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The Convergence of Big Data and Accounting: Innovative Research Opportunities

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Abstract

This study aims to develop accounting standards, curriculums, and research to cope with the rapid development of big data. The study presents several potential convergence points between big data and different accounting techniques and theories. The study discusses how big data can overcome the data limitations of six accounting issues: financial reporting, performance measurement, audit evidence, risk management, corporate budgeting and activity-based techniques. It presents six exciting research questions for future research. Then, the study explains the potential convergence between big data and agency theory, stakeholders theory, and legitimacy theory. This theoretical study develops new convergence points between big data and accounting by reviewing the literature and proposing new ideas and research questions. The conclusion indicates a significant convergence between big data and accounting on the premise that data is the heart of accounting. Big data and advanced analytics have the potential to overcome the data limitations of accounting techniques that require estimations and predictions. A remarkable convergence is argued between big data and three accounting theories. Overall, the study presents helpful insights to members of the accounting and auditing community on the potential of big data.

Keywords: Big data; Analytics; Accounting; Data Science; Business Intelligence.

I. INTRODUCTION

Data is the heart of the accounting profession (ICAEW, 2014). However, big data is much more than accounting and financial data. Big data includes financial and non-financial data, accounting and non-accounting data, and quantitative and qualitative data, which become available in massive amounts, in different formats, and in real-time (Bag et al., 2020; Basukie et al., 2020; Blazquez & Domenech, 2018; Ghani et al., 2019). Big data could improve management accounting, financial accounting, financial reporting practices (Warren et al. 2015) and develop auditing as well (Brown-Liburd, Issa, and Lombardi. 2015; Iqbal et al., 2020; Yoon, Hoogduin, and Zhang. 2015). Potential convergence points between big data, accounting, and auditing, include the convergence between big data and financial reporting, performance measurement, audit evidence, risk management, corporate budgeting and activity-based techniques. Therefore, this study aims to address the following questions; (i) How big data converge with accounting, (ii) how big data capabilities meet the accounting data needs, and (iii) how big data could develop the traditional accounting techniques and theories.

If high-quality data is available and processed in real-time, this could mean that companies will be able to present more accurate financial reporting, better performance measurement, and reliable budgeting. Big data could help improve the data quality by improving accuracy, completeness and make it available in real-time (Cockcroft &Russel, 2018). Further, estimations of depreciation, measurements of historical cost, FIFO, and LIFO would become more accurate using big data technology (Vasarhelyi et al., 2015). In auditing, Big data can help auditors comply more with the auditing standards and increase the overall assurance level through obtaining more appropriate and sufficient audit evidence (Moffitt & Vasarhelyi, 2013; ICAEW, 2014; Yoon et al. 2015; Alles, 2015). Big data will allow auditors to employ 100% of the population to decrease associated risks to zero (Brown-Liburd et al., 2015). Data has always been the main limitation of accounting and auditing techniques, especially for those that require estimations or apply predictions models, such as deprecation, risk assessment, and budgeting. However, big data and advanced analytics technology provide promising solutions that can provide a massive amount of processed data in real-time, which is more likely to animate the accounting heart through the instant flow of high-quality data.

The convergence of big data and business has been reflected in the significant incorporation of big data in accounting, finance, and academic management disciplines (Alles, 2015; Frizzo-Barker et al., 2016; Gupta et al., 2019; Hughes & Ball, 2020; Kiani Mavi & Kiani Mavi, 2021; Liedong et al., 2020; Vecchio et al., 2019; Wang et al., 2020). The computing and business

schools, particularly in the U.S. and Europe have constructed new teaching degrees such as Computational Finance, Business Computation, Financial Computing, and Business Analytics. Despite the development of business disciplines to incorporate big data, the academic research on the convergence of big data and accounting is underexplored and does not cope with the rapid development in big data (Chen et al., 2015). The actual use of big data for accounting is still in its infancy (Scott & Orlikowski, 2012). Moreover, Frizzo-Barker et al. (2016, P.403) state, "…, we found that big data remain a fragmented, early-state domain of research in terms of theoretical grounding, methodological diversity, and empirically oriented work". The main reason may be the inability of researchers to access big datasets of companies and governments (Moffitt & Vasarhelyi, 2013) or maybe the need to learn advanced analytics, such as algorithms. Besides, Muller et al. (2016) argue that big data is not self-explanatory, and researchers need to apply advanced computational techniques to recognize patterns in data and that using the traditional statistical models to analyze big data may not work with big data. Arafat et al. (2020) suggest that big data needs novel processing architectures and intelligent algorithms to effectively and efficiently explore valuable insights from big datasets, particularly the unstructured part.

Accordingly, the study addresses the following questions: (1) how big data can reshape accounting, (2) how big data can be incorporated into accounting theories, research, and curriculums, and (3) what are the implications of big data incorporation in accounting? Moreover, the study has two objectives: (1) discuss six potential convergence points between big data and accounting and auditing, and (4) discuss the possible convergence between big data and three common theories applied in accounting and auditing research. There is a potential that big data as technology will reshape accounting through providing full population auditing, high-quality financial reporting, and more effective performance measurement. More accurate budgeting and forecasting could be a business advantage when adopting big data and using advanced predictive analytics. Big data could reshape accounting by providing real-time and instant financial statements. On the other hand, accounting and business research should explore how big data and analytics could be applied to develop strategic management accounting techniques? This study provides several research ideas and nine research questions to develop accounting techniques, research, and curriculums to adapt the current development of big data and advanced analytics.

This study contributes to the literature in the following ways. First, the study discusses nine convergence points between big data and accounting practices and theories. Second, the study proposes nine research questions that could develop accounting research and relevant theories.

Third, based on the potential that big data can assist with creating and refining accounting standards (Warren et al. 2015), this study provides valuable insights that could help accounting standards setters recognize the big data and accounting convergence to develop accounting standards? Fourth, the study supports the governance regulators and auditors understand whether big data penetration into business may require new regulations to control the big data risks and whether the corporate management control systems may need updates. Finally, the study could help the academic institutions update the accounting curriculums to accommodate big data.

The study continues as follows. The following section is a discussion of six convergence points between big data and accounting. The third section is a review of how big data could develop three accounting theories. The fourth section discusses big data and its job market, and its involvement in accounting curriculums. The fifth section summarizes the potential big data implications on the accounting community, while section sixth concludes. The study structure is presented in Figure 1.

Insert Figure 1 about here

2. The CONVERGENCE OF BIG DATA AND ACCOUNTING

2.1 Traditional Data and Big Data

Traditional data has grown to become big data with new dimensions; volume, velocity, variety, veracity, and value. The emerging data storage and processing solutions helped change traditional data's nature and expand traditional data to appear with new dimensions. Figure 2 discusses emerging data sources according to Moffitt and Vasarhelyi (2013). The primary source of traditional data was the ERP data, but the data volume expanded with the emergence of scanners. An automatic data collection source is the web, where customers can react on social media or write reviews, or via emails. Customers can place orders by themselves and instantly fill in personal information about their preferences. The companies' websites also became a primary source of data collection. They work to catch data from the outside world and get them inside for analysis. The spread of smartphones helps to create more data (mobility data), including customers locations. Data in different formats such as media recordings, security recordings, and telephone recordings became available. The new sources of data create big datasets with massive volumes and variety. Internet-of-Things (IoT) is a relevant concept

where devices become smart and connected to the internet. More connected devices mean more data and more data points. Thus, companies can develop their technology capabilities all the time to be able to store, organize, analyze, and get valuable insights from this continuous data stream.

Insert Figure 2 about here

2.2 Quantitative Facts on Big Data

During the last two years, the volume of data created has been more than that created throughout the entire human history (Marr, 2016). Table 1 shows some quantitative facts on the three basic dimensions of big data: volume, velocity, and variety. For volume, the table shows data metrics of zettabytes (Septillions) and petabytes (Quadrillions). A few years ago, these data metrics were not used frequently. For velocity, the table shows that 2.5 petabytes can be processed per hour and that every minute, people upload 300 hours of new videos to YouTube. For variety, the table shows big data in different formats such as tweets, sound, photos, video hours, etc. Furthermore, the table indicates that big data invaded different sectors, including governments, healthcare, libraries, and business companies. Regarding the job market and according to McKinsey Global Institute (2011), there is a shortage of data analysts and talented analysts, where the U.S. only needs 140,000-190,000 talented analysts. Figure 3 shows that the big data market is predicted to increase to 103 billion U.S. dollars by 2027, more than triple its actual market size in 2017 (Statista, 2021).

Insert Figure 3 about here

2.3 Big Data and Accounting

Big data provides several remarkable development opportunities in the accounting field. Big data predictive models can improve budgeting, risk management and increase the efficiency of audit activities (ICAEW, 2014; Chen et al., 2016). However, the current state of accounting research on big data is underdeveloped. It is mainly theoretical, and there is a lack of empirical evidence on the effectiveness of big data in accounting. This encourages us to propose some interesting research questions on the convergence between big data and

accounting to help further accounting researchers extend the extant literature. The following sub-sections discuss the convergence of big data and financial reporting, performance measurement, audit evidence, risk management, corporate budgeting, and activity-based techniques.

Table 1: Quantitative facts on big data

IBM (2014)	➢ 43 Trillion Gigabytes (40 Zettabytes) of data will be created by 2020.
	➢ 2.5 Trillion Gigabytes of data are created every day.
	➢ Most firms in the U.S. have 100,000 Gigabytes of stored data.
	➢ The New York Stock Exchange captures 1000 Gigabytes of trade information each session.
	➢ Data on world healthcare was about 161 Billion Gigabytes in 2011.
	➢ More than 5 Billion hours of videos are watched each month on YouTube.
	➢ 30 Billion Pieces of content are shared each month on Facebook.
	➢ 400 Million Tweets are set each day.
McKinsey Global Institute (2011)	➢ A $600 disk drive can store the entire world's music.
	➢ 5 Billion Mobile phones in use in 2010.
	➢ 235 Terabytes data collected by April 2011 by the U.S. Congress Library.
	➢ 15 out of 17 sectors in the U.S. have stored data per firm more than the U.S. Congress Library.
	➢ Many U.S. firms have more than 1 Petabyte.
	➢ The discrete manufacturing sector in the U.S. stored data more than 966 Petabytes in 2009.
	➢ The government data reached 848 Petabytes in 2009.
	➢ The banking data reached 619 Petabytes in 2009
	➢ The communication and media data reached 715 Petabytes in 2009.
	➢ 140,000-190,000 more deep analytical talent positions are required in the U.S. only.
	➢ 1.5 million more data-savvy managers needed to take full advantage of Big Data in the United States.
Gandomi & Haider (2015)	➢ Facebook is estimated to store 260 billion photos using storage space of over 20 petabytes.

