Technological Forecasting & Social Change 205 (2024) 123507

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

The power of big data affordances to reshape anti-fraud strategies

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ARTICLE INFO

Keywords:
Big Data
Affordance
Sociomateriality
Fraud
Accounting

ABSTRACT

This paper examines how the integration of big data in forensic accounting practices is reshaping fraud detection processes. To capture the effects of this integration we used the perspective of affordances enabled by big data, an approach derived from sociomateriality. The research adopts a qualitative approach based on seventeen semi-structured interviews with forensic accountants. This qualitative approach allows us to identify dispositional and relational affordances. Findings show that big data enables some significant affordances. As dispositional affordances, big data and big data analytics tools ensure a greater depth of the analysis. The power of visual analytics in fraud detection is highlighted in both dispositional and relational affordances.

1. Introduction

The Association of Certified Fraud Examiners (ACFE) reports that firms lose more than 5 % of their annual revenue to fraud and that fraudulent events last, on average, 12 months before detection (ACFE, 2022). The 2022 ACFE Report classifies fraud into three main types: corruption, asset misappropriation, and fraudulent financial statements. Fraud concerns regulators, investors, and entrepreneurs identifying effective anti-fraud mechanisms and procedures. As corporate scandals and fraud significantly impact economies and societies (Montesdeoca et al., 2019), effective processes for detecting, preventing, and prosecuting perpetrators must be developed. As a result, forensic accounting has received increasing attention in recent years. It is a mixed field of professional practices that supports organisations and governments by providing a wide range of services to fight fraud (Howieson, 2018). Forensic accounting practices include fraud examinations (Crumbley et al., 2017; Louwers, 2015), litigation support (Heitger and Heitger, 2008), expert witnesses (Rezaee et al., 2004), computer forensic analyses (Pearson and Singleton, 2008) and business valuations (Digabriele and Lohrey, 2016). Timely detection of fraud is crucial to reduce financial and reputational damage to victims, and there is an urgent need to develop more effective investigation procedures. Technological advances in Big Data offer significant opportunities to improve the effectiveness of forensic accounting. Big Data provide an unprecedented amount of structured and unstructured data, and the high volume, velocity, and variety that can be analysed through Big Data analytics (BDA, henceforth) techniques can help decision-making (Gartner, 2014). These elements represent the unique features of Big Data that can provide a relevant source of benefits if properly exploited. Big Data are an essential element of debate among academics and practitioners regarding the future of accounting and auditing practices (Moffitt and Vasarhelyi, 2013), and many researchers have noted the need for further empirical research to address its integration (Gabrielli et al., 2022; Ibrahim et al., 2021; Pickard et al., 2013; Rezaee and Wang, 2019). Moll and Yigitbasioglu (2019) state that '*scholars have not given sufficient attention to these technologies and how these technologies affect the everyday work of accountants*'. Forensic accounting could benefit from exploiting Big Data (Ernst and Young, 2016). For example, it can use social media, web monitoring, visualisation, and reporting tools. However, few studies analysed the impact of Big Data on forensic accounting, and they have mainly focused on reshaping forensic accounting education and integrating BDA courses into academic curricula (Rezaee and Wang, 2019). There is a lack of studies on the practical implications of Big Data applications in forensic accounting and, more generally, fraud detection and examination procedures.

As requested by Ibrahim et al. (2021) and Rezaee and Wang (2019), this study addresses the impact of Big Data and BDA on forensic accounting practices and how Big Data produce changes in fraud detection and investigation. The literature on Big Data and BDA diffusion in the accounting and auditing fields lacks empirical studies assessing their contributions and usefulness. This study contributes to the debate by filling this research gap and offering useful empirical insights, as Big Data are underutilised as an effective tool for fraud detection (Aboud and Robinson, 2022). The existing literature predominantly focuses on

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https://doi.org/10.1016/j.techfore.2024.123507
Received 19 December 2022; Received in revised form 28 May 2024; Accepted 5 June 2024
Available online 12 June 2024

the application of Big Data to auditing. In contrast, this study investigates the utilisation of Big Data and BDA to detect and investigate fraudulent activities. This study is timely and relevant because it aims to comprehend the implications of anti-fraud practices. The unique features of Big Data may play a historical role in fraud detection, prevention, or even prediction. Fraud can have a significant financial impact on individuals, organisations, and society. Hence, effective fraud-detection methods enabled by BDA can help mitigate these impacts, save resources, and protect the economy from potentially relevant losses. In addition, BDA may be an effective tool for fraud detection and prevention, which could bring even greater benefits to the economy and society. This study addresses the following research question: How do the unique features of Big Data and BDA affect forensic accounting practices?

This study uses a qualitative approach based on 17 semi-structured interviews with forensic accountants from Italy. Italy is an interesting setting with a history of scandals and financial crimes, including the Parmalat scandal of 2004 and the Cirio scandal of 2003. It also exhibits a high and costly level of corruption and organised crime (de Blasio et al., 2022), and significant pressure from tax crimes often induces money laundering. Ardizzi et al. (2014) estimate that the amount of money laundered at the national level equals 6 % of the gross domestic product. Increasingly agile and complex organised crime enterprises and a flourishing black market economy pose significant risks to the financial system, and attention to anti-fraud practices is growing. Forensic accounting plays a vital role in investigating and combating criminal operations due to the significant threats posed by these activities. To address the above research question, this study resorts to the sociomateriality perspective, with particular reference to the concept of affordance first developed by Gibson (1979). Originally observed in animal environments, affordances describe what the environment offers, whether beneficial or harmful. This framework can also be applied to objects and technologies in relation to men, allowing a better understanding of their offerings to users (Senyo et al., 2021). Objects have crucial properties that determine their utility. This perspective is useful for studying the impact of Big Data on combating fraud. This concept was subsequently applied by other scholars in fields related to forensic accounting, such as managerial accounting (Wagner et al., 2011) and audit (Salijeni et al., 2021). This approach provides a lens for assessing Big Data and BDA characteristics and how they reshape and improve the operation of forensic accountants. This study reveals the influence of dispositional and relational affordances on the evolution of fraud investigation and examination practices. The scalability and granularity of Big Data offer significant benefits to forensic accounting, enabling the comprehensive scanning of data with increased operational depth. This approach allows for the analysis of entire information populations, longer timeframes, and data aggregation, all in much shorter times, owing to the computational power of BDA. In addition, visual analytics, particularly interactive dashboards, play a crucial role in gathering evidence, providing novel ways to interpret data beyond traditional tables and spreadsheets. Benefits also arise from the communicative strength of these dashboards when presenting findings and fostering a more collaborative relationship with clients, who gain a clearer understanding of the evidence-production process and feel more engaged with it. The contribution of this study is threefold. First, it contributes to the forensic accounting literature by shedding light on the role these services can play in detecting fraud and preventing these events, as tools and procedures based on Big Data used in the detection process may also be implemented by companies for fraud prevention. Second, this paper enriches the sociomaterial and affordance literature by showing that technologies are implemented when users can identify the benefits of their use. In this sense, Big Data affordances are only actualised when they offer relevant advantages to forensic accountants. Third, this study contributes to the literature on the application of Big Data solutions in accounting and auditing. Findings highlight the relevance of Big Data and BDA in detecting fraud, and the contribution may be of interest to firms willing to develop fraud-prevention systems based on this technology.

