeness by enriching its own knowledge base through the integration of suppliers, customers, and external knowledge sourcing. The most frequently used inbound practices are: consumer co-creation, informal networking, publicly funded R&D consortia, contracting with external R&D service providers, supplier innovation awards, crowdsourcing, and specialized services from open innovation intermediaries.

Outbound (inside-out) practices. Companies that establish these practices focus on externalizing their knowledge and innovation in order to bring ideas to market faster than they could by relying exclusively on internal strengths. Inside-out practices refer to earning profit by bringing ideas to market, selling intellectual property, and transferring ideas to the outside environment. The most frequently used outbound practices are: joint venture activities with external partners, participation in public standardization, corporate business incubation and venturing, intellectual property out-licensing and patent selling, donations to commons or nonprofits.

Some authors have come up with the third practice of open innovation and named it *coupled process* [16, pp. 312-313]. Companies that establish the coupled process combine the outside-in with the inside-out processes to jointly develop and commercialize innovation through alliances, cooperation, and joint ventures.

Companies as innovation engine

According to *Joseph Schumpeter* (1942) "there was a time, not so long ago, when 'innovation' meant that companies needed to invest in expensive internal research laboratories, hire the most brilliant people they could find, and then wait patiently for novel products to emerge. Not anymore" [8, p. 12]. The question is no longer whether open innovation will replace the traditional, closed innovation concept, but rather how open innovation processes need to be managed in order to be successful [36]. Open innovation assumes that useful knowledge is widely distributed and that even the most capable R&D organizations must identify, connect to and leverage external knowledge sources as a core process in innovation [10]. But, it is important to acknowledge that open innovation concept goes beyond the externalization of research and development, it reflects a transformation of how firms use and manage

their intellectual property [42], it requires significant organizational change and a redefinition of the tasks and boundaries inside the organization, to the point that "open innovation can be considered as an organizational innovation" [12]. Engaging in open innovation practices, companies are becoming the key facilitators of innovations, and collaboration with different entities has become a strategic imperative for them [37, p. 2].

In order to absorb new ideas from external sources and to find the way to integrate them with internal processes companies need dynamic capability [13] which refers to the company's ability to integrate, create, reconfigure internal and external competences in order to achieve innovation [41, p. 516]. Further, companies need to find the ways to increase their ability to grow into new business fields fast and foster innovation in fields in which they do not have any prior experience. Also, absorptive capacity as the ability of a company to recognize the value of new, external information, assimilate it and apply it to commercial needs [13, p. 28] is of crucial importance to its innovative capabilities.

Big data as innovation fuel

Companies which engage in open innovation practices interact with many other organizations and individuals, collect, integrate, manage, store and analyze data from of variety of sources with greater frequency. They are focused on data analysis and real time decision-making based on tremendous amount of data [6].

Pioneers in the research into the amount of data produced, stored and transmitted, *Hal Varian* and *Peter Lyman,* professors at the University of California, Berkeley, estimated as a part of their project "How much information", ran from 2000 to 2003, that 5 exabytes of new data were stored globally in 2002 and that 18 exabytes of new original data were transmitted. Information management company EMC sponsored the survey "Digital Universe" whose results showed that in 2007 the amount of digital data created in a year exceeded the world's data storage capacity for the first time. Some other studies also revealed that while global storage capacity grew at an annual rate of 23%, the ability to generate and process data measured with general-purpose computing capacity grew at a much higher annual rate of 58% [24, pp. 18-19]. IBM estimates that humanity creates 2.4 quintillion bytes of data every day – so much that 90% of the data in the world today has been created in the last two years alone [35, p. 19].

The progress of the ICT industry has led to the emergence of big data which refers to the datasets whose size is beyond the ability of typical database software tools to capture, store, manage and analyze data [24]. Big data is not just matter of size, it is best described by 4V [40, p. 4]: 1) *Volume* as the huge amount of data that organizations are trying to harness to improve decision-making across the enterprise, 2) *Variety* which refers to different types of data and data sources: data from social networks, digital TV, credit cards, medical devices, sensors, bar codes, surveillance cameras, etc., 3) *Velocity* as the speed at which data are created, processed and analyzed reflects the need for real-time nature of data creation and decision making, and 4) *Veracity* which refers to the level of reliability associated with certain types of data and reflects the need for high-quality data.