Marr (2016)	➢ Data created within the last two years exceeds that created across the entire history of mankind. ➢ By 2020, 1.7 megabytes will be created every second by every human being. ➢ Every minute, people upload about 300 hours of new video to YouTube. ➢ By 2020, more than 50 billion devices will be connected to the internet. ➢ Walmart announced in 2015 that they are working to create the world's largest private data cloud that will be able to process 2.5 petabytes of data per hour.
www.sas.com	➢ In 2012, the amount of Data stored worldwide exceeded 2.8 Zettabytes. ➢ In 2018, the amount of Data stored worldwide reached 18 zettabytes. ➢ By 2025, the estimated Data will grow to 175 Zettabytes.

The six accounting issues were chosen to investigate because we see an apparent potential convergence between big data and these techniques. In addition, these selected techniques depend heavily on data and represent strategic importance to businesses. For example, when applying activity analysis, data should be collected on the organization's activities. For large companies such as Amazon, the number of activities may exceed 1 million. In addition to the identification of activities, the costs of each activity need to be estimated. Other techniques could depend on prediction, such as budgeting, and here, predictive analytics could help and add value. A significant task of budgeting is cost estimation, which could be improved by employing predictive analytics. Another example is financial reporting, where companies are required to report on different financial and non-financial aspects of their organizations, and a vast amount of data is needed. Figure 4 shows the main types of analytics, which are descriptive, predictive, and prescriptive.

Insert Figure 4 about here

However, other potential points of convergence between big data and accounting that are not considered in this study include SWOT analysis, target costing, the organizational environmental impact, cost estimation, and Six Sigma. To apply target costing, businesses need to conduct customer research to know the affordable prices and unique product features that customers require. For companies with millions of customers, achieving these tasks needs advanced solutions. Likewise, SWOT analysis could be improved by applying big data solutions since it needs internal and external data collection and analysis. Another exciting point not explored in the study is how the effectiveness of Six Sigma could be improved when applied in a big data environment. Koppel and Chang (2020) present an interesting study on the implementation of Sig Sigma in big data environments. They believe that Six Sigma applied in a big data environment could provide a competitive advantage.

2.3.1 Big data and financial reporting

Transparency is the main objective of corporate reporting and governance systems. Big data can improve financial reporting, enhance transparency and accounting information quality (Warren et al., 2015), and enrich financial reporting information (Moffitt & Vasarhelyi, 2013). One of the main questions that Hans Hoogervorst– Chairman of the (IASB) - proposed in the 2015 AICPA conference in the USA was "What about the influence of big data on financial reporting?" Besides, Cockcroft and Russel (2018) argue several significant data opportunities to improve financial reporting quality and when using financial and non-financial metrics for performance evaluation. Big data can combine different and irregular data sources into one integrated information accounting system.

Financial reporting is the final product of financial accounting and a primary interest for management and stakeholders. However, corporate reporting does not meet the users' needs that develop over time. First, financial reporting is still provided quarterly, semi-annually, and annually in the big data era. Often, financial reports become available to the public after being audited later at the end of the financial year, which implies that some information may lose its relevancy. Investors and other stakeholders have become in need of timely financial information, maybe daily. In this regard, one of the big data dimensions is velocity, which refers to the pace at which data is processed and created; big data systems have become able to process and create data in real-time. This could help companies release their financial reports in a brief period. For example, Royal Bank of Scotland, Walmart, and Amazon have adopted big data systems that process and provide data on a real-time basis (Marr, 2016). This indicates that when companies adopt a big data system, this can significantly influence their ability to provide financial reporting to the public during a desirable period. However, to the best of our knowledge, the accounting research did not empirically address this relation to date. One recent study, Al-Htaybat and Alberti-Alhtybat (2017), examines the impact of big data on corporate reporting by conducting interviews with 25 participants. Respondents believe that accountants and data analysts should co-operate to improve financial reporting using advanced analytics. Moreover, Arnaboldi et al. (2017) conducted a literature survey and concluded that big data could improve financial reporting quality by transforming narratives into numbers and visualization.

Second, in the information age, the pressure on management is increasing for more integrated reporting that incorporates non-financial information in addition to the traditional financial information. The tendency of integrated reporting towards non-financial information

is increasing. Further, PWC (2013) states that some companies in the U.S. have shown an interest in reporting more non-financial information voluntarily and that nearly all of the S&P 500 companies made at least one sustainability-related disclosure. This indicates that companies will depend on non-financial information sources to report non-financial information to stakeholders in addition to the financial information. Big data is an excellent opportunity to improve integrated reporting. ACCA & IMA (2013, p. 25) state, " integrated reporting recognizes the importance of non-traditional indicators and predictors in company reports and long-term assessments-and, therefore, makes big data more important." Accordingly, an integrated ERP system is required to store each piece of data enter the company and should be developed to summarize and report both financial and non-financial information. How big data could improve and help in integrated reporting is an interesting question for future research as no study has addressed it to date, to our knowledge.

Third, risk disclosure is one of the essential corporate disclosures since it reveals the present and potential risks facing firms that could threaten their continuity. Risk disclosure informs investors about the risks that threaten their investments, helps assess the firms' risk profile (Linsley & Shrives, 2006), and has significant liquidity, investment, and financing implications by reducing agency and information asymmetry problems (Abraham & Cox, 2007; Elamer et al., 2019; Ntim et al., 2013). However, managers have to assess and measure the present and potential risks efficiently to disclose high-quality risk information. Managers need backward and forward data on internal and external risks and need to employ advanced risk assessment models. Big data can play a significant role in providing a massive amount of internal and external data to managers in real-time. Advanced big data analytics can employ this big data for better risk assessment and measurement. Moreover, Avantage Reply (2014) argues that big data can enhance monitoring of risk, risk coverage, and the development of advanced risk-assessment models. Chen et al. (2015) conduct a case study on how *Alibaba Group* uses big data in fraud risk management; they state that Alibaba Group has a fraud risk management system based on real-time big data processing and intelligent risk models. As a result, the final information on risks will be more accurate and reliable and can be provided on a real-time basis. This could significantly improve the quantity and quality of risk disclosure. Future studies may examine how big data could affect the risk disclosure quality and whether the companies employ big data to enhance risk disclosure.

Overall, big data technology can contribute by increasing the quality of different financial reporting types, such as social, risk, integrated disclosures, thus decreasing information asymmetry. A comparison of financial disclosure quality between big data Adopters and Non-

adopters based on the following research question can provide empirical evidence on the economic feasibility of big data:

R.Q. (1): Do big data adopters present higher-quality financial reporting?

2.3.2 Big data and performance measurement

Balanced Scorecard (BSC) is a performance management system introduced by Kaplan and Norton in 1992. It helps managers measure, monitor, and manage performance from four different perspectives: financial, customers, business process, and learning and growth. Unlike the traditional performance measures that focus only on financial performance, BSC adopts a comprehensive view of performance measurement that covers both financial and non-financial performance through measuring several Key Performance Indicators (KPIs), including several financial and non-financial metrics.

Information technology can provide a new dimension to the performance measurement process. Usually, management accountants collect data on the four perspectives of BSC using structured data such as customer satisfaction surveys, worker retention, and return level (Richins et al., 2017). Accountants and finance professionals must use big data to measure organizational performance (ACCA & IMA, 2013). First, Vera-Baquero et al. (2015) introduce a big data solution that can provide business analysts with insights on business performance and make metrics and key performance indicators available in real-time. Second, an effective BSC system needs large and diverse internal and external financial and non-financial data. For example, the BSC customer perspective needs a lot of external data on customers, their preferences, and their experience with the company products in addition to their personal data. Big data technology can provide massive and diversified customer data that will help managers construct the objectives, measures, targets, and initiatives of the BSC customer perspective effectively. Elkmash et al. (2021) conducted an experimental study on the influence of big data analytics on customers performance as one of the BSC perspectives. They conclude several benefits of using big data analytics in customers' performance measurement, such as decreasing the cost of customers' unstructured data analysis and increasing the ability to handle customers' problems promptly. Sardi et al. (2020) explore the relationship between performance measurement and big data and argue that an integrated performance measurement system based on big data could help achieve competitive advantages for businesses.

In practice, the Royal Bank of Scotland has adopted the "Personology" strategy that focuses on the customers' needs and uses big data analytics to collect and analyze customers' primary focus (Marr, 2016). Furthermore, Amazon has adopted big data to obtain a 360-degree view of their customers (Marr, 2016). Imagine the difference in the effectiveness of the BSC system in a company that adopts a big data system that can feed the BSC in real-time and a massive data amount on customers and the effectiveness of the BSC system that depends on the traditional data.

Furthermore, setting the companies' vision and strategy may be the most critical stage in implementing the BSC. Failure to develop the right vision and strategy may result in catastrophic losses since the company's total resources and efforts will be directed to achieve the wrong vision and strategy. Big data predictive analytics (Duan & Xiong, 2015) can help managers set the most appropriate vision and strategy based on future events forecasting. In addition, Arnaboldi et al. (2017) conducted a literature review and concluded that big data could improve performance measurement by producing new performance indicators. We argue that big data can provide a large volume of actual and predicted, internal and external, past and future, and financial and non-financial data on a real-time basis, which will significantly improve the BSC's effectiveness. However, it remains a theoretical argument without empirical evidence. To our knowledge, no study has been found to address how big data and Analytics could improve performance measurement by implementing BSC. The study of Vera-Baquero et al. (2015) proposes big data as a solution that could enable managers to analyze and measure performance more effectively, but the study does not refer to BSC at all. Therefore, a big data-Balanced Scorecard is a suggested terminology that could be introduced and investigated. The following is an interesting research question to examine the above argument:

R.Q. (2): Does applying BSC in a big data environment improve corporate performance measurement effectiveness?

