Chapter 11
From Conventional Methods to Contemporary Neural Network Approaches: Financial Fraud Detection

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Abstract This chapter provides insights on the underlying reasons to replace the conventional methods with contemporary approaches—the neural network-based machine learning methods—in financial fraud detection. To do this, we perform a systematic literature review on the evolution of financial fraud detection literature over the years from traditional techniques towardmore advanced approaches such as modern machine learning methods like artificial neural networks. Additionally, this chapter provides concise chronological progress of the fraud literature and country-specific fraud-related regulations to draw a better framework and give the idea behind the corpus. Using the metadata in the existing literature, we show both benefits and costs of using machine learning-based methods in financial fraud detection. An accurate prediction using contemporary approaches is essential to minimize the potential costs of fraudulent financial activities for stakeholders, reduce the adverse effects of fraudsters' and companies' fraudulent activities, and increase trust in capital markets via continuous fraud risk assessment of companies.

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11.1 Introduction

Fraud is not a new concept. Tricks, deceive, and rip off were always an issue of trade activities since the early trade era. Greek merchant Hegestratos, who lived 300 B.C., was the first fraudster of known history, according to many historians. He had a deal with the lender to transport corn by his boat. In exchange for thatthe lender gave him money to finance this operation. Hegestratos will pay his debt when the duty is fulfilled. However, he decided to intentionally sink his empty boat, sell the corn secretly, and never pay back his debt. Unfortunately, the plan went wrong, and he lost his life with his sunken boat (Johnstone 1998).

Since the early trade era, while there are significant regulations to prevent fraudulent activities and identify the loopholes potentially increasing fraud attempts, it is still a major issue of today's business life. Consequently, still, ex-ante detection and prevention of fraud attract significant attention from researchers from different research fields. Managerial approaches, psychological methods, surveys, statistical models have been developed to understand the backstage of financial fraud. In addition to academic research, diverse legal regulations were put into practice by authorities to monitor companies and financial markets. However, despite all those joint efforts to understand the reasons behind the fraudulent activities to prevent its occurrence in advance and minimize the costs of financial fraud on society, the concept of fraud is still a fact that cannot be avoided. Association of Certified Fraud Examiners (ACFE) reports in their review "*2018 Global Study on Occupational Fraud and Abuse*" that the yearly cost of fraud to the countries is approximately USD 4 trillion.[1] In recent years, studies document that instead of applying traditional analysis and regulations, alternative data analytics techniques should be used to detect and overcome fraudulent financial activities (Deloitte 2019). Therefore, this chapter aims to provide summarizing the chronological progress of the fraud literature and country-specific fraud-related regulations to draw a better framework and give the idea behind the corpus.

11.2 What Is Fraud?

The intentional act of material misstatement is the critical point that distinguishes financial statement fraud from an error. ISA 240 (IAASB 2018) defines fraud as the intentional activities of one or more professionals that aim to deceive the shareholders or group of stakeholders to gain an advantage. The American Institute of Certified Public Accountants (AICPA) defines financial fraud in SAS No. 99 as the intentional decisions that result in materially misstated financial statements. However, the definition of fraud or using the right term for misstatements is not clear for each case. Financial misreporting, financial misrepresentation, financial fraud, or financial misconduct can bear the same meaning (Amiram et al. 2018). Nevertheless,

[1] See https://www.acfe.com/report-to-the-nations/2018/.

maximizing self-interest and excessive gain over a transaction are always attractive motivators for individuals (Wang et al. 2011).

11.3 Progress of Financial Fraud Perspectives

11.3.1 Traditional Approaches

In a classical efficient market perspective, investors are fully informed, have rational expectations, and markets are efficient on some levels (Malkiel and Fama 1970). However, none of the market bubbles can be explained if the market conditions are in perfect balance. A typical investor in a market mostly misprice stocks or securities (Fama 1965). On the other hand, in most cases, investors have incomplete information. Additionally, most of the stock market, "manias" and underlying fraudulent acts are triggered by irrational behaviors of investors (Kindleberger and Aliber 2011). Whether we accept this kind of definition or the contrary, none of them can fully explain the effects of fraudulent activities.

