ESTRATÉGIA

BIG DATA ANALYTICS UNDER THE ORGANIZATIONAL THEORY PERSPECTIVES

Abstract. This research intends, in an exploratory way, to systematize the operational management of big data analytics technology in a company that operates from the perspective of business networks. The approach seeks to fill the gap in the literature on the use of BDA with a focus on Organizational Theory and to present management mechanisms that can guide the use of big data analytics in a company. The option for the industry 4.0 segment intends to highlight the possibilities of using BDA by the company, since in this manufacturing model several digital technologies are used that produce huge amounts of data. The conclusion of the study showed that managing big data analysis from an organizational perspective leads to two complementary types of employment: employment in the internal analysis of the enterprise network data, which is oriented towards efficiency, and in the external data available in the WWW that promote the competitiveness of a company. As the main contribution to organizational theory, the study made it possible to systematize the operational management of big data analytics technology in manufacturing companies of Industry 4.0 and to suggest resource savings in the formation of BDA capabilities for the benefit of a company belonging to a business network.

Keywords: big data analytics, business network, industry 4.0, operational management, Organizational Theory.

1 Introduction

Economic and financial globalization and recent scientific and technological advances have produced a new business order with increased competitiveness between nations and companies on a world scale. The existence of new business logic, in addition to reducing the presence of companies competing in isolation, is imposing the creation and development of alliances between partners forming business networks (Gulati, Nohria & Zaheer, 2000) in this highly unstable and transformative context.

In this scenario, the growing use of digital technologies by companies, organizations, and people has intensified the current traffic of data, information, and communication, in the World Wide Web (WWW) - Internet, or even in corporate networks, with important consequences in inter-company relationships (Gligor, Pillai & Golgeci, 2021). The existence of an immense, varied and complex database available (Kumar, Kar & Ilavarasan, 2021) in these networks gives meaning to the term big data (Wang *et al*., 2016; Papadopoulos *et al*., 2017). Many companies are using Big Data Analytics (BDA) technology to extract value from extraordinarily large volumes of data (Mikalef *et al*., 2019), in near instant time (Papadopoulos et al., 2017) and through cognitive computing. (Gupta et al., 2018).

In this sense, the strategic relevance of companies established in business networks, particularly in competitive environments, lies in their capacity for synergy of efforts between them (Balestrin & Verschoore, 2020). This condition points to the possibility of compliance, whether in planning or using BDA holistically (Ghasemaghaei & Calic, 2020) for the benefit of the network or its companies. The preference for the approach through Industry 4.0, of a multidisciplinary nature (Piccarozzi, Aquilani & Gatti, 2018), intends to highlight the apparent relationship between BDA technology and the two main characteristics of this industrial model: the existence of intense data traffic produced by the diverse digital technologies and manufacturing machines, and digitally integrated production and real-time business environment (Wang *et al*., 2016).

Academic studies have been developed to explore the uses of BDA technology in cybersecurity (Leenen & Meyer, 2021) and in data management and storage (Wamba et al., 2017; Kushwaha & Dwivedi, 2021). However, several authors have noticed an important gap in carrying out studies involving a perspective centered on organizational theory (Sheng, Amankwah-Amoah & Wang, 2017; Wamba et al., 2017; Kar & Dwivedi, 2020).

