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New-Age Technologies to Combat Tax Evasion: Technological, Ethical, Legal, Social, and Economic (*TELSE*) Implications and a Scientometric Analysis

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Abstract: The sudden surge of digitalization escalates the challenges faced by traditional tax systems to detect and combat tax evasion, and it is a pivotal concern for the smooth functioning and sustainable development of any nation. The paradigm shift offered by the emergence of new-age technologies presents unprecedented opportunities to tap their potential for administering effective tax systems. In our paper, we provide a systematic scientometric analysis of existing literature to analyze four focal new-age technologies in combating tax evasion. We also propose a novel holistic framework to understand the intricacies of this multifaceted landscape of tax evasion from technological, ethical, legal, social, and economic (*TELSE*) perspectives. The research methodology gives a quantitative scientific mapping to analyze research publications from Web of Science and Scopus databases using Biblioshiny. A total of 117 documents were examined, spanning over the last decade (2014-2024). The research findings highlight considerable traction regarding the number of publications from the two most populated countries in the world. The analysis of the most frequent keywords yields an increasing trend towards the adoption of other new-age technologies as well and depicts different factors that affect tax evasion, which is in line with varied laws and regulations across countries. The interdisciplinary research efforts need to be aligned to tap the full potential of these technologies and to develop effective intelligent taxation systems that are fair, accountable, and explainable.

Index Terms: Artificial Intelligence, Machine Learning, New-Age Technologies, Tax Evasion, Deep Learning, Data Mining, Scientometric Analysis, Tax Fraud.

1. Introduction

Taxation is of paramount importance to the nation's economy. It serves as the primary source of revenue generation for governments, ensuring the provision of essential public services that sustain societal well-being. Revenue generated from taxes is not merely a financial obligation. Still, it forms the cornerstone of governance, facilitating efficient administration and promoting economic stability, equity, and the fair distribution of resources among all citizens. However, the importance of taxes also presents an inevitable challenge for governments in maintaining an effective tax system. Taxpayers continuously seek opportunities to lessen their tax burdens, leading them to explore various legitimate and illegal tax avoidance strategies. Tax avoidance is a legal strategy to reduce one's tax obligation. It is permissible under laws and can impact the fairness and equity of the tax system by inadvertently shifting the tax burden onto other taxpayers [1]. In contrast, tax evasion involves illicit practices that aim to reduce tax liabilities [2],

leading to direct revenue loss for the government. Tax authorities should prioritize detecting and preventing tax evasion to safeguard revenue and ensure tax compliance. This underscores the necessity to develop robust strategies and deploy tools to detect tax evasion.

With the ubiquitous growth of technology, the global landscape has witnessed an accelerated shift towards a digital future, marked by the proliferation of new-age technologies [3,4]. New-age technologies refer to disruptive innovations, technologies, and advanced methodologies that can revolutionize processes, practices, and systems that facilitate transformation to the existing environment. Artificial Intelligence (AI), Data Mining, Machine Learning, and Deep Learning are the four focal new-age technologies that have emerged as transformative tools for harnessing large amounts of data across various domains- from astronomy, cybersecurity, e-commerce, and healthcare to engineering, recommender systems, and agriculture [5,6]. In tax administration, these technologies present unprecedented opportunities and have garnered significant attention from tax authorities to optimize revenue collection and effectively combat tax evasion [7,8]. By analyzing relevant information and features, these technologies can estimate the risk to identify high-risk taxpayers and determine the behavior of taxpayers to detect patterns of tax evasion [9].

However, despite the advancements of new-age technologies in tax enforcement, human decision-making remains indispensable to ensure the reliability and integrity of these technologies in tax administration. While these technologies offer significant capabilities in detecting anomalies and patterns indicative of tax fraud, human involvement remains essential for interpreting complex outcomes and verifying conclusions at the forefront of tax evasion and new-age technologies [10]. The intelligent systems developed by applications of these technologies should be interpretable, trustworthy, and produce explainable models with a high level of performance. Human oversight is also crucial for developing such intelligent systems to maintain the principles of fairness, transparency, and ethical conduct, ensuring that decisions based on AI insights are justified and accountable [93].

There is a need to map the research landscape of the application of new-age technologies in combatting tax evasion and explore the significance of their implications. An attempt has been made to study the role of a few of these new-age technologies but only for tax administration [11]. Only a few research studies have addressed the implications of these technologies in detecting tax evasion individually [35, 36]. However, to the best of our knowledge, none of the previous studies have focused on providing a complete framework encompassing all intertwined implications and the scientific mapping of the research landscape of using popular new-age technologies in combating tax evasion. The key contributions of our paper are as follows:

1. This study represents a pioneering attempt to provide a scientometric analysis of the four focal new-age technologies to combat tax evasion. Specifically, we focus on the four focal new-age technologies: AI, data mining, machine learning, and deep learning to enhance tax enforcement and tax evasion detection.
2. We also propose a novel *TELSE* framework to holistically capture this multifaceted landscape from technological, legal, ethical, social, and economic (*TELSE*) perspectives of new-age technologies to combat tax evasion.

Our research fills the gap by incorporating findings from various aspects, offering crucial insights, and identifying potential research opportunities within the field, ultimately providing a more comprehensive understanding of how these interconnected factors can collectively enhance the effectiveness of tax enforcement strategies in combating tax evasion and would facilitate future research endeavors.

In our paper, we address the following research questions to explore the adoption and continuity of new-age technologies in detecting tax evasion from multiple perspectives:

RQ1. How has the growth of the annual scientific publications of new-age technologies in detecting tax evasion evolved over the last decade (2014-2024)?

RQ2. Who are the most prominent authors in this field?

RQ3. Which countries have made the most significant contributions through publications and citations within this field?

RQ4. What are the most prevalent keywords and the emerging trends within this research domain?

RQ5. What are the technological, ethical, legal, social, and economic implications of new-age technologies in combating tax evasion?

The remaining sections of this paper are organized as follows: Section 2 presents the literature review. The methodology used, and the results of scientific mapping are discussed in Section 3. Section 4 provides the comprehensive framework with *TELSE* implications of four focal new-age technologies in combating tax evasion. Section 5 presents the discussion, and then Section 6 provides the conclusion of our research study.

2. Literature Review

In this research, the literature review encompasses a multidisciplinary approach to combating tax evasion using new-age technologies, covering technological, ethical, legal, social, and economic aspects. The literature review of this

paper is structured as follows. Section 2.1 provides an overview of the current research state of new-age technologies in combating tax evasion highlighting techniques, and emerging trends in this interdisciplinary field. Section 2.2 further examines the technological, ethical, legal, social, and economic implications.