Modern fraud literature begins with the influential work, "White-Collar Criminality", of Edwin H. Sutherland in 1940. It is a milestone in the fraud literature because, starting with his study, criminologists have started to acknowledge that criminal activities are not only associated with the actions of immigrants or poor people but also with the actions of rich and powerful people (Coleman 1987). In short, Sutherland's (1940) interdisciplinary article combines the perspectives of economists and criminologists to identify business-related criminal activities.

Following Sutherland's work, in 1953, Daniel Cressey, one of his students and a well-known criminologist, developed several hypotheses to understand what triggers people to commit financial fraud. He conducted interviews with 250 prisoners who were accused of violation of financial trust. The findings of his study document that among all other factors, perceived pressure and opportunity, and rationalization are the key motivators of fraudsters which are lately named like the elements of the Fraud Triangle. Although, Cressey's work has been criticized by many aspects such as the ignorance of major white-collar crimes—collective fraud and tax evasion, highlighted in Sutherland's (1940) research, the sample selection procedures, and the lacking angles of Cressey's theory research (Trompeter et al. 2013; Morales et al. 2014).

Agency theory is an influential theory that tries to explain the underlying reasons for the fraudulent activities of managers. In general, shareholders (principals) delegate their managerial duties to the professional managers with an employment contract. This employment procedure brings out agency problems (Jensen and Meckling 1976). The underlying reason for the agency problem is that the parties of this relationship seek their self-interest in most cases. Smith (1776) highlighted this problem centuries ago in his famous book. He argues that the managers of a company never treat shareholders' money as their own, and it should not be expected. Spence

and Zeckhauser (1971) discussed agency-related issues from an individual perspective and argued that those issues are related to the limited monitoring capability of companies and the utility function maximization of the individuals. Alchian and Demsetz (1972) mention contractual issues and monitoring the cost of individuals within the organization. Centuries long, accumulated knowledge about the principal-agent relationship leads perspectives to solid principal-agent theory. Nevertheless, Ross (1973) had proposed the first integrated perspective about the agency theory and followed by the research of Mitnick (1975). Besides, Jensen and Meckling (1976) develop a perspective on the agency theory that explains the complicated relationship among the shareholders, managers, and third-party stakeholders.

Agency theory mostly focuses on the separation of the CEO and the chair of the board positions to effectively manage and audit the managerial decisions and safeguard the shareholders. However, Stewardship Theory raises several red flags against the arguments of the Agency theory. Donaldson and Davis (1991) argue that a manager's fraudulent action cannot solely be explained through opportunistic motivators. There are also several other internal motivators of an individual to perform managerial duties perfectly and be a good and loyal agent of the company assets. To prevent the negative impact of such behaviors and to lower agency costs, and organizational structure should be carefully constructed.

Wolfe and Hermanson (2004) argue that the position of a manager in the organization, competencies, and psychological attributes has an interlinked connection about the perpetuator's ability to identify potential fraud and realize it. Therefore, following the critiques, Wolfe and Hermanson (2004) extended the Fraud Triangle theory and proposed the Fraud Diamond theory. While the Fraud Triangle theory argues that the fraudster has three thought steps before committing fraud; incentive, opportunity, and rationalization, Fraud Diamond theory considers the idea that a fraudster should also have the ability to recognize potential fraud opportunities and realize the fraudulent activity, which is the fourth angle and named as "capability". This additional pillar is valuable because, without the necessary abilities, a fraudster cannot realize the incentivized and rationalized fraud opportunity (Kapp and Heslop 2011). Additionally, the capabilities angle not only covers the ability to do the job but also covers the position within the organization, intelligence, self-confidence/ego, pressure, effective lying, and resistance to stress (Wolfe and Hermanson 2004). Those characteristics play an important role when fraudulent activity consists of large sums and continue over the long run (Dorminey et al. 2012). This additional perspective directly affects the fraud decision procedures of the Fraud Triangle theory. Boyle et al. (2015) investigated 89 auditors' fraud decision aid types. They found that Fraud Diamond leads to more conservative fraud risk assessments than the Fraud Triangle.

