Influence of Big Data on Manufacturing Industry and Strategies of Enterprises: A Literature Review

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Abstract. Along with the rapid development of information technologies, such as cloud computing, mobile internet and internet of things, and the promotion of IT application, all kinds of data are generated and accumulated rapidly in various ways, big data era is coming, in which enterprises are faced with both opportunities and unprecedented challenges. Various processes, from decision making to operation and from designing to marketing, are being influenced by big data in manufacturing industry. This paper, according to the nature and features of big data, analyzes and extends a classical model of organizational change, Leavitt's model of organizational change, in order to explore the ways for enterprises to cope with challenges and seize chances of development in big data era. Then, using the extended Leavitt's model, opportunities and challenges derive from big data are combed, and approaches to making use of big data and coping with big data are generalized from five perspectives, including task, structure, people, technology and environment.

1 Introduction

"Big data", emerged at 2008, has profound influence on various fields such as commerce, consumers and society [1], even deeply changes them all [2]. All walks of life, like enterprises, governments and research institutes, have begun to explore the connotation of big data and the approaches to using it to optimize different activities one after another. For instance, many research institutes, including EMC, IBM, McKinsey and so on, reported their diverse understandings of "big data", many countries, such as America, England, France and Japan, also adopted different measures to make full use of it, so did China. Li Keqiang, the Chinese Premier, attended the China's big data industry summit and the development of Chinese e-commerce innovation summit, emphasizing that we should combine the technological innovation of big data and the craftsman spirit of traditional industries to rebuild the industry chain, supply chain and value chain, and indicating that the government will play a role in the process of promoting information sharing, strengthening information security and so on, in May 5, 2016.

According to the report from Cisco, mobile data traffic increased 4000 times over the past decade, and rose four billion times over the past 15 years. It is not only the data volume explodes, but the rate of data transfer also grows faster and faster, as well as the proportion of unstructured data becomes bigger and bigger. There is more and more various data around enterprises internal and external. At the same time, more and more companies regard it as their own data asset as they could create more opportunities, optimize allocation of resources, make real time decisions, and improve production and services, by using it. In addition, there are new types of business organizations, new data brokers, in the context of big data, they acquire benefits by circulating data [3]. Besides, the existence of big data impacts the competition mode between enterprises, which is to say that it is no longer focus on products but knowledge technologies [4]. Thus, there is an issue corporations must solve, how they take certain steps to seize the opportunities to gain competitive edge in the intense competitive environment, in the big data era. Being centred on the matter companies are facing with, for different purposes, a large number of researches are made by disparate scholars from diverse views. The aim of this paper is, basing on the Leavitt's model of organizational change and integrating literatures correlation with manufacturing enterprises in big data era, to comb the opportunities and challenges derived from big data, finally generalizes approaches to capitalizing on it.

Theoretical bases, the definition and features of big data and Leavitt's model of organization change, are introduced in the first part. The second part is the opportunities and challenges enterprises are faced with, while the third part is their coping strategies. Finally, there are a few conclusions.

2 Theoretical bases

2.1 The definitions and features of big data

Although the word, big data, has been received wide attention in recent years, there is no specific definition about it [5]. Some researchers define it in the technology field, while others consider it as data, which has certain characteristics. Big data is the accumulation of mass techniques that are related to processing a great deal of data [6]. Schroeck et al treat it as a technique that contains complex analysis tools, and enterprises would find as well as access to data and then analyze it rapidly to dig up its value by using them. However, big data has no longer been limited in the field of technology. A large portion of scholars think that it is a data asset of companies, which implies lots of value that can be used by them [5, 7]. Besides, Manyika et al deem it to a data set whose size go far beyond the abilities of getting, storing, managing and analyzing of traditional database software [3].

There is a definition, which has been widely applied, that big data is information asset whose volume is large, velocity is high, and forms are various [8]. It is the "3v" characteristic of big data, volume, velocity and variety, we can derive from the definition. Therein, volume refers to unceasing accumulation of data, its size expands constantly, velocity refers to its high speed of generating and timeliness, so it must be analyzed in time, while variety refers to its various forms, it can be classified into structural data, unstructured data and semi-structured data [5]. There are a few researchers to enrich the "3v" features to "4v" after Gartner's definition. Schroeck et al [6] added veracity into above three characteristics to emphasize on the uncertainty of certain types data such as weather, economy, the consuming intention of consumers and so on, while Li et al [9] added value into "3v" in order to explain the feature of huge value but low-density. So, big data is some kinds of data with above characteristics, as well as technique related to data analysis tools, because many researches defined it from diverse views in different fields.