2.1 New-age technologies to combat tax evasion

Tax authorities around the world are grappling with the complexity of tax evasion in the global economy. A growing body of literature shows that the tax administration is experiencing digital transformation and progressed remarkably by adopting different new-age technologies, including AI, data mining, machine learning, and deep learning to detect tax evasion [12]. In recent years, various techniques such as statistical models, supervised and unsupervised learning, and deep neural networks have been widely used to detect tax evasion within tax administration 3.0.

Data mining techniques have emerged as a crucial tool for identifying fraudulent activities and detecting anomalies in various contexts of tax evasion. Wu et al. [13] explored data mining techniques to reduce value-added tax (VAT) evasion by screening non-compliant VAT reports. Additionally, Ruzgas et al. [14] investigated data mining techniques in the context of a developing economy. Several supervised learning algorithms, such as regression and Bayesian networks, have been harnessed to forecast the probability of tax evasion [14]. Visitpanya and Samanchuen [15] applied supervised learning techniques to identify suspicious tax evasion behavior and utilized publicly available financial data. Support vector machines and decision tree classifiers have been deployed to detect anti-money laundering [16]. Also, Mojahedi et al. [17] proposed a swarm optimization algorithm to enhance multilayer perceptron and support vector machine classification problems to detect tax evasion accurately.

Recent research has explored different unsupervised learning algorithms to detect tax evasion and their behavior patterns. A study has been employed to pinpoint traders who are highly susceptible to circular trading in commercial taxation systems [18]. In indirect taxation, Mehta et al. [19] perform spectral clustering combined with TrustRank algorithm and kernel density estimation to identify tax evaders. Another notable contribution was by De Roux et al. [20], who presented an unsupervised approach for identifying under-reporting taxpayers, demonstrating its effectiveness on real tax declarations without requiring labeled historical data.

As tax evasion schemes become more sophisticated, the integration of deep learning models has gained prominence. In social e-commerce, Zhang et al. [21] developed a multimodal deep neural network to detect transaction-based tax evasion. In the context of property acquisition tax returns, Lee [22] applied autoencoders to select suspicious cases for audit.

Studies have demonstrated that hybrid approaches have also emerged as a promising strategy to detect tax evasion. A study by Rahimikia et al. [23] introduced a hybrid algorithm with evolutionary feature selection techniques to uncover instances of corporate tax fraud in Iran. Another study by Zumaya et al. [24] utilized hybrid techniques, which include network science and machine learning methods such as deep neural networks and random forests to identify potential tax evaders in electronic invoice records.

Beyond the mainstream detection of tax evasion, new-age technologies are being used to track tax fraud within the shadow economy. The shadow economy, also known as the black economy, hidden economy, or underground economy, encompasses unreported activities to the tax authorities [25]. Tax evasion constitutes an intrinsic facet of the shadow economy and various efforts have been made to identify and understand tax evasion in the shadow economy [20, 26, 27, 28, 29]. De Roux et al. [20] employed unsupervised learning to detect taxpayers who were underreporting their income to regulatory authorities. De Oliveira et al. [26] focused on the fuel industry, where fraudulent activities such as illegal alterations to the printed circuit boards were used to evade taxes. Oliveira et al. [27] emphasize the use of deep learning techniques to predict the production of monitored plantations to reduce tax evasion within the agribusiness. Son et al. [28] proposed different approaches to handle the class imbalance of machine learning algorithms to predict the undeclared work in the labor market. Furthermore, Alogogianni and Virvou [29] discussed the effective implementation of a street vendor management system to prevent tax evasion.

All of the above research studies show a considerable amount of traction among researchers in this area. However, the technological advancements of new-age technologies in tax administration 3.0 create a need to perform scientometric analysis, identify key trends, and explore potential research opportunities in this amalgamated field to combat tax evasion.

2.2 Implications of New-age Technologies

Despite substantial research on new-age technology and tax administration, significant efforts are underway to ensure the safe deployment of these technologies. The safe deployment of these technologies presents numerous implications, such as technological, ethical, legal, social, and economic.

Resilience has gained prominence within the intelligent tax system [30]. Daly [31] highlighted the role of resilience and adaptability of taxation systems during the COVID-19 pandemic, to sustain economic growth. However, the focus on resilience also introduces challenges related to the responsibilities across different stakeholders, including developers, tax professionals, and taxpayers within the tax system [32]. This challenge of responsibility is likely to, therefore, pose a consideration on ethical dimensions also. Several research have contributed to the concern of accountability associated with the integration of these technologies into the tax system [33,34]. Zadeh et al. [35] explored the ethical considerations of using AI in managing rental tax evasion in Iran.

Recent research shed light on the importance of legal standards for explainability, which arise from the ethical principle of accountability [36, 37]. For example, a study by Kuzniacki et al. [38] examines the role of explainability in tax administration for the protection of taxpayer's rights. Research studies also underscore the importance of legal principles for fostering trust in the intelligent tax system [39, 40]. Also, the intersection of legal and ethical considerations profoundly impacts trust and social acceptance from the public within the tax system. The extensive literature further demonstrates the importance of addressing the social factors that can enhance the sustainable growth of the economy and reduce tax evasion [41, 42]. And further, facilitate the tax authorities and government to adapt and invest in other new-age technologies [43].

The objective of combating tax evasion cannot be achieved by simply making a system that only detects the instances of tax evasion, the approach must also align with broader goals of economic sustainability [44]. The development of a sustainable society needs to uncover the multidimensional landscape of new-age technologies that includes technological, social, legal, ethical, and economic factors. None of the previous studies have addressed all these factors together. In our work, these diverse implications of new-age technologies have been brought together in a unified framework, *TELSE*, to address the unforeseen consequences of new-age technologies in this area. This framework will contribute help to the sustainable growth of society and effectively combat tax evasion.

3. Scientific Mapping Analysis

Our research provides a comprehensive bibliometric analysis to examine the application of new-age technologies in detecting tax evasion. Through scientific mapping, we address the first four research questions RQ1- RQ4 of our study.

3.1 Methodology

Our study collected data from two well-known databases, namely- Web of Science (WoS) and Scopus, published between 2014 and 2024. This timeframe was chosen due to the surge in new-age technologies in detecting tax evasion research. Fig. 1 outlines the methodology used for document identification and follows the Preferred Reporting Items for Systematic Reviews and the Meta-Analysis (PRISMA) approach. The PRISMA framework encompasses data sourcing, retrieval, screening, and constraints [45]. The preliminary criteria for selecting documents were based on specific query terms. The document search was conducted in English using the following query string.