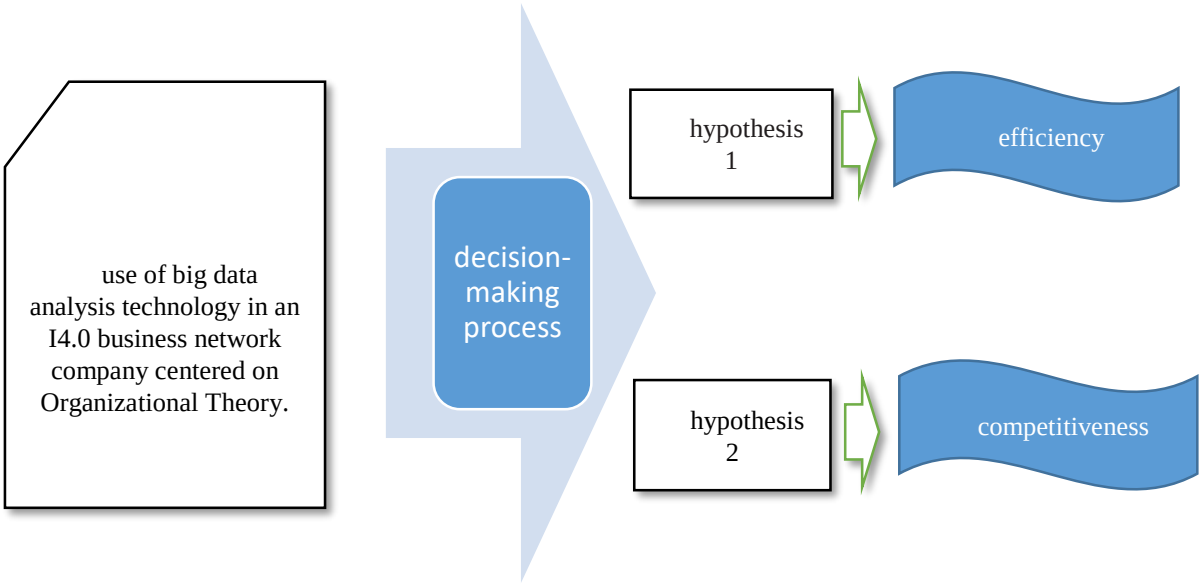
They support the need to develop a BDA employment doctrine (Camargo Fiorini *et al.,*2018), including in the manufacturing segment (Dubey *et al.,*2019), as they understand this digital technology as an organizational challenge (Mikalef *et al.,* 2019). This study intends to systematize, based on organizational theory, the operational management of BDA technology in manufacturing companies. For this, the business network perspective was chosen because this field of study is deeply rooted in organizational theory (Humphrey *et al*., 2020).

Two hypotheses are proposed:

H1 - The use of big data analytics technology provides efficiency gains for the organization.

H2 - The use of big data analytics technology provides competitive gains for the organization.

Figure 1: Proposed theoretical model



Source: author

The objectives of this research are, based on Organizational Theory, to characterize the main elements that form the I4.0 business networks and confirm/or refute the hypotheses presented above. The subject is current and relevant to the scientific community and practitioners since several organizations are investing in building Big Data Analytics capabilities (Kushwaha & Dwivedi, 2021).

This work develops, in an exploratory way, an operational management model that can be applied to the BDA digital technology used by manufacturing companies of Industry 4.0 and is organized as follows: introduction; theoretical foundation with content related to the organizational perspective of business networks and its relationship with the BDA literature; discussions and methodology. Section 5 presents the results found in this research in the form of a BDA employment model for companies in the Industry 4.0 business network. The work ends with a conclusion.

2 Theoretical Foundation

To fully achieve the objectives of this research, the theoretical basis needs to reveal the fundamental elements of organizational theory and BDA literature. In this line, the perspective of business networks plays the role of link of convergence between the two approaches.

2.1 Organizational theory - perspective of business networks

In organizational theory, some authors consider that the network is the way to organize economic activities through coordination and cooperation between companies (Grandori & Soda, 1995). Business networks can be understood as a set of two or more organizations that develop business relationships with each other and that have market relationships with suppliers, customers, and competitors (Lu *et al.,* 2020). Other authors consider business networks as the participation of companies in multiple relationships (Leick & Gretzinger, 2020) and also the complex interaction with suppliers, buyers, and other actors encompassing many companies and business relationships (Hedvall, 2020).

Industry 4.0 must be understood as a new paradigm of production with a very broad domain (Piccarozzi, Aquilani & Gatti, 2018). Business networks formed by Industry 4.0 organizations comprise an integration of suppliers, manufacturers and customers in a Cyber-Physical System (CPS) composed of robots, intelligent

machines, mechatronics and mobile devices, among other elements (Saniuk, Saniuk & Cagáňová, 2021) in environments of digital trust (Mubarak & Petraite, 2020). The concept of network production, mass, and customized provides an abundant amount of information about the manufacturing process itself to all companies in the network (Preuveneers, Joosen & Ilie-Zudor, 2018) and allows the exchange of information in real time about the resources used (Saniuk, Saniuk & Cagáňová, 2021). This condition becomes attractive for the use of Big Data technology, seeking to improve the efficiency and profitability of companies (Saniuk, Saniuk & Cagáňová, 2021), notably suppliers and customers, which makes the smart manufacturing industry a prominent segment in this aspect (Kushwaha & Dwivedi, 2021).

These cyber industry networks (Saniuk, Saniuk & Cagáňová, 2021) facilitate business by bringing together companies connected via the Internet and through intelligent resources (Grabowska, 2020), providing benefits as information sharing, increased transparency and visibility of operations, optimization of manufacturing systems, in terms of energy and resource consumption, and reduction of operational and production costs (Bhatia & Kumar, 2020).

