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Data analytics and efficiency of value-added tax revenue generation in Nigeria

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ABSTRACT

The efficiency of Value-Added Tax (VAT) revenue generation serves as a vital and stable source of income for the Nigerian government, particularly in addressing the fiscal gap created by fluctuating oil revenues. Despite this, the government has not fully harnessed the potential of VAT to deepen revenue generation. Existing studies highlight that the application of data analytics tools presents opportunities to enhance VAT efficiency in the country. This study investigated the impact of data analytics on the efficiency of VAT revenue generation in Nigeria using a survey research design. The target population, estimated at 2,000,000, comprised staff of the Federal Inland Revenue Service, professional accountants, tax consultants, and individuals knowledgeable in data analytics and tax matters. A sample of 400 respondents was determined using Taro Yamane's formula, with purposive sampling applied for participant selection. Data were collected using a structured questionnaire, and the instrument's validity and reliability were established through KMO and Bartlett's tests, with Cronbach's alpha values between 0.798 and 0.880. A 96% response rate was recorded. Descriptive statistics showed strong agreement on the positive effect of data analytics, while regression results confirmed a significant impact on VAT efficiency. The study recommended prioritizing VAT efficiency enhancement to boost government income.

Contribution/ Originality: This study provides a novel contribution by empirically examining the effect of data analytics on the efficiency of value-added tax revenue generation in Nigeria, where inefficiencies, tax evasion, and limited databases and data analyses have been major challenges. This study affords opportunities for tax administrators and taxpayers to leverage data analytics technologies to collect, process, and analyze large amounts of structured and unstructured tax data from value-added tax revenue generation in Nigeria.

1. INTRODUCTION

The efficiency of value-added tax revenue generation is of great importance for several reasons, given the need for increased tax revenue for the government, Nigeria's ongoing fiscal challenges, dependence on oil revenue, and the pursuit of economic diversification. Ihenyen, Buseri, and Okoro (2022) opined that the efficiency of value-added tax revenue will deepen the fiscal sustainability and revenue diversification of Nigeria, suggesting that the country's fiscal health has been threatened by unstable global oil prices, which had hitherto dominated the revenue base in Nigeria. Hence, efficiency in value-added tax revenue as a consumption tax provides a more reliable, stable, and predictable

non-oil income revenue than oil revenue. Studies have shown that the value-added source of income offers the Nigerian government insights to reduce its dependence on unstable oil income and, at the same time, promote a more balanced revenue portfolio in line with the Nigerian National Development Plan of 2021-2025 (Ajuonu & Anizoba, 2024; Busayo et al., 2023). Incidentally, despite the crucial role and strategic position of value-added tax as a source of income, the efficiency of value-added tax revenue generation has been complex and problematic in Nigeria.

Literature has argued that there are factors impacting the effective efficiency of value-added tax revenue generation in Nigeria (Aguguom, Appolos, Obasi, & Ajah, 2023; Chiamaka, Obinna, Friday, & Oraekwuotu, 2021). Bari, Khan, and Ullah (2022) posited that administrative deficits reduce enforcement capacity, enabling widespread tax evasion and non-compliance, especially among high-net-worth individuals and corporations who can exploit legal loopholes. Due to difficulties in enforcing direct taxes, many African nations rely heavily on indirect taxes, such as value-added tax (VAT) and customs duties. Although VAT is easier to collect, it often disproportionately impacts low-income households, potentially worsening income inequality (Abbasi, Hussain, Radulescu, & Ozturk, 2022; Bassongui & Houngbédji, 2023). Technological barriers further complicate tax revenue generation. Many African tax administrations lack modern digital systems for tax filing, record-keeping, and compliance monitoring. This technological gap restricts authorities' ability to improve taxpayer registration, track incomes, and detect irregularities (Bruno & Emmanuel, 2019). Despite Rwanda's progress in digital government services, including electronic tax filing, challenges remain in ensuring universal adoption among businesses, particularly in rural areas.

