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THE BIG DATA ERA: CHALLENGES AND OPPORTUNITIES IN THE PERCEPTION OF THE SOFTWARE INDUSTRY EXPERTS

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ABSTRACT

Software industry organizations are known by being intensive in producing different types of knowledge during all the software development process. That's because this industry builds different types of software-based solutions, as well as storing a large amount of data for their customers and their projects. This amount of data is stored in databases so that it can be used in different tasks in the organization in the future. Thus, many of these databases are characterized as Big Data. In this sense, this article aims to investigate the challenges and opportunities of using Big Data within organizations of the software industry under the perception of specialists. For this, it is exploratory research based on interviews with experienced professionals of the software industry. Our results show that Big Data benefits decision making by providing more accurate data analysis, using tools, and requiring trained professionals to create and update knowledge with the support of Knowledge Management. On the other hand, the results point to the hardware challenge for Big Data processing and analysis.

INTRODUCTION

Nowadays the large volume of data produced by organizations has become a challenge since thatorganizations produce data constantly, so-called Big Data. The Big Data refers to a massive quantity of data, which requires complex processing through traditional storage and analysis technologies (Debortoli, Müller, & vom Brocke, 2014). Big Data allows companies to generate new ideas and products further to high productivity and profitability and is also capable of creating new knowledge through data analysis(Begoña Lloria & Peris-Ortiz, 2014). However, the techniques to analyze the Big Data are relatively new (Rothberg & Erickson, 2017), requiring tools adherent to the processing of such data(Hazen, Boone, Ezell, & Jones-Farmer, 2014; Provost & Fawcett, 2013). It is considered a complex task that requires a powerful hardware infrastructure (Bhat & Quadri, 2015; Hashem *et al.*, 2015; Wang, 2014). Moreover, to such hardware infrastructure, it

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also needs the data scientist, i.e., a professional specialized in data preparing and Big Data analysis. The data scientist is more than a professional whichmust have skills associated with statistics, behavioral and social sciences, industrial engineering, and computer science (van der Aalst, 2014; Varian, 2014). So, this kind of professional is indispensable in the organizations that deal with Big Data such as software industry organizations. Therefore, such organizations produce different types of data and information at all times and stand out from the other areas of the market by having a final product that is a result of the intensive knowledge usage. This means that the final product (software) goes through several processes, in which it getsthe specific knowledge so that it can be consolidated (Bjørnson & Dingsøyr, 2008). However, often within software industry organizations, organizational knowledge tends to become dispersed. In this way, it is necessary to have processes and practices adherent to such industry. To that end, the KM assists organizations in structuring and systematizing organizational knowledge through its processes and practices (Dalkir, 2013). Besides, KM in its broadest sense is a conceptual framework that

encompasses all the activities and perspectives needed to obtain an overview in order to deal with and benefit from the knowledge assets of the corporation and its conditions (Wiig, 1993). In this context, this article aims to investigate the challenges and opportunities of Big Data usage for the organizations of the software industry. For that, we took place qualitative exploratory research conducting ten interviews with experienced professionals from three different organizations of the software industry. Therefore, this article is organized into six sections. In addition to this introduction, the second section presents a review of the literature on the concepts of Big Data and Knowledge Management (KM). Furthermore, the use of Big Data in organizations of the software industry is also presented. In the third section, the methodological procedures of this research are presented. The fourth section presents the results obtained in this work followed by its discussions. Finally, in the sixth section, we present the conclusion of the research followed by the bibliographical references used.

Literature Revision: Big Data is responsible for storing complex data in a variety of organizations. However, it is possiblethrough KM processes and practices, to renew and update knowledge. In this context, the software industry has been looking for solutions based on Big Data to enhance the organizational knowledge. In this sense, this section presents the main concepts of Big Data and KM and the use of Big Data in organizations of the software industry.

