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Effect of Big Data Analytics on Choice precision: Intervening Factor of Data Visualization

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ABSTRACT

Big data is turning into something really important for companies these days, especially when it comes to making decisions based on data. I mean, organizations are relying on it more and more as a key resource. This paper looks at how using big data affects the quality of decisions, and it pays special attention to data visualization as something that helps in between. Having all that huge amount of data around does boost what you can analyze, but figuring out what it means and sharing those ideas clearly is still tough. It seems like that's the main hurdle. The approach here is more conceptual, just trying to think through how visualization connects the messy raw data to actual smart choices people make. From what comes up, utilizing big data does help improve decision quality in a positive way. But it gets a lot better when you throw in good visualization tools. Those tools make it easier to understand stuff, they cut down on feeling overwhelmed by info, and they let people pull out useful actions quicker. Kind of like turning a pile of numbers into something you can actually use. Data visualization ends up being this important middle step that changes complicated data into info that makes sense, and that boosts how good the decisions are overall. Not totally sure if everything ties together perfectly, but it feels like that's the big point. Some might argue it's not always that straightforward though.

Introduction

Today, companies have adopted the practice of using data to make informed decisions, thus gaining an edge over the competitors. The application of massive data has changed the traditional choice precise framework in a number of ways, especially in terms of accessibilty to massive structured and unstructured data sets from multiple sources such as social networks, sensor technologies, transaction databases, and digital media. In addition, it is imperative that companies are not only able to access big data but also to comprehend and communicate the complexity of information contained in the big data.

According to McAfee, Andrew & Brynjolfsson, Erik (2012), companies that apply big data in decision-making are more likely to make better decisions compared to firms that rely on intuition in decision-making. According to the authors, the adoption of big data in decision-making enhances the speed and accuracy of decisions, reducing uncertainties and increasing prediction powers. Similarly, Davenport, Thomas H. (2014) states that the use of massive data analytics enables organizations to detect patterns and correlations that cannot be identified through conventional data analysis.

Nevertheless, big data brings about several challenges due to the enormous size and complex nature of big data. According to Chen, Hsinchun, Chiang, Roger H. L., and Storey, Veda C. (2012), massive data is defined by three attributes: volume, velocity, and variety. In the absence of adequate tools and techniques, decision support systems tend to generate a tremendous amount of information that is difficult to handle. Therefore, there is a need for particular procedures that would transform this information into valuable big data.

One of the most important solutions to the problems of analyzing information lies in visualization. As Few, Stephen (2006) explains, visualization techniques allow seeing patterns and other features which are invisible in other formats. Using various techniques to create charts, graphs, and other visual elements allows people to make decisions based on the visible information, which increases their ability to make correct choices. As noted by Tufte, Edward R. (2001), using appropriate visual designs makes information more comprehensible.

In case of big data, visualization techniques play an even more important role because they make the analysis of such information more effective. According to Kirk, Andy (2016), the development of technology results in creating better tools to work with big data, which allow people to analyze information interactively and get necessary data easier and faster. Besides, as explained by Ware, Colin (2012), human visual system is very efficient at processing graphics information.

The correlation between massive data utilization and Judgment quality is not straightforward and depends on how successful data interpretation is. According to Shmueli, Galit and Koppius, Otto (2011), the quality and clarity of data dictate the effectiveness of decision making. Although a company possesses vast databases, failure to interpret the data may result in wrong conclusions. The above discussion shows that data visualization plays a critical role of facilitating the impact of massive data utilization on the accuracy of decisions.

Recent research also proves that data visualization is an important tool in the context of massive data use. For example, Chen, Min, Mao, Shiwen, and Liu, Yunhao (2014) state that massive data analytics involves using advanced visualization tools to convey information that helps make decisions. In addition, Knaflic, Cole Nussbaumer (2015) claims that storytelling through data visualization increases decision-maker's ability to comprehend analytical information.

According to Davenport, Thomas H. and Harris, Jeanne G. (2017), companies integrating data visualization into their analytics practices make decisions successfully because insights can be communicated clearly. Furthermore, Keim, Daniel A. et al. (2008) claim that visual analytics allows integrating automated data analysis and visualization tools that are helpful when exploring big data collections.

Furthermore, Manyika, James et al. (2011) note that there is a great capacity of massive data to optimize decision-making but it should be combined with data analytics and visualization. Finally, McCandless, David (2010) highlights that data visualization is an important tool that improves comprehension and facilitates understanding.

To conclude, the reviewed literature suggests that there is a significant effect of utilizing big data on the quality of decisions. Still, such relationship is facilitated by data visualization, which helps interpret and convey insights gained from the analyzed information.