11.3.2 Legal Regulations to Prevent Financial Fraud

OECD Corporate Governance Principles

In a comprehensive perspective, corporate governance practices constitute all regulations that balance the relationship between a company and society. OECD was the key institution, which had published the OECD Corporate Governance Principles in 1999 and revised it in 2002, 2004, and 2015. The revision in 2015 was different from others because it was published under the mutual authority of G20 and the OECD. The reason behind the revisions is to meet the new requirements because of worldwide corporate scandals (Jesover and Kirkpatrick 2005). OECD is an organization that aims to promote and improve economic conditions around the world. From that point of view, OECD corporate governance principles are a guide that can be adapted for each country's particular economic conditions (OECD 2004).

The nature of corporate governance activities can be associated with fraud because of the relationship between managerial activities and corporate governance. Shi et al. (2017) claimed that the external corporate governance regulations force managers to act fair and truthful. Additionally, corporate governance practices regulate the role of independent directors in the board of directors and CEO duality (separation of the CEO and the chairperson of the board of directors) to avoid an uncontrolled decision-making process (Sharma 2004). Corporate governance practices also regulate the organizational structure of companies (Carcello et al. 2011). Chen et al. (2006) highlight that the number of outside directors, CEO tenure, and the total number of board meetings isalso linked with fraud-related activities.

Sarbanes–Oxley

Sarbanes–Oxley Act was prepared to overcome the company-related fraud and accounting cases and enacted on July 30, 2002. The main idea of the Sarbanes–Oxley Act is to protect the rights of shareholders and overcome conflicts among shareholders and companies by improving the precision and the correctness of companies' announcements (Li et al. 2008). Officially, the Corporate and Auditing Accountability, Responsibility, and Transparency Act of 2002 is the name of the Sarbanes–Oxley Act. Later on, it was titled the Sarbanes-Oxley Act after U.S. Senator Paul Sarbanes and U.S. Senator Michael Garver Oxley.

The Sarbanes–Oxley Act has several positive impacts on the legislative environment of the U.S. economy after the gigantic Enron scandal. New enforcement extensively affects the board structures of companies. Corporate boards become much more independent after the Sarbanes–Oxley Act (Linck et al. 2008). The adoption of the Sarbanes–Oxley Act lowered the fraudulent financial activities (Patterson and Smith 2007). Additionally, the adoption of the Sarbanes–Oxley Act also reduces the risk-taking level of the listed companies (Bargeron et al. 2010).

International Financial Reporting Standards

International Financial Reporting Standards (hereafter, IFRS) are proposed to set top-notch reporting standards for companies. IFRS standards aim to construct transparent,

accountable, and efficient financial markets (IFRS 2019). The conceptual framework of IFRS was firstly published in 1989 and updated in 2010 and 2018. The following two years are voluntary adoption periods. In 2005, a huge milestone was reached, and IFRS became mandatory first time.

International Standards on Auditing

International Standards on Auditing (hereafter, ISAs) are published by the International Auditing and Assurance Standards Board (hereafter, IAASB) of the International Federation of Accountants. Those published standards comprise 36 single standards. Each ISA addresses the introduction and purpose of the standard, definitions, and requirements of the related terms and mentions the application procedures (IFAC 2019).

ISA 240 regulates the auditor's liabilities concerning fraudulent financial activities. ISA 240 splits fraudulent financial activities or misstatements into two categories; intentional misstatements count as fraudulent activity, and unintentional misstatements count as errors (IAASB 2018). This distinction results in great differences before legislative bodies and laws. Additionally, ISA 240 discusses and highlights the importance of professional skepticism in auditing and lays a burden on auditors (Quadackers et al. 2014).

ISA 315 regulates the auditor's responsibility for recognizing materially misstated financial statements through understanding internal control practices and the economic environment of the company. Additionally, the auditor is responsible for the assessment of the firm's risk evaluation procedures. Moreover, auditors should recognize material misstatements on financial statements, account balances, transactions, and disclosures level (IAASB 2018).

