How Big Data Transforms Manufacturing Industry: A Review Paper

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ABSTRACT

This paper describes an overview of what Big Data is and explains how it transforms the manufacturing industry. Firstly, this paper defines what Big Data means for the manufacturing industry. It explains four advantages about Big Data analytics and their benefits to manufacturing. Then, it describes about what ethical issues of Big Data are. Next, it discusses more deeply about the ethical issues of Big Data in manufacturing with both individual and organizational perspectives. Finally, this paper sums up with some principles to show the ethical governance of the interests of Big Data stakeholders.

Keywords: Big Data, Manufacturing, Industrial Informatics, Ethics

INTRODUCTION

This paper discusses the role of Big Data in the manufacturing industry. It attempts to provide a holistic review of the literature and offers discussion around the underlying gaps. The manuscript further discusses the ethical issues within the context.

BIG DATA

Big Data is a term that describes the large volume of structured and unstructured data with the potential to be mined for information. It figures a new technology paradigm for data that are created at massive volume and high velocity, and comes from various sources (Lee, 2017). Herschel and Miori introduces Big Data is to capture, store, share, evaluate, and act upon information that generated and distributed by humans and equipment using networks and computer-based technologies (Herschel and Miori, 2017). Gartner also defined Big Data as a high volume, high velocity and high variety information property that requires new handle mode to enhance decision-making ability, insight discovery, and process optimization (Gandomi and Haider, 2015).
Big Data is defined by IBM data scientists in terms of four dimensions: volume, variety, velocity, and veracity (Yin and Kaynak, 2015). Volume means the amount of data is huge, which is from TB level up to PB level. Variety means data comes from different kinds of formats, such as video, image, location, weblog and so on. Velocity means the speed of data processing is very fast and this is essentially different from traditional data mining. Veracity means the quality and trustworthiness of the data. The importance of Big Data depends on the support for decision-making. The size of the data does not determine whether it helps to make decisions, but the authenticity and quality of the data are the basis for making successful decisions. In a word, the ability to acquire valuable information rapidly from various data can be classified as Big Data technology. Using Big Data becomes a critical factor in improving core competitiveness, and decision-making is transforming business-driven into data-driven in all walks of life (Carillo, 2017).

Nowadays, data has infiltrated every industry and business function. It is generated always and transmitted by every digital process and social media exchange, such as GPS positioning, purchase transaction records and posts on social platform. How to manage and further use data and information to support the decision-making of organizations has become an urgent need and even become the core competitiveness of enterprises (Dobbs et al., 2011).
The emergence of Big Data keeps changing people's existing habits and life patterns and gradually changing the production patterns of manufacturing enterprises. The demand for today is no longer in short supply situation like 30 years ago but the era that manufactures rack their brains for marketing. In China, since the reform and opening-up, the Internet has played an important role on the rapid development of science and technology (Xu, He and Li, 2014). As the same time, both logistics technology and information and communication technology have provided a great support for the development of the Internet. Therefore, the increasing amount of data has brought great challenges to manufacturing industry while also offering golden opportunities for business and transformation.

BIG DATA IN MANUFACTURING INDUSTRY

Manufacturing is one of the main areas of Big Data applications and it can be described as a 5M system consisting of materials, machines, methods, measurements and modeling (Lee et al., 2013). Big Data provides a transparent infrastructure for manufacturing that addresses such uncertainties as inconsistent component performance and availability (Inukollu, 2014). One of the Big Data applications in manufacturing is predictive manufacturing and its conceptual framework starts with data collection, where it is possible to obtain different types of sensory data such as stress, vibration, acoustics, voltage, current, and controller data (Inukollu, 2014). These sensory data combine with historical data to form the Big Data for manufacturing.
Big Data analytics plays a catalytic role in realizing the idea of digital manufacturing and also forms the basis of modern mass customization, which means meeting the needs of a personalized customer market (Mourtzis, Viachou and Milas, 2016). In addition, Big Data analytics will have an important influence on R & D, manufacture, customer service, maintenance, recycling and remanufacturing, promoting the implementation of cleaner production and the development of sustainable production and consumption effectively (Zhang et al., 2016; Daneshkhah et al., 2017).
As shown in Figure 1, the process of using Big Data for manufacturing can be in a sequential way. It starts with the exploratory study on how Big Data's influences on manufacturing. Benefits in manufacturing should be highlighted. When Big Data and manufacturing are connected together, manufacturing begins to be influenced by Big Data and data analytics. There is no doubt that Big Data and analytics technology can bring great convenience to manufacturing. They not only improve the production efficiency and the quality of products, but also make the products serve consumers more accurately. Meanwhile, the application of Big Data also comes with ethical issues like privacy and safety and these issues should arouse people's wide concerns. In terms of the manufacturing sector, there are also ethical issues posed by Big Data. Therefore, it is necessary to propose the ethical governance to deal with these issues.