The remainder of this paper is organised as follows. Section 2 reviews the literature. Section 3 presents the study's theoretical framework. Section 4 describes the methodology and data analysis. Section 5 reports the findings, and Section 6 offers a discussion and conclusions.

2. Literature review

2.1. Forensic accounting: an overview

The major accounting scandals of recent decades, such as the Enron Corporation in 2001 and WorldCom in 2002, have shown the importance of preventing and detecting corporate fraud as early as possible. The estimated direct and indirect costs of corporate crime are so high (Payne, 2016) that 'corporate social irresponsibility' has attracted academic attention worldwide (Alcadipani and de Oliveira Medeiros, 2020). The United States Congress in 2002 responded to high-profile accounting scandals with the Sarbanes-Oxley Act, which aimed to protect shareholders and employees by improving the quality of financial disclosure and audits (DeFond and Lennox, 2011). Other countries followed the example of the United States and enacted new regulations to improve the quality of internal and external audits to minimise the probability of corporate fraud (Beattie et al., 2013; Ryu and Won, 2022).

Despite legislative attempts to enhance fraud detection, auditing does not ensure the absence of fraud. The financial auditor is responsible for issuing an opinion on the financial statements that certify compliance with the law and the absence of material misstatements based on sampling procedures (No et al., 2019). However, accounting fraud may concern non-material amounts, making it difficult for auditors to detect them despite the perceptions of external users, which often generates the so-called 'audit expectation gap' (Leung and Chau, 2001; Sale et al., 2001). New professional fields in forensic accounting and fraud auditing have emerged in recent years. Unlike financial auditors, fraud auditors operate whenever fraud is suspected and must put themselves in the fraudster's shoes to identify potential weaknesses in the internal control system and how they might be exploited in a tailor-made approach. Forensic accountants have a more comprehensive background than fraud auditors and usually exhibit multidisciplinary accounting, legal, and financial skills. (Albrecht et al., 2008) noted that '*forensic accounting is a challenging discipline that substantially interacts with auditing, economics, finance, information systems, and law*'. DiGabriele et al. (2015) define forensic accounting as *'[…] a multidisciplinary field that encompasses both a profession and an industry, where civil or criminal economic and financial claims, whether business or personal, are contested within established political structures, recognized and accepted social parameters, and well-defined legal jurisdictions, and informed by the theories, methods, and procedures from the fields of law, auditing, accounting, finance, economics, psychology, sociology, and criminology'*.

Given the significant impact of fraud on the socioeconomic system, the roles of forensic accountants and fraud auditors are crucial. A growing body of literature highlights how they can be extremely useful to clients, such as firms, courts, or prosecutor offices. They may help to deter, prevent, and investigate fraud on the company and enforcement sides (Akinbowale et al., 2020; Clavería Navarrete and Carrasco Gallego, 2022; Hopwood et al., 2012; Kaur et al., 2022; Kranacher and Riley, 2019).

Companies are increasingly requesting forensic accounting due to its interdisciplinary approach, and forensic accounting services have emerged as an essential practice for accounting firms (Crumbley et al., 2017). In addition, the growing complexity of accounting fraud (Ozili, 2020) requires forensic accounting practitioners to update their skills to address new challenges.

2.2. The rise of Big Data

The increased complexity of corporate fraud in recent years has resulted from digital disruption, bringing new challenges and opportunities for firms and professionals. Advances in Information Technology, including the cloud, social media, and analytics, have provided access to unprecedented amounts of structured, semi-structured, and unstructured data. Big Data are widely accepted and applied in the business community, and >98 % of all information stored is now electronic, compared to approximately 25 % in 2000 (Crumbley et al., 2017). Big Data have three fundamental characteristics that distinguish them from traditional data: volume, velocity, variety (Gartner, 2014). Volume refers to the vast amounts of data generated every second from various sources, including social media, sensors, transactions, and more. Velocity pertains to the speed at which data is generated and processed. In this context, data streams in at an unprecedented pace, requiring real-time or near-real-time processing to derive timely insights and actions. Variety refers to multiple formats, such as structured, semi-structured and unstructured data that characterise Big Data. Managing and integrating these diverse data types poses significant challenges but also offers richer insights.

Bhimani and Willcocks (2014) have found that client expectations of Big Data can be used as they may already have met significant changes in the *modus operandi* of management structures and strategies. Prior literature has provided evidence of the benefits that can arise from the exploitation of Big Data features such as the volume, variety, and granularity of information. These elements foster a deeper understanding of a specific organisation or event (Caputo et al., 2023; Davenport et al., 2012; Polyakova et al., 2019).

In discussing financial audits, Cao et al. (2015) argue that consultants should embrace BDA for risk assessments and substantive procedures, considering their clients' frequent and widespread use of Big Data. Similarly, Issa and Kogan (2014) highlight the growing demand for auditors with Big Data knowledge and skills, as they are thought to make better professional judgements (Krahel and Titera, 2015; Power, 1999). Previous studies have investigated the current situation in terms of the digitalisation of audits and reported a mismatch between demand and supply, as financial auditors do not appear to exploit Big Data techniques sufficiently despite the pressure from clients (Gepp et al., 2018; Issa and Kogan, 2014). The audit literature shows how Big Data impact auditors' interactions with their clients (Salijeni et al., 2019), and forensic accounting could face a similar reshaping due to Big Data use.