2.3.3 Big data and audit evidence

Big data and its analytics can improve the efficiency and quality of audit activities (ICAEW, 2014). A significant convergence is arising between audit evidence and big data. Yoon et al. (2015, p. 436) state, "Big data will play an important role in auditing because it complements traditional evidence with sufficient, reliable, and relevant information." Alles (2015, p. 447) states, "The major facilitator for the use of big data by auditors is the openness of audit

standards to sources of audit evidence outside the traditional general ledger data." The auditing standards allow auditors to collect evidence from any source and in any format if it helps formulate an opinion. According to the International Standard on Auditing (ISA 500) "Audit Evidence" released by the British Financial Reporting Council (FRS), the audit evidence is any information, whether contained in the accounting records or other information that is used by the auditor. Section A8 (p. 6) of the standard states, "More assurance is ordinarily obtained from consistent audit evidence obtained from different sources or of a different nature…" Furthermore, SAS No. 106 (AICPA, 2004) states that audit evidence is all the information used by the auditor whether contained in the accounting records or other information to arrive at an audit opinion. This auditing standards flexibility in collecting the audit evidence is congruent with the unique dimensions of big data.

Big data dimensions could enable auditors to reach evidence from different sources, in different formats, and in real-time for the same items to be audited. For example, the first dimension of big data "Volume" can help reach more than sufficient evidence because of the massive volume of data. This enormous volume can encourage auditors to increase the sample size and get more evidence that could lead to a higher assurance level. ICAEW (2014) argues that auditors can exploit the big data opportunities to improve the audit quality by analyzing whole data sets. The second dimension, "Velocity," enables the auditor to reach the required evidence on a real-time basis since big data can be created and processed at a very high speed (Gandomi & Haider, 2015). The third dimension, "Variety," implies that a wide range of pieces of evidence in different formats such as image, sound, video, GPS location, and sensor recordings have become available to auditors, compared with the traditional audit evidence in the form of receipt or invoice. These new evidence formats complement and may replace the conventional audit shreds of evidence (Moffitt & Vasarhelyi, 2013).

However, the idea is not only a massive amount of diversified pieces of evidence, but the evidence should also be sufficient and appropriate (relevant and reliable) according to the requirements of auditing standards (SAS No. 106 -AICPA, 2004; Alles, 2015; Brown-Liburd et al. 2015; Yoon et al. 2015). Fortunately, auditors will no longer accept any available evidence because of evidence shortage or non-availability since big data will enable them to choose from a vast amount of shreds of evidence, the most appropriate and sufficient ones. Big data unique characteristics can satisfy sufficient and reliable audit evidence (Yoon et al., 2015). The availability of massive amounts of data in different formats and in real-time and the advanced capabilities of big data Analytics increases the probability of obtaining the most sufficient and appropriate audit evidence. Overall, big data and its related analytics can boost

the auditors' capabilities to collect adequate and appropriate audit evidence and conclude an opinion with a higher assurance level. However, no empirical evidence is provided on whether big data boosts the audit profession through the big data audit evidence, which is an interesting question for future research. The above arguments need empirical evidence that could be provided by investigating the following research question:

R.Q. (3): Does auditing in a big data environment improve assurance and auditing quality?

2.3.4 Big data and risk and fraud management

Companies face several internal and external risks that could threaten the companies' continuity unless there are assessed and managed effectively. Risk management is one of the top management priorities and a primary requirement of the governance codes. The U.K. Corporate Governance Code (2014, p. 17) states, "The board should maintain sound risk management and internal control systems." Furthermore, several accounting standards and regulations require companies to disclose risks and strategies used to assess and manage risks, such as IFRS 7, Pillar 3 (2004; 2009), and Pillar 3 (2015) of Basel 2 Accord

Big data has the potential to improve risk monitoring, risk coverage, and the development of models that will support risk decisions (Avantage Reply, 2014). Big data and its analytics provide several opportunities for accountants that can exploit to improve risk management (ICAEW, 2014). First, Key Risk Indicators (KRIs) are measures used to indicate how risky an activity is or whether the firms are subject to risk. Incorporating big data in KRIs measurements will improve these indicators' accuracy and predictive power and make KRIs available in real-time. Second, since most of the risks are future-oriented, the more data is available, the more accurate the risk assessment and prediction. Big data predictive analytics can increase risk assessment models' predictive power and stability and help managers estimate the risk predictions more accurately (Duan & Xiong, 2015). Third, big data can help auditors assess the risks of their present or potential clients, such as risks of bankruptcy, management fraud, risks of material misstatement of financial statements, and risks associated with design and implementation of internal controls, more effectively than before (Cao et al. 2015). Aboud and Robinson (2021) found that the use of data analytics as an effective tool to prevent or detect fraud is under-utilized, recommending further research. Fourth, Bollen et al. (2011) analyzed Twitter data and predicted the daily fluctuations of the Dow Jones Industrial Average (DJIA). Similarly, managers and investors could expect the global economic mood to protect their firms

and investments against any financial or market risks, such as the risks of foreign currency, liquidity, and share price fluctuations, by employing advanced risk assessment and prediction analytics. Fifth, managers could analyze the massive amount of data they have on their customers to evaluate their preferences and consider their opinions about the product, which could help reduce the risk of brand name erosion and risk of customer dissatisfaction. In this regard, Amazon, Walmart, Acxiom, Facebook, and Royal Bank of Scotland apply customer analytics to assess and prevent any customer risks (Marr, 2016). Sixth, financial and credit institutions can analyze big data to evaluate the financial creditability of their customers. (Avantage Reply, 2014) states that instead of waiting for financial reports of the clients asking for credit, banks can utilize big data to reach early warning signals. Further, the Experian Company uses big data and provides banks and credit institutions data on their customers' credit risk (Marr, 2016). Overall, ACCA & IMA (2013, p. 14) state that big data in risk management can expand the data resources used in risk forecasting, identify risks in real-time for fraud detection and forensic accounting, and test the risks of long-term investment opportunities.

Big data with its unique dimensions could help improve risk assessment, prediction, and measurement besides fraud detection. For example, the "Volume" and "Variety" dimensions will provide a vast amount of financial, non-financial, internal, and external data in different formats that will overcome the data shortage limitation. Further, in the risk forecasting process, managers will have a hundred inputs used in risk prediction models, which will increase the risk prediction accuracy than using models with fewer inputs (Duan & Xiong, 2015). The "Velocity" dimension will help process and predict the present and potential risks on a real-time basis so that companies can prevent some risks before their occurrence. Chen et al. (2015) argue that the big data system in *Alibaba Group* can monitor and assess fraud risks in real-time and send alarms to prevent fraud. More research is still needed on how big data could improve fraud prevention and detection (Cockcroft & Russel, 2018; Aboud & Robinson, 2020). Besides, the traditional procedures of auditing and reviewing financial reporting may not be sufficient to recognize fraudulent financial reporting (Aboud & Robinson, 2020). Therefore, advanced analytical tools could be applied to help improve the assurance level and audit quality.

Empirically, companies have started to apply big data solutions to develop their risk management systems. For example, the Royal Bank of Scotland has announced £100 million investments in big data and its analytics to achieve several objectives, including assessing customers' credit risk (Marr, 2016). Further, Alibaba Group has developed a fraud risk management system based on real-time big data processing and intelligent risk models, which can capture fraud signals and produce thousands and thousands of attributes in addition to

employing advanced risk fraud models (Chen et al., 2015). Experian company has invested in big data to provide credit references and information on creditworthiness and insurability of customers to banks and lending institutions to help assess the credit risks (Marr, 2016).

Strong convergence is apparent between big data and risk management. Since companies face several risks continuously, data available on all these risks is the most critical factor in risk management and applying advanced risk assessment analytics. However, the academic empirical research on the effectiveness of big data in improving risk management systems experiences an evident paucity; the study of Chen et al. (2015) is the only empirical study that we find, to the best of our knowledge. Accordingly, further empirical evidence is required by investigating the following research question:

R.Q. (4): Does big data improve risk and fraud management effectiveness?

2.3.5 Big data and corporate budgeting

Gleim and Flesher (2015, p. 285) define the budget as "…a realistic plan for the future that is expressed in quantitative terms". CIMA (2005) defines a budget as "A quantitative expression of a plan for a defined period. Budgets include planned sales volumes and revenues, resources quantities, costs and expenses, assets, liabilities and cash flows" (CIMA, 2008). The budgeting process is a planning function that is based on forecasting. The budgeting process as a planning function has several challenges. First, the budgeting process suffers from inaccuracy of the future forecasts, the unavailability of accurate data on time, and ambiguity and uncertainty. Collier and Berry (2002) argue that the budgeting process typically considers the risk and uncertainty and needs data about internal and external events. Second, setting a budget requires managers to collect financial and non-financial data, internal and external data, past and future data, and quantitative and qualitative data. Third, setting a budget also requires managers to put many assumptions and estimations that need data. Fourth, the data need does not stop at the planning stage but extends to the budget implementation stage. Managers will need data to evaluate the budget assumptions and control the gap between the actual and budget levels. Data is the common factor between all these challenges. The data is the primary driver and a critical factor for any budgeting process.

Big data and its analytics could help overcome all these challenges. ICAEW (2014) argues that accountants can use big data predictive models to improve budgeting and forecasting activities. Chen et al. (2016) state that big data analytics is an organizational information

system that can reduce uncertainty and make better predictions about future resource requirements, while Cokins (2014) argues that the integration of predictive analytics and big data in business operations has changed the traditional cost-center budgeting and cost variance control. First, the big data first dimension, "Volume," will provide a massive amount of data inputs to managers in budgeting to achieve more accurate budgeting estimations and forecasts, which will reduce variances. Using hundreds of inputs in forecasting can provide better and more accurate estimates than using fewer (Duan & Xiong, 2015). The second dimension, "Velocity," will provide data processed in real-time so that managers can continuously follow the budget implementation process, which could reduce any implementation errors. Kudyba (2014) argues that one of the main features of big data analytics is data streaming. Data streams in real-time from their sources, processed and become available to decision-makers immediately. The third dimension, "Variety," could provide different data formats so that managers can use the most suitable for each situation. Empirically, using advanced analytics to analyze the vast amount of data available on customers' preferences, competitors' products, and economic conditions could provide more accurate forecasts on demand and sales continuously and in real-time. Big data predictive analytics can forecast the future more accurately based on past events (Duan & Xiong, 2015). Analyzing the data on customers from social media and other sources can help segment customers, understand their experiences with the company products, and expect any changes in their preferences. This could help estimate the expected sales and the desired price and thus set more accurate budgeted sales.