Query- (("Tax Evasion" OR "Tax Fraud") AND ("Artificial Intelligence" OR "Machine Learning" OR "Deep Learning" OR "Data Mining"))

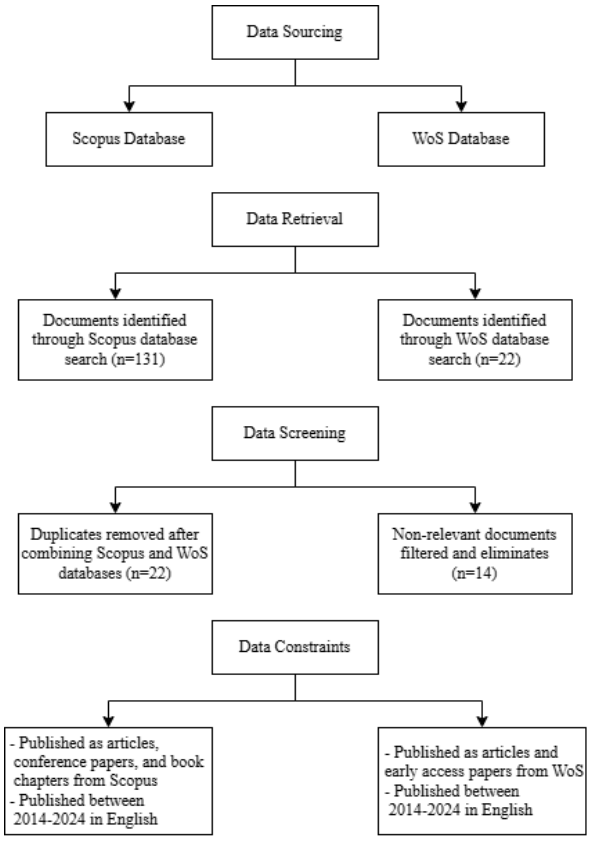

Fig. 1. Research framework of methodology for document identification

Articles, Early Access from WoS, and Articles, Book Chapters, and Conference Papers from Scopus were retrieved as document types. Excluding document type corresponding to the book. After the preliminary search, 22 records from WoS and 131 records from Scopus were returned. 22 records common to both WoS and Scopus were excluded. In the next phase of screening, we carefully scrutinized each document. The primary criterion for inclusion and exclusion was the document's alignment with the research topic. Specifically, we excluded the documents that mention keywords from our search string but were not directly related to the scope of our research for scientific mapping and did not contribute to the application of new-age technologies to combat tax evasion. As a result, 14 documents were found irrelevant and omitted from the analysis. Finally, 117 articles were found relevant and consolidated into a .csv file for scientometric analysis. Data analysis was performed using "Biblioshiny" (Bibliometrix package) of R studio software. This tool was developed to facilitate comprehensive evaluation through visual representation of the dataset and key themes based on the body of literature.

3.2 Research Analysis

The summary of the key findings obtained from the descriptive statistics is presented in Table 1. The bibliometric analysis data comprises 117 documents, which include 50 articles, 8 book chapters, and 59 conference papers. This descriptive analysis highlights the distribution of 339 distinct keywords and the contributions of 317 authors.

Table 1. Main Information about the Dataset

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2015:2024
Sources (Journals, Books, etc)	93
Documents	117
Annual Growth Rate %	18.19
Document Average Age	3.13
Average citations per doc	6.556
References	3892
DOCUMENT CONTENTS	
Keywords Plus (ID)	687
Author's Keywords (DE)	339
AUTHORS	
Authors	317
Authors of single-authored docs	12
AUTHORS COLLABORATION	
Single-authored docs	13
Co-Authors per Doc	3.65
International co-authorships %	17.95
DOCUMENT TYPES	
article	50
book chapter	8
conference paper	59

3.2.1 Growth Analysis of Published Documents

Fig. 2 provides a thorough overview of publication trends of the new-age technologies in detecting tax evasion. The figure demonstrates that this research domain has received traction as these new-age technologies were in breakthrough or early expectation stages over the last decade. The graph illustrates the significant number of articles

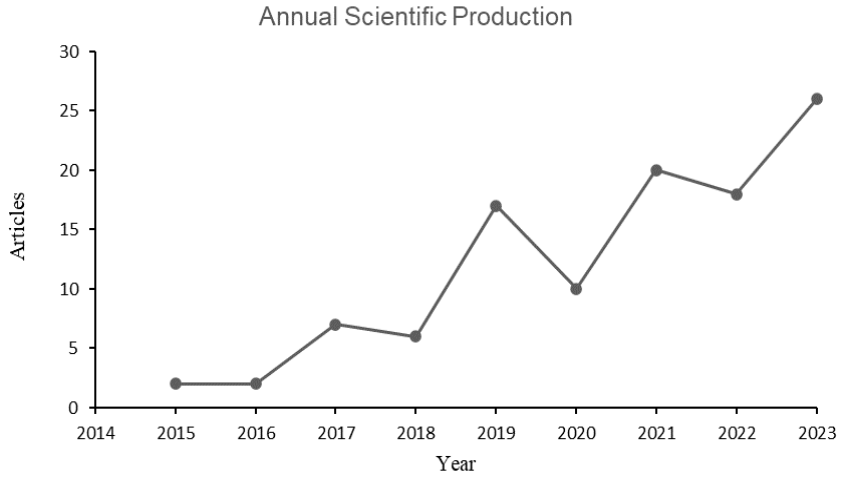

Fig. 2. Growth of annual scientific publications over the last decade

published with noticeable fluctuation in 2020, a year likely influenced by the COVID-19 pandemic. The data for the year 2024 is still partial and covers only the months elapsed so far and, therefore, is not covered in this figure. Fig. 2 depicts the upper trend, which aligns with the continuous development of new-age technologies and highlights the significant growth path in this research area.

3.2.2 Author Analysis

Fig. 3 illustrates the publication timeline of prominent authors in the amalgamated field of new-age technologies to tackle tax evasion. Zheng Q, Dong B, and Ruan J demonstrate consistent annual publications. Overall, 2019 and 2023 stand out as years of high research output for several authors, highlighting active engagement and significant advancements in their respective fields during these years.