Furthermore, the diverse challenges in the efficiency of tax revenue generation in Nigeria include incompetency, corruption, revenue diversions, lack of tax equity and fairness, poor utilization, inadequate technology, weak data and information systems, and inconsistent tax policy and legislation (Adefulu, Makinde, Akinyosoye, & Nwankwere, 2024; Adegbie & Akinyemi, 2020; Hamisu & Akintoye, 2023). A recent survey carried out by Desi, Smith, Kumar, and Lee (2023) and Emuebie, Ogundeyi, Chukwu, and Akintoye (2023) showed that over half of the respondents agreed with the statement that, "If I were not caught, I would not pay my taxes." Thus, suggesting that only the policeman approach tends to motivate taxpayers to pay taxes in Nigeria. Egiyi and Udeh (2020) noted that up to 5% of Nigerians think that tax evasion is acceptable, and said that even if it is wrong, it makes sense to avoid paying taxes as there is zero evidence of tax optimality in Nigeria. Oladipo, Nwanji, Eluyela, Godo, and Adegboyegun (2022) observed that, to put it simply, the loop keeps feeding itself. At first glance, it appears that both sides benefit from the arrangement: citizens pay fewer taxes, and the government has few checks on the form of government it has chosen. Nonetheless, there is a significant opportunity cost associated with the taxes avoided due to residents' insufficient political engagement. While Ogunmakin and Owoniya (2022) argued that a government that suppresses all forms of dissent, is hard to live with, is unresponsive to the needs and desires of its people, or at the very least, is not representative of those choices.

The Nigerian government has been fulfilling its obligations in this regard for some time, and in order to address these disparities, citizens must participate in tax payment and demonstrate civil responsibility obligations in all ramifications (Aguguom, 2019; Oladele, 2021). Nigeria's ambition of becoming one of the greatest economies in the world by 2030 will continue to be elusive if the country fails to completely embrace technology to reduce the level of direct interaction between taxpayers and tax authorities, thereby aiding in the detection of unethical behaviors. The deliberate neglect of sophisticated technologies and best practices in tax administration has further entrenched tax fraud, under-remittances, and corrupt practices, grossly impeding efficiency in tax revenue generation for the government (Oladele, 2021). Besides, data analytics has been adjudged to have the capacity and analytical tools to mitigate and solve the problem of efficiency in value-added tax revenue generation in Nigeria.

In addition, the strength and significance of data analytics and its emergence in enhancing operational efficiency in tax revenue generation are new developments in global taxation and are a welcome innovation in developing economies. The role of data analytics lies in its transformative potential across various industries, driving operational efficiency, cost reduction, and innovation. Nigeria's tax system has, over the years, lacked sufficient technologies and

innovations in tax administration. Adelusi (2022) posited that the era of data analytics has arrived for tax administration and collection due to the swift advancement of information technology. The widespread use of data has presented tax work with a number of obstacles in addition to previously unheard-of development potential (Aremu & Siyanbola, 2021; Odukwu, Eke, Effiong, & Karimo, 2023).

The efficiency of tax revenue generation in Nigeria has become increasingly critical due to the government's need to generate adequate funding to drive national development. Efficient tax collection mechanisms are essential for achieving fiscal stability, addressing budget deficits, and reducing dependency on external borrowing (Ashafoke & Obaretin, 2023). Inefficiencies in the tax system are evident in the collection and allocation processes, which result in revenue leakages, high administrative costs, and low compliance rates (Bari et al., 2022). Tax revenue generation efficiency, which involves maximizing collection relative to potential revenue, remains suboptimal due to inconsistent data management practices, limited taxpayer segmentation, and outdated revenue projection models (Busayo et al., 2023; Eneche, 2021). The Nigerian tax system, though showing gradual improvement, is characterized by reliance on manual procedures and incomplete data capture, hindering efforts to accurately forecast revenues and target high-yield revenue segments (Ganyam, Ivungu, & Anongo, 2019).

Research on the importance of data analytics and the effectiveness of value-added tax revenue generation in Nigeria is evidently limited because this appears to be a recent development with minimal empirical support for the impact of data analytics on VAT revenue generation in Nigeria. Although research has examined VAT from various perspectives, the relationship between data analytics and the effectiveness of VAT revenue generation in Nigeria is novel, leaving a significant gap in the literature. This research offers a new approach to bridging this gap and expanding the boundaries of knowledge. In light of the aforementioned and the aim to advance knowledge in the literature, this study investigated how data analytics affected the effectiveness of VAT revenue generation in Nigeria.

Hypothesis: Data analytics do not significantly affect the efficiency of value-added tax revenue generation in Nigeria.

This is how the remainder of the study was organized: The study provided a theoretical framework and literature review in section 2. The study considered methodology in section 3, and data analysis, results, and findings discussion were taken into consideration in section 4. The conclusion and recommendations were equally presented in section 5.