The characterization of an Industry 4.0 business network is conditioned to an unlimited communication of companies with their suppliers and customers through modern communication networks, block chain or IoT (Internet of Things) (Saniuk, Saniuk & Cagáňová, 2021). This enables secure and real-time data exchange (Saniuk, Saniuk & Cagáňová, 2021). In this sense, Wamba (2017) considers the existence of a digital infrastructure that includes aspects like connectivity, compatibility and modularity. In the case of competitors, although they may be considered passive actors in business networks, a growing participation of this group in the formation of alliances and organizational networks with focal companies has recently been observed (Tauhata & Macedo-Soares, 2004).

2.2 Big Data Analytics literature in business networks

Big Data should be understood as an immense amount of data continuously generated by multiple sources (Sheng, Amankwah-Amoah & Wang, 2017) and its analysis comprises modern analytical resources of Information Technologies (Leenen & Meyer, 2021). The BDA has become a necessary technology in business operations (Sheng, Amankwah-Amoah & Wang, 2017) that aims to detect patterns, correlations, trends and useful information (Leenen & Meyer, 2021). It allows companies to see things they would otherwise not be able to see (Ranjan & Foropon, 2021) and facilitates decision making (Mikalef *et al.*, 2019) by reducing errors (Fanelli et al. 2022) particularly in operations management (Bertsimas, Kallus & Hussain, 2016).

The flexibility provided by BDA technology (Grover & Kar, 2017) enables the transformation of business operations through its insights (Mikalef et al., 2019) and the achievement of competitive advantage (Ghasemaghaei & Calic, 2020; Wamba et al., 2017). Technological innovation produced by the use of BDA promotes changes in company management and operations in addition to fostering new business (Sheng, Amankwah-Amoah & Wang, 2017) and improving company performance (Ghasemaghaei, 2018), operational efficiency (Dubey et al., 2019; Mikalef et al., 2019; Srinivasan & Swink, 2018) and supply chain management (Mandal, 2018; Mikalef *et al.*, 2019). In business networks, there is an improvement in operational performance (Matthias et al., 2017) allowing an increase in company revenue of around 8% (Liu, 2014).

BDA facilitates near-real-time decision-making processes (Papadopoulos et al., 2017), based on large amounts of data, improving the relationship between companies

and their customers (Fox & Do, 2013), by increasing the volume of business and online customer transactions (Wright et al., 2019) and decreasing customer acquisition costs by around 47% (Liu, 2014). It also allows the identification of customer requirements (Sheng, Amankwah-Amoah & Wang, 2017; Kumar, Kar & Ilavarasan, 2021) which generates benefits in marketing, due to the efficiency of data management (Lichtenthaler, 2021), and realignment of the business strategy (Mishra et al., 2017). In general, the use of BDA enables a better understanding of customers' preferences (Tan et al., 2015) and their needs (Zhang et al., 2017). Some authors also suggest that the BDA confers greater bargaining power in negotiating with customers and suppliers (Zhang *et al.,* 2017).

It also makes it possible to collect data on the Internet, allowing companies to identify ongoing competitions (Sheng, Amankwah-Amoah & Wang, 2017) and organize their competitive counterintelligence by collecting and analyzing information about competitors (Kamboj et al., 2018). The mining of textual information on the websites of competing companies (Nassirtoussi et al., 2015) helps in market forecasting and allows companies to receive alerts about the movements of these competitors (Ranjan & Foropon, 2021). The potential for using BDA with competitors is still very low (Ranjan & Foropon, 2021).

Regarding the Industry 4.0 business network the wide use of digital technologies allows for superior integration between companies, and the combination of Big Data with cloud computing makes real-time collaboration between companies, improving productivity and security (Maskuriy et al., 2019). The existence of cooperation in the sharing of customer and supplier databases, with standardization of formats and exchange protocols, allows the full use of the BDA, favoring cyber security (Leenen & Meyer, 2021) and the development of a data analytic culture (Dubey *et al.,* 2019).

3 Organizational perspective for using BDA in Industry 4.0 business networks - discussion

Some authors argue that the value produced by the BDA is the result of organizational diffusion (Mikalef *et al.,* 2019; Wamba *et al.*, 2017) that can be leveraged in network operations. In business networks, several actors stand out that form groups of companies with their own characteristics and similar interests, like suppliers, customers, and competitors (Lu *et al.,* 2020). The presence of other organizations as public, financial and university (Hedvall, 2020) in these relationships also indicate excellent possibilities for the use of the BDA aiming at developing the operational management of the focal manufacturing company.