Analyzing large data sets gives a company the opportunity to gain insights into new types and sources of data to make businesses more agile. McKinsey Global Institute estimated that big data creates value for companies in several ways [24, p. 5]: 1) creating transparency – simply making big data more easily accessible to relevant stakeholders in a timely manner; 2) enabling experimentation to discover needs, expose variability, and improve performance; 3) segmenting populations to customize actions – companies can create highly specific segmentations and tailor products and services precisely to meet those needs; 4) replacing/supporting human decision-making with automated algorithms; 5) innovating new business models, products, and services.

Advances in ICT definitely "brought the firm to the world, but they also brought the world to the firm" [43, p. 665]. In order to extract value from big data, it must be processed and analyzed in a timely manner by analytics. By pure definition, analytics is the discovery and interpretation of meaningful patterns in data – but for business, analytics should be viewed as the extensive use of data, statistical and quantitative analysis, and predictive

models to drive fact-based business management decisions and actions [17, p. 6]. Analytics enable organizations to meet stakeholder demands, create market advantages, manage risk, improve internal processes and enhance organizational performance by turning data into innovations [3]. Outperforming companies will be those that make data and analytics central to their innovation processes [32]. These companies, known as "analytical innovators" [20, p. 7], tend to view external data created in open innovation activities as a core asset, and they form analytics function in order to monetize innovative ideas.

As technological progress allows companies to collect increasingly vast quantities of data from external sources through open innovation practices, the analysis of these data sets has emerged as a powerful new tool, and data is becoming the currency of the knowledge economy [1].

In order to benefit from big data, from business perspective, companies must learn to [27, p. 13]:

- Use big data analytics to drive value and create competitive advantage for company.
- Capitalize on new technology capabilities and leverage the existing technology assets.
- Enable the appropriate organizational change to move towards fact-based decision, adoption of new technologies and create a single multidisciplinary analytics team.
- Deliver faster and superior results by embracing and capitalizing on ever-increasing rate of change that is occurring in the global market place.

Several research documents have highlighted the state of big data among companies, IT executives and professionals.

IBM surveyed 900 business and IT executives from 70 countries. Results show that leaders are 166% more likely to make most decisions based on data; are 2.2 times more likely to have a formal career path for analytics; 75% of leaders cited growth as the key source of value from analytics; 80% of leaders measure the impact of analytics investments [19].

Bain company, by surveying more than 400 large companies, found that the leaders in big data practices are [33]: twice as likely to be in the top quartile of financial performance within their industries; five times as likely to make decisions much faster than market peers; three times as likely to execute decisions as intended; twice as likely to use data very frequently when making decisions.

TEK systems surveyed more than 2000 IT professionals and more than 1500 IT leaders on the topic of big data. Results showed that: 90% of IT leaders and 84% of IT professionals believe investments of time, money and resources into big data initiatives are worthwhile; only 14% of IT leaders report big data concepts are regularly applied in their organizations; 60% of IT leaders say their organizations lack accountability for data quality [42].

Accenture surveyed C-level executives and other senior technology leaders from 19 countries. Results showed that 89% of those respondents rate big data as "very important" or "extremely important" to transforming operations into a digital business, and 82% of executives agree that big data provides a significant source of value for their companies. The study noted that companies are using big data moderately or extensively to identify new sources of revenue (95%), retain and acquire customers (90%), and develop new products and services (89%) [39].

The concept of the research

The goal and object of research. The object of research, the companies in ICT industry, was not selected randomly. The ICT industry is a promoter of society informatization, as it implements and maintains ICT infrastructure in other organizations and, according to literature, is at the forefront in the implementation of new technologies and business practices.

Many authors have highlighted the role of information and communication technologies in increasing the ability of firms to work across time, space and culture, facilitating knowledge flow, and thus helping to support the shift towards more open and collaborative innovation practices. On the one hand, these technologies shape the strategic orientation of industrial companies towards external environment, and on the other facilitate the realization of innovative activities [14, p. 333]. Also, the reasons for this object of research are the facts that open innovation practices are the most advanced in high-technology

industries [11] and that these industries create a fertile ground for innovation [18].

The importance of research. The global crisis is reflected in Serbian economy through high unemployment, rising foreign debt, poor living standard. On the other hand, there are some bright points, such as export of software and ICT services: in 2007, the software export amounted to EUR 62 million; in 2011, it was up to EUR 166 million, while in 2012 it exceeded EUR 200 million [5] and in daily jargon it can be heard that Serbia is *the country of farmers and ICT specialists* (e.g. Radio Television of Vojvodina). ICT industry has been recognized by the state as a significant segment for further development of the Serbian economy and the government has adopted several policies and strategies. The best example of how organizations may use new technologies and competent employees positioned in a new way to achieve competitive advantage is the example of ICT companies [34].