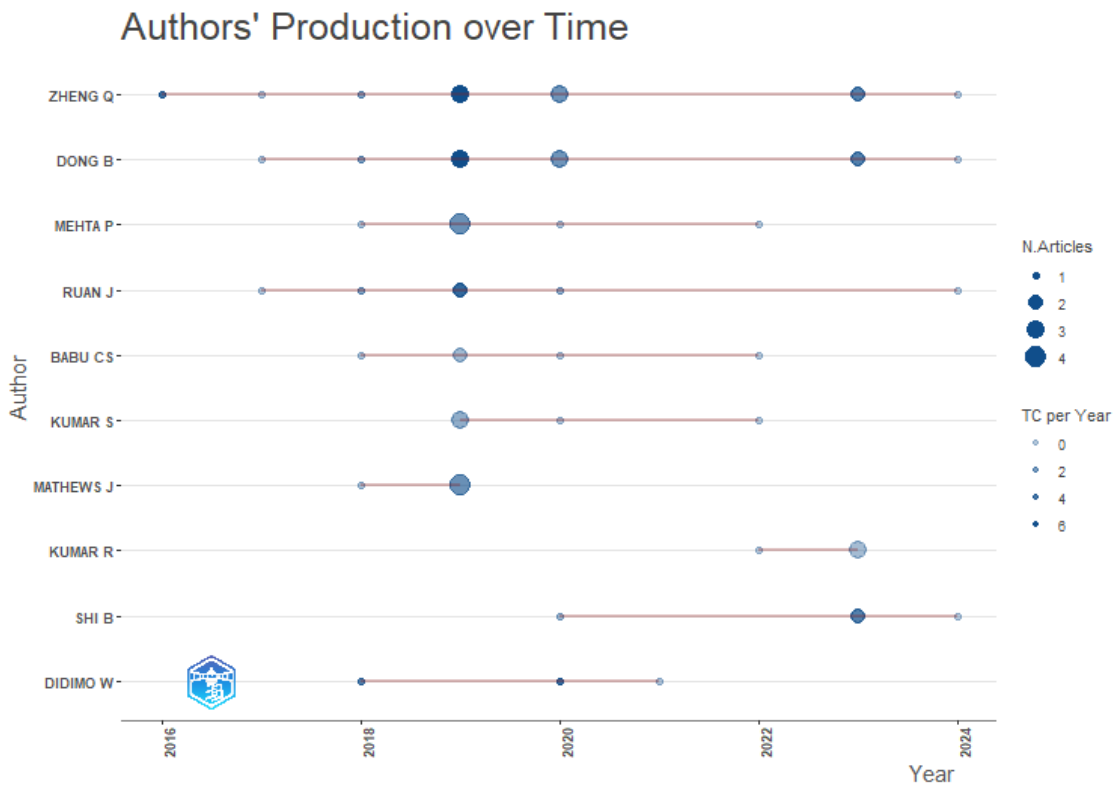

Fig. 3. Growth of author's production over the past decade

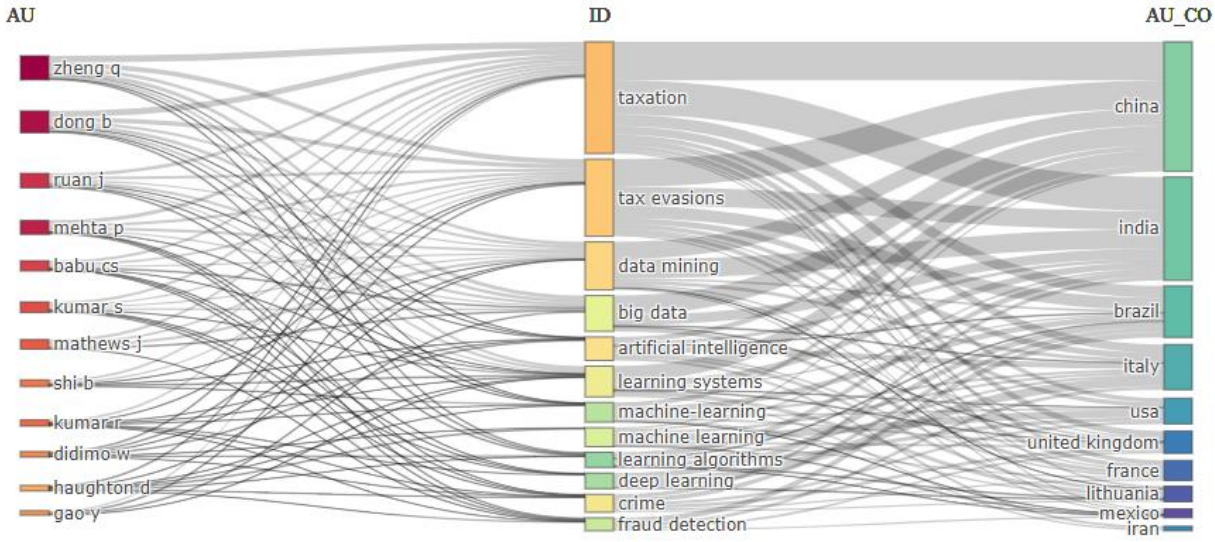

Fig. 4. A three-field plot showing the network between Authors (left), Keywords Plus (middle), and Countries (right)

The prolific authors Zheng Q, Dong B, and Ruan J have collaboratively contributed to this domain, and their research is inclined towards identifying the suspicious groups of tax evasion, especially in corporate tax. Their research encompasses various models and approaches such as transfer learning, graph attention networks, positive and unlabelled learning, etc. Other significant authors are Babu CS, Mehta P, Kumar S, and Mathews J, who have also worked collaboratively. Their research is focused on detecting fraudulent transactions in good and service tax, particularly in circular trading. In recent years, they are exploring the applicability of Generative AI and deep learning in this field.

A three-field plot based on the Sankey diagram is shown in Fig. 4. It illustrates the prominent authors (left), keywords plus (middle), and countries (right). Only a few countries have explored new-age technologies like AI, big data, learning algorithms, machine learning, and deep learning in the domain of taxation and tax evasion.