Big Data: The web 4.0 gave birth to an era in which data is heavily produced and stored in large quantities. This is due to the fact that with the advancement of technology, data is generated from multiple sources, allowing access and creation of new content at all times(Waller & Fawcett, 2013). In this context, the term Big Data refers to the volume, variety, velocity and veracity of the data (Schroeck, Shockley, Smart, Romero-Morales, & Tufano, 2012), being these arranged in different formats, structures and semantics (Sumbal, Tsui, & See-to, 2017). The 'volume' refers to a large amount of data and its many types generated through different sources that tend to expand (Laurila *et al.*, 2012). The 'variety' refers to the collection of different types of data such as videos, images or texts, regardless of their format or structure (O'Leary, 2013). The 'speed' refers to the content of the data that can undergo constant changes since this data originates from different sources (Berman, 2013). Finally, 'veracity' refers to the quality and usefulness of the captured data(Schroeck *et al.*, 2012).The use of Big Data makes it possible to leverage traditional businesses, as it gives a more significant competitive advantage to the organization, enabling more precise management of the data that permeates internal business decisions(McAfee & Brynjolfsson, 2012). To do so, it is necessary to perform the Big Data analysis. This analysis involves the use of different tools to examine this data, in which organizations obtain from internal and external sources. Thus, through accurate data analysis, it is possible to find patterns and relationships between such data. Also, organizations have been struggling to find tools that support Big Data analysis (Strategic Direction, 2017).

Therefore, the term Big Data is intrinsically linked to the volume, variety, speed, and veracity of the data. Such data can be different formats, such as videos, texts, and images. The use of Big Data has become recurring in organizations given the possibility of extracting information from the stored data, to support decision making. However, the stored data need the KM processes to become continuously updated, and thus produce new knowledge.

Knowledge Management: Knowledge is already recognized as one of the most significant resources in organizations. This is because knowledge assists in the creation of new skills, making it possible to add value to the products or services of organizations. In this way, it is understood that knowledge is created from an earlier process, in which it must be continually improved. In order to do so, KM arises through its processes to support knowledge in organizations. KM, in its broadest sense, is a conceptual framework that encompasses all the activities and perspectives needed to get an overview. Such overview aims to benefit from knowledge in the most diverse areas of the organization (Wiig, 1993). In addition, KM is seen as a process-oriented approach. These processes aim to identify, capture, store, disseminate and apply knowledge throughout the organization. Thus, the activities carried out within the organization can be completed more quickly, reducing costs and reworking in production (Mohapatra, Agrawal, & Satpathy, 2016). KM is, therefore, a process that allows the organization to use their knowledge to obtain a competitive advantage.The competitive advantage must be built through the logic of the active market, and this means that it should explain the concentration of the industry, as well as prices, economic performances and also complement institutional analyses (Vassolo, Garciá-Sánchez, & Mesquita, 2017). In this context, Brito (2012) points out that competitive advantage is the central hypothesis to support explanations of performance heterogeneity between organizations. However, competitive advantage is often treated empirically as superior profitability, neglecting the other implications for organizational performance.In addition to providing organizations with competitive advantages, KM supports informed decision-making, through its processes and practices. Well-grounded decision-making can avoid mistakes and coordinate more favorable actions, making it possible to save time and reallocate resources in a strategic way (Wiig, 1993). However, the understanding of the domain area for decision is fundamental for people to act quickly and objectively under the information (Becerra-Fernandez & Sabherwal, 2014). For this, every choice must be interpretable. This is because it must be understood so that it can be adequately grounded (Choo, 2003). Therefore, KM supports organizations through its processes of creation, storage, sharing and acquisition of knowledge. In this way, knowledge becomes available and up-to-date, being essential within organizations of the software industry, because these organizations perform several tasks at the same time with different levels of complexity. In this context, the next section shows the relationship between the use of Big Data within organizations of the software industry and the need to use KM within these organizations.

The Big Date usage within the software industry organizations: Much data is being continuously generated in the software industry. In this way, the organizations belonging to such industry need support to deal with the data produced and consumed. In this sense, Big Data refers to large volumes of data, with high processing speed or a wide variety of types of information, which requires new forms of processing to be used in the process of decision making and generation of ideas or insights (Laney, 2012). Davenport *et al.* (2006) state that collecting, analyzing and disseminating these data is necessary for better decision-making. In addition, the large amount of data generated encourages practitioners to explore new ways

