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The Impact of Big Data Analytics on Decision-Making

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Abstract (12pt)

The application of the technologies of industry 4.0 plays a critical role in developing a fact-based and data-driven culture to achieve performance excellence. A vast amount of data is generated through digital devices, such asmobile phones, social networks, desktop and laptop computers, and wearable devices. The management, effective use, analysis, and improvement of these data to support strategic processes are critical for performance improvement. Data constitute raw facts that are processed to produce insights and knowledge that are used to guide decision-making. A data-driven decision support system for organizational performance improvement requires a large amount of data and a technique to extract knowledge from data. Digital transformation is necessary to improve processes and operations and harness the benefits of integrating data science into organizational workflows. Big Data Analytics (BDA) provides the mechanism for extracting value from big data to improve decision-making quality. This paper discusses the impact of big data and advanced analytical techniques on the quality of decision-making and improving organizational performance to achieve performance excellence. The ability to leverage big data analytics capabilities with organizational resources and capabilities will ensure the achievement of performance excellence. An effective technique for extracting knowledge and meaningful insights from big data can enhance strategic decision-making to achieve performance excellence and competitive advantage.

Keywords:

Big Data;
Data Science;
Decision-Making;
Performance Excellence;
Performance Improvement.

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1. Introduction

The technologies of industry 4.0, characterized by the integration of computational applications with physical devices, is unlike any of the earlier industrial revolutions because of its impact on all disciplines, economies, and industries. The revolution has deeply permeated our lives through the Internet of Things, big data, artificial intelligence, quantum computing, and cloud computing that have created the current "hyper-connected society" [1], that have enabled the generation and analysis of a vast of amount of data. The extraction of insight and knowledge from big data plays a critical role in developing a fact-based and data-driven culture to achieve performance excellence.

Organizational performance is reflected in product and service performance, process effectiveness, and efficiency, and the data collected from these processes constitute raw facts that can be processed to produce insights, while knowledge is information that guides decision-making. A data-driven decision support system for organizational performance improvement requires a large amount of data and a technique to extract knowledge from data. Performance improvement is enabled by data, information, and knowledge. This paper discusses the role of big data and advanced analytical techniques for supporting strategic decision-making and improving organizational performance.

The Baldrige Performance Excellence Program provides a framework for using data-driven evidence to support performance improvement activities. The framework requires organizations to develop strategies for collecting and using reliable and relevant data and information for strategic planning process and decision-making [2]. While the use of data to support decision-making is not new, the availability of large volumes

and variety of data makes it imperative to apply the power of available data processing technologies in supporting data-based decisions. However, traditional data processing technologies are limited in their ability to effectively process and analyze big data for decision-making [3] and performance improvement. An effective technique for processing big data can provide value and knowledge for decision-making, performance improvement, and competitive advantage for an organization. The ability to leverage big data analytics capabilities with organizational resources and capabilities is essential to performance excellence. The management of the knowledge and information from big data in developing predictive capabilities is crucial to the ability of the organization to enhance performance. Hence, it is essential to know how an organization can leverage its data, knowledge, and information to gain and maintain its strategic objectives and enhance performance and competitive position.

2. Internet of Things and Cyber-Physical System

The Internet of Things has led to the exponential growth in data through processes and transactions. Internet of Things is an amalgamation of sensors, actuators, networking with cyber-physical system (CPS) technologies, and facilitates the functionalities of production machinery. Sensors and microprocessors provide the means for collecting a massive amount of production data in manufacturing operations and consumers' transactional data, including personalized data. The development of cloud computing and the Internet of Things contribute to the increase in the amount of data through digital devices, such as mobile phones, desktop and laptop computers, wearable devices, connected to the Internet of Things to generate, capture, and store many different types of data. This enormous amount of data that constitute big data are generated through the interactions between the CPSs and the Internet of Things and uploaded to a cloud computing data center for storing and analyzing. Collecting and analyzing big data on customer preferences provide information to understand customers' needs and improve the quality of products and services to meet customer expectations. Big data technology provides valuable information in a variety of data types to gain an in-depth understanding to support accurate decision-making [4].

A Cyber-Physical System (CPS) is an intelligent networked system that is capable of collaborating, adapting, and evolving through the digitalization of big-data and information; and can be sustainably and efficiently utilized in managing quality, and improving productivity and organizational performance. CPS is transforming industrial production machinery into digital, adaptive, networked, and knowledge-based systems [5]. The increasingly rapid pace of emerging digital technologies, including cloud computing, has given rise to new opportunities for enabling industrial production efficiency. The self-awareness of a system is related to the ability to use current or past condition of a machine to determine the output. Such a health assessment can be performed by using a data-driven algorithm to analyze data and information collected from the production system and its environment. This transforms the production system to smart and cost-efficient processes for improving performance and producing quality products that meet customer expectations [6].