The budget slack is the main budgeting problem, which refers to the deliberate managerial over-estimation of the budgeted costs or under-estimating the budgeted revenues (Gleim & Flesher, 2015; Baerdemaeker & Bruggeman, 2015). Budget slack creates a bias in budgets and reduces firm profits (Fisher et al., 2002). However, automated big data systems can provide more accurate targets free from any bias or manipulation by using advanced prediction analytics and analyzing the vast amount of available data and real-time. Empirically, IBM provides Planning Analytics and invites companies to automate their planning, budgeting, and forecasting activities (www.ibm.com/analytics/). Further, big data analytics enables managers to automate complex decisions that have traditionally dependent on human judgment and intuition (Chen et al., 2016).

Overall, corporate planning, budgeting, and forecasting processes must embrace big data, and companies must automate these functions (KPMG & ACCA, 2015). Incorporating big data into the budgeting process could improve performance management, better allocate the company resources, and better implement the strategic targets with the lowest variance levels.

However, this remains a theoretical argument without any empirical evidence. It would be interesting if researchers examine the following research question supported by the above arguments:

R.Q. (5): Does big data improve the effectiveness of strategic corporate planning and budgeting?

2.3.6 Big data and activity-based techniques

Blocher et al. (2010, p.12) state, "Activity analysis is used to develop a detailed description of the specific activities performed in the firms' operations." The activity analysis is the basis for some management accounting techniques, such as Activity-Based Costing (ABC), Activity-Based Management (ABM), and Activity-Based Budgeting (ABB). To conduct activity analysis, managers have to collect a lot of data on the relevant activities, indicating that ABC, ABM, and ABB are too detailed techniques that require a lot of data, time, and analysis. In this regard, ABC systems allocate overhead costs to products using cause-and-effect criteria with several cost drivers (Blocher et al. 2010) and identify individual activities as the fundamental cost objects (Horngren, Data, and Rajan, 2012). However, companies suffer from applying ABC. Kaplan and Andersen (2007) state an example of a company that used ABC and had to employ 14 full-time people just to collect and process data and prepare management reports and it took more than 30 days to do this job. They also state that Hendee Enterprise took 3 days to calculate costs for 150 activities, 10,000 orders, and 45,000 line items. Therefore, many companies considered the ABC problems and costs of data-collecting, storing, and processing and stopped ABC entirely or suspended it (Kaplan & Andersen, 2007). Next, Kaplan and Andersen (2007) proposed Time-Driven ABC as a new approach. However, the data is still a critical factor of the proposed method, and several measurement errors of time-driven ABC were examined by Cardinaels and Labro (2008). The data problem for costing systems has been amplified, especially during today's more complicated manufacturing environment with less labour, more mixed production lines, and a large portion of overhead costs.

However, adopting a big data system with advanced analytics can overcome the majority of ABC's obstacles. The big data volume can overcome the shortage of data. The big data velocity can provide data in real-time, and the big data veracity can provide free from error and credible data. Furthermore, advanced analytics can also help select the best cost driver, another major issue in ABC implementation (Homburg, 2001; Kim & Han, 2003; Cavalieri et al., 2004;

Cardinaels & Labro, 2008). Managers have to select the best cost driver for each cost pool. There are several cost pools and several cost drivers, but which one is the best cost driver? Big data and its analytics will provide managers with a great volume of data on different cost drivers, and analytics will help determine the ones with the highest significant correlations so that managers can choose the best one and in real-time, which will help avoid any distortions in cost estimations.

Furthermore, ABM and ABB are activity-based techniques that use activity-based costing data (Horngren et al., 2012). Similarly, the unique characteristics of big data and its analytics capabilities could provide ABM and ABB with a massive amount of relevant data in different formats and on time that could significantly improve its effectiveness. Overall, automating and integrating activity analysis techniques with a big data system could dramatically improve these techniques, overcome their data limitations, and help avoid misleading decisions. However, empirical evidence is needed to assert these arguments through investigating the following research question:

R.Q. (6): Does big data improve the effectiveness of activity-based techniques?

3. THE CONVERGENCE OF BIG DATA AND ACCOUNTING THEORIES

The literature presents several theories that explain several managerial decisions, such as agency theory, stakeholders theory, legitimacy theory, capital need theory, political costs theory. However, to the best of our knowledge, no study is found to link any of these theories to big data. Accordingly, this section contributes by building bridges and proposing three exciting research questions on argued relations between big data and three theories commonly employed in accounting research: agency theory, stakeholders theory, and legitimacy theory, which are the most used theories in this field.

The selected theories were chosen due to the reliance on financial and non-financial data. The agency theory motivates managers to disclose high-quality information to reduce agency costs and ambiguity. The stakeholders theory requires managers to understand the informational needs of all stakeholders rather than the shareholders only. The legitimacy theory argues that businesses should reduce information asymmetry, be transparent, and provide high-quality disclosure to gain social acceptance.

3.1 Big data and agency theory

Agency theory has been widely employed in accounting, finance, marketing, and other fields. Agency theory predicts potential conflicts between managers and owners due to ownership separation, which creates agency conflicts and causes information asymmetry (Jensen & Meckling, 1976). Agency theory argues that monitoring mechanisms, such as independent boards, effective audit committees, and institutional ownership, can increase transparency and disclosure quality and reduce information asymmetry and agency conflicts (Jensen & Meckling, 1976; Abraham & Cox, 2007; Barakat & Hussainey, 2013). Craswell and Taylor (1992) argue that disclosure is one of the monitoring tools used to mitigate agency issues. Then, effective monitoring mechanisms, including high-quality disclosure, can reduce the potential agency problems and information asymmetry.

Big data technology can play a similar role in monitoring tools, thus reducing agency costs. Vera-Baquero et al. (2015) hypothesize that big data solutions could enable monitoring the business processes performance. First, the big data system has become an instant monitoring system that can instantly analyze massive amounts of data and provide alarms for any malicious acts (Chen et al., 2015). Second, the companies that adopt big data solutions will find it easy to disclose high-quality information in real-time. Managers will satisfy the mandatory disclosure requirements and provide more voluntary disclosure that can mitigate information asymmetry and agency costs. Data Streaming is the main feature of big data systems, where data flows in and out like a river (Kudyba, 2014). Then, the big data solution will leave no justification for not disclosing high-quality disclosure by managers. Big data solutions can help managers disclose a lot of processed valuable, and free from error data (volume, value, and veracity dimensions) through different sources and in different formats (variety dimension) and in real-time (velocity dimension). Consequently, big data adoption is more likely to mitigate agency costs.

Accordingly, agency theory can be developed and extended to incorporate big data technology to improve monitoring outcomes, transparency, and disclosure quality, thus reducing information asymmetry and agency costs. However, this needs empirical evidence. A comparison of financial disclosure quality of big data adopters and non-adopters can provide empirical evidence on economic consequences of big data, especially its influence on financial reporting quality, which could be examined in the light of agency theory through proposing the following research question:

R.Q. (7): Does big data decrease information asymmetry and agency costs?

3.2 Big data and stakeholders theory

Edward Freeman detailed the stakeholder approach in his book *"Strategic Management: A Stakeholder Approach,"* which was published in 1984. Freeman (1984) argues that shifts in companies' traditional relationships require a new conceptual approach, which he named "the stakeholder approach." The conventional approach considers the shareholders only the vital party that the company should give full attention to. However, the stakeholder approach considers every party affected by a company's relation to a company as important. Freeman (1984, p. 46) defines the stakeholder as "…any group or individual who can affect or is affected by the achievement of the firm's objectives". Stakeholders include internal parties such as employees and managers, and external parties such as suppliers, governments, and customers, and sometimes competitors. The stakeholder theory requires managers to recognize and consider all stakeholders (Freeman, 1984; Barakat & Hussainey, 2013). Therefore, managers must work on behalf of all stakeholders for benefit maximization.

Further, Rowley (1997) argues that managers must answer the simultaneous demands of multiple stakeholders. In this regard, Ntim et al. (2013) say that providing detailed and comprehensive risk information can effectively gain the support and satisfaction of influential stakeholders such as the government and regulators. However, it is not easy to understand and consider the needs of too many diversified internal and external stakeholders. At the same time, ignoring any party could be costly for companies during today's highly competitive business environment. A limitation of stakeholders theory is the vagueness regarding the identity of stakeholders and the limited capacity to predict and understand their needs (Ntim et al., 2013).

Big data can play a very crucial role in considering and maximizing the benefits for all stakeholders. Big data solutions can collect and process massive volumes of financial and non-financial, internal and external data on different stakeholders. In addition, big data analytics can process huge amounts of unstructured data and provide insights to decision-makers in real-time (Kudyba, 2014). Thus, big data solutions will increase the managers' awareness of all their stakeholders, especially the most influencing ones. This could help companies resolve any arising issues with stakeholders quickly, help meet their needs, and improve communications with all stakeholders.

Big data will deepen the understanding of the needs of different parties. First, the availability of complete data in real-time on employees and their different needs can help managers satisfy their needs and reduce the probability of any arising disputes. Second, big data and customer analytics can provide massive data and insights on customers. Amazon has adopted a

customers' 360-degree view, and the Royal Bank of Scotland has adopted the "Personology" strategy that provides a wide range of processed data and insights on customers (Marr, 2016). Third, big data solutions can help choose the best suppliers and build strong ties with important ones. Fourth, big data solutions can provide data on strategies and acts of competitors, which help managers follow and predict any aggressive actions. Furthermore, big data will make it easy to communicate with all stakeholders through effective and timely disclosure. Gray et al. (1996) argue that disclosure is the managers' primary tool to manage or manipulate their relations with stakeholders. Accordingly, big data can build continuous and two-way communications with all stakeholders.

Overall, big data could enable managers to understand and consider all diversified stakeholders' needs and better communicate with, which helps managers work for the benefit maximization of all stakeholders. However, empirical evidence is still needed on the integration of big data and stakeholder theory, which could be examined through proposing the following research question:

R.Q. (8): Does big data improve communication and satisfying the needs of all stakeholders?