3.2.3 Country Analysis

Fig. 5 shows the clustered column-line chart of the top 20 countries sorted by total citations. It illustrates the global research efforts on using new-age technologies to combat tax evasion. The analysis aims to identify the most prolific countries in publications and citations. China leads India in publication frequency. However, India has more total citations than China. Italy and Brazil also show substantial contributions with a high number of publications. Italy has a higher research impact due to a high number of citations. The figure also provides insights that research activity is high in the most populated countries of the world, which is due to the surge in large and complex economies and advancements in economic growth in these countries. It is also important to note that a significant portion of the research efforts has been concentrated in developed countries. The research studies in developing countries were mainly focused on identifying suspicious groups that evade taxes and also identifying return defaulters- the most brazen form of tax evasion using deep neural networks. In the tax field, researchers are exploring the concept of inter-region transfer learning to optimize tax evasion detection by exploiting relevant features of one region to another region where tax authorities lack the training or labeled data and sufficient data.

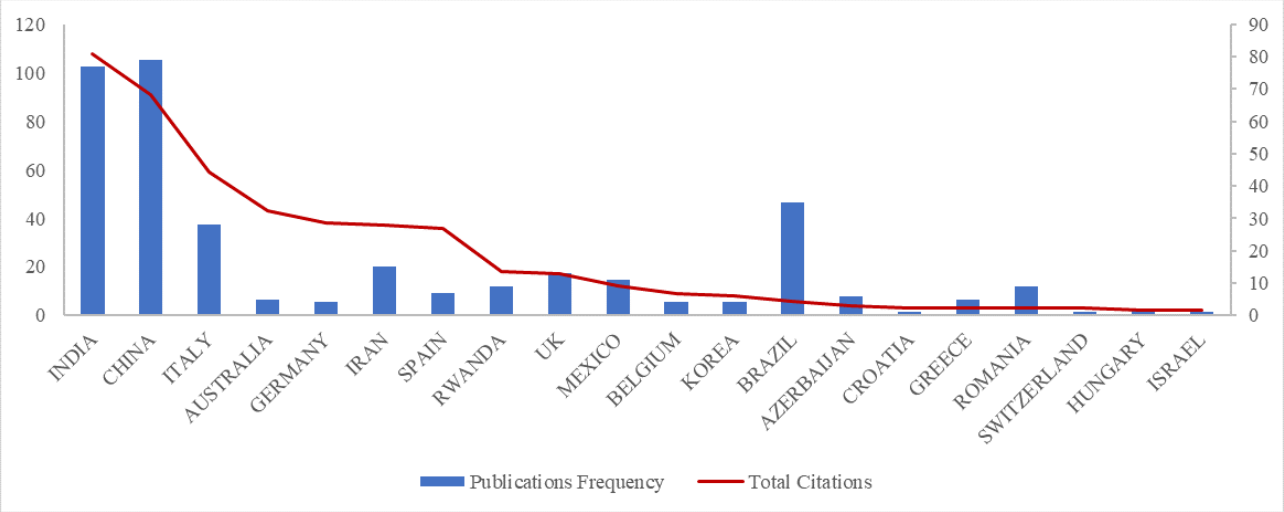

Fig. 5. Plot of the top 20 countries' total publications and total citations, sorted by total citations

3.2.4 Keyword Analysis

Fig. 6 illustrates the word cloud of frequently used terms and concepts associated with the research on new-age technologies in detecting tax evasion. The size of the term reflects its frequency in the literature. We excluded the keywords used in the search query to uncover research frontiers in this domain. Since taxation deals with data for the entire country, it poses a challenge to handle big data. Therefore, it necessitates applying big data analytics, predictive modeling, and cloud computing to deal with such a vast amount of big data. Various studies have explored graph mining, network analysis, and social network analytics techniques to analyze the transaction network data and detect tax evasion activities by monitoring unreported income and undeclared work in the shadow or hidden economy and facilitate tax authorities in tracing digital footprints, as evident from Fig. 6. Several statistical and machine learning methods, such as logistic regression, neural networks, genetic algorithms, kernel density estimation, and clustering, are employed to analyze and predict tax-related activities and assist tax authorities where the labeled data is not available, analyze huge amounts of transactions, selecting relevant features between the variables to identify different forms of tax evasion.

Fig. 6. Word cloud of most frequent keywords

Fig. 7. Treemap of top 50 Author's Keywords

The figure also reveals significant attention towards essential factors such as the shadow economy, informal economy, circular trading, and undeclared work within tax evasion research. It sheds light on the hidden economic activities and strategies to combat tax evasion. The availability of varied types of data across different countries has spurred interest in exploring more new-age technologies like blockchain, Generative AI (autoencoder), and cloud computing to advance the efforts in detecting and preventing tax evasion. Generative AI has gained significant traction among researchers due to its ability to analyze huge amounts of transaction data to identify indirect tax evaders who provide false tax return information, detect corporate tax fraud, and facilitate tax authorities in reducing the expenses of audits while recovering revenue loss. Cloud computing offers information technology infrastructure to the tax authorities for monitoring real-time transactions and the identification of suspicious groups involved in cross-border activities.

Fig. 7 demonstrates a treemap of the top 50 Author's keywords. The figure provides an overview of the terms used, offering insights to researchers for identifying opportunities and potential areas for future research. Keywords such as neural networks, deep learning, clustering, and genetic learning indicate that some previous work has been done around these techniques and also highlight the potential for future research in cloud computing, blockchain, and Generative AI (autoencoder) to identify unusual patterns that may indicate evasion in large and unlabelled datasets. Terms like *value-added tax, personal income tax, labour inspectorate,* and *agriculture* application show the wide range of contexts to explore tax evasion.

4. Proposed *TELSE* Framework

In today's hyperconnected world, new-age technologies are significantly aiding tax authorities in detecting tax evasion. Despite the potential of these technologies, integrating them into tax administration to combat tax evasion poses several challenges related to privacy, accuracy, explainability, transparency, and sustainability. Therefore, it is essential to comprehensively understand and explore the implications of these technologies from multiple perspectives. In our study, we have introduced a comprehensive *TELSE* framework to holistically capture and examine the technological, ethical, legal, social, and economic considerations manifested in the application of new-age technologies to combat tax evasion that address the research question RQ 5 of our study. Fig. 8 shows the proposed *TELSE* framework.