The application value of big data has covered most fields, including education, communication, healthcare, manufacturing industry, financial industry, government, public utilities and so on [4, 10]. At the same time, it has permeated into different behaviors of enterprises, they can use it to make optimization. For instance, product bundling and pricing, reacting to market sentiment and consumer demand, product design, market positioning and obtaining new massage about dynamic competition could be improved or enhanced by using it [1, 11]. But the "big value" and "big impact" of big data are waiting to be further studied and explored.

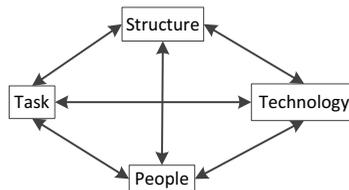### 2.2 Leavitt's model of organizational change

Fig. 1. Leavitt's model of organizational change.

In the Leavitt's model of organizational change, which has been wide applied and extended, Leavitt categorized organization into four variables, technology, people, task and structure, and considered that those four variables interacted with each other, if there were a certain variable changes, other one or more variables, including itself, would change as well [12]. Thus, there are a large number of researchers have a thought that it is necessary to keep a balance between them in order to make the organizations operate steadily and effectively [13-15].

Though Leavitt and other researchers, combining with certain specific issues, defined those four variables diversely in the process of model application, the essential connotation has been maintained. Technology refers to the techniques and mechanisms of solving issues directly [12, 13], like the platform of computer software [16], the storage and aging treatment of information and some technical norms [14, 17]. People accounts for everything related to individual or group inside of organizations, such as the power, responsibilities, abilities and attitude [12, 13], as well as the direct relationship between individuals [17]. While there are various specific definitions about task because of diverse research problems, it refers to the aims or missions of organizations or techniques, like the performance of production of products and services [12], the behavior of strategy implementation [13], the aim of a certain system or work supported by the system [14-17]. And structure mainly accounts for internal frameworks, no matter visible or invisible, of enterprises, such as business process, organizational departmentalization or systems of authority, information systems inside of organizations and size of it [12, 17] as well as the immaterial structure, like corporate culture [13]. This paper defines technology as data management and data techniques related to big data, people as the power, responsibilities, abilities and attitude of individuals, task as strategic management, operations management, marketing management and human resource management, and structure as the internal information systems, organizational structures, business process and corporate culture.

In addition, the Leavitt's model has been widely expanded in the process of application. Scott et al, the first one who added environment variable into this model, considered that environment interacted and interdepended with each other four variables, so did Lyytinen et al [15] and Mandt et al [18]. Although it is enough to categorize enterprise into above four variables or dimensions in the context of big data, factors outside of organizations, such as public policies, economy and environment of industry and technology, also influence them, which cannot be ignored. Thus, environment variable is added in this paper.
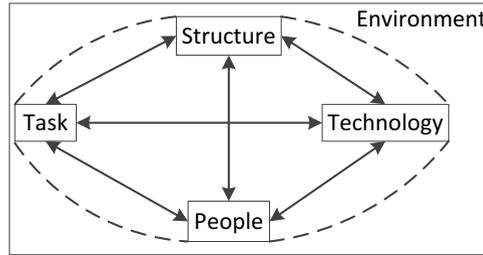

Fig. 2. Model in this paper [6].

Table 1. The definitions of model applied in this paper.