3.3 Big data and legitimacy theory

According to the legitimacy theory, there is a social contract between companies and communities where they operate; thereby, companies should consider the community norms and values and meet their expectations (Suchman, 1995; Ntim et al., 2013). Suchman (1995, p. 574) defines legitimacy, "A generalized perception of assumption that the actions of any entity are desirable, proper, or appropriate within some socially constructed system of norms, value, beliefs, and definitions." Businesses need to provide detailed information to support their legitimacy and reputation (Elamer et al., 2019). However, if companies breach any of the community norms or values, they may be punished in the form of inability to raise funds or acquiring materials or goods from suppliers (Deegan, 2002). However, some businesses manipulate the informational needs of influential stakeholders to get their acceptance (Ntim et al., 2013). Companies have become under great pressure, especially the multi-national companies, where they have to comply with a variety of diversified traditions and cultures of different communities to be socially legitimated and to meet the informational needs of different stakeholders

However, big data systems can help companies overcome this challenge and behave more socially, even in the multi-national business environment. First, the big data system can collect

a vast amount of data directly from citizens of any community through different means, such as social media. This could help companies understand the preferences, norms, and traditions of the citizens directly and help companies test the community reactions to any new policy or activity the companies think to introduce. For example, a big data system allows Amazon to draw a 360-degree customer view. When customers browse the Amazon website searching for products, the amazon big data system collects and analyses a vast amount of data on customers from around the world instantly. It is noteworthy that Amazon Inc. has different versions of their main website in different languages for several regions, such as Amazon U.K., Amazon Middle East, Amazon South Africa, Amazon Germany, and Amazon China. The amazon big data system can provide instant insights on citizens' traditions and norms and thus help companies comply with the values and norms of the community where they operate and therefore behave more socially. Furthermore, big data analytics can also predict future changes in citizens' values so that companies will adjust and react appropriately.

Second, a big data system can facilitate direct and two-way communication with citizens of any community, which could help resolve any disputes or correct any negative impressions on the company activities and increase the social acceptance of undesirable activity. Third, multi-national companies may have more than 100 branches in different countries around the world. This means that these companies have to consider a total of 100 different cultures, where neglecting the values or norms of one community in today's highly competitive business environment will be highly costly. However, a big data system can collect data in different formats and from various sources, such as media and electronic newspapers, not only on customers, but also on citizens even if they are not customers and analyze this data to recognize the attitudes, values, and norms of the target community.

To conclude, a remarkable relation is evident between big data and legitimacy theory. Big data systems can help companies satisfy the propositions of theory, comply with any community norms and traditions, and obtain more benefits by behaving more socially. However, the following is an exciting research question on integrating big data and Legitimacy theory that is not empirically examined yet.

RQ9: Do big data adopters behave more socially and responsibly?

4. BIG DATA, JOB MARKET AND ACCOUNTING CURRICULUMS

The job market suffers from a shortage of data analysts who can deal with massive amounts of unstructured data. McKinsey Global Institute (2011, p. 3) report, "The United States alone faces a shortage of 140,000 to 190,000 people with great analytical skills as well as 1.5 million managers and analysts to analyze big data and make decisions…". Moreover, Davenport and Patil (2012) state that the shortage of data scientists is becoming a serious constraint in some sectors. This indicates that highly skilled data analysts and data scientists who can extract insights from big data have become urgently required and essential intellectual capital for companies.

Data scientists can make discoveries while swimming in data (Davenport & Patil, 2012). Big data like a big black box and an urgent need for skilled people to discover what lies inside this box. The companies that ignored big data may target a takeover by companies that adopted big data (Marr, 2016). Data has become a product that can be bought from the market. Data analytics has become more critical than data since holding big data without analysis worth null. However, this depends on the availability of highly skilled data scientists.

A fundamental problem in the big data job market is that persons who hold strong business-related experience, lack experience in business analytics, and data scientists who hold strong experience in data analytics cannot participate effectively in solving business issues. There is an urgent need to integrate the two jobs. Provost and Fawcett (2013, p. 52) state, "Successful data scientists must be able to view business problems from a data perspective." Moreover, Baesens et al. (2015) believe that data scientists should hold a solid business understanding to apply big data correctly and extract valuable insights. On the other hand, risk managers should learn risk analytics; they should have different risk management and measurement techniques and learn how to apply advanced risk analytics to draw the best results. Business education in some business schools has developed to educate business students on advanced data analytics and incorporate artificial intelligence tools to solve business matters. Today, we see some degrees that combine business and data analytics, such as Master of Science (MSc) in "Computational Finance," "Algorithmic Trading," "Business Analytics," and "Financial Computing." Mcbride and Philippou (2021) present an interesting study on the required advanced analytics skills that should be incorporated in accounting Masters Courses to help students gain mixed accounting and analytical skills to meet the job market demand.

Baesens et al. (2015, p. 30) state some qualifications for fraud data scientists. They explain that fraud data scientists should hold a solid business understanding, should be creative in selecting the best tools to clean, transform, and analyse data, should be good programmer where working with data needs programming skills such as SAS and R, should be excel in

communication and visualization skills to be able to represent analytical model and the accompanying statistics and reports in user-friendly ways.

The potential role of the accountant in the big data age is to be an accountant and data analyst as well. Pickard and Cokins (2015) recommend strongly accountants improve their skills in data analytics. Dubey and Gunasekaran (2015) list the skills required for a successful career in big data to include statistics, forecasting, optimization, quantitative finance, financial accounting, multivariate statistics, multiple criteria decision making, marketing, research methods, and finance. Accordingly, accounting curriculums should be developed to include additional subjects such as research methods, forecasting, and quantitative finance in addition to the traditional accounting subjects such as financial accounting. The accountant with knowledge in accounting subjects only without additional knowledge in statistics, research methods, and finance would be like a bird with one wing that could not fly in the sky of big data. Finally, AACSB (Standard A7) calls the business schools to develop their accounting programs to include knowledge related to data creation, data analytics, data mining, data reporting and data storage (Pickard & Cokins, 2015; Alles, 2015).

5. THE IMPLICATIONS OF INCORPORATING BIG DATA IN ACCOUNTING

The previous discussions present the following implications. *First,* for accounting researchers, the discussions show several convergence points between big data and Accounting. Big data can develop accounting and overcome data limitations of several accounting techniques. Accordingly, the study presents nine research questions that future researchers can contribute by empirically investigate. Further, the discussion of convergence between big data and three accounting theories can help extend the arguments of these theories by incorporating big data. The significant lack of empirical evidence on big data and Accounting relationship may back to the lack of experience of business researchers with advanced analytics that is needed to analyze big data, such as Python and Algorithms. Therefore, business researchers should develop their research skills by learning such advanced analytics of big data, which will help broadly develop business research on big data. *Second,* there is a high demand for data analysis and data science jobs for accounting teaching bodies and a shortage in the job market for such jobs. Therefore, business education institutions should develop business curriculums to incorporate big data in business materials. As shown from the discussions, the future accountant should have knowledge of different business matters and a solid knowledge of various big data techniques and how to apply them in business. *Third,* for managers, the

discussions show how big data has a very promising future for companies. *Fourth*, governance regulators could also play a role by setting governance frameworks for big data to organize its use and avoid the misuse of this technology. Accordingly, the study summarises the following research questions to consider by future research:

1. Do big data adopters present higher-quality financial reporting? Empirical evidence is required to confirm our arguments on the benefits that businesses could gain in the form of better financial reporting when adopting any of the big data solutions. Case studies of businesses that adopted big data can be produced to evaluate the quality of financial reporting before and after implementing big data solutions.

2. Does applying BSC in a big data environment improve corporate performance measurement effectiveness? Our discussion shows how performance measurement effectiveness could be improved if a big data solution is adopted. Future researchers have to conduct case-study research on a company (s) that has big data embedded in their I.T. system. Besides, interviews should be performed with managers and adopters to see how and whether the overall business performance was improved because of big data and performance measurement quality. Sardi et al. (2020) and Elkmash et al. (2021) attempt to explore whether big data could improve the effectiveness of performance measurement.

3. Does auditing in a big data environment improve assurance and auditing quality? One of the common argued benefits of adopting big data is the higher assurance and auditing quality level. Big data is argued to help auditors audit the entire population and run an automated and continuous auditing process. However, empirical evidence from big-4 auditors is required.

4. Does big data improve risk management effectiveness? Another vital question is whether risk assessment, measurement, and management have been enhanced when applying big data solutions. Again, a case study and interviews have to be conducted to discover these issues.

5. Does big data improve the effectiveness of strategic corporate planning and budgeting? In this context, predictive analytics can be examined to enhance budgeting and planning accuracy effectively. An experimental research approach could be suitable to investigate his research question.

6. Does big data improve the effectiveness of activity-based techniques? For a company like Alibaba or Amazon, the number of daily activities could exceed thousands. The cost and

effectiveness of each exercise are required to estimate better and manage costs. Could any big data solution help in completing the steps of ABC effectively and adequately?

7. Does big data decrease information asymmetry and agency costs? As a central argument of agency theory, improved and increased financial reporting help reduce information asymmetry and agency costs. This argument needs to be tested in a big data environment. Big data could help provide vast amounts of information in real-time and affect financial reporting quality, thus reducing agency costs.

8. Does big data improve communication and satisfying the needs of all stakeholders? A primary argument of the stakeholders' theory is that businesses should consider all information needs of all stakeholders and not shareholders only. This puts more burden on managers to investigate and satisfy the information needs of a considerable number of stakeholders. Big data as an advanced information system can help, but how is a vital research question. 9. Do big data adopters behave more socially and responsibly? Businesses worldwide adopt the concept of sustainability that motivates them to contribute financially, socially, and environmentally. Big data could help in several ways to behave socially and responsibly. Big data could help when applying ABC to identify the environmental activities and estimate their social and environmental impact in an attempt to protect the environment. However, evidence is required.

10. What are the implications of big data on accounting measurement? More empirical research through a qualitative research approach is encouraged. Interviews with professional accountants and accounting regulating bodies could help get insights into these implications.

11. What are the implications of big data on auditing, audit evidence, and fraud detection? Promising implications are expected based on the argument that big data solutions could help in increasing the assurance level, audit quality through real-time auditing, continuous auditing, and full population auditing. However, empirical studies will be a significant contribution.

12. What governance rules and data privacy and confidentiality policies are required to be applied in outsourcing data analytics? Data privacy and security are the main concerns in big data environments. Regulating big data environments becomes an urgent need. Future research can introduce big data governance framework with recommendations and suggestions to help protect data privacy and security.

6. CONCLUSION

The study's primary objective is to develop accounting research and practices by discussing 9 convergence points between big data and accounting techniques and theories. The study presents nine innovative research questions for future research. The study argues that big data can overcome the data limitations of several accounting techniques that depend on data, such as financial reporting, performance measurement, and audit evidence. The study also argues that Big data as new technology will reshape accounting because data is the heart of accounting. Further, our discussions on the convergence between accounting and big data enable us to propose that big data adopters are more likely to provide high-quality financial reporting, measure and manage performance more effectively, provide more sufficiently and appropriately audit evidence, manage risks more effectively, experience less budgeting variances, and conduct activity-analysis more effectively than non-big data adopters.