Figure 1: the process of using Big Data for manufacturing

In manufacturing, the whole lifecycle of the product will generate a mass of structured and unstructured data from the process of market planning, design, production, sales, maintenance and so on, which will form the Big Data of manufacturing industry (Shao, Shin and Jain, 2014). Generally, product lifecycle consists of three phases: beginning of life, middle of life, and end of life (Zhang et al., 2016). The first phase involves design and making; the second involves use, service and maintenance; and the last phase includes remanufacturing, recycling, reuse and disposing (Zhang et al., 2016), as shown in Figure 2.

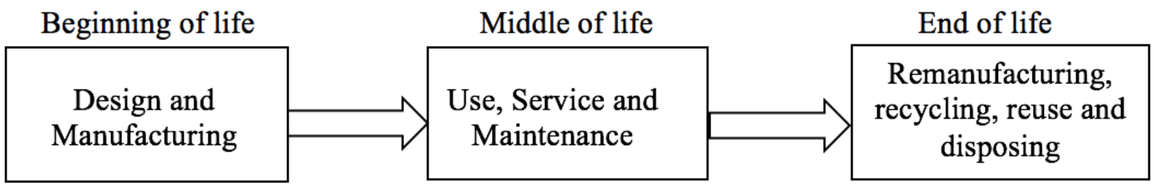

Figure 2: three stages of product lifecycle

The leaders in manufacturing companies are increasingly interested in effectively using lifecycle Big Data to benefit their companies (Zhang et al., 2017). Given the volume and complexity of production activities that affects the decision of manufacturing companies, manufacturers need more effective ways to diagnose and correct problems in the decision-making process (Auschitzky, Hamemer and Rajagopaul, 2014). Manufacturing enterprises can use Big Data and advanced analytics to make an in-depth analysis of historical lifecycle data, to discover patterns and relationships for each step, and then to optimize the process of product lifecycle management (Zhang et al., 2017).

To understand how Big Data can be used by the manufacturing industry, there are two ways that Big Data can help traditional manufacturing industry transform into a new generation of smart factories.

The first way is to adopt and implement intelligent production. After analyzing and transmitting data, manufacturing enterprises can monitor the production data in real time. This production mode, which is terminal control through the data, simplifies the production process and improves the production efficiency.

The second way is to achieve mass customization. Due to the huge change in consumption patterns, the original seller’s market has become the current buyer’s market. This kind of consumption pattern requires manufacturers to take personalization as the main manufacturing paradigm. Through the integration of a large number of buyers’ information, sellers can tailor their production strategies to improve the sales speed.

Data measurements collected by devices, physical environments and processes will lead to the increase of data production. These raw data can be transmitted by the technologies such as the Cyber Physical Systems (CPS) and Internet of Things (loT), both of which offer new and emerging paradigms (O’Donovan et al., 2015; Hosseinian-Far et al., 2018). While the recent developments have offered the increased usability and affordability of sensors, data collection systems, and computer networks, an increasing number of factories have to adopted high-tech approaches to survive in today’s environment (Lee, Bagheri and Kao, 2015). To the current manufacturing, Big Data and advanced analytics are critical competitive weapons for manufacturers and enterprises.

HOW BIG DATA ANALYTICS BE BENEFICIAL TO MANUFACTURING?

Data has become an important factor of production for various purposes (Nedelcu, 2013). However, raw data could not produce any useful information until it is transformed into a high value strategic asset by data analytics (Lee, 2017). Several benefits are contributed using Big Data analytics (Hosseinian-Far et al., 2017), such as reducing the costs (Campbell et al., 2015), making better decisions, and providing more satisfactory products and services (Davenport, 2014).

In a recent survey, McKinsey & Company introduces the significance of Big Data for manufacturing. The report said that the exploitation of Big Data in manufacturing can reduce product development and assembly costs up to 50% and may result in a reduction of working capital by 7% (Dobbs et al., 2011).