CPS serves as a decision-making approach for overseeing and collecting data on equipment conditions. The ability to collect data and perform real-time analysis of big data enhances the effectiveness of the decision-making process in managing resources and optimizing operations. Advances in information analytics have created the technologies for networking intelligent production equipment that can gather information from other system components, as well as self-learning and self-resetting. A self-aware and self-maintained system can self-assess its health in making smart maintenance decisions to avoid potential problems. It expands the capability to control, monitor, collect, and process more data from the production system to optimize the efficiency and effectiveness of the production and processing equipment. This paper discusses the impact of big data and advanced analytical techniques on the quality of decision-making and improving organizational performance to achieve performance excellence.

3. Data Analytics and Decision-Making

Big data analytics provides evidence-based decision support system in various industries. Data-based decision-making requires that appropriate principles, processes, and techniques are utilized in collecting, analyzing, examining, and interpreting data to extract meaningful information and knowledge from data generated from a variety of sources to support decision-making [7][8]. Big data plays a critical role as an agent of the 4th industrial revolution and refers to volumes of data that exceed 10^{18} (exabytes) and require data processing technologies to manage and process [9]. The analysis of big data is guided by the 7Vs of volume, velocity, variety, veracity, value, variability, and visualization. Volume refers to the amount of data accumulated by a vast majority of the world population who are using Internet-connected digital devices, such as mobile phones, desktop and laptop computers, and wearable devices. Velocity is the speed at which data is transferred and processed in real-time. Variety refers to diverse sources and formats of data. The data

includes text, pictures, film, and sound, including those that are captured by wearable devices. Veracity is the quality and source of data and its conformity to facts and authenticity [10]. The value in data is based on the benefits and satisfaction derived through processing. Big Data variability reflects the period peaks associated with highly inconsistent data flows [11]. Data visualization is the means for interactively exploring and analyzing data to effectively identify patterns and draw conclusions about relationships and causalities to support decision-making [12]. The leadership has the responsibility to develop a fact-based and data-driven culture to ensure that decision-making is guided by information and knowledge. The quality of the volume and diverse sources, the transfer, process, and visualization systems, the authenticity of data, and big data analytic capabilities of the organization will determine the quality of decision-making.

The scale of big data makes it impossible to use conventional data analysis tools, and data scientists apply appropriate tools to derive valuable insights from data. Data science and data-driven decision-making have become important due to the increasing emphasis on data-based performance excellence. The generation of knowledge from data is critical for evidence-based decision-making to support key strategic and policy decisions on core competence and work systems necessary to facilitate effective and efficient performance improvements. Hence, it is imperative that an organization addresses its strategic challenges and develops its customer, market, and strategies based on data. Data science techniques can be applied to explore the pattern in data to confirm what the organization suspects and to provide the organization with new knowledge that might lead the organization to take a new approach in responding to competitive opportunities. The new knowledge is then communicated to the stakeholders, and data visualization tools are utilized to ensure that stakeholders understand the nature of the results, and appropriate actions are specified. The digital devices, such as mobile phones, desktop and laptop computers, wearable devices, connected to the Internet of Things generate, capture, and store many different types of data. The ability to extract real-time business insights and knowledge from internal and external data for competitive advantage will require organizations to invest in technologies for extracting value from data.

The digital transformation to effectively derive value from data to achieve performance excellence will require fundamental changes in the culture of the organization and total commitment and the support of the top management. The top management must demonstrate its commitment to the use of data science through the provision of process measurement systems, capturing and analyzing data, and access to a team of data scientists with strengths in different areas of data science to achieve performance excellence. Hence, it is imperative that the leadership ensures that digital technology for collecting data from all the operations of the organization is integrated into the organization's processes. The ability to utilize data science techniques to understand and analyze the organization's large data sets will contribute to the ability of the organization to achieve performance excellence. Data science techniques provide data scientists with the ability to process and extract knowledge and insights from data through the theories, technologies, and processes that are provided by data analytics [13].

Big data analytics facilitates the processing of big data. The ability to analyze massive amounts of data is key to the discovery of insight and knowledge for decision-making and critical for performance improvement. An integrated decision support system for decision-making and real-time processing and analysis will drive performance improvement and provide a competitive advantage to the organization. This paper discusses the impact of big data and advanced analytical techniques on the quality of decision-making to achieve performance excellence.