	Classifications of definitions	Examples
Technology	Data management [14]	Data privacy management, standards related to data management and so on.
	Data technology [14-16]	Techniques and infrastructures related to big data
People	Individual power [12,13]	Individual privacy
	Individual ability [14]	Ability of mastering multiple knowledge
	Individual attitude [14,17]	Support to big data application
Task	Strategic management [13]	Making sure competitive edge, generating strategy and so on
	Operations management [12]	Product design and manufacturing, specific policies and so on.
	Marketing management [12]	After-sales service
	Human resource management [12]	Recruitment, the vocational development planning and so on.
Structure	Internal information system [12, 13, 15]	Communication between individuals or groups
	Organizational structure [12, 13, 17]	Systems of power, distribution of employees and so on
	Business process [12-14]	Specific process about data management
	Corporate culture [13]	Culture of hiring and firing, sharing information atmosphere and so on
Environ-ment	Political system, economic, social and technological environment [13]	This paper focuses on technological environment such so techniques have not been applied.

The Leavitt's model has been applied in various research fields, like medicine [18], risk management [16], information system [15, 17, 19], information technology [13, 20], computer science [21], organizational design [20], performance evaluation [14] and so on, since it was created. Besides, there are three approaches to applying this model roughly. 1. Redefining variables according to the original model, from different perspectives. For instance, technology variable affects others [18, 19, 21] or itself, serves as dependent variable, is affected by others [17]. At the same time, some researchers apply the category of this model to categorizing diverse factors of different issues [16]. 2. Expanding model to do some researches, like discussing the relationship between different variables [13, 15]. 3. Using the thought of this model to state a certain perspective [22, 23]. Mainly, this paper applies the expanded Leavitt's model to integrating current living conditions and coping strategies of manufacturing corporations under the background of big data.

3 The opportunities and challenges in the big data era

In the big data era, there is more and more valuable and multiple-structure data inside or outside of enterprises. It is a focus all over the world that how to make full use of it availably [10]. However, it is well-known that the application of big data is not only an opportunity to developing and optimizing, but also a challenge for corporations.

Table 2. The opportunities and challenges in the big data era.

	Domains	Dimension	Explanation
Opportun-ities	Environ-ment	Technological environment	More and more data could be used by enterprises [1]
	Task	Strategic management	Market segmentation [7]
			Making decision more clearly [24, 25]
		Operations management	Optimizing production planning or obtain new business opportunities [26]
			Optimizing service or division of customers [3]
			Reducing the cost and flaws of product, or optimizing product design [3]
		Marketing management	Optimizing after-sales service [3]
		Human resource management	Improving the accuracy of online recruitment [27]
Challenges	Technology	Data management	Cannot apply and manage data effectively [28]
		Data technology	The types of data does not match techniques [29]
			Lacking of the abilities of data acquisition, analysis and processing [6, 26]
	Task	Human resource management	The lack of talent [1, 3]
	People	Individual power	Privacy security is threatened[31]
			Increased working pressure [31]
	Structure	Corporate culture	Stability is threatened [31]

3.1 The opportunities in the big data era

In the ever- changing technological environment of enterprises, there is more and more data and relevant techniques. Many behaviers of corporations, such as strategy, operation and human resource, would be optimized because of the application of big data, which is full of abundant value and waiting to be explored.

Big data techniques could provide a great deal of information, which has been processed already and abounds with a mass of commercial value, to enterprises, would help them to gain competition advantages as well[6]. Thus, they are able to observe the business environment more clearly, and then would find a way to become more accurately and quickly response to market. As a result, they could separate themselves from other competitors [7]. Moreover, the employ of big data could also render decision makers more clear-eyed, they are capable of understanding how to create, deliver and gain more value, when they are making either long-term or short-term decisions [24, 25].

Meanwhile, it is possible for enterprises to make use of relevant data to analyze in real-time, and make timely or near-timely decisions to enlarge the benefits [1, 6, 26]. 1. Using data about the market, they can comprehend the highly unstable market environment, get more accurate information of market demand, and then optimize allocation of resources and adjust production plans [27], or create new business opportunities [26]. 2. Using data about the consumers, corporations would focus on the features of products certain consumers pay more attention to, see the customers demand and forecast their consuming behaviours. Thereby, there will be more specific product positioning and higher level of services [3]. Otherwise, enterprises could divide the groups of consumers for marketing more efficaciously [32]. 3. Using data about the products, manufacturers are able to do quick and low-cost simulation experiments to test various designs, and chose both components and suppliers to calculate the relevant manufacturing costs. As a result, the production cost and development time could be saved. If there is any information about products flaws, productive process would be adjusted, and new design would be developed, then the product defects would be removed before production. Enterprises can also analyze data about the products, which were already sold, to improve their quality of after-sales service and level of marketing. Before the trouble occurs, it would be fixed up, like the preventive maintenance of aircrafts and elevators [3].