of thinking. These forms include revealing how data are produced, organized and analyzed, leading organizations to adopt and refine their data analysis functions (Hazen *et al.*, 2014). Thus, data analysis is a dynamic process which uses inputs of different kinds such as data or information, knowledge, and insights, resulting in intelligence and responses, all of this to support actions (Rothberg & Erickson, 2017). In this way, it is relevant to emphasize that the presentation format of the data to obtain the knowledge must be aligned with Big Data, through comprehensible formats such as panels, reports or visualization systems(Bose, 2009). In this sense, knowledge becomes essential for organizations to excel in a highly competitive market.According to Nawinna (2011), managing knowledge has become a significant factor because, due to the intensive use of knowledge and the complexity of its tasks, these organizations perform several tasks at the same time. In this context, knowledge was managed in organizations so that they could gain a prominent place in the market, improving their performance, maximizing their business opportunities and minimizing their risk of loss (Schiuma, Carlucci, & Lerro, 2012). Therefore, the analysis of Big Data for organizations of the software industry is fundamental, as it assists in the process of decision making, cost reduction and productivity in a highly competitive market.

MATERIALS AND METHODS

This paper is characterized as qualitative field research, with exploratory goals. Exploratory research is devoted to determining the nature of the problem. However, it does not provide conclusive evidence, but it helps to gain a better understanding of the problem (Saunders, Lewis, & Thornhill, 2006). The qualitative research method is used since it discusses conceptions and research methods for interpreting the results achieved (Creswell & Creswell, 2017). In this sense, this research was carried out in two stages. The first stage searched for publications related to Big Data in order to identify their use within organizations of the software industry. The searches were done on the online databases Emerald Insight, ACM Digital Library, Google Scholar and in the Revista de Administração de Empresas (RAE) using the following keywords in Portuguese: "gestão do conhecimento", "tomada de decisão" and "análise de Big Data". Also, the same keywords were searched in the English language: "knowledge management", "decision making" and "Big Data analysis". In the second stage of the research, interviews were conducted with four professionals working in software development organizations in the State of Paraná. Two of these organizations are located in the city of Maringá, one in the city of Cianorte and another in the city of Londrina. The profile of the interviewees and the characteristics of the companies are presented in Table 1. The interviewees comprised a non-probabilistic sample and accessed for convenience. Non-probabilistic sampling is one in which the selection of the elements of the population to compose the sample depends, at least in part, on the judgment of the researcher or the interviewer in the field (Mattar, Oliveira, & Motta, 2014). The four participants of the research were chosen for working for more than five years in the software industry since only professionals working at this level have the necessary information for this research.We collected the data from July 9th to August 3rd, 2018. For this purpose, a script of interviews was elaborated, composed of eight open-ended questions and that was intended to investigate the details about the use of Big Data within the respective organizations of

respondents. The questions that made up the interview protocol, as well as the purpose of each question, are presented in Table 2. The interviews were conducted face-to-face and by WhatsApp. At the time, all the participants signed a term allowing interviews to be recorded and, subsequently, such interviews were transcribed and submitted to content analysis following Krippendorff's (2003) proposal. The transcripts were uploaded to the Atlas.Ti tool which allows the codification and the analysis of the interviews.

RESULTS

The interviews resulted in four findings of Big Data, that is, decision making, data analysis, KM, and hardware support. Considering 'decision making', all respondents pointed out Big Data makes it possible to make more precise decisions, which can be based on the stored data. However, one of the interviewees points out that for decision-making based on Big Data it is necessary that its data originate from reliable sources. For only then stored data can favor the attainment of intelligence for decision makings, such as reallocation of resources or people, the creation of new projects and planning. Thus, when a decision is well-founded on the Big Data, it tends to be more likely to succeed. Thus, it is observed that the respondents understand and recognize the use of Big Data in support of decision making.Regarding the 'data analysis' factor, it was observed that all the interviewees recognize that it is only necessary to use Big Data if tools that support such analyzes support it. To do so, the organization of the interviewees uses different technological tools that support data mining, the discovery of knowledge and creation of new knowledge from the existing ones. Thus, respondents stressed tools such as Hadoop, SQL Server, MongoDB, and Cassandra, are vital to supporting the analysis of Big Data. However, for more precise analysis, it is necessary the presence of the data scientist, a professional with the necessary knowledge of techniques and tools to explore from different perspectives the data stored within Big Data. However, only an interviewee working in a multinational organization has data scientists on his team. In that sense, one of the interviewees, from a small company, commented that "in the organization, we do not have professionals who really know how to use this kind of data, because for it to happen a financial investment is needed" (CEO SWTransportation, 07/31/2018). Thus, it is observed that small and medium-sized organizations do not usually have professional data scientists because of the investment cost that is needed for them to have such a professional. Therefore, due to the cost of this professional, only large organizations can hire them.