However, this lacks empirical evidence. This study contributes by presenting the theoretical arguments and research questions for nine exciting research opportunities. Despite the argued benefits of big data, some challenges and risks should be taken into consideration. The risks associated with big data are still under-investigated (Cockcroft & Russel, 2018). Besides, Mehmood et al. (2015) list a number of risks and challenges associated with big data implementation, such as agility, unstructured data, data ownership, privacy invasion, and security breaches. All these risks should be further investigated by researchers. Furthermore, how big data and its analytics could improve fraud prevention and detection is an interesting research question (Cockcroft & Russel, 2018; Aboud & Robinson, 2020). Future research can build on the argument that traditional auditing procedures may be insufficient to detect fraudulent financial reporting (Aboud & Robinson, 2020). How auditors could implement advanced analytics to improve the assurance level is an interesting research question. Besides, Mehmood et al. (2015) advise future researchers to explore how big data could revolutionize supply chain management. Richey et al. (2016) globally analyze big data in the supply chain and argue that future research opportunities are urgent to explore big data integration in the supply chain management systems. Big data analytics are argued to help in continuous auditing since big data processes data in real-time, but more empirical research cases are needed (Zhang et al., 2015). Another exciting research area that is still unexplored is the implementation of Six Sigma in big data environments. Koppel and Chang (2020) argue that Six Sigma is a data-driven technique that, if applied in a big data environment, could help businesses achieve a competitive advantage. Finally, Sardi et al. (2020) recommend integrating big data solutions

with performance measurement systems and suggest new themes to research in the light of big data.

This study provides important implications for several parties. *First*, for accounting researchers, nine research questions are proposed as innovative research opportunities to develop accounting research. *Second*, for accounting standards setters, the study discussions are helpful and will enable them to stand upon the recent developments in big data technology and how big data will change accounting to recognize early the developments required for accounting standards. Large amounts of non-financial data inside companies may need the issuance of special standards to summarize and disclose. Further, accounting standards should develop to treat big data as an asset since it is sold in markets. *Third*, for managers, the study could help managers recognize the usefulness and the economic feasibility of big data and their risks, which will help managers make better decisions. *Fourth*, for academic institutions, the study will help develop the accounting curriculums by incorporating big data and data analytics in the accounting subjects. Mcbride and Philippou (2021) is a recent study that discusses how to integrate big data and its analytics in accounting master courses. *Fifth*, governance regulators may benefit by adopting governance rules that govern issues related to data security.

Despite its contributions, the study does not provide empirical evidence on its suggested arguments. The nine research questions are built on arguments of literature and theories and views of authors, but presenting empirical evidence for each of these arguments would significantly contribute. Still, it is out of the study scope and is left to future research. We are enthusiastic about providing empirical evidence for each of these arguments in future. Also, some accounting techniques that big data could effectively influence were not covered, such as SWOT analysis, target costing, the organizational environmental impact, cost estimation, and Six Sigma. In addition, only three theories were covered in this study and still more to be examined in the context of big data by future researchers, such as political costs theory, proprietary cost theory, and costs asymmetry theory. Future research can determine whether the arguments of these theories are still valid in a big data environment. Finally, despite the argued benefits that big data could provide to the business community, some risks can result when some people misuse big data. As the availability of data everywhere can help companies, it can help terrorists as well. Therefore, a legal framework and a big data Act should be developed to protect humanity from the misuse of big data.

REFERENCES

Aboud, A., and Robinson, B. (2021). Fraudulent financial reporting and data analytics: an explanatory study from Ireland. *Accounting Research Journal*. Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/ARJ-04-2020-0079

Abraham, S., and P. Cox. 2007. Analysing the determinants of narrative risk information in the UK FTSE 100 annual reports. *The British Accounting Review* 39 (3): 227-248.

Al-Htaybat, K., and L. V. Alberti-Alhtaybat. 2017. Big data and corporate reporting: impacts and paradoxes. *Accounting, Auditing & Accountability Journal* 30 (4): 850-873.

Alles, M. G. 2015. Drivers of the Use and Facilitators and Obstacles of the Evolution of Big data by the Audit Profession. *Accounting Horizons* 29 (2):439-449.

American Institute of Certified Public Accountants (AICPA). 2004. *Audit Evidence.* Statement on Auditing Standards No. 106. New York, NY: AICPA.

Anderson, M. C., Banker, R. D., & Janakiraman, S. N. 2003. Are selling, general, and administrative costs' sticky'? *Journal of Accounting Research*, *41*(1), 47–63.

Arfat Y., Usman S., Mehmood R., Katib I. (2020). Big Data Tools, Technologies, and Applications: A Survey. In: Mehmood R., See S., Katib I., Chlamtac I. (eds) Smart Infrastructure and Applications. EAI/Springer Innovations in Communication and Computing. Springer, Cham. https://doi.org/10.1007/978-3-030-13705-2_19

Arnaboldi, M., C. Busco., and S. Cuganesan. 2017. Accounting, Accountability, social media and Big data: a revolution or hype? *Accounting, Auditing & Accountability Journal* 30 (4): 762-776.

Association of Chartered Certified Accountants (ACCA) and Institute of Management Accountants (IMA). 2013. *Big data: Its Powers and Perils.* ACCA, London. Available at: http://www.accaglobal.com/content/dam/acca/global/PDF-technical/futures/pol-afa-bdpap.pdf (accessed: June 2016).

Avantage Reply. 2014. *Applying big data to risk management: transforming risk management practices within the financial services industry*. A white paper available at: http://www.reply.eu/en/content/big-data-and-risk-management (accessed: Jan 2016).

Baerdemaeker, J., and W. Bruggeman. 2015. The impact of participation in strategic planning on managers' creation of budgetary slack: The mediating role of autonomous motivation and affective organisational commitment. *Management Accounting Research* 29:1-12.

Baesens, B., Van Vlasselaer, V., and Verbke, W. 2015. Fraud analytics using descriptive, predictive and social network techniques;: A guide to data science for fraud detection. Wiley. United Kingdom. ISBN: 978-1-119-13312-4.

Bag, S., Pretorius, J. H. C., Gupta, S., & Dwivedi, Y. K. (2020). Role of institutional pressures and resources in the adoption of big data analytics powered artificial intelligence, sustainable manufacturing practices and circular economy capabilities. *Technological Forecasting and Social Change*, 120420. https://doi.org/10.1016/j.techfore.2020.120420

Barakat, A., and K. Hussainey. 2013. Bank governance, regulation, supervision, and risk reporting: evidence from operational risk disclosures in European banks. *International Review of Financial Analysis* 30 (December 2013): 254-273.

Basukie, J., Wang, Y., & Li, S. (2020). Big data governance and algorithmic management in sharing economy platforms: A case of ridesharing in emerging markets. *Technological Forecasting and Social Change*, *161*, 120310. https://doi.org/10.1016/j.techfore.2020.120310

Blazquez, D., & Domenech, J. (2018). Big data sources and methods for social and economic analyses. *Technological Forecasting and Social Change*, *130*, 99–113. https://doi.org/10.1016/j.techfore.2017.07.027

Blocher, E. J., D. E. Stout., and G. Cokins. 2012. *Cost Management: A Strategic Emphasis*. 5th Edition. McGraw-Hill Irwin, Inc. NY.

Bollen, J., H. Mao, and X. Zeng. 2011. Twitter mood predicts the stock market. *Journal of Computational Science* 2 (1): 1-8.

Brown-Liburd, H., and M. A. Vasarhelyi. 2015. Big data and Audit Evidence. *Journal of Emerging Technologies in Accounting* 12 (1):1-16.

Brown-Liburd, H., H. Issa, and D. Lombardi. 2015. Behavioural Implications of Big data's Impact on Audit Judgment and Decision Making and Future Research Directions. *Accounting Horizons* 29 (2):451-468.

Cao, M., R. Chychyla, and T. Stewart. 2015. Big data Analytics in Financial Statement Audits. *Accounting Horizons* 29(2): 423-429.

Cardinaels, E., and E. Labro. 2008. On the determinants of measurement error in Time-Driven Costing. *The Accounting Review* 83 (3): 735-756.

Cavalieri, S., P. Maccarrone., and R. Pinto. 2004. Parametric vs. neural network models for the estimation of production costs: A case study in the automotive industry. *International Journal of Production Economics* 91 (2): 165-177.

Chartered Institute of Management Accounting (CIMA). 2008. *Budgeting: Topic Gateway Series No. 27.* CIMA, London, UK. Available at: http://www.cimaglobal.com/Documents/ImportedDocuments/cig_tg_budgeting_mar08.pdf (accessed: March 2016).

Chen, D. Q., D. S. Preston, and M. Swink. 2016. How the Use of Big data Analytics Affects Value Creation in Supply Chain Management. *Journal of Management Information Systems* 32 (4):4-39.

Chen, J., Y. Tao, H. Wang, and T. Chen. 2015. Big data based fraud risk management at Alibaba. *The Journal of Finance and Data Science* 1 (1):1-10.

Cokins, G. 2014. Mining the past to see the future. *Strategic Finance* 96 (11): 23-30.

Craswell, A. T., and S. L. Taylor. 1992. Discretionary disclosure of reserves by oil and gas companies: an economic analysis. *Journal of Business Finance & Accounting* 19 (2): 295-308.

Davenport, T.H. and Patil, D.J. 2012, 'Data Scientist: The Sexiest Job of the 21st Century', *Harvard Business Review*, 90 (1): 70–6.

Deegan, C. 2002. Introduction: The legitimising effect of social and environmental disclosures – a theoretical foundation. *Accounting, Auditing & Accountability Journal* 15 (3):282-311.

Duan, L., and Y. Xiong. 2015. Big data analytics and business analytics. *Journal of Management Analytics* 2 (1):1-21.

Dubey, R., and Gunasekaran, A. 2015. Education and training for successful career in big data and business analytics. Industrial and Commercial Training 47 (4): 174-181. DOI:10.1108/ICT-08-2014-0059

Fisher, J. G., L. A. Maines., S. A. Peffer., and G. B. Sprinkle. 2002. Using budgets for performance evaluation: effects of resource allocation and horizontal information asymmetry on budget proposals, budget slack, and performance. *The Accounting Review* 77 (4): 847-865.

Freeman, R. E. 1984. *Strategic Management: A Stakeholder Approach*. Boston, MA: Pitman.