Compared with the traditional manufacturing industry, the biggest breakthrough of Big Data technology is to test product defects, enhance quality, and improve supply planning. In addition, the benefits of big data include predicting manufacturing output, simulating new manufacturing processes, and prompting energy efficiency (Nedelcu, 2013).

Manufacturing can generate massive amounts of data from thousands of sources at every step in the chain. With Big Data and data analytics, a growing number of traditional manufacturing industries are constantly upgrading their industries. There are a lot of obvious value that Big Data analytics can be beneficial to the manufacturing, as shown in Table 1 (Msrcosmos.com, 2018).

Table 1: Benefits of Big Data Analytics for Manufacturers

Reduced process flaws	Save time and money
Reduced production and packaging costs	Inventory costs savings
Improved quality and safety	Improved workforce efficiency
Better collaboration	Regulatory compliance
Have real-time shop-floor data	Increased process performance
Better forecasting	Avoid / remove unplanned down-time

The first major benefit is the cost reduction. Big Data can help change the way the process has been designed. It can help save the cost of production and operation. Data analysis can also reduce transportation, packaging, and storage costs, so the cost of inventory has been greatly reduced. Manufacturing firms use Big Data analytics to achieve more accurate demand forecasting, more efficient transmission path with visualization and real-time tracking, and more optimal distribution network management (House, 2014).

The second major benefit is security and quality improvement. While there are a lot of manufacturing enterprises use computer sensors to filter out products of the poor quality through assembly lines in the manufacturing process (Lee, Kao and Yang, 2014). With the right software analytics, factories can use the data generated by such sensors to improve product performance instead of simply discarding these poor products. For example, some car manufacturers use large amounts of data to produce simulation models through software analysis prior to production. Thus, before these products enter the market, the risk is reduced, and the quality is also improved by these models.

The third major benefit is the improvement in work efficiency. Management and employee productivity can be improved using Big Data. Manufacturing companies use data analytics to avoid mistakes in the production line and use this information to assess where employees work well and where they do not perform well enough (Rüßmann et al., 2015). The speed of the production floor can be increased by the same set of Big Data software and data information, especially in heavy-duty factories. Using Big Data analytics also helps managers identify whether products are good or not.

The fourth major benefit is a better cooperation. Improving the ability of information processing within the group is one of the great benefits of IT-based data collection and data analysis. Data and information, machine operations, engineering, management, and quality control combined with the workflow, so that teams can play a better job in the work. The fast feedback mechanism in a data-driven environment, so that each employee can timely adjust the work behavior according to the situation.

Big Data has already transformed manufacturing in a good way but on the edge of technology development and corporate earnings, there are some ethical problems waiting to be explored.

ETHICAL ISSUES

Nowadays, Big Data and data analytics has brought huge benefits to individuals, organizations, and society. The changing technology provides detection of fraud and abuse (Lopez-Rojas and Axelsson, 2016), personalized service (Rust and Huang, 2014), efficient use of resources (Sun et al., 2016) and prevention of failure or accident (Huang et al., 2017). People start to consider what questions are raised about the ethics of Big Data and data analytics. From 2001 to 2016, Big Data usage has increased along with the instances of actual and perceived ethical violations (White and Ariyachandra, 2016). Many industries affected by data and ethics including manufacturing, retail, education, and healthcare.

Within these industries, there are four major ethical themes found in literature and each of the challenges is being illustrated below (White and Ariyachandra, 2016).

- Privacy: sharing of personal information without permission
- Security: protection of data from outside threats
- Ownership: the rightful ownership of the data used for analytics
- Evidence-Based Decision Making: the use of data to make decisions about a population based solely on quantitative information

Sensors are widespread in various electronic products such as smart health equipment and smart car emergency services. Privacy has attracted public's attention since these sensors collect a mass of data on users' position and moving route, physical conditions, and buying preferences (Lee, 2017). Data security is a serious challenge that it is not only related to the safety of personal information but also involves an enterprise's reputation and financial risk. Speak of ownership, although users believe that they are the owner of their data, the fact is that their data are used without knowing. As data can be gathered from a variety of platforms and they are hard to track the source, most people even do not know how to use their data (White and Ariyachandra, 2016). Often individuals do not have the ownership of the data but just have a stop in the transmission of Big Data (White and Ariyachandra, 2016). Evidence based on decision making is a kind of predictive analysis. It may arouse controversy on individuals and society, keeping prejudices, which are no longer new (Tene and Polonetsky, 2013). For instance, classifying individuals into the group based on race, gender, wealth, and social position could lead to discrimination as a kind of ethical issues to the society (Zuboff, 2015). Individuals or groups will be offered or restricted by special services or treatments because of this profiling (Newell and Marabelli, 2015).