A relatively unexplored topic is the application of new technologies, such as BDA, data mining techniques, and artificial intelligence, as tools for detecting and examining fraud. The following technologies could be crucial for the success of fraud investigation, with particular reference to the early detection of criminal conduct: predictive analytics, machine learning, artificial intelligence, visualisation techniques (dashboards), data warehouses, dedicated database management systems, and Big Data technology (e.g., Hadoop and distributed file systems). Forbes (2013) reports that the Securities and Exchange Commission in the USA uses BDA, known as 'RobotCop', to identify securities law violations and financial statement irregularities. Tang and Karim (2019) state that using BDA in brainstorming sessions can mitigate the issues of low-quality discussions and improve the overall effectiveness of detection. Social media data are also crucial for detecting fraud in financial statements (Dong et al., 2018).

Among BDA, data visualisation tools represent some of the most interesting solutions for fraud detection. They entail the creation of interactive data representations, facilitating the systematic examination of various phenomena (Dilla and Raschke, 2015). Visual analytics serve as a means of converting raw data into scalable insights across diverse domains (Leite et al., 2018; Lokanan, 2022; Singh and Best, 2016). These tools have proven highly efficacious in fraud investigations because they can graphically portray data, enabling the precise examination of intricacies by eliminating irrelevant observations. Thus, this approach can reveal insights that manual analysis does not (Argyriou et al., 2014). The use of Big Data in the fraud domain may also be extended beyond mere detection logic to a more dynamic strategy for fraud prevention, as evidenced by previous studies (Chen et al., 2015; Duan and Xiong, 2015). BDA can enhance firms' risk assessment procedures by enabling them to better recognise anomalies and red flags.

Prior studies focus on the integration of Big Data into accounting curricula (Mcbride and Philippou, 2022; Rezaee et al., 2018; Rezaee and Wang, 2019) and the importance of implementing BDA into forensic accounting practices (Deniswara et al., 2022; Kılıç, 2020). To the best of our knowledge, there is a void in the existing literature, as there has been limited exploration of the tangible utilisation of Big Data in forensic accounting. This study aims to bridge this research gap by examining forensic accounting practices with special regard to the practical integration of Big Data. Doing so, it provides valuable insights into the implications of this practice for socioeconomic development.

3. Theoretical framework: an affordance theory perspective

We use a sociomateriality perspective as a new approach to understanding the relationship between Big Data, BDA, and forensic accounting practices. This perspective has been adopted in various domains, such as sociology, technology, and organisation. It represents a post-humanist viewpoint that shifts away from the human element. Instead, it examines how non-human entities exert agency, impacting human actors' practices and organisational behaviours (Fenwick et al., 2015). This approach is rooted in the concept that sociality and materiality are inherently interconnected within real-world practices. It claims that sociality and materiality are produced together, leading to the concept of sociomateriality (Leonardi, 2012). Along these lines, Leonardi (2012) argues that, first, materiality is social as it is the result of a social process and is used in a social context; second, every form of social action is made possible by an underlying material component or aspect. Based on this perspective, material and social dimensions cannot be disentangled based on the assumption that human and non-human actors interact at the same level without considering humans as privileged or superior entities. The sociality emerges from this interaction, where the two involved actors mutually shape and influence each other, becoming intertwined and inseparable in practical contexts.

The contemporary social world's reliance on interactions between human and non-human elements has been extensively discussed in the literature. Different interconnected theoretical constructs and viewpoints have been discussed to explain the depth and complexity of these interactions, such as actor-network theory, complexity theory, and spatiality theory (Bispo et al., 2018; Moura and Bispo, 2020; Orlikowski, 2007, 2010; Orlikowski and Scott, 2008).

The literature based on sociomateriality has also provided useful insights into how technology can reshape certain operations using the concept of *affordance*. Affordance has been defined in different ways in the literature; however, it was first developed by Gibson (1979) to observe the relationship between an animal and its environment. The affordances of the environment are what it offers the animal, what it provides, or furnishes, either for the good or ill. This relationship can also be observed between humans and technologies to understand what technologies offer users (Senyo et al., 2021). Technologies have crucial properties, which determine the use that can be made of objects themselves. Hence, affordance theory is an interesting lens to study how Big Data impact the fight against fraudulent operations in relation to how they are integrated into these practices.

Affordance theory offers an interesting platform for analysing the technical and social aspects of the interrelationship between digital tools and human actors (Chatterjee et al., 2020). This approach can reveal how technology permits different types of reciprocal actions to achieve goals (Lehrer et al., 2018). The lens of affordance theory has been used in multiple scientific fields ranging from psychology and sociology to science, technology, engineering, and mathematics. It is widely applied

in multidisciplinary fields and has a high explanatory power related to potential performable actions with specific technologies (Anderson and Robey, 2017; Chatterjee et al., 2020).

Affordance has been defined in various ways (Dremel et al., 2020; Hultin and Mähring, 2014; Leonardi., 2011; Pollock and D'Adderio, 2012). Lindberg and Lyytinen (2013) summarise the most widespread definitions, which include 'actual and perceived material properties of technology', 'means of using technology', and 'emergent possibilities of action when humans and technology interact'. Hutchby (2001) further elaborates that technology can offer humans several possibilities for action, but the way in which it is used depends on the human perception of what the technology can allow them to do. In other words, affordance is 'a bridging concept that conceptually links the design and use of technology' (Faraj and Azad, 2012). We follow the approach of Strong et al. (2014), who consider affordances as possibilities for actions which are goal-directed and provided by an object in relation to a goal-oriented actor. Affordances are considered a prerequisite for action. Therefore, it is possible to identify how Big Data technologies can be used in forensic accounting to produce proactive actions to achieve a specific objective. We also integrate Strong et al.'s (2014) approach with concepts derived from other studies based on the theory of affordances (Bérard, 2014; Hutchby, 2001; Leonardi., 2011; Salijeni et al., 2021). Following Salijeni et al. (2021), technology affordances can be split into dispositional and relational. Dispositional affordances refer to how a user employs technology; in this case, they refer to how a forensic accountant exploits Big Data to detect fraud. Relational affordances produce a particular relational dynamic relating to properties that technology brings out, the relationship itself, and how the properties affect relationships (Fayard and Weeks, 2014) (Fig. 1). In terms of relational affordances, this study focuses on how Big Data affect how forensic accounting practices are reshaped in terms of client relationships. Big Data technologies appear to be an interesting digital platform for studying dispositional and relational affordances, as they are characterised by specific physical and digital features which draw attention to the multiple interactions between users and technologies (Lehrer et al., 2018).