Frizzo-Barker, J., P. A. Chow-White, M. Mozafari, and D. Ha. 2016. An empirical study of the rise of big data in business scholarship. *International Journal of Information Management* 36 (3):403-413.

Gandomi, A., and M. Haider. 2015. Beyond the hype: Big data concepts, methods, and analytics. *International Journal of Information Management* 35 (2):137-144.

Ghani, N. A., Hamid, S., Targio Hashem, I. A., & Ahmed, E. (2019). Social media big data analytics: A survey. *Computers in Human Behavior*, *101*, 417–428.

Gleim, I. N., and D. L. Flesher. 2015. *Gleim CMA Review, Part. 1: Financial Reporting, Planning, Performance, and Control.* GLEIM Publications, Inc. USA.

Gray, R., D. L., Owen., and C. Adams. 1996. *Accounting and Accountability: Changes and Challenges in Corporate Social and Environmental Reporting*. London: Prentice-Hall Europe.

Gupta, S., Chen, H., Hazen, B. T., Kaur, S., & Santibañez Gonzalez, E. D. R. (2019). Circular economy and big data analytics: A stakeholder perspective. *Technological Forecasting and Social Change*, *144*, 466–474. https://doi.org/10.1016/j.techfore.2018.06.030

Homburg, C. 2001. A note on optional cost driver selection in ABC. *Management Accounting Research* 12: 197-205.

Horngren, C. T., S. M, Datar., and M, Ragan. 2012 *Cost Accounting: A Managerial Emphasis*. 14th edition. Upper saddle River, NJ: Prentice Hall.

Hughes, J., & Ball, K. (2020). Sowing the seeds of value? Persuasive practices and the embedding of big data analytics. *Technological Forecasting and Social Change*, *161*, 120300. https://doi.org/10.1016/j.techfore.2020.120300

Institute of Chartered Accountants in England and Wales (ICAEW). 2014. *Big data and Analytics- What's New?* Chartered Accountants' Hall, London, United Kingdom. Available at: https://www.icaew.com/~/media/corporate/archive/files/technical/information%20technology/technology/what-is-new-about-big-data-v2.ashx (accesses: May 2016).

Iqbal, R., Doctor, F., More, B., Mahmud, S., & Yousuf, U. (2020). Big data analytics: Computational intelligence techniques and application areas. *Technological Forecasting and Social Change*, *153*, 119253. https://doi.org/10.1016/j.techfore.2018.03.024

Jensen, M. C., and W. H. Meckling. 1976. Theory of the firm: Managerial behaviour, agency costs and ownership structure. *Journal of Financial Economics* 3(4): 305–360.

Kaplan, R. S., and S. R. Andersen. 2007. *Time-driven activity-based costing: a simpler and more powerful path to higher profits*. Boston, USA: Harvard Business School Press.

Kiani Mavi, R., & Kiani Mavi, N. (2021). National eco-innovation analysis with big data: A common-weights model for dynamic DEA. *Technological Forecasting and Social Change*, *162*, 120369. https://doi.org/10.1016/j.techfore.2020.120369

Kim, K-J., and I. Han. 2003. Application of a hybrid genetic algorithm and neural network approach in activity-based costing. *Expert Systems with Applications* 24: 73-77.

Koppel and Chang. 2020. MDAIC – A six sigma implementation strategy in big data environments. *International Journal of Lean Six Sigma*, 12 (2), 432-449.

KPMG and ACCA. 2015. *Planning, Budgeting, and Forecasting: An Eye on the Future*. A KPMG and ACCA Thought Leadership Report. Available at: https://home.kpmg.com/content/dam/kpmg/pdf/2015/08/an-eye-on-the-future-kpmg-acca-report.pdf (accessed: April 2016).

Liedong, T. A., Rajwani, T., & Lawton, T. C. (2020). Information and nonmarket strategy: Conceptualizing the interrelationship between big data and corporate political activity. *Technological Forecasting and Social Change*, *157*, 120039. https://doi.org/10.1016/j.techfore.2020.120039

Linsley, P. M., and P. J. Shrives. 2006. Risk reporting: A study of risk disclosures in the annual reports of U.K. companies. *The British Accounting Review* 38 (4): 387-404.

Marr, B. 2016. *Big data in Practice: How 45 Successful Companies used Big data Analytics to Deliver Extraordinary Results.* John Wiley & Sons Ltd, United Kingdom.

Mcbride, K., and Philippou, C. 2021. Big results require big ambitions: big data, data analytics and accounting in masters courses. *Accounting Research Journal.* Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/ARJ-04-2020-0077

McKinsey Global Institute. 2011. Big Data: The Next Frontier for Innovation, Competition, and Productivity. Available at: https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/big-data-the-next-frontier-for-innovation (accessed: May 2021).

Mehmood, R., Meriton, R., Graham, G., Hennelly, P., & Kumar, M. (2017). Exploring the influence of big data on city transport operations: a Markovian approach. *International Journal of Operations & Production Management*. 37 (1): 75-104.

Moffitt, K. C., and M. A. Vasarhelyi. 2013. AIS in an Age of Big data. *Journal of Information Systems* 27 (2):1-19.

Muller, O., Junglas, I., Brocke, J. V., and Debortoli, S. 2016. Utilizing Big data analytics for information systems research: challenges, promises and guidelines. European Journal of Information Systems 25 (2): 289-302.

Price Waterhouse Coopers LLP (PWC). 2013. *Integrated Reporting: Going Beyond the Financial Results.* Available at: http://www.pwc.com/us/en/cfodirect/publications/point-of-view/integrated-reporting-pov.html (accessed: Feb 2016).

Pickard, M., and Cokins. G. 2015. From bean counters to bean growers: accountants as data analyst – a customer profitability example. Journal of information systems 29 (3): DOI:10.2308/isys-51180

Elkmash, M. R. M., Abdel-Kader, M. G., and Badr El-Din, B. 2021. An experimental investigation of the impact of using big data analytics on customers' performance measurement. Accounting Research Journal, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/ARJ-04-2020-0080

Richey, R.G., Morgan, T.R., Lindsey-Hall, K. and Adams, F.G. 2016. A global exploration of Big Data in the supply chain. *International Journal of Physical Distribution & Logistics Management*, 46 (8): 710-739. https://doi.org/10.1108/IJPDLM-05-2016-0134

Richins, G., Stapleton, A., Stratopoulos, T. C., and Wong, C. 2017. Big data Analytics: Opportunity or Threat for the Accounting Profession. *Journal of Information Systems* 31 (3): 63-79.

Riggins, F. J., & Klamm, B. K. (2017). Data governance case at KrauseMcMahon LLP in an era of self-service BI and Big Data. *Journal of Accounting Education*, *38*, 23-36.

Rowley, T. J. 1997. Moving beyond dyadic ties: a network theory of stakeholder influences. *Academy of Management Review* 22 (4): 887-891.

Sardi, A., Sorano, E., Cantino, V., and Garengo, P. 2020. Big data and performance measurement research: trends, evolution and future opportunities. Measuring Business Excellence, Vol. ahead-of print No. https://doi.org/10.1108/MBE-06-2019-0053

Scott, S. V., and W. J. Orlikowski. 2012. Reconfiguring relations of accountability: Materialization of social media in the travel sector. *Accounting, Organizations and Society* 37(1): 26-40.

Suchman, M. C. 1995. Managing Legitimacy: Strategic and Institutional Approaches. *The Academy of Management Review* 20(3):571-610.

Statista (2021). Big data market size revenue forecast worldwide from 2011 to 2027. Available at https://www.statista.com/statistics/254266/global-big-data-market-forecast/?fbclid=IwAR3jy4jwfZMbV43sXEqxpND6Pzyn8InODKx_8UXE9OAX29GYrnT5ZRUBch8. Access date 16 June 2021.

The U.K. Corporate Governance Code. 2014. Financial Reporting Council (FRC). London, UK.

Vasarhelyi, M. A., A. Kogan., and B. M. Tuttle. 2015. Big data in Accounting: An Overview. *Accounting Horizons* 29 (2):381-396.

Vecchio, P. Del, Secundo, G., Maruccia, Y., & Passiante, G. (2019). A system dynamic approach for the smart mobility of people: Implications in the age of big data. *Technological Forecasting and Social Change*, *149*, 119771. https://doi.org/10.1016/j.techfore.2019.119771

Vera-Baquero, A., R. C. Palacios, V. Stantchev., and O. Molloy. 2015. Leveraging big-data for business process analytics. *The Learning Organization* 22 (4):215-228.

Wang, H., Yao, Y., & Salhi, S. (2020). Tension in big data using machine learning: Analysis and applications. *Technological Forecasting and Social Change*, *158*, 120175. https://doi.org/10.1016/j.techfore.2020.120175

Warren, J. D., K. C. Moffitt, and P. Byrnes. 2015. How Big data Will Change Accounting. *Accounting Horizons* 29 (2):397-407.

Yoon, K., L. Hoogduin, and L. Zhang. 2015. Big data as Complementary Audit Evidence. *Accounting Horizons* 29 (2):431-438.