The use of BDA at the level of the company established in a business network proposes governance schemes with definition of responsibilities and cooperation between departments/organizations to reach the analytical maturity desired by the company (Mikalef et al., 2019). Some authors consider the need for a solid analytical infrastructure to facilitate departmental operations to optimize manufacturing processes in terms of costs and resources (Grover & Kar, 2017) since using data in management has become a necessity for organizations (Kushwaha & Dwivedi, 2021). In this sense, one should avoid focusing exclusively on collecting a large amount of data, but giving preference to the possibility of integration between different types of data (Ghasemaghaei & Calic, 2020) available in the business network.

The perception that Industry 4.0 model brings together companies in the business network connected through smart resources (Grabowska, 2020) needs to be better understood. If, on the one hand, there is a predominantly private connection – including the intranet, with its customers, suppliers (Leenen & Meyer, 2021; Wright *et*

al., 2019) and even financial organizations, on the other hand, there are relationships with competitors (Ranjan & Foropon, 2021), and other actors, carried out exclusively by the world wide web, reinforcing in this case the public nature of this typology of data, even though it is subject to the laws of access to information in numerous countries. Thus, the application of BDA by an Industry 4.0 company could be performed from two network perspectives: internal and external.

In an internal view, the potential for using the BDA is strictly related to the level of coordination and cooperation between companies (Grandori & Soda, 1995) existing in the inter-company relationship, especially trust (Mikalef *et al.,* 2019). Thus, the sharing of structured, semi and unstructured data (Leenen & Meyer, 2021; Papadopoulos *et al.,* 2017; Talón-Ballestero *et al.,* 2018), including those generated by sensors and machines (Grover & Kar, 2017), among companies, it can be intense, allowing fullness in the use of the BDA with advantages in cybersecurity (Leenen & Meyer, 2021) and in the development of a data analytic culture (Dubey *et al.,* 2019). The benefits in the operational management of companies with the use of the BDA can be reproduced, or even increased in Industry 4.0, with customers improving decision-making processes (Papadopoulos *et al.,* 2017), favoring the relationship (Fox & Do, 2013; Wright *et al.,* 2019) and the development of new products (Chan *et al.,* 2016), and generating benefits in marketing (Mishra *et al.,* 2017). Otherwise, the advantages of operational management with suppliers can be seen in innovation (Wright *et al.,* 2019) and in supporting supply chain operations (Lee & Mangalaraj, 2022; Mikalef *et al.,* 2019; Mandal, 2018; Tan *et al.,*2015).

In its external use, the BDA in Industry 4.0 assumes legal limits that directly influence relations with competitors (Ranjan & Foropon, 2021), and other actors in the business network. In this environment, the data of interest are essentially semi- and unstructured (Leenen & Meyer, 2021; Papadopoulos *et al.,* 2017; Talón-Ballestero *et al.,* 2018) requiring the mining of textual information and websites of competing companies (Nassirtoussi *et al.,* 2015) and enabling the check of public information from government agencies, class associations and educational institutions, among other elements. In operational management, benefits are related to decision making (Kamboj *et al.,* 2018; Sheng, Amankwah-Amoah & Wang, 2017) and to the organization of competitive counterintelligence (Kamboj *et al.,* 2018).

Figure 2. Logical construction based on arguments

BDA internal view	BDA external view
insights indicating efficiency	**insights indicating competitiveness**
improve the efficiency (Saniuk, Saniuk & Cagáňová, 2021)	achievement of competitive advantage (Ghasemaghaei & Calic, 2020; Wamba et al., 2017).
improving productivity (Maskuriy *et al.,* 2019)	to fostering new business (Sheng, Amankwah-Amoah & Wang, 2017)
by reducing errors (Fanelli et al. 2022)	development of new products (Chan *et al.,* 2016)
improving company performance (Ghasemaghaei, 2018)	greater bargaining power in negotiating with customers and suppliers (Zhang *et al.,* 2017)
operational efficiency (Dubey et al., 2019; Mikalef et al., 2019; Srinivasan & Swink, 2018)	identification of customer requirements (Sheng, Amankwah-Amoah & Wang, 2017; Kumar, Kar & Ilavarasan, 2021)
decreasing customer acquisition costs by about 47% (Liu, 2014)	benefits in marketing and realignment of the business strategy (Mishra et al., 2017)
improvement in operational performance (Matthias et al., 2017)	enables a better understanding of customers' preferences (Tan et al., 2015) and their needs (Zhang et al., 2017).
improving productivity (Maskuriy et al., 2019)	generating benefits in marketing (Mishra *et al.,* 2017) and online marketing (Wright *et al.,* 2019)