Accounting literature has also resorted to affordance. Wagner et al. (2011) use it to study how universities implement an Enterprise Resource Planning (ERP) system. This study found that the system encountered user resistance, prompting adjustments to its features to align with user preferences. The features of the ERP system represent dispositional affordances, whereas user preferences are relational affordances. It is important to note that technologies can also impose constraints and affordances. Sociomaterial elements that support technology can limit user actions (Pollock and D'Adderio, 2012).

In this study, the exploitation of Big Data in fraud detection is seen as a sociomaterial practice that allows for different human-technology interactions. Affordances embedded in technology shape the possibilities for action available to users, whereas users decide which technological properties they take up and how (Pollock and D'Adderio, 2012) (Fig. 1).

4. Methodology and data collection

This analysis focuses on the use of Big Data technologies to fight fraud. Given the need for empirical studies on this topic (Aboud and Robinson, 2022; Ibrahim et al., 2021; Rezaee and Wang, 2019), we followed a qualitative approach based on interviews with forensic accountants; every interviewee was certified as a fraud examiner. We began by conducting a detailed review of the reports issued by the Big Four companies and the ACFE to preliminarily assess the importance of the topic. Deciding the minimum number of interviewees is crucial in qualitative research. The literature offers different thresholds as a reference: at least 10, according to Glaser and Strauss (1968) and at least 12, according to Guest et al. (2006). This study decided the number of interviews following the data saturation principle (Guest et al., 2006). In other words, interviews were conducted until no new evidence was provided. Seventeen semi-structured interviews were conducted with forensic accountants and certified examiners of fraudulence. Forensic accountants were selected from Big Four firms, investigative agencies, and smaller consulting firms in Italy specialising in fraud detection and investigation. We interviewed both partners and senior managers to obtain insights from different perspectives because senior managers were more interested in the operational impact and partners' overall changes, including those regarding relationships with clients and competitors. The variety of interviewees and the opportunity to interact with different types of operations made capturing different facets of the topic possible.

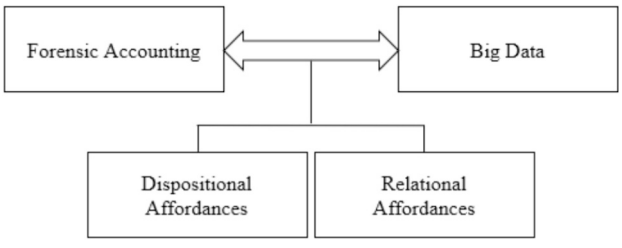

Fig. 1. Affordances produced between forensic accounting and big data. Source: Author's own elaboration.

Before the interviews, the researchers explained the aims and purpose of the study to potential respondents and contacted them via email. The emails informed the participants about the research and, more importantly, aimed to determine whether the potential respondent was sufficiently knowledgeable about the topic.

Interviews were conducted online in Italian from January to July 2022 and lasted between 30 and 90 min each. The data were digitally recorded and immediately transcribed verbatim. Once each interview was transcribed and translated into English, the respondents were asked to check the transcripts to ensure they were not misrepresented. All the respondents' observations were considered. All participants were aware that their results would be processed anonymously (Segal, 2019). The interviewees had professional experience ranging from five to more than 20 years. They were thus able to provide an accurate opinion of the 'state of the art' with regard to Big Data and BDA in forensic accounting practice and also offer insights into the historical evolution of the field. Table 1 presents an overview of the interviewees.

It was clarified at the beginning that the interviews were being carried out for academic purposes (Maroun, 2017). The interviews began with an initial approach that focused on general questions regarding the interviewees' roles and backgrounds to make them feel comfortable and free to express themselves. The following section focuses on Big Data and BDA in forensic accounting practice and aims to address the opportunities and issues related to their adoption. A comprehensive set of closed questions was omitted to prevent any potential influence on the research participants or to inadvertently limit the scope of the topics under consideration. The interviewees were granted latitude to guide the conversation. As a result, the researchers allowed flexibility in the sequence of topic discussion, but as a minimum standard, they ensured that all fundamental points were discussed during the interview. When possible, the researchers also requested respondents to elucidate specific considerations to obtain examples and different phrasing or to speculate on whether their peers might share similar viewpoints. This approach aimed to enrich the depth of the discussion and confirm the absence of misinterpretations (Alvesson, 2003).

4.1. Data analysis

Data for analysis were collected through interviews from the sociomateriality perspective, with particular reference to affordance (Fayard and Weeks, 2014; Leonardi., 2011). The aim was to investigate how Big Data and BDA tools affect anti-fraud operations in enabling specific

Table 1
Overview of interviewees. Source: Author's own elaboration.