The research questions. Which open innovation practices are the most frequently used in Serbian ICT companies? Do they have need for big data, and which data are important to them? What are the primary benefits of big data? Which factors are critical to successful business adoption of big data?

The research was conducted by using the questionnaire technique for data collection: the questionnaire was sent via e-mail to 318 ICT companies. The questions were inspired by New Vantage Big Data Executive Survey which has been following corporate adoption of big data approaches and solutions from 2012. New Vantage Partners provides expertise and guidance to Fortune 1000 business and technology executives who are seeking to leverage data and analytics to derive business value and transform critical business processes [30].

The questionnaire consists of 20 questions asking about:

- General information about companies: age, number of employees, key characteristics in conducting their businesses;
- The key practices of open innovation and satisfaction with individual partners in open innovation activities;
- The importance of data and analytics for value creation;
- Primary business benefits resulting from big data;
- Factors that are of crucial importance to successful business adoption of big data.

The questionnaire was active from 8th September until 20th October and was completed by 54 companies, making the response rate of 17%. Collected data from the questionnaire were analyzed and interpreted by the description method.

Discussion of research findings

Measured by the number of permanent employees, 83% of surveyed ICT companies belong to the group of small companies. One half of surveyed companies operate from 5 to 10 years, almost one third operate from 10 to 15 years, while 20% of companies represent very young companies which operate less than 5 years.

The survey highlights that a 91% of surveyed companies responded that they have big data initiative planned or in progress. This result indicates that big data is becoming a reality within Serbian ICT companies. Among the primary data issues driving companies to use big data are the possibilities of analyzing data from diverse sources (54%) and analyzing new data types (33%). Only 8% of surveyed companies analyze data sets larger than 1TB (terabyte), so big data in surveyed companies is not about volume, but variety and velocity. Big data techniques and technologies enable surveyed companies to address the key data challenges, including real-time data, unstructured data, higher quality data, and more granular data (see Table 1).

Table 1: Data challenges that companies are addressing with big data

Statements	Pct.
Using real-time data	61%
Understanding unstructured data	50%
Using higher quality data	44%
Using more granular data	44%
Using more current data	37%
Storing more historical data	20%
Integrating a wider variety of data	17%
Understanding streaming data	15%
Cleansing data	11%

Source: Author

Business functions that are the most important users of big data and analytics in surveyed ICT companies are

customer service, customer and market analysis, internal processes and operations, and product development (see Table 2).

Table 2: Business functions that are the most important users of data and analytics

Business functions	Pct.
Customer Service	57%
Customer and Market Analysis	56%
Internal Processes and Operations	53%
Product Development/Management	30%
Direct and Digital Marketing	28%
eCommerce, eBusiness, Digital Operations	22%
Risk Management	15%
Human Resources	13%
Fraud Management	4%

Source: Author

As regards the tangible benefits they want to achieve through big data, surveyed ICT companies most frequently stated (see Table 3): higher quality products and services (65%), better, fact-based decision making (61%), more efficient operations (52%).

Table 3: Tangible benefits that companies hope to achieve through big data initiatives

Benefits	Pct.
Higher quality products and services	65%
Better, fact-based decision making	61%
More efficient operations	52%
Increased sales	37%
Reduced risk	13%
Improved customer experience	9%

Source: Author

It comes as a surprise to find out that big data initiatives are in 48% of surveyed companies mostly IT driven, with minimal business involvement, while 46% of companies stated that big data initiative is driven by IT and business collaboration. Choosing the right technologies (with 56% of responses) is perceived as the most important factor in ensuring business adoption of big data initiatives. At the top of the list of the most important factors are successful implementation of technology capabilities (46%), agreement on the importance of analytics (46%), and strong organizational alignment (39%).

It concerns us that a small number of companies indicated the importance of executive sponsorship (only 7%), clear definition of business questions and objectives, and recognition that data are shared corporate asset (20%). New technologies are very powerful and provide a real chance to improve decision-making, but technology is not enough. It is required that companies carefully plan, formulate clear goals, work hard, and embrace organizational change. Successful business adoption of big data requires new processes and roles in organization. There is no company that answered that data are not important, and more than a half of companies indicate that data are of tremendous importance for success. For that reason, they engage in open innovation practices.