supporting supply chain operations (Mikalef *et al.,* 2019; Mandal, 2018; Tan *et al.,*2015).	helps in market forecasting and allows companies to receive alerts about the movements of these competitors (Ranjan & Foropon, 2021)
	innovation (Wright *et al.,* 2019)
	to competitiveness (Nassirtoussi *et al.,* 2015; Ranjan & Foropon, 2021; Sheng, Amankwah-Amoah & Wang, 2017)
	organization of competitive counterintelligence (Kamboj *et al.,* 2018).

Source: author

On the one hand, the two perspectives for approaching the BDA in Industry 4.0 differ substantially from each other in their form of organization. The sharing of information between the manufacturing company and its customers and suppliers, arranged and integrated into CPS systems (Saniuk, Saniuk & Cagáňová, 2021), is processed through a simple data collection, based on an exchange of information in real time (Saniuk, Saniuk & Cagáňová, 2021) and organized in the degree of trust desired by the actors. On the other hand, in the external approach, the process is characterized by being exploratory and the search for data involves all sorts of difficulties, since legal, even the access to sources of interest and the reliability of the data. This dichotomy can result in the existence of a confused analytical culture in the organization, which would somehow justify the arguments of some authors indicating that the BDA has even hindered the operational decisions of the company (Merendino *et al.,* 2018).

In this way, organizing activities with the use of the BDA technology by the Industry 4.0 company becomes essential. The external perspective of the focal industry, of an aggressive BDA on the internet, embrace aspects related to competitive intelligence (Kamboj *et al.,* 2018), to competitiveness (Nassirtoussi *et al.,* 2015; Ranjan & Foropon, 2021; Sheng, Amankwah-Amoah & Wang, 2017) and online marketing (Wright *et al.,* 2019). This mode of operation, of fundamental importance for the company and covered with confidentiality and legal assistance, needs to be conducted by an analytical element/group directly directed by Industry 4.0 – focal company. Otherwise, in the business network environment, the focal company collects data from customers, suppliers and organizations of interest. This internal perspective, which guides the search for efficiency, may suggest the creation of BDA units by the business network itself, taking advantage of its synergistic nature of efforts (Balestrin & Verschoore, 2020), spreading costs and sharing the analysis for all interested actors.