Code	Position	Gender	Experience	Duration	No. of pages transcribed
R1	Partner - Head of Forensic accounting	m	> 20 years	1 h14	12
R2	Partner - Forensic & Integrity Services	m	> 20 years	1 h05	10
R3	Partner - Forensic Accounting	m	> 15 years	0 h33	5
R4	Founding Partner	m	> 20 years	0 h31	5
R5	Senior Advisor - Forensic & Integrity Services	m	> 20 years	0 h53	8
R6	Senior Advisor - Forensic services		> 20 years	1 h01	8
R7	Managing Director - Head of Italy, Forensic Investigations and Intelligence	m	> 10 years	0 h47	7
R8	Senior Manager - Forensic & Integrity Services - Digital Forensic	m	> 10 years	0 h41	7
R9	Senior Manager - Forensic	m	> 7 years	0 h49	8
R10	Senior Manager - Forensic	m	> 7 years	0 h35	6
R11	Director - Forensic Services	m	> 10 years	0 h36	6
R12	Manager - Forensic accounting	f	> 5 years	0 h37	5
R13	Senior associate	f	> 15 years	0 h40	6
R14	Director	m	> 20 years	0 h39	7
R15	Chief Executive Officer	f	> 20 years	0 h48	8
R16	Data Analysts	m	> 20 years	0 h41	7
R17	Director	m	> 10 years	0 h39	6

functional uses and dispositional affordances and how they can generate changes in client relationships, especially in terms of delivery and communication. The recordings were transcribed verbatim to avoid subjective interpretation. Two researchers performed transcribing, one transcribing and the other checking the transcription against the recordings. Before starting the analysis, it was essential to familiarise with the data, so transcriptions were printed and read in their entirety by the researchers. The researchers then noted the key factors related to dispositional and relational affordances. The second stage was the data codification, performed manually following Braun and Clarke (2006). The first coding round identified key elements consistent with the study's aims. Following Malsch and Salterio (2016), this phase identified contradictions and differences between interviewees regarding the role of Big Data and BDA.

The second round of coding identified specific affordances using a sociomaterial approach.

5. Findings

This section presents the affordances identified through data analysis. It first presents the dispositional affordances offered by Big Data and BDA and, second, the relational affordances between forensic accountants and clients (See Table 2).

5.1. Dispositional affordances

This section focuses on how Big Data reshape the procedures and operations carried out in forensic accounting operations (dispositional affordances).

Table 2
Summary of Big data and Big data analytics affordances. Source: Author's own elaboration.

Dispositional affordances	Relational affordances

– Improved operational depth;
  – Data scalability and granularity;
  – Combination of unstructured and structured data
  – Data triangulation;
– Visualisation tools and analytics application;
	– Role of visualisation tools;
	– Legitimation with clients;
	– Enhanced team relationship and collaboration

5.1.1. Improved operational depth

In the domain of fraud identification, which inherently deals with rare events, the volume of data analysed for anomalies and outliers can be significant. Leveraging Big Data and analytical tools can be extremely useful for fraud examinations and investigations. The two main characteristics of the interviewees are scalability and granularity. In the corporate landscape, data are obtained from diverse sources. Apart from transactions and accounting data, sources such as emails, telephones, employee interactions on social media, and global media reports require consideration. In addition, in today's digital landscape, the permanent deletion of information presents a formidable challenge because it can be restored through data recovery efforts. This option further increases the data volume and the need to manage extensive datasets. Big Data offer a unique opportunity, but they must be handled carefully.

> *'To reconstruct certain events, in fact, it is essential to be able to process and manage data that is often unstructured. And then, try to give it a form by putting it in a context so that it can be deciphered and understood' (R9).*

The effective management of Big Data is crucial for processing such information, and integrated systems such as Hadoop (an open-source software framework) are beneficial for managing fraud investigation datasets. The scalability of datasets is crucial because it represents the ability of a system to adapt and react to changes in volume without losing performance (Bondi, 2000). Big Data technology helps forensic accounting practices extract, collect, and store information without losing potential insights.

> '*By now, the size of the data used for financial-economic investigations is enormous, and it is different from financial audit. In the initial phase, all digital equipment is digitally acquired. […] Then ERP systems are source of all kinds of accounting analysis on company data. Without BDA software, you cannot manage this amount of data*' *(R2).*

Through scalability, Big Data technology enables the exploitation of the variety and volume of information to identify and investigate fraud. The BDA software is a determinant because it can easily adapt to the volume of data, especially when data from different sources are added to an initial set. This phenomenon may occur when information from social media profiles is added to an initial firm accounting and digital equipment set.

Certain interviewees pointed out the potential downside of the vast amount of data available today. A large volume of valuable data can introduce risks. At times, the sheer amount of data can overwhelm an investigator to the point where relevant information is overlooked. The ability of the investigator to identify relevant data for a specific case remains crucial. Investigators' concerns reflect the socially constructed nature of fraud; societal pressures and historical contingencies, such as whether a society encourages risk-taking or rule-following, contribute to the progressive identification of fraud. As fraud remains an event closely related to an individual's personality, there is a human component that can never be intercepted by analytical tools or data availability alone. Therefore, Big Data tools cannot be the sole answer; they require the integration of an innate investigative sense.

'The role of the investigator is strengthened by the tools, but the fact that the fraud is consequence of an intentional act of a person means that human intelligence cannot completely take over' (R7).

The volume of available data is insufficient to ensure fraud detection. Effective fraud detection depends on accurate analysis and testing of data. One of the crucial affordances given by Big Data lies in its granularity. BDA affords deeper and progressively finer levels of detail for analysis, enhancing the granularity of both collected and testable data. Recent BDA software provides specific, flexible queries that enhance investigations' operational depth. It is possible to identify the area of interest of the investigation from the full set of collected information and gradually increase the level of detail of the analysis. This is highly significant, especially when relationships between individuals need to be analysed, for example, in corruption cases. The BDA software, applied to the full population of information, allows the exploitation of different levels of connections between subjects. Investigations can be limited to family or business relations or deepened with social media information or other elements.

'Performing analysis on the universe rather than on a sample is very important, because one, you identify an abnormal event you can drill down on that element. Once I have identified in the mass of data the point to focus on, I can drill down' (R14).

BDA further enhances the operational depth of fraud investigations by allowing quicker and semi-automatic data triangulation or three-way matching. This approach ensures greater procedural efficiency and a more complete analysis by performing simultaneous tests on data from different sources. This is a crucial aspect of fraud investigations, and the use of open-source information is becoming increasingly important. Proficiency in comprehending and dissecting cast datasets and intricacies swiftly holds significance. The practice of cross-referencing data beyond conventional accounting data and lengthening the analysis timeframe amplifies the volume of accessible data. However, the absence of BDA systems renders these analyses impractical. This capability not only saves time but also allows for a heightened focus on the investigative facets of the task.