In addition, there are still a number of potential ethical concerns bringing impacts on individuals, organizations, and society. One of the ethics is the use of algorithms which enables Big Data analytics to support human decisions. This algorithm analyzes data that are collected and combined from a variety of sources and designs to forecast individual's favor and behavior based on their past and current behavior, which is called algorithmic decision-making (Newell and Marabelli, 2015). The purpose of this algorithm is to identify the relationships within large quantities of data sets but sometimes may ignore the essence of things (Mayer-Schonberger and Cukier, 2013).

Another ethical issue is individuals have less awareness of what happens to their data after they provided them consciously or unconsciously (Asadi Someh et al., 2016). Due to the high speed and various approach to data transmission, ethical problems could happen in each segment of the information value chain when initial data begins to move and flow. Thus, the initial consumers who generated the data at the original place will face potential risks and dangers because the initial intention and the using purpose of the final data might have a great difference (Asadi Someh et al., 2016).

Laws and regulations guide the people and the society to define what can be done and what cannot be done with enforcement. However, the definition of ethics is more like a moral guidance for behaviors and principles of truth. Big Data usage has significantly increased in the past decade and ethical guidelines are still in the development. Researchers and experts have studied ethics in information systems and information technology for a long time but the discussion in Big Data ethics is still in the infancy (White and Ariyachandra, 2016).

Therefore, identifying and exploring ethical implications of Big Data technology is significant and urgent for people who produce the data and those who use the data. Next, this review will further explore the ethical issues of Big Data in the manufacturing industry.

ETHICAL ISSUES IN THE CONTEXT OF MANUFACTURING BD

Every coin has two sides. While Big Data has brought profits to the manufacturing industry, it has also generated some ethical problems when people collect data and use data. This review will discuss them from individuals and organizations these two perspectives.

Individuals

For individuals, privacy can be one of the ethical issues. The development of Big Data in the manufacturing industry is more about making products into a data terminal. There are many products have sensors like smartphone and smart band which will generate data when customers use them. By collecting these data, they can be re-analyzed and used. Some customers might consider they are safe if they do not tell their personal information like name, address and credit card, they are safe (Eastin et al., 2016). However, since data can be used again and again, information fragments can be intersected, recombined, and correlated. When all these data put together, manufacturers can find a large amount of valuable information. As a result, data become the most asset, but it also comes along with two ethical questions for customers.

1. **Do customers have the right to ask for their own information to be deleted?**

In fact, the possibility of this is low unless they refuse to use these products. Once their data are recorded by the sensors or uploaded to the website, these data will be stored permanently. Now everything people have done is stored in the form of data, so it is easy to get their privacy if master their data. So, if the manufacturers want to get our privacy, they just need to have our data. For example, the sensors record our location. Of course, just having our data alone is not necessarily a source of our privacy, and they have to be able to deal with it quickly. Data can be processed rapidly by cloud computing that allows large-scale and complex computing and parallel processing (Hashem et al., 2015). Other methods such as dimensional reduction and sampling can also be used to speed up the computation time of data analytics (Tsal et al., 2015). The wide variety of data types opens up the door to our privacy and glimpses our privacy through different forms of data. The value of data is a fundamental incentive for malicious people to steal privacy (Inukollu, Arsi and Rao Ravuri, 2014). Precisely because of its immense value, some manufacturing industries are continually tapping into the data the treasure they need, driven by profit. Thus, although customers are Big Data producers, they even do not have the right to choose what kind of data can be saved and what kind of data can be deleted.

2. **Can customers protect their privacy?**

Data is known as the Big Data era of oil, which holds great value. Due to the essential modalities of Big Data manipulation, data may impact privacy after they are reused, repurposed, recombined, or reanalyzed (Collmann and Mateo, 2016). Once industrialized oil was consumed, it disappeared, or in another form - energy - existed. The data in the era of Big Data, after being used for the first time, is still presented to us in its original appearance. It not only has not disappeared, but also can continue to be used, and does not generate waste to form pollution. This means that once our privacy is leaked out, it seems like the ink on a white cloth can never be eliminated.