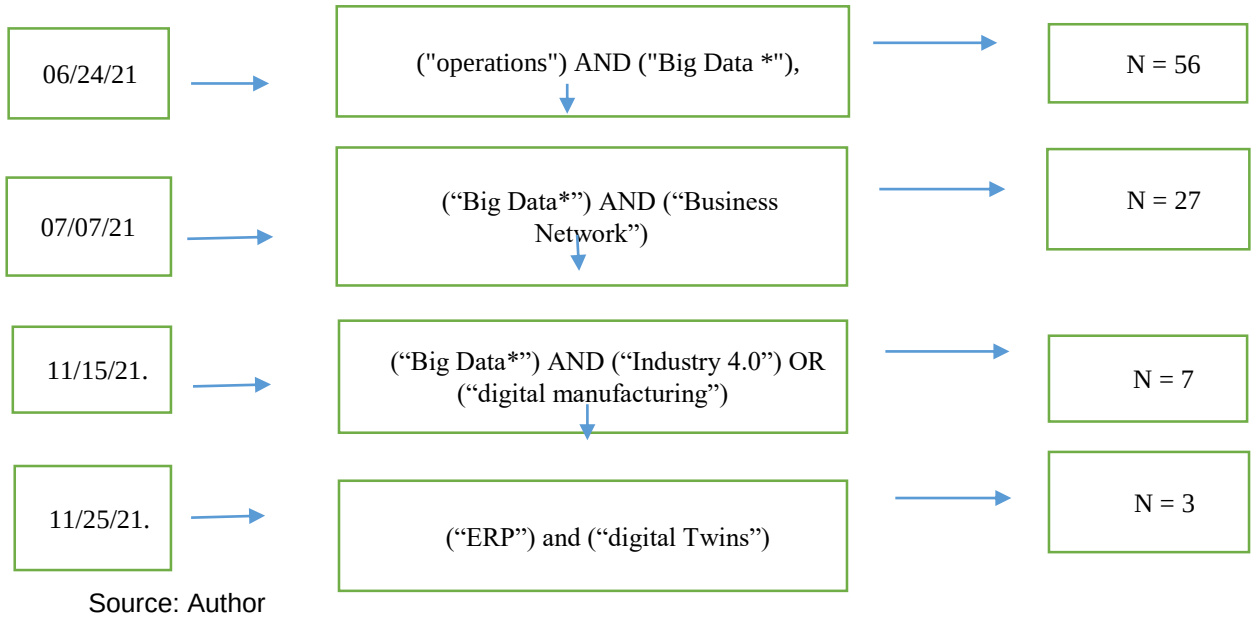
4 Methodology

This research is exploratory in nature and originated from the perception of several authors who noted an important gap in the conduct of BDA research involving a perspective centered on organizational theory (Sheng, Amankwah-Amoah & Wang, 2017; Wamba *et al.*, 2017; Kar & Dwivedi, 2020). The organizational theory chosen was the perspective of business networks due to the possibility that this model offers in saving resources for the creation and development of BDA teams. In this way, all companies belonging to the business network can contribute to the acquisition and maintenance costs of a BDA element to provide services to organizations.

Higgins et al., (2019) consider that a systematic review of the literature needs to establish a search protocol, that is, the combination of keywords to perform the data search. On 06/24/21 a documental search was carried out in the Scopus (Elsevier) database, internationally known, using the search fields by title, abstract and keyword with the chain ("operations") AND ("Big Data *"), from 2012 to 2021 and with the filters:

(a) study area only Administration, Business and Accounting, (b) type of documents, only scientific papers, and (c) English language. The result was 56 documents that had their abstracts read and 14 papers dealing with BDA technology and its relationship with the operational level of organizations were used.

Fig. 3. Search results on the Scopus platform



Source: Author

The second search in the Scopus database took place on 07/07/21 with the terms: ("Big Data*") AND ("Business Network") for paper title, abstract, and Keywords and under the same conditions as above. There were 27 documents left, which after analyzing their abstracts, left over six papers of interest that were read and helped in the construction of the theoretical framework of this study.

The theme was expanded in order to absorb practical research that dealt with the application of BDA in manufacturing companies, thus carrying out a third search on 11/15/21. In the Scopus platform and in the conditions previously reported, changing only the search current ("Big Data*") AND ("Industry 4.0") OR ("digital manufacturing") the investigation resulted in seven scientific papers that were used in this work. Due to the exploratory characteristics of the research, a final search was needed on 11/25/21 to know the elements ("ERP") and ("digital Twins") in the context of Industry 4.0, finding three useful papers for the work.

5 Results : BDA employment in Industry 4.0 business networks

This section proposes to present the BDA employment modeling based, to a large extent, on the organizational perspectives of the industry 4.0 business network. Two fundamental aspects of the use of BDA technology are presented below, which refer to the source and the preparation of data and algorithms for the development of an efficient analysis. At the end of the section some techniques that have been used in BDA are cited.

5.1 Data Sources for Big Data Analysis

It can be considered that the big data source plays a decisive role in the verification and analysis of BDA technology results. Some authors point out that cognitive systems that facilitate the emergence of innovations and the development of new products suffer external and internal influence (Gupta *et al*, 2018). The sources available for this purpose are presented below.

5.1.1 Internal - *Intranet*

The corporate Enterprise Resource Planning (ERP)

Because it is a system based on Information Technology (Iris & Cebeci, 2014) with a high degree of integration of information systems for the processing of company information (Werner, Wiese & Maas, 2021) and also because it is considered a system source information with process recognition (Dumas *et al*., 2005) enterprise resource planning can provide data, and even information, about business processes (Iris &Cebeci, 2014) of companies, particularly those related to the organization's event registration like product sales and existing stocks.

There are several types of ERP systems: ERP SAP R/3, Oracle, BAAN, MFG Pro, JDEdwards, People Soft, etc., and there are even systems developed by the companies themselves (Tarigan *et al*., 2021) that contribute to the construction of a system single database that companies can share with suppliers (Tarigan *et al*., 2021). Some authors even consider the application of process mining in organizational purchases in an ERP system viable (Werner, Wiese & Maas, 2021).