'We use big data analytics software that can quickly process impressive masses of data and enable comparisons between different datasets by unifying analyses and triangulating data from different sources. Previously we had to do manual matching, now we can save a lot of time with BDA' (R10).

Regarding the operational depth that Big Data enables in fraud investigations, interviewees noted the potential for analysing longer time series. This potential is also crucial for investigations because in cases where fraud has been in progress for some time, the abnormality it causes may be mistaken for a particular trend, or the mechanism for concealing the fraud may mislead the investigator. BDA enables a much longer time series to be scanned, which may reveal the fraudster's behaviour and allow the identification of the actual fraud scheme.

'Recently, I investigated cash flows trend. While studying the week's data, no significant deviations were seen, but extending the analysis to five years, the issue emerged. Fraud is not always a one-time event; its effects can span years. A shorter analysis may seem fine, but extending it reveals the problem' (R9).

5.1.2. Leveraging unstructured data

One of the most frequently debated feature of Big Data is that they consist of both structured and unstructured data (Warren et al., 2015). Big Data technologies allow insights to be generated from unstructured data, making huge datasets useful for fraud investigations. Emails, social media posts, and phone messages can offer relevant evidence to support the timely identification of potential ongoing fraud. The interviewees emphasised the key role of unstructured data in fraud detection and noted its practical implications. They enable the transformation of unstructured data into a single format that can be quickly tested to obtain evidence. They foster the automation of some data pre-processing tasks that are crucial for properly analysing the information collected.

'*Today you can do combinations of internal and external data that you could not do before[..] Tools allow you to do text analysis or text interpretation, to combine documents of various natures and formats. [..] BDA make it possible to exploit unstructured data that leads to new evidence that can be used to intercept a fraud' (R6).*

The significance of BDA lies in its pivotal capacity to model and render usable data. Data from sources such as the Internet, social media, and news media are invaluable for investigative purposes. This information can be continuously cross-referenced with more structured evidence, such as accounting data. BDA plays a transformative role in expediting this process while facilitating a broader cross-referencing scope.

Our respondents underscored the significance of unstructured data for forensic accounting practices and acknowledged the challenges of managing vast amounts of such information. Careful handling is essential to ensure its utility without confusing the fraud-detection process. As Vasarhelyi et al. (2015) have noted, semi-structured and unstructured data availability requires a higher tolerance level for ambiguity and the ability to identify false positives. The interviewees also highlighted the risk of information loss when modelling unstructured data to make them usable.

'There is a risk that this unique volume of data lead to the loss of information. The risk is real, and it is also related to understanding how to structure the data and how to interrogate it in the right way' (R7).

The capacity to organise unstructured data into a usable format is of critical importance. The structure is one of the most critical factors in this regard. Substantial amounts of unstructured data present a valuable opportunity for anti-fraud efforts. However, it is essential to acknowledge the associated risks in structuring and subsequently manipulating data to render them comprehensible.

5.1.3. Visualisation tools and analytics application

Another type of BDA that is valuable in fraud investigations involves visualisation tools that provide dispositional affordances. Our respondents provided substantial evidence, underscoring the significance of these tools for data analysis in identifying fraudulent activities. A diverse array of technological solutions is available, comprising options such as Power BI in the Microsoft Office package, SAS packages, and bespoke solutions crafted internally by prominent firms, such as the Big Four. These packages provide dispositional affordances by seamlessly amalgamating data aggregation and granular data examinations. Notably, they permit the aggregation of data based on specific criteria identified by the fraud examiner while concurrently affording the capability to delve deeply into each transaction contained within the dataset through interactive dashboards. Thus, visualisation tools guarantee both macro- and micro-levels of information, a feature of immense utility in fraud investigation. Interviewees conveyed that visual analytics played a pivotal role in identifying unusual data patterns, particularly over extended timeframes. Once anomalies are identified, a meticulous analysis of specific transactions ensues. Another remarkably effective application of visual analytics pertains to link analysis and exploration of relationships among various entities. As noted by Lokanan (2022), the visual representation of networks is invaluable for discerning connections within large datasets.

'These tools are crucial for analysis because visuals are more effective than trivial tables. In accounting, they help spot unusual transactions in datasets and provide access to all relevant information at a visual level once data is imported into the software' (R8).

Interactivity is an essential feature of interactive visual tools. They extend beyond mere graphical depictions of data to facilitate real-time interrogation (Lehrer et al., 2018). This dual dimension of visual analytics is paramount for forensic accounting practices requiring internal and external data management. They can be used to combine and analyse data from different sources in a coordinated manner.

'We have developed a high-tech system that allows you to enter a company and create a map with all the people connected to it. Once the perimeter is defined, it produces a press review based on a certain crime taxonomy and then I go and consult all this information with the system, which skims out cases of homonymity or non' (R10).

A final insight into the visual analytics provided by our interviews was the time saved due to the faster process of elaboration and comprehension of the information afforded by graphical representation. Forensic accounting can construct a comprehensive 'visualisation' of information from diverse sources, from official documents and social media to emails, texts, and even conversations.

'Visual analytics is crucial; we heavily use graphical representation to swiftly gasp fraudulent mechanism. These tools, combining analytics with visualisation, are indispensable for expediting fraud analysis and detection, crucial in minimizing financial losses generated by fraud' (R1).

Our interviews revealed the unanimous approval of visual analytics tools; our respondents saw them as one of the key elements of Big Data, which provided specific affordances. Interestingly, none of our respondents reported concerns about applying visual analytics technology to fraud investigations, as they did for other elements of BDA.

5.2. Relational affordances

This section describes the changes in relationships in fraud-investigation service delivery, focusing on how Big Data disrupt the relationship between forensic accountants and clients. These changes are enabled by the relational affordances of both Big Data and BDA. Note that, in addition to private and public-owned firms, clients of forensic accountants and fraud examiners include courts and prosecutors' offices in lawsuits related to fraud.

Our interviewees reported a growing demand by clients, both firms and courts, for BDA and advanced investigation procedures and a widespread expectation that they will be used. This is also considered a competitive advantage in the market.

'It's the firms themselves which often ask to use these tools, because they feel that their ERP systems provide huge masses of data that must be managed with advanced tools. Today, then, it is unimaginable not to also do this from a competitive perspective' (R2).