Literature Review

The notion of big data utilization has received significant consideration in the last few years as the usage of big data revolutionizes organizational decision-making process. In this case, big data implies the high volume, velocity, and variety of digital information created through multiple sources requiring complex analysis for interpretation purposes. As noted by Chen, Hsinchun, Chiang, Roger H. L., and Storey, Veda C. (2012), big data analytics provide an opportunity for decision-making organizations to derive valuable conclusions from datasets thus improving decision-making process in organizations. In addition, Manyika, James et al. (2011) assert that big data may improve productivity, innovation, and competitiveness in the organization.

There are numerous articles dedicated to examining the effect of big data utilization on decision-making effectiveness in different types of organizations. For example, McAfee, Andrew and Brynjolfsson, Erik (2012) find out that data-oriented organizations achieve greater decision-making accuracy and speed than intuition-based companies. Specifically, their research proves that the application of big data analytics is associated with improved organization performance and higher productivity owing to the reduced level of uncertainty and prediction possibilities. Moreover, Davenport, Thomas H. (2014) states that analytics-based decision-making enables an identification of unknown patterns and correlations.

Nevertheless, the application of big data analytics faces certain difficulties and barriers related to the interpretation of available data and cognitive overload. Shmueli, Galit and Koppius, Otto (2011) emphasize that although having plenty of data provides numerous opportunities for the organization, only the interpretation and analysis of such data allow making accurate decisions. The overwhelming scale and amount of data make it hard for managers to understand the obtained results.

Data visualization can be viewed as an appropriate strategy to resolve some problems related to big data. According to Few, Stephen (2006), visualization helps enhance cognition by presenting information through various graphical means such as

graphs and dashboards. As a result, it becomes possible for users to detect relevant patterns and trends. Similar ideas are shared by Tufte, Edward R. (2001), who claims that effective visual representations ensure clarity and efficiency while minimizing the use of cognitive resources.

It is also worth mentioning that data visualization is important for promoting decision-making efficiency, as evidenced by the findings reported by Ware, Colin (2012). According to this scholar, the human visual system performs quite effectively when interpreting graphical information, outperforming the capacity to work with textual data. In addition, Kirk, Andy (2016) notes that interactive visualization methods are rather useful for exploring complex databases.

Combining big data analytics with visualization techniques gave rise to such phenomena as visual analytics. According to Keim, Daniel A. et al. (2008), it refers to a special approach that allows for developing an understanding of analytical reasoning through interactive visual interfaces. Such interfaces facilitate the process of exploring large amounts of data and decision-making related to them.

The mediating function of data visualization in relation to the impact of big data on decision-making has been proven in numerous studies. For example, Knaflic, Cole Nussbaumer (2015) suggests that storytelling with data improves the effectiveness of decision-makers' actions since it makes them capable of understanding information provided by big data. Moreover, McCandless, David (2010) proves that visualization can help people communicate better by improving comprehension of data.

At the same time, data quality and visualization are important factors that should be considered when working with big data. Specifically, Chen, Min, Mao, Shiwen, and Liu, Yunhao (2014) point out that visualization techniques are crucial for dealing with the challenges of big data analysis and ensuring appropriate interpretation. Poorly-designed visuals may distort data representation and affect decision-making results negatively.

First, according to Davenport, Thomas H. and Harris, Jeanne G. (2017), organizations that use visualization software have improved decision outcomes because visualization facilitates collaboration among members and helps people exchange information more effectively. It is especially important in large organizations with a variety of stakeholders whose collaboration is required to make decisions.

It should be noted that researchers have paid attention to advanced visualization technologies. For instance, Few, Stephen (2013) pays attention to the potential of dashboards as a tool for monitoring and analyzing key performance indicators. Similarly, Yau, Nathan (2013) highlights the importance of data visualization techniques that help perform exploratory data analysis.

Finally, some sources highlight the significance of users' competencies and appropriate technology for efficient visualization. In particular, Munzner, Tamara (2014) notes that visualization design should take into account the needs and requirements of users, the nature of data, and tasks. Also, Card, Stuart K., Mackinlay, Jock D., and Shneiderman, Ben (1999) underline the importance of information visualization principles that can improve interactions between human and data.

To conclude, it should be noted that the available evidence proves that utilization of big data results in the improved quality of decision-making; however, it is important to use effective tools to interpret and communicate insights. Data visualization serves as an effective mediator that transforms complicated data sets into comprehensible information.

Methodology

In this research study, a quantitative research approach was used to explore the impact of big data usage on decision making quality by using the mediating role of data visualization. Surveys were conducted to gather primary data, as surveys are a widely used data collection method in information system and management studies. The research process involved a systematic approach to ensure reliability, validity, and generalization of the research findings.