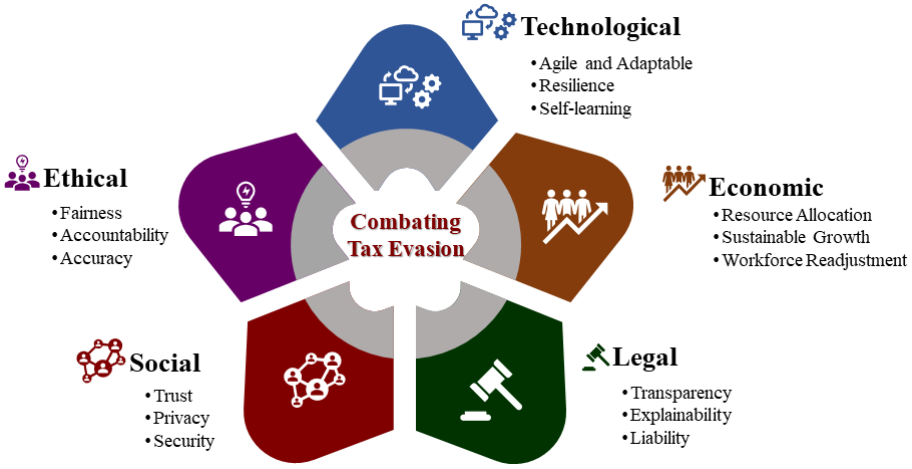

Fig. 8. *TELSE* implications of new-age technologies to combat tax evasion

4.1 Technological Implications

The expeditious advancement of new-age technologies to detect tax evasion has reshaped the dimension of tax administration. These advancements underpinned several technological implications that encompass agility and adaptability, resilience, and self-learning.

The need for agility and adaptability in deploying new-age technologies in tax systems to combat tax evasion is indispensable and arises from various factors such as market volatility, changes in tax laws, economic shifts, technological advancements, and more [46]. The ubiquitous growth of the digital economy affects the earning pattern of the taxpayer and gives rise to the shadow economy [47], cross-border investments [48], and digital currencies like cryptocurrencies thus, provides various opportunities for taxpayers and businesses to evade tax [49]. Also, the changing patterns in recent tax laws and amendments, such as tax rates and deductions, can impact the investment decisions of the taxpayers [50]. This all necessitates that the tax system should be agile and adaptable to various changes [51], swiftly integrate these changes in real-time, and predict instances of evasion patterns tailored to diverse taxpayer profiles, thus improving the accuracy, efficiency, and responsiveness of the intelligent system in the dynamic environment.

Resilience in the intelligent tax system is the ability to respond smoothly during pressure [52]. In today's fast-evolving structure of society and global economy, large firms also deploy these technologies for evasion tactics that exploit legal loopholes [53]. Economic crises such as inflation and recession exacerbate these challenges by impacting taxpayer employment and investment decisions, complicating tax enforcement. The growing volume of both structured and unstructured data and the proliferation of the complex nature of the business model necessitates resilience in the system. During COVID-19, countries faced the profound challenge of adapting to new relief measures and increased data [54, 31]. Several attempts have been made by different countries across the world. One notable example is Germany, which built resilience into its tax system to respond to economic relief and handle digital tax filings while maintaining data integrity [55]. Therefore, it is a crucial technological implication that helps tax authorities to incorporate new features while effectively countering evasion tactics. Also, updating and securing the system against

cybersecurity threats provide robustness and responsiveness to the system against evolving tactics. Moreover, self-learning mechanisms allow these new-age technologies to learn from their outcome and augment their capability to perform better. Ensuring resilience and self-learning mechanisms in the intelligent tax system helps authorities deploy other new-age technologies and integrate them seamlessly into the existing systems to uphold effectiveness in detecting tax evasion.

4.2 Ethical Implications

The ethical implications of adopting new-age technologies in tax administration are both profound and multifaceted, encompassing accuracy, fairness, and accountability.

The attention of developers in the tax administration is predominantly focused on the efficiency and accuracy of the system [56]. Accuracy refers to the system's ability to correctly identify instances of tax evasion without misclassifying legitimate taxpayers [57]. It is crucial because incorrect determinations can lead to wrongful accusations or missed cases of evasion. The literature has criticized the Wisconsin Supreme Court in the US for a conviction based on a risk assessment report derived from the Correctional Offender Management Profiling for Alternative Sanctions [58] and pointed out that the court has focused more on data quality standards which set a low bar for predicting risk assessment [59, 60]. If a system is not accurate, it may flag legitimate taxpayers as fraudulent, thus leading to potential financial harm, reputational damage, and legal battles.

Along with accuracy, fairness in new-age technologies to combat tax evasion is also important. The efficient and accurate system of taxation can also produce errors due to inadequate design of the system, reliance on biased data due to imbalanced datasets that represent the population's demographics, or the process of flow of information [61]. These issues can inadvertently impact taxpayers which leads to unfair treatment. It is also a fundamental principle in a democratic society that treats individuals equally without discrimination in behavior, race, gender, income, demographics, or geography [62]. In the US, the Internal Revenue Service audited income tax, and there was a higher rate of auditing lower-to-middle-income earners than high-income earners due to bias in their algorithm [63]. The unfairness in the system not only undermines public trust but also creates inequitable access to public resources in society. When taxpayers perceive it as unfair, it can exacerbate tax evasion and erode public trust.

Another ethical implication of new-age technologies in tax administration is related to accountability which pertains to who is responsible for actions and decision-making towards the tax enforcement actions [64]. The new-age technologies in tax administration introduce various obstacles related to constitutional rights and legal certainty [65]. Thus, there must be accountability for the compliance actions. In tax administration 3.0, there are different stakeholders, which include tax authorities, developers, and taxpayers, to make the unfair decision contestable, interpretation and explanation of the decision-making of the tax system are paramount to ensure accountability and build trust in the system, ensuring that the automated detection of tax evasion adheres strictly to the principles of the rule of law.

4.3 Legal Implications

Tax secrecy is a critical concern for tax authorities globally and involves the protection of collected confidential information by tax officials and varies by country [66, 67]. In countries like Chile, Peru, Brazil, Colombia, Ecuador, Argentina, and Mexico, the tax administration does not disclose the design, development, or implementation of new technologies for auditing taxes and detecting tax fraud [68]. Similarly, in Germany, tax authorities use automated systems for risk assessment in tax audits and operate under a veil of tax secrecy, preventing taxpayers from understanding how a case will be classified as low risk or high risk, either before or after-tax assessments [69]. Furthermore, the deployment of these technologies introduces complexities due to the "black box" effect, where systems generate insights without transparently disclosing their internal decision-making processes to the tax authorities and developers also due to the complex nature of mathematical models [70]. This opacity obscures how decisions are made when auditing a taxpayer or taking enforcement actions without clear reasoning [71].

In legal terms, transparency is a fundamental principle and a human right to receive information from public administration unless the secrecy of such information is essential to the safety of the state [72]. Thus, it necessitates to explain the requirements in the decision-making process to protect human rights. This lack of transparency leaves taxpayers in the dark and raises important concerns regarding human rights and is compromised when tax authorities fail to provide clear explanations of how new-age technologies function in tax authorities.