The BDA also confers a higher level of legitimacy on the evidence that a forensic investigation provides to clients, especially in court proceedings, and our respondents say that they enhance credibility when they present the results of an investigation. BDA means that forensic accounting services are perceived as being well executed with adequate tools and analysis capabilities. BDA enhances the reliability of the findings. This aspect is vital in court proceedings, where the risk of making a mistake is perceived to be higher than in an internal investigation.

'Data set dimension and BDA tools guarantee greater reliability of the results, especially in court because evidence obtained by analysing the entire dataset is better than a limited sample. In addition, the possibility of integrating unstructured data that can be successfully analysed helps to provide more complete evidence' (R2).

BDA legitimises forensic accountant procedures, meets client expectations, and offers greater reliability for evidence. However, the main relational affordances Big Data provide in fraud investigations are from visualisation tools. Visual analytics offers two main relational affordances: first, they enhance the communication of findings, and second, they foster client involvement.

'Visual analytics are crucial, first they are very powerful in delivering the message. Firms are often not familiar with aspects of fraud investigations and therefore need clear, non-aseptic messages […] We develop dashboards that can be navigated almost 100 per cent by the client who can see all the evidence that has emerged, drill down and possible simulations. In this way the client feels in a way part of our analysis process' (R2).

Visual analytics facilitate the communication of evidence with clients. The ability to graphically present the investigation findings, even without requiring the client to read the entire final report, enhances the effectiveness of persuading the client about the quality of the work. This aspect is crucial because, often, the report's reader may not be familiar with the underlying investigative methods and reasoning that form the basis of the activity.

A system that allows to develop a correlation and linkage map or simply present the findings in an appealing manner is important because those who have to make decisions on the basis of the report can immediately understand what they need by quickly responding to their information needs' (R4).

Visual analytics can reduce the distance between forensic accountants and their clients, enhancing the perception that investigational procedures follow rigorous protocols. All evidence is meticulously conveyed to clients through visual means.

6. Discussion and conclusions

Drawing on the sociomateriality literature (Dremel et al., 2020; Hutchby, 2001; Leonardi, 2012; Salijeni et al., 2021) and, specifically, on the concept of affordances originally developed by Gibson (1979), this study contributes to the current understanding of the impact of Big Data in forensic accounting practices (Gabrielli et al., 2022; Ibrahim et al., 2021; Rezaee and Wang, 2019). To analyse our findings, we follow the approach of Salijeni et al. (2021), who view technology affordances as both dispositional and relational. Big Data is becoming a debated topic in accounting for academics and practitioners (Vasarhelyi et al., 2015; Warren et al., 2015). However, few accounting studies offer empirical insight into the changes arising from Big Data integration in these fields, including fraud detection. This study examines how Big Data and BDA utilisation reshape the modus *operandi* of forensic accounting. As an explorative study, it follows a qualitative approach based on semi-structured interviews. Experienced professionals in forensic accounting and fraud investigations are carefully selected and interviewed. Considering the inherent interconnection between the social and material aspects of professional activities (Moura and Bispo, 2020; Orlikowski, 2007), the use of BDA is expected to have different implications for fraud investigations (Ibrahim et al., 2021; Rezaee et al., 2018; Rezaee and Wang, 2019). Empirically, from the perspective of affordances, the study shows that technological improvements are implemented in professional practices when users understand their properties and that utilisation can generate advantages and profits (Lindberg and Lyytinen, 2013; Orlikowski and Scott, 2008). According to this view, the affordances provided by Big Data are actualised when forensic accountants perceive their usefulness (Dremel et al., 2020; Gibson, 1979). These advantages include enhanced investigative