11.3.3 Evolution of Fraud Detection

ANN applications in the accounting and finance area began with the article of Tam and Kiang (1990). In the infant era, ANN models are mostly employed to predict the risk of bankruptcy (Odom and Sharda 1990; Tam 1991; Wilson and Sharda 1994; Tsai and Wu 2008). In addition to that, ANNs came into prominence among scholars to forecast the economic time series data (Kaastra and Boyd 1996; Thawornwong and Enke 2004). Later on, ANNs are applied on different finance-related topics such as stock market index predictions (Guresen et al. 2011; Niaki and Hoseinzade 2013), exchange rate predictions (Adhikari and Agrawal 2014; Galeshchuk 2016), credit risk predictions (Bekhet and Eletter 2014; Zhao et al. 2015). Fanning et al. (1995) published the first fraud-related research that employed an artificial neural network. Their research consists of a prediction power comparison between Bell et al.'s (1993) cascaded logit model and artificial neural network. According to their results, artificial neural network outperforms cascaded logit model in accounting fraud prediction. This first bullet drew many researchers' attention, and much research published on this topic since that time (Table 11.1).

Table 11.1 Summary of articles, presented in chronological order

Author(s)	Journal name	Method(s)	Variables	Summary of findings
Persons (1995)	Journal of Applied Business Research	Stepwise logistic models, Jack-knife method	Firm-specific financial and accounting data	Capital turnover, firm size, financial leverage, and asset composition are the main predictors of fraudulent financial reporting. Stepwise logistic models outperform other inadequate strategies
Sohl and Venkatachalam (1995)	Information & Management	Backpropagation neural network	Firm-specific financial, industry-specific, and demographic data	In the prediction of financial fraud, the neural network model works with adequate accuracy even with small training data. Additionally, neural networks outperform traditional forecasting methods with similar datasets
Green and Choi (1997)	Auditing: A Journal of Practice & Theory	Backpropagation neural network	Firm-specific financial and accounting data	Authors compare three different neural network algorithms depending on Type I and Type II errors
Fanning and Cogger (1998)	International Journal of Intelligent Systems in Accounting, Finance & Management	Artificial neural networks, Generalized adaptive neural network algorithm	Firm-specific financial, accounting, and governance data	Two employed artificial neural network models outperform the logit model in Bell et al.'s (1993) work
Summers and Sweeney (1998)	The Accounting Review	Cascaded logit model	Firm-specific financial, accounting, auditor data	A cascaded logit model effectively separates companies with fraud from non-fraudulent companies
Bell and Carcello (2000)	Auditing: A Journal of Practice	Logistic regression	Firm-specific financial, accounting, non-financial management data	Logistic regression-based decision aid tool effectively classifies the fraudulent and non-fraudulent cases

(continued)

Table 11.1 (continued)

Author(s)	Journal name	Method(s)	Variables	Summary of findings
Lin et al. (2003)	Managerial Auditing Journal	Fuzzy Neural Network (FNN), Logit model	Firm-specific financial and accounting data	Fuzzy neural network outperforms artificial neural networks
Koh and Low (2004)	Managerial Auditing Journal	Decision trees, neural networks, logistic regression	Firm-specific financial and accounting data	In the prediction of going concerns, the decision tree model outperforms the neural network and logistic regression models
Kirkos et al. (2007)	Expert Systems with Applications	Decision trees, neural networks, Bayesian belief networks	Firm-specific financial and accounting data	Relative to others, Bayesian belief networks performs better and has higher classification accuracy
Ngai et al. (2011)	Decision Support Systems	Literature review	–	According to the literature review, this paper highlights that financial fraud detection's major weakness is the cost of misclassification of the cases
Zhou and Kapoor (2011)	Decision Support Systems	Response surface methodology	Firm-specific financial, accounting, non-financial management data	Relative to conventional fraud detection techniques that employ historical data, using a response surface method, which can automatically pivot the program according to the unique cases, predict financial fraud more effectively
Goel and Gangolly (2012)	Intelligent Systems in Accounting, Finance, and Management	Chi-square test	Firm-specific non-financial management (linguistic) data	The use of complex sentence structures, difficult readability, passive voice sentences, uncertainty, and excessive use of adverbs are signs of possible financial fraud
Lin et al. (2015)	Knowledge-Based Systems	Logistic regression, decision trees (CART), and artificial neural networks	Firm-specific financial, accounting, and corporate governance data	In fraud detection, artificial neural networks and CART models that were trained and tested with subsamples have higher classification rates than logistic regression models