Sophisticated techniques are required for extracting insights and knowledge from a voluminous amount of data. Data science provides the mechanism for extracting knowledge and insights from big data to support strategic decision-making and achieve performance excellence and competitive advantage, while big data analytics (BDA) enhances the data-driven decision-making process. BDA provides a mechanism for analyzing a large volume of data to retrieve meaningful insights from data and examine the pattern in the data and use the recognized data pattern to predict future performance. The ability to develop strong big data analytics capabilities would be essential for realizing the potential of big data analytics for decision-making and performance improvement [14]. Data analysis, a component of big data analytics, is categorized into the descriptive, predictive, and prescriptive analysis [15][16]. Descriptive analytics uses summary statistics to provide insights and knowledge on current performance and how decision-making can be improved based on lessons learned. Predictive analytics uses data mining and machine learning to provide insights and knowledge on what could happen by analyzing past performance to predict future performance. Prescriptive analytics uses simulation and optimization techniques to provide insights and knowledge on the evaluation of new modes of operation to take advantage of opportunities and improve decision-making and performance. BDA capabilities provide organizations with the ability to achieve sustainable performance. BDA has been successfully used to track customers' purchasing behavior and predict their future buying trends, improve customer experience, reduce fraud, reduce operational costs, improve quality of life, enhance manufacturing and industrial automation, and improve business transformation [17]. A data science toolbox for predictive tasks in manufacturing has been developed by integrating machine learning with business information systems techniques [18].

The exponential growth of big data provides organizations with the impetus to develop big data analytics capability BDAC) for improving organizational performance [17][19]. BDAC is essential for directing organizational resources and applying the knowledge and insights from data to achieve strategic competitive advantage and performance excellence [20]. In a study of 209 organization executives who use big data analytics for decision-making in India, [21] examined the relationship between managerial and technical big data analytic capability and operational, financial, and marketing performance. The study found that big data analytic capability has a positive effect on organizational performance. The relationship between big data and organizational performance was investigated by [22]. Their study of 259 managers of large European organizations established a positive relationship between BDA capabilities and organizational performance. Also, they identified that the ability to adapt to change and the fit between BDA capabilities and existing capabilities are pertinent to achieving the benefits of BDA. The effect of data-driven decision-making on the performance of an organization was investigated by [23]. Their survey of 179 large public firms found that the application of data analytic tools for decision-making led to improved organizational performance.

4. Conclusion

The technologies of industry 4.0 are shaping performance improvement initiatives through the application of Internet of Things, big data, artificial intelligence, quantum computing, and cloud computing. This paper has presented big data analytics as the knowledge discovery process for analyzing big data for improving decision-making and organizational performance to achieve operational excellence.

Big data analytics and data science provide the methodology for learning directly from data. For example, comparative data from industry publications can be used to benchmark organization performance against best practices and recognize its strategic challenges and advantages in the competitive marketplace. In the same vein, the analysis of internal and external data and information would enable an organization to draw conclusions that are necessary for making predictions on the course of action for performance improvements. Also, results from customer satisfaction and dissatisfaction surveys would provide the organization with information on the strength of its customer engagement activities in understanding customer behaviors and preferences. It is imperative that an organization invest in BDA capabilities and has the personnel with the required BDA skills to appropriately interpret the results and realize the benefits of BDA.

The performance measurement system must be aligned and integrated with the strategic objectives of the organization to effectively provide data and information to support performance improvement. However, the effective utilization of data to measure, analyze, and improve performance depend on the quality and availability of data to support timely information. The management, effective use, analysis, and improvement of data, information, and knowledge are essential to support strategic processes for performance excellence. The ability to leverage big data analytics capabilities with organizational resources and capabilities will contribute significantly in achieving performance excellence. Identifying and extracting valuable information from large amounts of data on the operations of an organization can be extremely beneficial in terms of performance metrics. Moreover, analytics of the performance data can help the organization in building and sustaining a competitive advantage and performance excellence. The quality of big data will influence the quality of strategic decision-making; hence, the ability of an organization to acquire the capabilities and processes for collecting quality data and extracting valuable information and insight from data will influence organizational performance. Recognizing that the quality of the output is a function of the input and the process for transforming the input into the output, an appropriate set of analytical techniques is required to transform big data into useful knowledge and insight for decision-making and performance excellence.

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