mechanisms, stronger and more reliable insights, well-communicated evidence, and greater legitimisation with clients. This study shows the significant benefits that BDA might offer in the timely and precise management of substantial data quantities while preserving the granularity of information needed to accurately depict the phenomenon (Caputo et al., 2023; Polyakova et al., 2019). As dispositional affordances, Big Data offer significant advantages for the investigation's depth owing to their scalability and granularity. BDA enables the management of unprecedented data volumes, including structured and unstructured data. Previous literature argues that Big Data and BDA enable a deeper understanding of business environments (Davenport et al., 2012) at a more granular level, providing evidence that dispositional affordances can assist forensic accountants in identifying the crucial elements necessary to detect fraud. This aspect assumes heightened significance in forensic accounting investigations because of the potential integration of internal organisational data with external sources. Such integration amplifies the evidentiary value derived from the expansive network of relationships surrounding an organisation. By synthesising internal data from external sources, investigators can better understand the operational landscape and uncover nuanced patterns and connections pivotal to fraud detection. The fusion of internal and external datasets augments the investigative toolkit, enabling forensic accountants to discern intricate relationships and detect anomalous behaviours that might otherwise evade detection. This holistic approach capitalises on the interconnectivity inherent within organisational networks, enriching the evidential framework and fortifying the efficacy of fraud-detection mechanisms. Moreover, the utilisation of external data sources complements internal investigations, providing a broader contextual lens through which to interpret the findings. By leveraging external data repositories, such as financial market data or industry benchmarks, investigators can contextualise internal anomalies within broader economic and market dynamics, enhancing the robustness of their investigative conclusions. Thus, the convergence of internal and external data enriches the evidentiary landscape and underscores the symbiotic relationship between organisational dynamics and external environmental factors in the context of forensic accounting investigations. This integrated approach enhances the precision and effectiveness of fraud-detection methodologies in contemporary business environments. The use of visual analytics in forensic accounting yields further affordances which change how an investigation is conducted (Ernst and Young, 2016). It enables graphical data analysis, and its interactive dashboards are more effective and proactive than tables and spreadsheets (Hultin and Mähring, 2014; Lindberg and Lyytinen, 2013). They make it easier to identify anomalies in datasets and links between people and organisations, and generate significant time savings (Lehrer et al., 2018; Pollock and D'Adderio, 2012). Visual properties can serve as valuable tools for gaining a comprehensive understanding of the overall organisational structure or specific operations, enabling the identification of potential areas of concern for forensic accountants. Forensic accountants can reactively respond to areas that demand focus or scrutiny (Pollock and D'Adderio, 2012). However, this capability may also benefit the entire organisation by facilitating the identification of critical areas that require attention. A significant advantage afforded by Big Data in forensic accounting is the impact of the time required for an investigation. BDA permits a drastic reduction in the time spent running an analysis and obtaining results, which is extremely important, as it can significantly reduce economic losses (Deloitte, 2018). When discussing the impact of Big Data and BDA on forensic accounting operations, it is crucial to highlight the relevant contributions that can be produced because of time savings in fraud identification. The rise of Big Data has approached instantaneous fraud-detection methods and real-time auditing (Lehrer et al., 2018; Salijeni et al., 2021). What was once a time-consuming endeavour involving the analysis of millions of data sources over weeks or even months has been dramatically reduced to a matter of days. This new approach significantly reduces the losses and impacts caused by fraud by contrasting the time lag between fraud perpetration and discovery. This transformation underscores the profound impact of proper analytical tools on response times, enabling swifter and more effective anti-fraud measures. This study demonstrates that despite the validity and reliability of the outcomes obtained through Big Data (Lehrer et al., 2018; Orlikowski and Scott, 2008), scepticism and individual proficiency of the investigator remain crucial factors in discerning certain distinctive features inherent to fraudulent occurrences. This phenomenon creates new opportunities for collaboration when BDA is combined with traditional investigative methods (Wagner et al., 2011). Moreover, this study refers to affordance as the possibility of a proactive approach to achieving a specific goal (Strong et al., 2014). This proactive approach might be very useful if we shift the focus from detection to fraud-prevention logic. Firms could implement what has been proven effective in forensic accounting practices as an internal mechanism aimed at preventing fraudulent events (Clavería Navarrete and Carrasco Gallego, 2022) and these tools might be enhanced by the implementation of BDA (Chen et al., 2015; Duan and Xiong, 2015). In line with this perspective, the use of Big Data affordances to combat fraud can extend beyond mere detection and investigation to encompass the development and implementation of predictive models, which may benefit organisations. By leveraging the capabilities of Big Data and BDA, organisations can harness predictive analytics to forecast potentially fraudulent activities with greater accuracy and with proactive mitigation strategies. By exploiting Big Data infrastructure coupled with advanced analytical techniques facilitated by BDA, organisations can build robust forecasting models to identify emerging fraud patterns and anticipate future threats (Ibrahim et al., 2021). These models can analyse historical transactional data, user behaviour, and other relevant variables to identify anomalous patterns indicative of fraudulent activities. Moreover, the integration of real-time data feeds enables organisations to continuously refine and adapt their forecasting models, thereby enhancing their predictive capabilities in dynamic business environments. This proactive approach empowers organisations to stay ahead of evolving fraud schemes, minimise potential losses, and safeguard their financial integrity. Overall, the adoption of forecasting models based on Big Data and BDA represents a strategic initiative in the fight against fraud, providing organisations with the predictive insights needed to effectively mitigate risks and uphold trust and transparency in their operations. By addressing relational affordances, this study focuses on the relationship between clients and professionals and how the presence of Big Data modifies it. Clients increasingly expect forensic accounting investigations to perform advanced analytics on Big Data (Bhimani and Willcocks, 2014). This is also becoming a competitive factor, leading to the evolution of the role played by forensic accountants towards that of valuable advisors (Guo, 2016). Our respondents note that Big Data offer the opportunity to enhance the legitimacy of the evidence obtained, as BDA ensures greater reliability of the results (Cao et al., 2015; Krahel and Titera, 2015; Power, 1999; Salijeni et al., 2019). The actualisation of relational affordances arising from the incorporation of visual analytics can significantly impact the relationship between clients and professionals by facilitating the communication of results. By utilising interactive dashboards, professionals can effectively convey the intricacies of investigative findings, illustrating the correlation between different elements and evidence (Hultin and Mähring, 2014; Lindberg and Lyytinen, 2013). Transparency enhances clients' comprehension of the investigative process and fosters trust and confidence in the results. Furthermore, the streamlined communication of clear and reliable results legitimises the role of forensic accounting as a valuable asset for clients and firms. By implementing enhanced fraud-prevention mechanisms informed by forensic accounting insights, firms can bolster their risk management practices and safeguard themselves against financial malfeasance. This, in turn, contributes to broader societal welfare by mitigating the adverse effects of fraud. BDA can enhance the quality of forensic accounting services and, therefore, its perceived utility for companies and society. Few previous studies have explored Big Data in

forensic accounting practices, but our results are consistent with previous academic research (Deniswara et al., 2022; Kılıç, 2020; Rezaee and Wang, 2019) and as well as practitioner publications (Deloitte, 2018; ICAEW, 2019). Both sides agree that Big Data and BDA can support fraud investigations. Our results are similar to those in financial audit, where many studies show the significant impact of Big Data (Salijeni et al., 2019, 2021). Future research should extend this analysis to other countries and legal systems. A comparison between developed nations (e.g., Italy) and emerging countries could also be made, and China, for example, would be an interesting setting. Another promising research area is the impact of Big Data and BDA on the investigation cost. The time savings guaranteed by these tools can be promising in containing costs, but they should be analysed in relation to the investment needed. The evolution of courses and qualifications in forensic accounting and fraud examinations adapted to the new scenario of Big Data is another line for further research. Another extension would be to conduct more detailed case studies on the application of Big Data in forensics, considering the role of artificial intelligence, such as machine learning, deep learning, and Robotic Process Automation.

Despite its contributions, this study is not without limitations. It only considers Italy, and this aspect and its explorative nature limit the generalisability of the results. The semi-structured nature of the interviews makes it possible to develop a flexible approach to topics raised during the interviews but given the complexity and breadth of Big Data, some relevant topics may not have been considered. For instance, artificial intelligence deserves further attention from academics and practitioners who deal with fraud-detection practices.

CRediT authorship contribution statement

Gianluca Gabrielli: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Carlotta Magri:** Writing – original draft. **Alice Medioli:** Conceptualization, Supervision. **Pier Luigi Marchini:** Conceptualization, Supervision, Writing – review & editing.

Data availability

The data that has been used is confidential.

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