In addition, the analysis of big data may help companies to find the more desired employees and insure the success rate of online recruitment. They are capable to obtain the information of employees more comprehensively from the various social platforms, so the ones they need could be found more accurately.

In summary, enterprises could apply the big data and relevant techniques to gain market insight, guarantee the variation of demand [26], and change the operating strategy and business models to optimize the abilities of marketing, production, service and human resource [27]. But meanwhile, in the context of big data, many domains of enterprises are faced with a large number of challenges because of the features of big data, such as big size, multiple types, timeliness, uncertainty and so on.

3.2 The challenges in big data era

It is challenging for current enterprises to manage and analyse a mass of data, which is continuously and quickly generated and accumulated, unstructured or semi-structured, high timeliness or low certainty, not only in the technology domain, but also in the aspects of people, task, and structure domain.

3.2.1 Technology

It is challenging to the abilities of enterprises from grasping data to managing and analyzing it. Although there is a great deal of data generates and accumulates, it is a small part of it can be explored and applied, uncover the rest part is still beyond the abilities of companies [28]. According to IBM and Intel, the 90 percent of data is unstructured and unemployed. Meanwhile, maybe, the enterprises of downstream supply chain, such as distributors and retailers, have no intention to share the data they consider is full of competing values. Hence, it is hard for manufacturing firms to get the comprehensive information of consumers, and that is doubtless a barrier for them to create value of data [3]. Not only cannot enterprises obtain the whole data they need, but their abilities also cannot grasp, manage and analyze such high-volume and high-variety big data [6, 24, 26, 29, 30]. Furthermore, there may be semi-structured or unstructured data does not fit with the type their techniques can process [29].

The corporate abilities to manage and analyze data are needed to be enhanced, just as the thought of Lavalle et al [28] that the biggest obstacle enterprises are faced with is guaranteeing the data quality and eliminating the useless data analyses. The problems, how to manage the big-size and multiple-type data, and how to distinguish the valid and actual data from a mass of disturbed and invalid data in the process of analyzing, are impeding firms applying big data effectively.

3.2.2 Other domains

It is more and more important for enterprises to response to the consumer demand in time and accurately since the marketing environment, being impacted by big data, becomes more and more unstable, besides the position of consumers gradually rises in the supply chain [32]. There is an approach for them to confront the changeful business environment flexibly, using the techniques, which are relevant to big data, to seize lots of data generated in the market, then analyzing and integrating the information, which is rich in value. Yet when they are processing the data with wide resources and multiple structures, they would need to utilize the comprehensive knowledge of statistics, economics, computer science and so on synthetically. From that, there would be much higher requirements for the abilities of analysts, so it is a considerable problem that the lacking of analysts [1]. Just as the report of the US Bureau of Labor Statistics, the number of the skilled analytical talent in demand in the US would be 50%-60% higher than its expected supply by 2018. In other word, the enterprises are short of capacity of applying big data sufficiently [3].

In the people domain, the application of big data not only requires complete integrative abilities increasingly, but also threatens the individual privacies and securities. Analyzing a lot of data, which is gathered without one's attention and might derive from phone record, consumption history, GPS and so on, could make others understand the habits and hobbies of individuals in depth. Hence, big data has direct threat on personal privacy [31]. Concurrently, although managers could supervise the status of their employees further closely, by using the corporate internal information such as data about individual work, and intensify the work flow and staff working abilities, by applying the relevant techniques, there must be greater heavy pressure for employees to complete tasks faster [31]. In the meantime, Blasiak considers that paying more close attention to the staff would not only cause heavier pressure on them, but also change the hiring and firing institution, and the stability could be under threat.

Although there are still a lot of challenges in the face of the enterprises in the big data era, there will be abundant benefits to them because of investing in the techniques relevant big data [30, 33].

4 The coping strategies

In order to follow the wave of big data, a majority of enterprises have already explored the application and development of relative techniques and endeavored to achieve competitive edge by taking advantage of them flexibly. That needs firms to make efforts in all domains, including technology, people, task and structure, when the managers attach importance to data analyses in daily operation and make decision based on data [24, 28].