Explainability becomes crucial for tax authorities to pass the proportionality test, ensuring that the use of new-age technologies in preventing tax fraud is not excessively intrusive. In that regard, it can be argued that if the system is explainable and justified, then taxpayers are aware of risk-assessment criteria or function; they could reverse engineer the function and escape tax inspection despite being involved in tax fraud [69]. Also, it can be argued that secrecy in tax leads to legal challenges to justify the decision of these technologies and ultimately puts a question on tax authorities' decision-making. There is a need to create a delicate balance between maintaining secrecy within the tax authorities to prevent tax evasion and ensuring taxpayers' rights are not violated.

Another major concern that arises from the deployment of new-age technologies is liability. When tax administration produces false decisions that can harm taxpayers' rights, they must be held liable for the decision-making. The Dutch Childcare benefits scandal is a strong example of the potential harm to welfare recipients. In 2021, Dutch tax authorities used a risk assessment system where flawed algorithms led innocent, wrongly accused taxpayers into substantial debt of 2 billion to detect overpayments [73].

In light of this, numerous countries globally have established legal frameworks to govern the storage and utilization of individuals' data in digital formats [74]. At the European Union (EU) level, this has evolved into the General Data Protection Regulation (GDPR) to address the scenarios involved in the processing of data related to natural persons, thereby excluding certain aspects related to corporate taxpayers within the tax domain [75]. This regulatory framework is heralded as the cornerstone of the AI Act to govern AI systems in Europe [76]. However, the widespread use of advanced technologies in tax administration falls outside the scope of these regulations for the development of the system.

4.4 Social Implications

The new-age technologies in tax administration designed to combat tax evasion have introduced a host of social implications. Over the past few years, it has become increasingly evident that social values such as privacy and security are at risk, leading to a growing sense of distrust in these systems within society [77].

Trust is a critical factor in the relationship between tax authorities and taxpayers, and these technologies can either bolster or erode this trust [78]. On the one hand, providing clear explanations of how decisions are made—why certain individuals are targeted for tax audits, which factors contribute to this decision, and how their compliance is assessed—will strengthen trust [78]. This transparency can lead to better integration of such systems, enhancing their reliability in combatting tax evasion within society. Taxpayers are more likely to perceive the system as legitimate and equitable, thus fostering greater public confidence in the objectivity of tax enforcement. The opacity resulting from biased data, flawed system design, and tax secrecy within tax administration can severely undermine trust [79]. Tax secrecy does not treat all taxpayers equally. The opacity in decision-making creates fears of arbitrary or biased outcomes. Larger firms, with access to sophisticated tax consultancy services, can successfully analyze the system's functioning, often in exchange for monetary remuneration, and exploit the system to their advantage while ordinary taxpayers, left uninformed, remain vulnerable [80]. This asymmetry in access to information not only diminishes trust but also exacerbates social disparities, ultimately undermining the social contract between taxpayers and tax authorities [81].

The taxation system, which often relies on new-age technologies around the world, makes the necessity of using a large volume of data rather than a choice [82]. This data is drawn from a variety of data sources of personal data, ranging from financial transactions to social media activities. In 2021, the French regulator issued a decree to all French tax authorities to collect data from online footprints for evidence of tax fraud [83]. Additionally, the UK tax authority, HM Revenue and Customs (HMRC), has been analyzing large datasets and connecting cross-reference taxpayers' information from multiple sources, including social media, bank accounts, and travel records, to identify discrepancies between declared income and spending history [84]. The UK tax authority was able to recover GBP 3 billion in taxes that would otherwise have been lost due to tax evasion [85]. These case studies show that digital footprints are being captured to analyze patterns. Taxpayers might not expect to be subject to such scrutiny, and the pervasive nature of such surveillance raises concerns about the privacy of taxpayers' personal and sensitive information by tax authorities. While it is true that mere knowledge of being monitored can lead to increased tax compliance due to fear of detection, the intrusive capturing of taxpayers' digital footprints erodes public goodwill towards government agencies [86]. In democratic societies, the right to privacy is a fundamental right, and any encroachment in the name of tax enforcement must be balanced [87].

Another enormously increasing area of great concern is regarding the security of personal and financial data. As new-age technologies handle an enormous quantity of sensitive information, they introduce concerns related to cybersecurity risks while detecting tax evasion [88]. In 2015, the US Internal Revenue Service was targeted, and hackers allegedly gained access to over 700,000 taxpayers' data. Such breaches not only compromised the financial security of individuals but also undermined the credibility of tax authorities [89]. Any failure to safeguard personal information can result in societal disruption as the public's confidence in protecting sensitive information from the government is fragile. Additionally, it introduces the threat of manipulating the algorithms to avoid detection or target specific groups unfairly, thus creating bias in tax administration.

4.5 Economic Implications

The emergence of new-age technology is not merely reshaping the detection of tax evasion but also refining the economic dimensions across the world, which include workforce readjustment, resource allocation, and sustainable growth of any country. Traditionally, tax systems were based on manual auditing and manual services; however, the advent of new-age technology in tax authorities is shifting towards automatic auditing and e-services to detect tax evasion [90]. New-age technologies in tax administration disrupt the tax workforce, and there is a significant surge in management positions and developers predominantly to design and deploy these technologies to reshape the tax authority [91]. As low-skilled and clerical jobs are fading, it is also crucial for tax authorities to transition into new roles and make significant efforts to upskill and reskill the workforce to adapt more technologies and efficiently work the system [92], as human intervention is necessary to ensure transparent and fair decisions by algorithms to protect the harmony of taxpayers' rights [93].

These new-age technologies will also aid tax authorities in managing and allocating their resources more effectively and efficiently to combat tax evasion more accurately. These technologies are resource-intensive, making them impractical for low- and middle-income countries that could otherwise gain from the advantages of these technologies in detecting tax evasion and exacerbating the risks of regulatory measures [94]. The shift towards

automation can lead tax authorities to potentially invest in more technological infrastructure to develop a more reliable and accurate tax management system for detecting tax evasion [95]. While initial investments can be high, achieving the goal of better tax revenue management can justify the cost. Additionally, reskilling and upskilling the workforce to encourage innovative thinking, complex problem-solving, adaptability to technological advancements, and a focus on high-value activities and in-depth investigations is crucial for identifying various taxpayer behaviors and factors responsible for tax evasion [96].