Thus, it can be stated that the high degree of automation, particularly that existing in industry 4.0, allows the capture of data and quantitative information about transaction processing (Werner, Wiese & Maas, 2021). In this way, ERP systems in use by companies can integrate all partners involved in the supply chain (Tarigan *et al*., 2021), particularly suppliers and customers (Zhao *et al*., 2013), and better performance in the purchasing process can be achieved by integrating the company with its suppliers (He *et al*., 2014).

The digital twin and Others

Digital twin comprises the existence of a physical entity and a related virtual entity that allows real-time simulation (Tao *et al*., 2019). This model is built by installing sensors (vibration, temperature, acoustics, force, velocity, position, and camera images) on the physical elements of the factory (Warke *et al*., 2021) generating huge amounts of data (Fattahi *et al*., 2021) in the digital simulation models that analyzed can favor the decision-making process and improve performance (Blomkvist *et al.*, 2020). This concept even enables digital representation applied to physical products (Grieves, 2015) and is also used in machine monitoring, predictive maintenance, process optimization, and economic production (Warke *et al*., 2021), allowing feedback from IoT manufacturing enablers (Zhang *et al.,* 2016). The use of Big data has been pointed out by researchers including in the field of construction. Using a digital twin can support infrastructure modeling and test model development activities before actual builds (Munawar, *et al.,* 2022).

Many authors understand that technological advances in data analysis and other enabling technologies present in Industry 4.0 facilitate the integration between digital twin and prominent fields (Fuller *et al.,* 2020). Some authors recognize that, in addition to the digital version of the documentation of operational activities, the datasets needed to build the digital twin must also be added to Big Data (Fattahi *et al*., 2021) since the creation of a twin phenomenon requires many steps and it becomes necessary to integrate it with the built-in IoT enablers (Fattahi *et al.,* 2021).

Customers, suppliers and even consumers provide data in different formats, whether structured, those coming from the company's databases, or semi-structured and unstructured coming from meta search engines and social networks, among others (Leenen & Meyer, 2021; Papadopoulos *et al.,* 2017; Talón-Ballestero *et al.,* 2018). Some authors consider that the digital transformation of the industry has

increased the quality and volume of unstructured data (Kumar, Kar & Ilavarasan, 2021). Unstructured data, which represent 80% of existing data (Tan *et al.,*2015), usually refer to text, multimedia, social media (Ghasemaghaei & Calic, 2020; Sheng, Amankwah-Amoah & Wang, 2017) and sensors embedded in factory machines.

5.1.2 External **-** *Internet*

The Internet can be considered the main source for data capture for BDA. Companies are increasingly using the Internet in their organizational strategies, whether in assessing market demand, brand promotion and reputation (Kumar, Kar & Ilavarasan, 2021), sharing information and collecting feedback (Choo 2006). The data used on the websites of organizations allow to identify and measure the changes that occur in the business environment (Arora *et al.,* 2020). Some authors also consider that social media promote entrepreneurship processes due to the possibility of social interaction that develops (Fischer & Reuber, 2011) and contribute feedback on services and products favoring Digital Marketing (Kumar, Kar & Ilavarasan, 2021).

Websites can demonstrate changes in market orientation, product portfolio and the composition of alliance networks (Li *et al*. 2016), even the company's ongoing research and development activities and the granting of patents (Gök *et al*., 2015). Despite these advantages, the use of data from these sites has limitations like sampling bias (Arora *et al.,* 2020), among others, which deserve special attention from BDA analysts.

With the development of the Semantic Web that proposes the exchange and use of information between large information silos, thus increasing the power of the Web (Berners-Lee *et al.,* 2006), Big Data sources multiply making it possible to organize information for computers and machines in RDF format (Resource Description Framework).

The analysis of real-time data sought in traffic applications and companies' transport information would facilitate operations by indicating available and efficient routes (Mishra & Tripathi, 2021). With the application of BDA in the network companies and in this context, new opportunities for cost savings could be revealed.

LinkedIn or Twitter platforms should also be considered as Big Data sources for business analysis and innovation. (Arora *et al.,* 2020), among other social media (Kumar, Kar & Ilavarasan, 2021). Certain authors also consider as sources for collecting big data: online forums, social media, emails, news and online forums, devices connected through the internet of things (IoT), telecommunications devices, applications based on sensors in devices, among others (Kar & Dwivedi, 2020). The analysis of existing Big Data sources on the Internet enables data intelligence that allows recognizing customer inclinations (Muthuveloo & Ping, 2013) and the development of competitive intelligence, market analysis and misinformation management (Kumar, Kar & Ilavarasan, 2021).