4.1 Technology

Enterprises, in the first place, ought to lay emphasis on the data management. They have to manage data effactually to be able to make some data reused. To achieve that, they need a large data warehouse to store and manage data, and have to affirm some certain issues, like the resource allocation, who has the responsibility to manage the data, what data and how long does it should be saved. Hence, there must be a series of criteria for the data scope and circulation to promote data to be obtained, delivered, compared and comprehended easily, as well as being reutilized [34]. However, it is worth nothing that the data management and storage are really not to treat the information as inventory in database, but to cognize, gather and analyze it continually and make it flow [29]. Beyond that, managers should pay more attention to the data privacy security management, if they cannot handle that, the stability of organization and the working

conditions of individuals would be influenced. Just as the thought of Schroeck et al, it is one of the most fundamental details of data privacy management. Thus, it is necessary for companies to communicate about the privacy issue with employees, users and other collaborators for the purpose of making sure the scope and transparency of relevant information [3].

It is very hard for companies to create better performance by integrating information and making more complex analyses, because their capacities for data processing cannot fit with the large-scale and various-type data. So they need applying the advanced data techniques effectively to integrate and analyze the ever-increasing information [28]. Besides, it is the basic of effective technology application that being sufficiently appreciated by users. Therefore, techniques related to big data based on the exact sources must be easy to understand, by explaining the reason of each result [35]. In addition, guaranteeing the quality of data, like veracity, possesses a very high position in the process of data manipulation [4]. There is an approach to insuring the quality and the effective application of relevant techniques. Before making the formal analysis, data should be pre-processed to become suitable for being analysed [31].

Goes [4] deems that the data integration is the key of big data technology, managers and analysts must comprehensively utilize information from the whole corporate perspectives to optimize various steps [3, 6, 7]. 1. Integrating and analyzing the demand data, inventory data and market data to make more valid decision in the highly unstable marketing environment [27]. 2. Integrating the product development, design and historical records to establish a digital model of the whole manufacturing process, then optimize production [3].

4.2 People

Big data would help enterprises to response to market demand and variation rapidly, which request them to flexibly master multiple disciplines, including computer science, mathematics, statistics and so on, to explore and make full use of the value of data they obtained [3]. Meantime, the synthetic abilities of analysts must be promoted, which is to say when they are grasping the analysis techniques, they are supported to own other business skills, such as effective communication with decision-makers, to conduct more valid analyses [31].

When big data techniques are introduced in organizations, it is significant to receive the support from top managers. Because applying big data, as a range of new technologies, would involve changes in corporate many aspects, including information technology, enterprise culture, daily operation and so on. So the support of the top manager is needed [6]. Besides, the application of big data also requires managers to attach importance to data analysis, and make decisions based on information [24, 28]. There is another voice that transformational leadership is more suitable for firms in the big data era than servant leadership, because they are more adjusted to the dynamic environment [36].

4.3 Task

There should be a big data schema, which would confirm the anticipation, strategy and demand of the application of big data, and must set up the relationship between business requirements and information technology, at the enterprises level. The schema could generate a certain consensus, like how to use the big data to achieve their aims and create value, certainly that is conducive to the application of new techniques and creation of corporation value [6]. Accordingly, during the process of daily operation, relevant standards are needed to help decision-makers to make sure decision process, whether the decision must be made and when a specific decision is required. For instance, managers ought to make sure the scope of certain data, when it is out of the scope, they need to do some specific work to guarantee to the value of data [28].

Enterprises need to find a series of approaches such as production differentiation or changing the location of products and service to distinguishing themselves from other competitors in the fierce competition. They should analyze their advantages, then focus on the field that would bring the maximum value to them [6, 28], and by combining big data techniques and handling the dynamic information outside and inside of them, optimize allocation of resources to promote their competitive edge [27]. Moreover, Manyika et al recommend manufacturing corporations to make different strategies in diverse staged market. For example, in the emerging market, they ought to gain the advantages about relatively low labour cost, but in the developed market, they should reduce cost and innovate in products and service by taking advantage of big data.