One of the points also revealed through interviews concerns the use of Big Data with the support of 'KM'. Thus, one of the interviewees points out that "in order to have effective results from Big Data it would be important to use KM, since its processes of creation, storage, retrieval, and knowledge sharing can support [decision making] through Big Data." (SW Management Director, 08/03/2018). In this way, KM allows evolution and update of the data from Big Data, besides the knowledge creation. However, another interviewee commented that "Big Data has no relation with KM." (CEO Telecom, 07/31/2018). There is a disagreement among interviewees regarding the relationship between Big Data and KM. However, the use of KM through its processes and practices for Big Data is essential since stored data can be updated, shared and also stimulate the creation of

Table 1. Profile of Interviewees and characteristics of their respective organizations

Interviwee	Experience (years)	Organization Size	Comprehensiveness	Software Department	Nº of Employess	Market Activity (years)
SW Project Manager	20	Big (Multinational)	National and International	Clothing Industry	10.000	13
CEO SW Transportation	10	Small	National and regional	Trasnportation Logistics	25	14
CEO Telecom	5	Medium	National and regional	Telecommunications	100	13
SW Management Director	10	Small	National and regional	Business Management and Export	5	16

Source: The Authors (2018)

Table 2. Interview Protocol

Nº	Question	Goal
1	What is your perception of Big Data within the software industry? What are the challenges of using Big Data today for your organization? And for your customers?	To investigate the interviewee's perception of the challenges of using Big Data for their organization and their customers.
2	From your perception, what are the main advantages of Big Data for your organization? And the disadvantages?	To identify key advantages and disadvantages of using Big Data in the interviewee's organization.
3	Does your organization perform data analysis for Big Data? If so, how is it done? What techniques are used? Could it be improved? How?	To investigate details about Big Data analysis, such as analysis techniques and strategies to improve such techniques.
4	Are the techniques cited in the answer to the previous question capable of making explicit the knowledge in your organization so that people have access to it? If so, how is this knowledge made explicit in your organization? (e.g., manuals, wikis)	To verify that Big Data analysis techniques in the interviewee's organization make explicit the knowledge within the organization.
5	From your point of view, what is the relationship between Big Data and KM?	To identify the interviewee's perceptionof the relationship between Big Data and KM.
6	In your understanding, how can the Big Data analysis be used for decision making?	To investigate, from the interviewee's point of view, if the Big Data analysis can be used for decision making.
7	Do you think it is important that organizations have a Big Data Department? Why?	To identify if the interviewee classifies as important for their respective organization a Big Data department.
8	Do you have something to add about Big Data and its use for your customers?	To get more details about using Big Data within the interviewee's organization and their respective clients.

Source: The Authors (2018).

organizational knowledge. Therefore, even if not all interviewees agree with one another, KM processes allied to Big Data promote organizational knowledge.Considering 'hardware support', one respondent believes that "nowadays the challenge goes beyond data volume, [...] the challenge is physical, is hardware" (SW Project Manager, 08/08 /2018). However, none of the other interviewees highlighted such a hardware challenge. Thus, considering that this interviewee's organization is a multinational, it is observed that hardware is already one of the challenges found in large organizations in the software industry. This is because these organizations produce data in an intense and constant way. Although the advancement of the internet and the technological resources associated with it, it is still challenging to deal with hardware in large organizations of the software industry.