5.2 BDA employment techniques

As it is a sophisticated technological tool, the BDA already has some employment techniques that can be seen below. Again, the techniques are guided by the organizational perspectives of the industry 4.0 business network.

5.2.1 Internal **-** *Intranet*

The data analysis technique that uses process mining is performed by algorithms that have the ability to investigate computer operating systems by gathering information about an organization's business processes (Werner, Wiese & Maas, 2021). This technique makes it possible to create reliable business process models

automatically as it uses data from recorded events (Werner, Wiese & Maas, 2021) helping to overcome difficulties related to using a large amount of data.

Real-time monitoring and control of manufacturing systems in the automotive industry uses unstructured datasets collected from sensors that are pre-processed by specific software (Apache Kafka, Apache Storm e MongoDB) and when analyzed allow the detection of failures (Syafrudin *et al.,* 2018). The sensors existing in the factory also produce a Big Data ecosystem that is handled by various technologies (data lake, banco de dados NoSQL, Apache Spark, Apache Drill, Apache Hive and OPC Collector) enable predictive maintenance (Yu *et al.,* 2019) of machinery and equipment. The use of BDA can also be developed to ensure low energy consumption of the cyberphysical industrial production system by matching the energy-related dataset with those relating to production (Zhang, *et al.,* 2020).

5.2.2 External **-** *Internet*

Searching the World Wide Web can preferably be performed by analytical software that captures text on standard HTML (Hyper Text Markup Language) website pages (Arora *et al.,* 2020). Greater sophistication can be achieved in investigating Adobe Flash and PDF content also used on the Internet. The site mining technique has advantages like accessibility and opportunity (Arora *et al.,* 2020) and limitations (Gök *et al.* 2015) requiring special preparation from the BDA teams particularly with regard to the reliability of data sources.

The Wayback machine tool despite its limitations (Arora *et al.,* 2020), can be used as a basis for starting website mining due to its ability to archive historical HTML pages. For web data extraction work can be used the software IBM Content Analytics (Arora *et al.,* 2020). In this context, the website pages of competing companies can be analyzed using the unstructured text mining technique and the strategic changes that have taken place over time can be verified, as the web content undergoes changes and you can even reveal the dynamic capabilities of each company (Arora *et al.,* 2020).

Ferreira (2016), in turn, indicates the use of datasets to optimize product price decisions in retail companies, improving Big Data forecasting models, since speed in decision-making is essential for companies to preserve stability in a market in changes (Siagian *et al.,* 2020).

Process mining has been widely used as an analysis technique in social networks (Maita *et al.*, 2018) and with the possibility of application also in the manufacturing industry (Lee *et al*., 2013). The main applications of text mining in management involve online reviews (eg Amazon, Yelp, TripAdvisor, Booking, Expedia) and social media data (eg Twitter and Facebook) (Kumar, Kar & Ilavarasan, 2021). Some authors have also indicated the use of word processing techniques to medical literature available in health and clinical pharmacology journals. (Salman *et al*., 2022).

6 Conclusions

As evidenced, both hypotheses were confirmed by the existing literature. Both can be considered complementary. It is concluded, therefore, that the use of the BDA in the operational management of a manufacturing company in Industry 4.0, established in business networks, suggests the organization of two structures, each with its own characteristics and distinct analytical culture. The first, preferably under the hybrid governance of the business network and with passive action, with the objective of collecting data from suppliers and customers, and eventually from organizations on the internet. The second structure organized and directly controlled

by the manufacturing company to actively search for data in an exploratory way on the World Wide Web.

As the main contribution to organizational theory, the study allowed to systematize the operational management of the BDA technology in manufacturing companies of Industry 4.0. The organization of two BDA employment mechanisms was evidenced in the company, collection and search, oriented towards efficiency or competitiveness, which can be adapted for companies in other economic sectors.

Second, research suggests that Industry 4.0 business networks can implement the use of BDA technology. This possibility shows advantages for the associated companies, since this technology brings benefits both to the focal companies, as well as to suppliers and customers, and allows cost savings for the installation of the necessary infrastructure.

The main limitation of this research study was the scarce literature on the use of big data analytics technology centered on Organizational Theory. For future research, it is recommended to better understand the existing analytical culture in companies, which use the BDA technology, in order to confirm the assumptions presented.

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