Obtaining the whole market data, in order to apply big data to analyze availably, requires enterprises to establish certain policies involved with stimulating information sharing, to stimulate relevant cooperative partners share information to an extreme. At the same time, organizations also have to make a series of policies about data privacy to limit the usage of data and protect the benefits of stakeholders from threat [31].

For improving the abilities of enterprises to process data and apply relevant techniques, managers ought to take care of the professional and career development of analysts to enhance their comprehensive skills and advance the corporate abilities indirectly [6].

4.4 Structure

To release the value of big data sufficiently, enterprises ought to optimize their internal information systems. For instance, they could make information about product freely transmit between many departments, including marketing,

research design and production department. Thereby, there is no any information isolated islands but a system inside of organizations [3]. Meanwhile, for managing data better, they need develop relevant work flow to define the responsibilities of data management [28].

With enterprises are paying more and more attention to the application of big data, the position of analysts inside of organizations should be changed too. For example, while there are analysts in internal consultant groups to help managers make decisions in the traditional firms, there are more and more analysts in product development groups, in big data era, to develop new products and product features in the manufacturing industry [28].

In addition, it is worth nothing that a large number of corporations need changing organization to make certain transformation as the groups, which have never shared data, would not share information simply because of the existence of information systems [3]. Enterprises could facilitate the application of big data, by changing culture to create the cultural atmosphere of using and sharing information [1]. Besides, according to the record, corporations with high benefit, which integrate data analysis into operation, combine analyses with making strategic direction more frequently than those with low benefit [28]. That might need them to re-establish their culture to promote employees to working on account of data more often [1].

Table 3. The coping strategies.

Approaches	Dimension	Explanations
Technology	Data management	Formulating relevant data standards [34]
		Grasping and analyzing data constantly [29]
		Communicating about data privacy and so on [3]
	Data technology	Data techniques must be understood sufficiently [35]
		Preprocessing the types of data [31]
		Integrating data [4,6,10,27]
People	Individual ability	Comprehensive talent [31]
	Individual attitude	Top managers must support to big data application [6]
		Transformational leadership is more suitable for big data firms [36]
Task	Strategic management	Making big data plan at strategic level [6]
		Optimizing allocation of resources [6, 27, 28]
		Different strategies to diverse markets [3]
		Establishing incentive policies about information sharing [3]
		Establishing policies related to information privacy security [31]
	Operations management	Establishing standards about the application of big data at operating level [29]
	Human resource management	Focusing on the development of internal analysts [6]
Structure	Internal information system	Circulating data among different departments [3]
	Organizational structure	Changing the position of analysts [29]
	Business process	Developing relevant work flow of data management [29]
	Corporate culture	Cultivating atmosphere to share information and so on [1, 28]

There is no entirely same technique applied in diverse firms. Similarly, the approaches they used to cope with the big data era need to be applied according to specific practical situations.

5 Conclusions

In the context of big data, enterprises are confronted with various obstacles, comprehensive abilities they have cannot obtain, analyze and process amount of diverse data effectively. At the same time, there is an urgent need for them to respond the unstable business environment timely. Different definitions of big data from different institutions and researchers are introduced. Then, combining the features of big data and the follow-up applications of Leavitt' model of organizational change, four internal dimensions, technology, people, task and structure, and an external dimension, environment, are defined under the background of big data. Manufacturing enterprises would optimize products and services, reduce the cost of production or obtain new business opportunities by using correlation technologies, which is more suitable for them, more effectively to make timely or near-timely decisions. Therefore, from the four internal domains, there are several solutions, which are for companies to enhance their competitive edges in the big data era business competition, are integrated.1. Develop data analysis techniques that could be made full sense of by users, and establish relevant rules and regulations to regularize the management and transfer of data. 2. Pay attention to train the comprehensive abilities of employees, and adjust the attitude of managers toward using big data and relative techniques. 3. Draw up a plan about the usage of big data to make staffs comprehend and use it more conjointly and effectively, and take the issues of privacy security into account. 4. Transmit data among different but relative departments to make information sharing more conveniently. However, it is worth nothing that there are various characteristics in diverse organizations, so as conditions. So, making relevant decisions, managers ought to focus on the strategies that are more suitable for their situations.

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