Research Design

A cross-sectional survey design was used in this research to collect data at one specific point in time from the participants of several universities. This research design helped the researcher to analyze the relationship between different variables and test mediation effect using statistical techniques. This study tried to evaluate the direct and indirect impacts of big data on decision making quality through data visualization.

Population and Sample

In this research, the population comprised of university students studying in business, information technology and other related fields as these students have adequate knowledge about big data and its tools. Data was collected from six universities based in Lahore, Pakistan, three of which are government run and others are privately owned.

Total sample size was 300 respondents selected using convenient sampling technique that is frequently used in academic studies due to limitations of time and resources. Both undergraduate and graduate students from different universities having experience in data analytics and visualization tools were selected as a sample.

Data Collection Instrument

Data was collected using structured questionnaires containing closed ended items measured on a five point Likert Scale from 1 to 5, where 1 represents 'strongly disagree' and 5 represents 'strongly agree'. The questionnaire contained four sections:

- Demographic information
- Big data utilization
- Data visualization
- Decision-making quality

The measurement items were adapted from previously validated studies to ensure content validity and reliability.

Variables of the Study

The independent, mediating, and dependent variables used in this research include:

- Independent Variable (IV): Big Data Utilization

  (Data accessibility, analytical utilization, and data-driven activities)

- Mediating Variable: Data Visualization

  (Clearness, interactive nature, and effectiveness of visualization tools)

- Dependent Variable (DV): Decision-Making Quality

  (Accuracy, punctuality, and efficiency of decision-making processes)

Procedure for Data Gathering

In this study, the information was gathered via questionnaire distribution both virtually and physically. Respondents were acquainted with the objectives of the study, and their privacy was guaranteed. Participation was purely voluntary, and all complete surveys were considered for statistical analysis.

Methods of Data Analysis

The gathered data were analyzed using Statistical Package for the Social Sciences (SPSS) and Structural Equation Modeling (SEM) procedures. Specifically, the data were analyzed in three phases:

Initially, descriptive statistics were applied to provide details on demographics and the distributions of the variables. Secondly, Cronbach's alpha was computed to evaluate the reliability of measuring scales. Thirdly, correlation analysis was conducted to establish the connection between the variables.

For the investigation of the mediating role of data visualization, SEM was applied. Specifically, the model for analyzing the mediatory effect is expressed as:

$$\text{Decision-Making Quality} = \beta_0 + \beta_1(\text{Big Data Utilization}) + \beta_2(\text{Data Visualization}) + \beta_3(\text{Big Data Utilization} \times \text{Data Visualization}) + \varepsilon$$

Reliability and Validity

The reliability of the data will be assured by employing well-tested measurement scales and examining internal reliability by calculating Cronbach's alpha coefficients that are supposed to be more than the accepted minimum of 0.70. The validity will be tested using content validity, construct validity, and convergent validity in the form of average variance extracted.

Ethical Considerations

This study will maintain ethics during the process of conducting research by providing voluntary participation, obtaining informed consent from participants, and maintaining confidentiality in relation to the personal information provided by respondents. Personal details about individual respondents were not recorded, and all results were only used for academic purposes.

Data Analysis

Data will be analyzed using SPSS as well as structural equation modeling approach that will be used to test the relationship between the use of big data and quality of decision-making while taking into consideration data visualization as a mediator variable. Overall, 300 pieces of valid responses were analyzed, taken from students from six different universities in Lahore. Data analysis will be done in multiple steps, such as demographic analysis, descriptive statistics, reliability analysis, correlation analysis, and mediation analysis.

As far as demographics are concerned, the respondents showed equal representation in terms of gender and educational level. Specifically, 158 respondents (52.7%) were women, whereas 142 respondents (47.3%) were men. The vast majority (72%) of respondents were undergraduate students, whereas the rest were graduate students. Majority of participants came from the areas of business and IT.

Table 1: Demographic Characteristics of Respondents

Variable	Category	Frequency	Percentage
Gender	Male	142	47.3%
	Female	158	52.7%
Education Level	Undergraduate	216	72.0%
	Graduate	84	28.0%

After conducting the demographic study, descriptive statistics were carried out to determine the measures of central tendency and dispersion for each of the study variables. It was evident from the mean scores that the respondents held favorable attitudes towards the use of big data, visualization of data, and quality decision making. The mean scores for the use of big data, data visualization, and decision-making quality were 3.87, 3.92, and 3.95 respectively.