In the Big Data era, there are three main types of Big Data stakeholders: Big Data collectors, Big Data utilizers, and Big Data generators (Zwitter, 2014). In manufacturing, products like mobile devices are Big Data collectors that they decide and govern the collection, storage and expiration of data (Chen and Liu, 2015). Manufactures are Big Data utilizers that they mainly use the data collected and stored by Big Data collectors to define the purpose of the data usage (Zwitter, 2014). Each of us can be considered as a "Big Data generator" who consciously and unconsciously produces data every moment of the day. Once the data customers produced is captured and stored by Big Data collectors, it will be continually mined and used by Big Data utilizers, making it hard to hold onto privacy. Customers do not know exactly what purpose the data they produced was queried and exploited, and how many times it was queried and exploited.

Therefore, since data can be used repeatedly, and other people may be involved in the process, it is not easy to keep privacy. Although some information about users can be processed anonymously, the Big Data utilizers have to inform people how they use and where they use with our permission. Nowadays many users feel that their privacy has been compromised and as Big Data becomes more prevalent, the situation will be even worse. The traceability of data dictates that Big Data collectors and Big Data utilizers are in a state of flux, or Big Data producers simply do not know who their information is captured, saved and used. In this way, customers certainly cannot hold the privacy.

ORGANIZATIONS

For organizations, security and labor force can be related to the ethical issues. In many factories, the manufacturing process relies on the computer or relies on the Internet. During the product design, product making and the final service throughout the process can rely on the Internet, which requires Big Data analytics technology and manufacturing technology generated. As a result, in all stages of the product is based on the data. In manufacturing industries, data are getting from manufacture devices, factory equipment, and network devices. By monitoring and analyzing the data, manufacturing companies can improve the productivity and make a huge profit. There is a great deal of benefits for data, so manufacturers all want to get as much as data and ensure that their own data are safe and in good quality. Besides, due to the high technology, many manufacturing factories have used advanced machines to reduce the labor cost and improve the productivity. Thus, data security and quality and labor force are two ethical issues that need manufacturing industries to raise concerns.

1. How to ensure the safety and quality of enterprise data?

The term of security is defined as the protection of data to ensure that others without the permission do not access the data (Jahankhani et al., 2014). Before data analysis, manufacturing industries acquire the data from their products and production process, they need platforms to locate and store these data. However, these platforms are vulnerable to hacking, especially there are thousands of users involved and some services need to lower security restrictions for optimum functioning. Many manufacturing factories are in different areas and their processors are not under the jurisdiction of the company. Besides, other service providers are also likely to steal data while the user company does not realize their data is being re-analyzed. The lack of suitable solutions to protect the data is a violation of ethics.

Data quality is one of the challenges that enterprises will face in Big Data (Cai and Zhu, 2015). Data quality means the suitability of data using with a specific purpose (Lee, 2017). As data quality is one of the keys in decision-making, if the manufacturing company uses the erroneous data, it is likely to make wrong decision and cause ethical problems. When the manufacturer makes an inference about individuals based on poor data, even not understand the algorithms, it may result in intricate ethical issues (Wigan and Clarke, 2013). In addition, if the data quality is low, manufacturers will give up using the data and turn it over to other parties (Lee, 2017).

2. Where is the labor replaced by machines to be?

Another ethical issue can happen when increasing manufacturing industries are replacing labor with machines, where the laid-off workers go. The development of the science and technology is to help manufacturing industries increase efficiency and provide consumers better products. However, higher efficiency means more advanced machines, which reduce labor greatly. The combination of smart machines and Big Data leads to task automation which could substitute a large proportion of employees soon (The Harbus, 2018). Researchers from Oxford University also estimate that nearly half of all jobs in the United States will be replaced due to the computerization in the next 20 years (Frey and Osborne, 2017). The potential ethical issue is how manufacturing companies deal with these surplus labors. It is important for them to think of this issue and take effective measures to solve this problem.

FURTHER DISCUSSION: ETHICAL GOVERNANCE OF THE INTERESTS OF BIG DATA STAKEHOLDERS

As discussed in previous sections, in manufacturing industry, products are Big Data collectors, manufactures are Big Data utilizers and each of us is a Big Data generator. In order to coordinate the conflicts of interests between Big Data stakeholders, it is necessary to carry out the corresponding ethical governance in order to achieve the orderly data sharing, and then to achieve the smooth development of the

era of Big Data. Therefore, the corresponding ethical principles need to be formulated for Big Data stakeholders.
Relative to Big Data collectors and Big Data utilizers, they should follow the following principles:

- Principle one: announcement.