The deployment of these technologies drives sustainable economic growth by improving tax compliance and fostering an efficient tax system that aligns well with the principle of sustainability [97]. These can enhance tax revenue collection, decrease tax evasion, and promote more significant investment in public services and infrastructure for long-term economic stability. It will significantly contribute to the country's sustainable growth of the country and can create a more transparent and fairer environment in society [98]. Increased tax revenue through these technologies can also provide opportunities to reinvest in Sustainable Development Goals (SDGs), supporting economic objectives and promoting technology where benefits are distributed equally, directly influencing the SDGs [99].

5. Discussion

The emergence of global technological advancements and the digitalization of tax administration opens up future research avenues for tax authorities to detect and prevent tax evasion more effectively. Our analysis highlights that while slight efforts have been made in this field, there remains a substantial potential for further exploration and research. Integrating new-age technologies like AI, machine learning, and deep learning in tax administration systems shows promising advantages in enhancing tax compliance and uncovering fraudulent activities.

Our exploration into this domain reveals that the research of new-age technologies has traditionally favored supervised machine learning algorithms like decision trees, bayesian networks, regression, etc. [100, 101] to classify instances of tax evasion. However, the scarcity and complexity of labeled data (ground truth information) pose a significant challenge and require multiple labeling methods and extensive expert knowledge. In light of this, the researchers are increasingly pivoting their attention towards the adoption of unsupervised learning (clustering, latent Dirichlet allocation, association rule mining, etc.), hybrid approaches, deep learning, and other new-age technologies such as active learning, transfer learning, blockchain, and generative AI to enhance the detection of tax evasion.

One of the major challenges in developing an effective and efficient intelligent taxation system is the unavailability of public datasets. The data must be collated from different sources like financial and bank transactional data, web activity logs, public records, and social network data. New-age technologies enable tax administration to build intelligent models and algorithms to identify taxpayer behavior and effectively detect tax evasion from these diverse sources. Another primary concern of these systems is the class imbalance problem in the data where the distribution of the dataset is biased towards the non-fraudulent cases, which may affect the performance by biasing the algorithms towards the majority class [102]. Therefore, there is a need to develop a computationally robust and resilient intelligent system that can handle multimodal data from diverse sources and can predict fraudulent cases by addressing class imbalance problems.

Our examination of the *TELSE* framework reveals the multifaceted consequences of new-age technologies to combat tax evasion and offers significant implications for developing intelligent systems. Our study highlights a pressing need for a globally unified regulatory framework to protect the harmony of taxpayer rights amidst deploying these technologies to detect tax evasion in democratic societies. The policies and regulations must establish precise levels of abstraction tailored to their needs to provide the explainability of these systems to relevant stakeholders, including taxpayers and judicial authorities, to contest the outcomes. This will reflect transparency in the system and is crucial to prevent the reengineering that might circumvent detection mechanisms, thereby enhancing the system's integrity. Moreover, policies must mandate detailed documentation of data collection processes to uphold data privacy and security and establish robust accountability mechanisms to effectively address the affected parties.

Our findings further emphasize the necessity of proper oversight mechanisms, asserting that humans should remain in the "driver's seat" in high-risk systems for the smooth functioning and reliability of the system [93]. It is also important for maintaining both within and beyond the technological loop and will ensure the correct interpretation of outcomes and foster trust in the system. Reduced human intervention will increase the risk of errors, highlighting the importance of human oversight in managing and interpreting complex outcomes.

To stay ahead of these technological advancements, developing a delicate understanding of these new-age technologies is indispensable. In the context of tax administration, tax authorities should prioritize the reskilling and upskilling of professionals to manage and operate the systems effectively. Similarly, taxpayer education should also focus on the functionality of these systems and their rights to have smooth interaction with the technology. Additionally, judicial bodies must be well informed about the functioning to make decisions if taxpayer rights are compromised, and the reliability and efficacy of the tax administration system can be enhanced.

6. Conclusion

Our research is a pioneering attempt to perform a scientometric analysis of new-age technologies in detecting tax evasion and mapping the evolving research landscape within tax administration 3.0 through the multifaceted lens of technological, ethical, legal, social, and economic perspectives. Our findings underscore that this interdisciplinary research field has substantial potential for future research endeavors. The limitation of our scientometric analysis is the reliance on two major databases, Scopus and WoS, to analyze the high-quality research publications in this domain. However, these databases may not comprehensively cover all relevant publications and may intentionally exclude potential research from non-indexed journals and conference proceedings.

Our analysis of the *TELSE* framework underpins notable global regulatory gaps in the domain of tax administration, considering the profound implications for multiple dimensions of society. Our study highlights the various challenges and consequences emerging within tax administration. While these obstacles are substantial, they are not insurmountable. These challenges can be addressed by coordinated efforts from the international research community and policymakers to establish standardized guidelines that account for the multidimensional aspects of tax evasion and the protection of taxpayer rights. International regulatory standards have yet to catch up with these technological advancements within tax administration. The EU AI Act of 2022 is pioneering by providing important guidelines for tax-criminal prosecutions in the digital revolution. However, significant efforts need to be deliberated to address all aspects of tax administration related to safeguarding human rights. These EU GDPR and AI Act will be a strong foundation for regulating legal policies to protect taxpayers' rights. Future research must focus on constructing a comprehensive regulatory framework both on a global scale and at the national level to foster trust in tax systems and safeguard human rights in the taxation system. Such a framework is essential for preventing disputes and strengthening public confidence, which would enhance tax revenue collection, provide equitable access to resources, and achieve goals of fairness and the SDGs within the society. Taxpayer trust would also help tax authorities collect more accurate data, thus leading to a more reliable and effective system that can predict accurately with fewer errors.

Tax secrecy and transparency represent two opposing yet essential elements within this area. Future research should aim to strike a balanced approach between tax secrecy and explainability to reflect transparency within tax administration in the legal sphere to mitigate the harm to taxpayers. In addition, researchers should also explore the deployment of other new-age technologies, such as the Internet of Things (IoT), cloud computing, blockchain, and generative AI, and the unexplored key drivers that perpetuate tax evasion to develop a more reliable, transparent, and intelligent system.

Our study would serve as an opportunity to promote cross-disciplinary learning among researchers, policymakers, and stakeholders by bridging the gap between new-age technologies and their application in taxation systems. This approach will help to ensure that technological advancements align well with technological, ethical, legal, social, and economic dimensions to combat tax evasion.

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