(continued)

Table 11.1 (continued)

Author(s)	Journal name	Method(s)	Variables	Summary of findings
Archambeult et al. (2015)	Nonprofit and Voluntary Sector Quarterly	Summary of press reports	Firm-specific media data associated with fraud	The organizational role of fraudsters has a significant impact on the size of fraud loss
Gong et al. (2015)	Journal of Institutional and Theoretical Economics	Wavelet analysis	Firm-specific media data associated with fraud	The fraudulent activities follow the cyclical path
Chen (2016)	Springer Plus	Regression trees (CART) and the Chi-squared automatic interaction detector (CHAID), Bayesian belief network, support vector machine, artificial neural network	Firm-specific financial and accounting data	The CHAID–CART model's performance on fraud detection is the most effective method relative to others
Karpoff et al. (2017)	The Accounting Review (2017)	Database comparison	–	The outcomes of employed models can be affected by the database selection (e.g., Government Accountability Office, Audit Analytics, Stanford's SCAC, and CFRM)
Perols et al. (2017)	The Accounting Review	Multi-Subset observation Under-sampling, Multi-subset variable Under-sampling	Firm-specific financial and accounting data	Under-sampling methods will reduce the cost of misclassification and increase the prediction ability of financial fraud detection models. Moreover, Observation and Variable Under-sampling methods are separately performed well for under-sampling
Gepp et al. (2018)	Journal of Accounting Literature	Literature review	–	The employment of big data in accounting and finance is essential in financial fraud modeling, stock market prediction, distress modeling, and quantitative modeling

11.4 Conclusion

The abovementioned theories and regulations have one common aim, to prevent shareholders' (or stakeholders') financial loss that occurs due to corporate fraud activities. The endless efforts of researchers identify that there are cultural, psychological, behavioral, country-specific, judicial, and managerial reasons behind fraud activities. Nevertheless, the combined effort of countries and researchers cannot hinder the greediness of top managers. Such activities still have heavy damage to countries and financial market players.

Financial fraud detection literature begins with behavioral perspectives like White-Collar Criminality, Fraud Triangle, etc. However, especially after the digital revolution, studies show us that the huge process of power, newly developed algorithms, and big data sets help to respond to previously unsolved issues. The combination of these two perspectives contributes to the efforts of reducing the risk exposures of investors and stakeholders due to the fraudulent financial activities of companies. These efforts also aim to lower the risk of material misstatements through continuous evaluation. According to the literature, utilizing algorithms can be beneficial to detect fraudulent activities and classify fraudulent cases beforehand. Such a kind of nature allows companies or related parties to evaluate potential fraudsters continuously.

Adoption of a neural network-based algorithm to the financial markets can be beneficial for regulatory bodies and beneficial for other stakeholders like banks, individual investors, investment funds, and companies. Commercial banks develop several ANN-based algorithms to evaluate credit risks (Angelini et al. 2008). Audit companies will also benefit from the developed algorithms as an auditor's decision aid tool. Recent researches will enlarge the audit companies' evaluation procedures for the risk of material misstatement. Additionally, auditors' trust-based relationship with companies' management teams can affect managerial fraud evaluation (Kerler and Killough 2009). An emotionally indifferent algorithm will reduce the risk of biased fraud assessment.

Constructing big data sets for the use of fraud detection algorithms need great effort and time. In most cases, a highly generalizable and robust algorithm needs company-specific and country-specific data. However, collecting and combining data from different databases, countries with different legal systems, languages will be challenging in most cases. To construct a robust algorithm, a researcher probably spends most of its' time on the dataset construction. This approach will highly contribute to the algorithm training step and will increase the efficiency and reliability of the algorithm.

Contemporary algorithm-based financial implications mostly focus on real-time applications. Future researches will be focusing on decreasing time deviations and the time-consuming nature of such studies to develop a simultaneously working algorithm with regulatory bodies and companies. Additionally, in some cases, macroeconomic conditions push managers to act fraudulently. They can be manipulative to reach market expectations or exceed investors' expectations. For this reason, future

researches should also take into account the macroeconomic variables as an input variable to understand the motivators behind fraudulent activities.

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