When collecting, storing, mining, forecasting, and using data, it is important to inform Big Data producers of the goals and uses, what the great value will be, and what negative effects it will have. People also consider what major precautions would be taken by Big Data gatherers and Big Data producers if there would be a significant negative impact. If the use of data harms Big Data producers, then what compensation would be taken must be announced to Big Data producers. In this way, data sharing can be achieved in a harmonious and orderly manner among Big Data stakeholders.

- Principle two: confidentiality.

In the process of data collection, storage, mining, prediction and utilization, it is necessary to achieve confidentiality. In particular, when it comes to the privacy of Big Data generators, it is necessary to take measures to deal with anonymity and ensure that Big Data producers will not get hurt unnecessarily because their own data was illegally stolen in the process of sharing. This is an important ethical principle that will ensure that the rights and interests of Big Data generators are not harmed.

- Principle three: self-discipline.

Self-discipline is a basic ethical principle that Big Data collectors and Big Data utilizers must work hard to develop. They must develop good ethical discipline in data collection, storage, mining, forecasting and utilization to ensure compliance with minimum codes of ethics and guidelines. Of course, this is a long-term process that cannot be achieved in a day or two. However, good ethical self-discipline should be developed anyway.

- Principle four: responsibility.

This requires Big Data collectors and Big Data utilizers to take responsibility. The strength of any technological force will lead to system rebound, leading to ecological imbalance (Herring and Roy, 2007). The fundamental reason for this is that some manufacturers did not assume the corresponding responsibility when using the technology. This requires that manufacturing enterprises must be brave enough to take on their responsibilities while struggling with data values, especially when negative consequences arise. Otherwise, the conflicts of interest between Big Data stakeholders will be difficult to be resolved satisfactorily.

In addition, as a consumer, he or she should also follow the following principles to avoid ethical issues:

- Principle one: change idea.

In the era of Big Data, as Big Data can "read the past, understand the current and predict the future", essentially everyone could be transparent in the process. This requires that every consumer must change their idea and actively protect the data they produce instead of being indifferent to the data they produce as the atomic age did. If they ignore the importance of their data, they will have possibilities of human crises that threaten privacy, confidentiality, transparency, identity, and freedom of choice. Therefore, Big Data generators must always pay attention to the data they produce and measure what negative effects these data will have rather than take for granted that the data will not have any impact on their future.

- Principle two: self-protection.

As Big Data producers are in a passive position, this requires them to raise their awareness of self-protection and actively pick up the corresponding legal and moral weapons to protect their legitimate rights and interests so that they will not be violated. When their legitimate rights and interests are violated, they should dare to pick up the corresponding legal moral weapons to fight against them and actively seek corresponding spiritual and material compensation. In short, consumers as the Big Data generators should actively adapt to the needs of the development of the Big Data era and become more proactive and active.

Principle three: focus on the data.
As data are mainly produced by Big Data generators, this requires that they should pay more attention to the data they produce. They cannot allow the data to be used for illegal purposes and negatively affect society as a whole. It is important to point out that Big Data producers should pay close attention to data rights.

CONCLUSION

This paper reviews the benefits of Big Data and discusses ethical issues of Big Data in manufacturing to illustrate how Big Data can transform manufacturing industry as follows. First, the meaning of Big Data and their ethical implications have been presented. Second, this paper turns to the analytical perspectives and the benefits of Big Data for the manufacturing industry. Third, this paper discusses about how Big Data combines with manufacturing and the impact it has made, with the equal emphasis for both benefits and ethical concerns. Around benefits by Big Data, four advantages of Big Data analytics were provided with explanations in each of them. For the ethical concerns, this paper analyzes the ethical implications of manufacturing from the perspective of individuals and organizations and explain them separately. Finally, this paper gives a further discussion about the ethical governance of the interests of Big Data stakeholders.

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Appendix

Table 2. Major Ethical Themes in Literature

Theme	Ethical Challenge	Example
Privacy	Sharing of personal information without permission – de-identifying information	Data used to determine Ebola outbreak in 2015 Facebook study in 2012 to test user's emotions without their consent
Security	Protection of data from outside threats	Hospital data ransomed in 2016 due to lax security
Ownership	The rightful ownership of the data used for analytics	Research in illegal behaviors where the courts want the data to build a case against a person
Evidence Based Decision Making	The use of data to make decisions about a population based solely on quantitative information	States make decisions about welfare guidelines using income as the sole factor