DISCUSSION

Given the opportunities and challenges of Big Data for software industry organizations, it supports decision making, enabling its users to identify and evaluate alternatives to be processed for action(Dalkir, 2013). These actions can be exemplified as reallocating resources or people within organizations. Besides, Laney(2012) points out that the use of Big Data is only necessary when it is possible to gain knowledge of the data for decision-making purposes. This is because it is through the data that it is possible to create knowledge for grounded decision making, with a higher probability of success. In this sense, Big Data becomes an aid, through which, it is possible to make grounded decision-making.Big Data analysis, which aims to contextualize the data for them to make sense, involves the use of several tools, whose purpose is to examine and detect patterns and significant correlations in such data(Strategic Direction, 2017). The tools pointed out by the interviewees allow, among several possibilities, to cross the stored data in order to investigate the

veracity of such data. Interviewees also pointed out that other tools such as Hadoop, SQL Server, MongoDB, and Cassandra are essential for Big Data analysis. Thus, according to Hazen *et al.* (2014), the tools used for data analysis are as necessary as the data on which they are based. However, the Big Data analysis is a relatively recent technique and has received attention from several professionals who work specifically in this area (Rothberg & Erickson, 2017). Such professionals are the so-called data scientists, who according to Varian (2014) can understand, process, extract, visualize and communicate Big Data. In this way, the data scientist is a high-level professional with training, know-how, know-why and expertise to make discoveries in Big Data(van der Aalst, 2014). However, only one respondent's multinational organization has a department with data scientists who deal with Big Data to exploit such data for innovation.

Therefore, using Big Data is only necessary when supported by tools and professional data scientists that enable greater utilization and innovation from Big Data.The use of KM as support for Big Data is seen as a connection for knowledge to be produced in the organization (Bose, 2009). Knowledge is seen as one of the foundations of organizations in the software industry(Pinto, Bortolozzi, Sartori, & Tenório, 2017) and, therefore, good management is necessary for the organization to obtain its benefits(Wiig, 1993). Also, KM is necessary for organizations, because it helps to make the most of knowledge and its resources(Becerra-Fernandez & Sabherwal, 2014). To this end, KM, based on its models, cycles, practices, and tools, allows organizations to store, code and constructively share knowledge, generating new knowledge and updating the existing one (Dalkir, 2013). Thus, in the software industry organizations, KM processes become indispensable. Therefore, using Big Data together with KM is critical. This is because, due to the large amount of data from Big Data in the organizations of the software industry, the processes of KM

are necessary to create new knowledge and to update the existing one.Bhat and Quadri, (2015) point out that one of the challenges facing Big Data relates to finding a hardware technology that supports the exponential growth of such data. The authors also point out that current trends in hardware technology have not evolved with the motivation to facilitate Big Data analysis. One of the reasons for this difficulty in hardware evolution concerns data processing of the Big Data analysis. This is because such processing demands considerable potentials to maximize memory, in addition to causing dependence on hardware operation(Wang, 2014). In this way, it is observed that thehardware support for Big Data analysis is still a challenge present within organizations of the software industry.Big Data is a reality within the software industry organizations. In this way, it is observed that it gives support to decision making since it is based on its data and the extraction of information. Besides, it is noted that the respective interviewees' organizations already recognize and use tools and trained professionals to provide more accurate data analysis. Thus, it is only necessary to analyze data from Big Data if it is allied to tools and professionals, in this case, the data scientist, who has the expertise to innovate from such data. However, over time, data stored in Big Data may become obsolete. For this, KM helps Big Data to create new knowledge and to update the existing one, through its processes. Regarding the challenges, it is observed that they are present within the organizations of the software industry, and, are related to adequate hardware for Big Data analysis.software industry.

Conclusion

This article investigated the opportunities and challenges of Big Data for the software industry organizations. For that, we conducted semi-structured interviews with four professionals working in different organizations of the software industry, with more than five years of experience in their respective functions. The results pointed out that Big Data is a means of benefiting decision making, accurate data analysis through tools and trained professionals, and the creation and updating of new knowledge with the support of KM. Regarding decision making, Big Data is used as a backup. This is because, through Big Data, such decision-making can be based on data and information. Data analysis accurately relates to the use of tools such as SQL and Phyton, Hadoop, Pentaho, SQL Server, MongoDB, and Cassandra, plus the support of trained professionals, so-called data scientists. In this context, Big Data analysis only becomes meaningful if it is allied to tools and data scientists, who have the expertise to innovate from such data. The creation of new knowledge with the support of KM is due to the fact that knowledge can become obsolete. For this, KM helps Big Data to create new knowledge and to update the existing one, through its processes. Regarding the challenges, it has been noted that they are present within the organizations of the software industry,and are related to adequate hardware for Big Data analysis. However, as future work, it is suggested to further study the hardware challenges for data analysis in software industry organizations.

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