Websites:

www.sas.com

www.ibm.com/analytics

Figure (1): The Study Structure

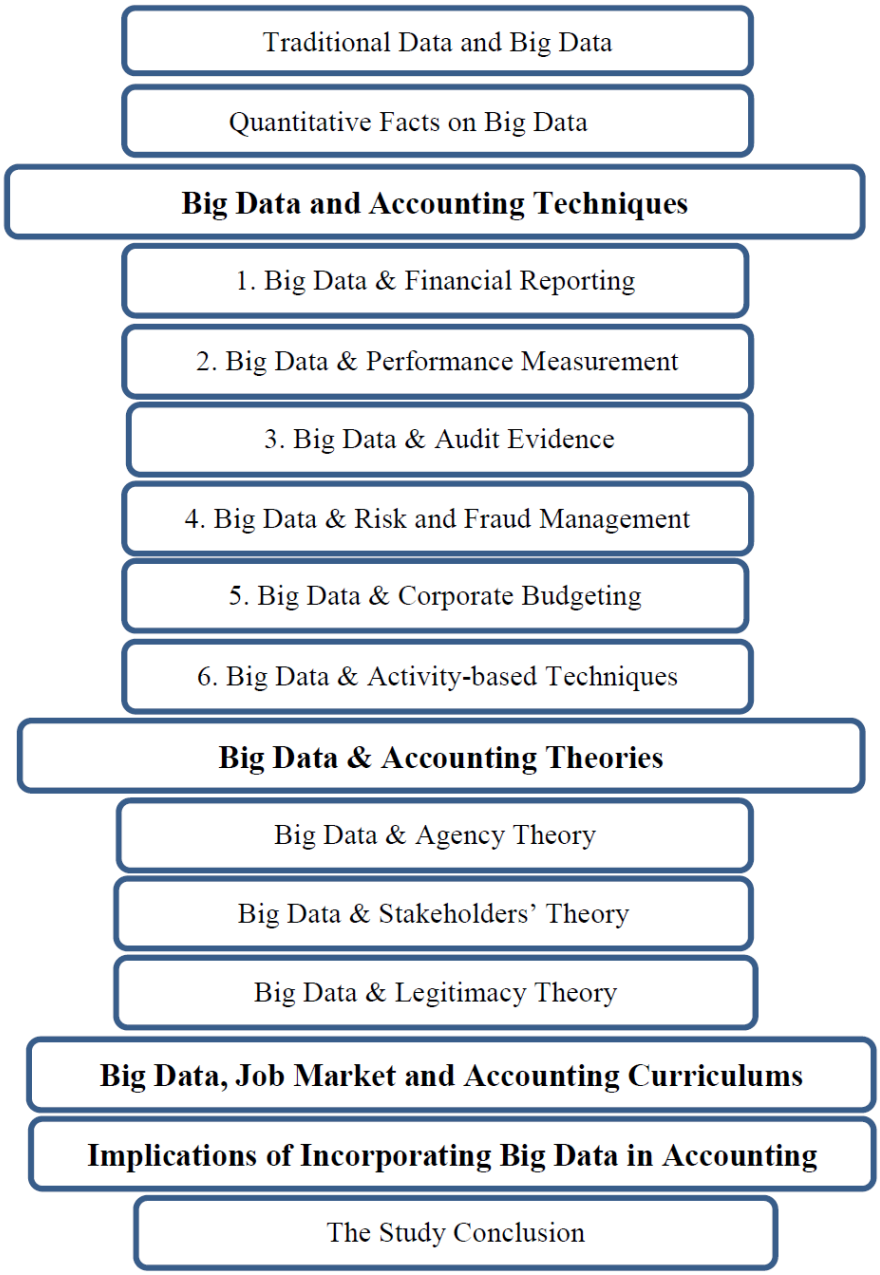


Figure (2): sources of data (Moffitt and Vasarhelyi, 2013).

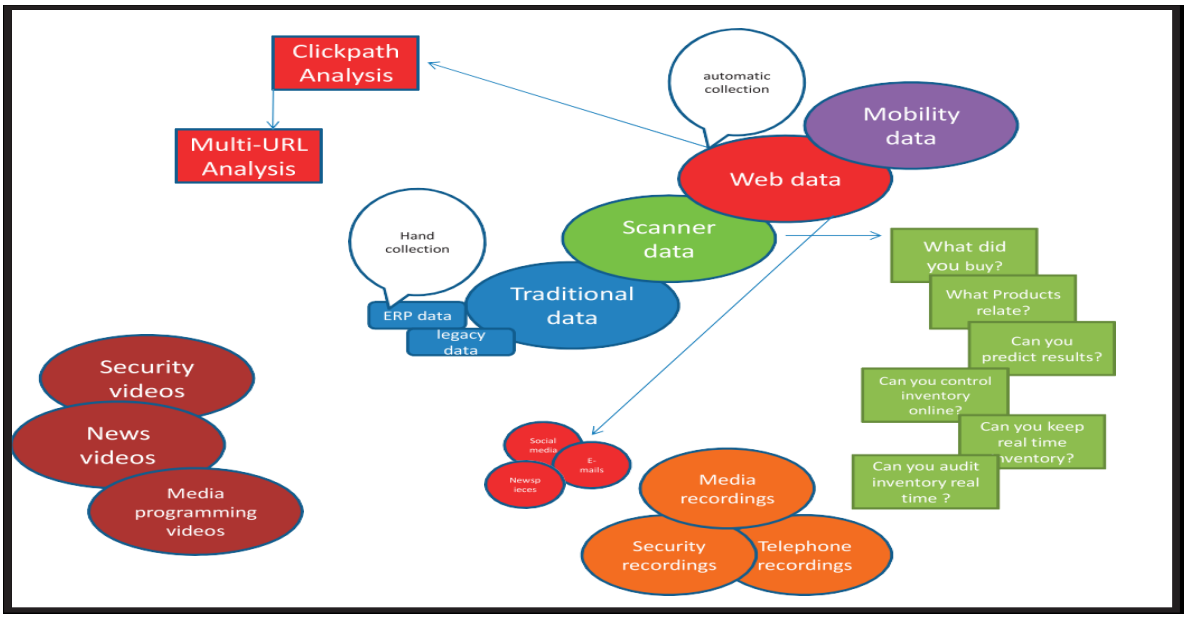
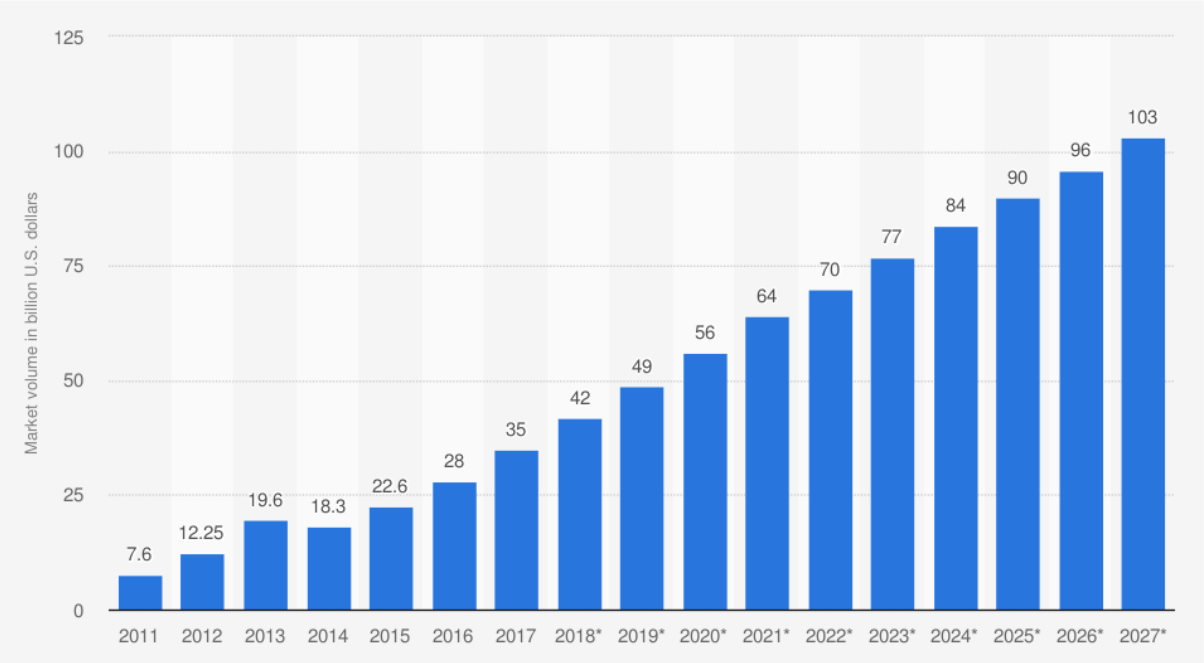
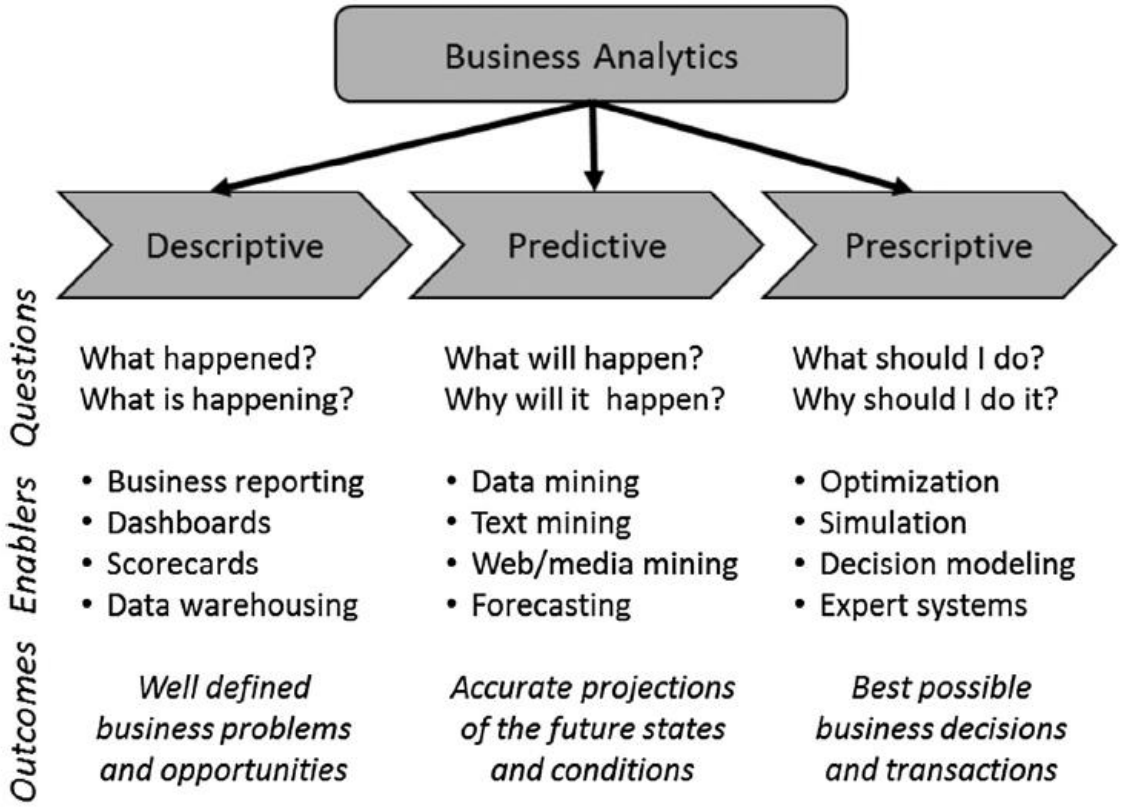


Figure (3): Big ta market size revenue forecast worldwide from 2011 to 2027



Source: Statista (2021)

Figure (4): Business analytics types



Source: Riggins and Klamm (2017).