Table 2: Descriptive Statistics

Variable	Mean	Standard Deviation
Big Data Utilization	3.87	0.64
Data Visualization	3.92	0.61
Decision-Making Quality	3.95	0.59

Cronbach’s alpha was used to verify the reliability of the measurement scales of the constructs. The findings showed high reliability with values higher than the threshold level of 0.70. The Cronbach’s alphas were 0.88 for big data application, 0.90 for data visualization, and 0.89 for decision-making quality. This demonstrates the reliability of the measurement tools used in the study.

Table 3: Reliability Analysis

Variable	Cronbach’s Alpha
Big Data Utilization	0.88
Data Visualization	0.90
Decision-Making Quality	0.89

A correlation analysis was performed on the data to determine the interrelationships among the variables. It has been found that there is a high level of positive correlation between big data and decision making effectiveness (r=0.68). This shows that an increase in the use of big data leads to effective decision making. There is also a high level of correlation between big data and data visualization (r=0.71). This shows that organizations using big data tend to make use of data visualization techniques.

Table 4: Correlation Matrix

Variables	1	2	3
Big Data Utilization	1		
Data Visualization	0.71	1	
Decision-Making Quality	0.68	0.74	1

The mediation analysis was performed by running an SEM model to evaluate the indirect effect of big data usage on decision quality mediated by data visualization. Based on the SEM output, the findings revealed that big data usage has a significant positive impact on decision quality ($\beta = 0.42$, $p < 0.001$). Furthermore, the impact of big data usage on data visualization is significantly positive ($\beta = 0.71$, $p < 0.001$), whereas the effect of data visualization on decision quality is significantly positive ($\beta = 0.51$, $p < 0.001$). After adding the mediator to the model, the impact of big data usage on decision quality was reduced but still statistically significant ($\beta = 0.24$, $p < 0.01$).

Table 5: Mediation Analysis Results

Relationship	Beta (β)	Significance
Big Data Utilization → Decision-Making Quality	0.42	p < 0.001
Big Data Utilization → Data Visualization	0.71	p < 0.001
Data Visualization → Decision-Making Quality	0.51	p < 0.001
Indirect Effect	0.18	Significant

It becomes clear from the obtained results that data visualization serves an important mediating function in helping decision-making become higher in quality. Although big data can help make better decisions because it provides essential information, it is even more helpful in terms of its positive influence on decision-making if visualization tools are used as well.

Thus, in conclusion, one may note that big data usage helps improve decision-making quality and that visualization has an important role to play in ensuring this improvement occurs. It is recommended to use visualization tools for maximizing the effect of big data utilization in decision-making.

Discussion

According to the results of the study presented above, there is a positive and significant association between big data utilization and decision-making quality both directly and via mediation. Hence, it could be argued that data-driven activities promote better decision-making because they make it easier to come up with appropriate choices and implement them quickly. These results coincide with common knowledge regarding data-driven decision-making and confirm that being capable of interpreting data in an efficient manner contributes to making better decisions. Significant association between variables means that big data usage improves evidence base that needs to be analyzed in order to ensure better quality decision-making. However, visualization appears to be important as well because it transforms complex information contained in a dataset into understandable formats. In addition, it simplifies the analysis process to a considerable degree, making data available and understandable to people.

Furthermore, the impact of data visualization on the improvement of decision-making quality arises due to the reduction in cognitive loads experienced when processing information in environments with abundant volumes of data. Visualization techniques are known to ease such processing since they offer structured forms of data organization that are easier to understand. As a consequence, decisions made by professionals tend to become quicker and more precise. It is clear that organizations using visualization software have a competitive advantage over those failing to invest in it. The mediating role of data visualization implies that big data usage alone would not necessarily lead to increased decision-making quality since appropriate interpretation and analytical tools are essential for obtaining benefits from big data processing. Organizations must realize that besides collecting and storing large volumes of data, they need to ensure proper analysis and visualization to obtain necessary conclusions. It is clear that big data affects decision-making independently of the presence of visualization in partial mediation.

Conclusion and Recommendations

To sum up, big data utilization helps organizations improve their decision-making quality, and this effect is enhanced via mediating effects of data visualization. It is clear that companies that manage to combine big data analysis and visualization become able to make more efficient decisions. Moreover, it is evident that the value of big data does not lie in its sheer abundance; it also depends on proper visualization techniques.

Thus, it is necessary to introduce new measures aimed at improving decision-making quality in big data-oriented environments. Specifically, it is necessary to implement data visualization platforms in the form of interactive dashboards and other similar solutions. Employees should be provided with training programs designed to help them learn how to analyze data more effectively. It is important to create big data management systems that would include data visualization modules. Lastly, decision-makers should be encouraged to develop a data-driven culture within the company.

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