The most frequently used open innovation practices in surveyed ICT companies are: 1) involvement of consumers and customers in generation, evaluation, and testing of new ideas for products, services, processes (59%); 2) networking with other organizations without a formal contractual relationship, e.g. at conferences, workshops, events, etc. (57%); 3) licensing of internal intellectual property to external organizations via licensing agreements or selling via single payment (35%); 4) outsourcing innovation problem sourcing via an open call to external organizations and individuals to submit ideas (17%). Partners whose ideas and information surveyed companies indicated as the most important are customers (87%), suppliers (30%), public research organizations (22%), entrepreneurs and start-ups (15%).

They stated that their access to relevant, accurate and timely data is more than adequate, so are their analytic capabilities. On the other hand, 81% of surveyed companies have not established analytics function and less than 5 employees in overall company are dedicated to analytics. Establishment of analytics function is very important, because it can identify innovative opportunities in key processes, functions, roles. Also, it creates a catalyst for innovation and change, and by challenging the status quo can help to create new possibilities for the businesses [17, p. 7].

Before the company can create value from big data, it must get data scientists and analytics expert. More than 80% of surveyed companies have the position "Data Scientist" and they mostly (65%) train existing analytics professionals or hire new people with new data science knowledge and skills (52%). These professionals must

have mathematical, technology, statistical knowledge and skills, but also the knowledge about business processes and so-called X-factor which is intellectual curiosity [21]. For surveyed companies it is challenging to find these professionals (see Table 4). This result is not surprising bearing in mind that recent McKinsey Global Institute study forecasts a significant shortfall in big data skills even in the United States. "By 2018, the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions" [24, p. 10].

Table 4: How challenging is to find employees with big data skills in general?

Statements	Pct.
It is easy	4%
Somewhat challenging	20%
Challenging	35%
Very difficult to find or hire	35%
Impossible to find or hire	0%

Source: Author

Throughout history, there has always been a significant gap between the rate of adoption of new technology by academia and industry [28]. Universities must align their programs with industry requirements and move quickly to ensure that their graduates have the required skills for the digital age. Educational systems are not preparing students to handle big data. Technology education programs are focused on hardware, software, and tools for dealing with big data, but they do not provide knowledge about business processes and operations. On the other hand, students with knowledge about business processes and operation do not have technological knowledge and skills. Certainly, data have swept into every industry, they become like other essential factors of productions, and data and analytics literacy must become a reality in all educational fields [23].

Conclusion

Innovation as the most important factor of economic growth requires collaboration and partnerships, so many companies are pursuing open innovation practices. With rapidly increasing volume, variety, velocity, and veracity of data companies are faced with challenge to manage all these data and to create value on their basis. Data gathered through open innovation practices are useless unless organizations are able to transform them into usable knowledge and value. In this paper, big data is viewed as a disruptive technology and the use of big data as a crucial way to stay competitive in the 21st century.

The research was conducted with the aim to identify the role of big data in open innovation practices in the case of Serbian ICT industry. The results indicate that big data is becoming a reality within Serbian ICT companies as 91% of surveyed companies responded that they have big data initiative planned or in progress. Among the primary data issues that drive big data are the possibilities of analyzing data from diverse sources as well as analyzing new data types. Only 8% of surveyed companies analyze data sets larger than 1TB (terabyte), so big data in surveyed companies is not about volume, but variety and velocity. Real-time data, unstructured data, higher quality data, more granular data present the key data challenges that surveyed companies are addressing with big data in order to achieve higher quality products and services, better, fact-based decision making, and more efficient operations. Serbian ICT companies are aware of the importance of cooperation and they are engaged in various open innovation practices: involvement of consumers and customers in generation, evaluation, and testing of new ideas for products, services, processes; networking with other organizations without a formal contractual relationship (at conferences, workshops, events); licensing of internal intellectual property to external organizations via licensing agreements or selling via single payment.

Open innovation practices require big data techniques, technologies and philosophy in order to integrate, process and analyze both external and internal data sources and translate them into value. Surveyed ICT companies stated that their access to relevant, accurate and timely data is more than adequate, so are their analytic capabilities. On the other hand, 81% of surveyed companies have not established analytics function and less than 5 employees in overall company are dedicated to analytics. These results are a matter of concern, especially if we look at how surveyed companies ranked the most important factors for big data business adoption. Choosing the right

technologies is perceived as the most important factor in ensuring business adoption of big data initiatives, and the following factors are successful implementation of technology capabilities, agreement on the importance of analytics, and strong organizational alignment.

Results indicate that big data is still in early development phase in surveyed ICT companies, with clear signs of increased awareness of their importance for competitive advantage. We hope that this paper will contribute to deepening the understanding of what big data is, why it is important for open innovation practices, and which factors are critical to successful business adoption of big data.

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