2. LITERATURE REVIEW

2.1. Conceptual Review

2.1.1. Efficiency in Value-Added Revenue Generation

The concept of efficiency in Value Added Tax (VAT) revenue generation serves as a critical proxy for the effectiveness of tax revenue systems in Nigeria, particularly in reflecting how well a government can collect due taxes from consumption-based transactions. Efficiency in VAT generation is often evaluated by examining the capability of the tax system to minimize gaps in VAT collection, streamline compliance processes, and improve collection methods, thus ensuring that the revenue collected aligns closely with the potential taxable base (Bunn, Asen, & Enache, 2020; Dibie & Raphael, 2020). An efficient VAT system supports the public revenue base without imposing excessive administrative costs, thereby enhancing tax sustainability. Rates of value-added tax differ (Abbasi et al., 2022). In line with the VAT Act, the exports are at a zero rate, meaning that the rates apply at zero, and input VAT can be claimed at 7.5% (old rate of 5%) for taxable items, while exempt items are not subjected to output VAT. The input VAT on VAT-exempt items is not available for offset, as exempt items are not covered by the output VAT credit mechanism.

2.1.2. Data Analytics

Data analytics is the process of examining, cleaning, transforming, and modeling data to extract relevant information, validate results, and support decision-making (Abdullah, Sanusi, & Savitri, 2022). Organizations now have the opportunity to transform tax data into valuable insights through data analytics. This enables them to analyze

the extensive transactional data stored in their systems, identify underpaid and overpaid taxes, and uncover untapped business opportunities (Ashafoke & Obaretin, 2023; Bari et al., 2022). Taxpayers as well as tax authorities can keep control of their tax procedures, recognize dangers, and take advantage of opportunities by easily obtaining data pertinent to tax. Organizations are using tax data analytics to examine their tax data, uncovering hidden hazards as well as unrealized benefits and financial returns, and the development of the tax function as a vital value resource at the core of corporate decision-making might result from the early identification of such possibilities and hazards (Arli, van Esch, Bakpayev, & Laurence, 2021; Bassongui & Houngbédji, 2023). Bunn et al. (2020) stated that data analytics is creating huge opportunities for tax authorities in expanding the horizons, providing timely and accurate data analytical possibilities. By using cutting-edge technologies to evaluate financial data, tax data analytics helps professionals make wise judgments, spot areas for tax savings, and guarantee adherence to constantly evolving tax regulations. Data analytics provides a thorough understanding of an organization's tax situation and any hazards by converting raw data into actionable information, and adopting tax analytics entails going beyond conventional, manual tax preparation techniques for both individual donors and finance leaders (Bokhari & Myeong, 2022). It entails implementing systems that reduce errors and save significant time by automating data gathering, processing, and reporting.

2.1.3. Data Integration Capability Analytics

Data Integration Capability Analytics (DICA) refers to the ability of an organization to systematically combine, process, and harmonize data from various sources to enhance decision-making, streamline operations, and foster a holistic understanding of activities (Chen & Nath, 2018). In the context of tax administration, DICA enables tax authorities to consolidate diverse data from various taxpayer sources and channels, improving the accuracy and efficiency of tax assessments and compliance monitoring (Okunola & Eleojo, 2021). Data integration supports tax agencies by ensuring that information across departments is consistent, thereby facilitating more accurate taxpayer profiling, improving compliance predictions, and contributing to efficient tax revenue generation (Azubuike, Edeh, & Okafor, 2019). Data integration capability analytics is the extent to which tax-related data are combined using digital enhancement skills to improve tax revenue generation (Feng, 2021). Data integrated capability analytics entail the possibility of allowing tax authorities to adopt digital tools to handle their tax procedures, and these procedural resources will eventually shape the requirements for fast, high-quality data analysis and reporting (Gbenga, Adeyemi, & Ibrahim, 2020; Gusc, Novak, & Smith, 2022). Specifications, in addition to influencing its capacity to make a more calculated contribution to the overall tax computation, the tax authorities must participate in data budgeting, analytical, and management projects comparable to those of other roles in the business.

2.1.4. Taxpayers Behavior Prediction Analytics

Taxpayers' behavior prediction analysis (TBPA) is the application of an analytical aided system to make a predictive and near-accurate assessment of taxpayers' reactiveness and behavior in terms of tax compliance using past events (Qin & Lin, 2022). According to Rahayu (2024) taxpayers' behaviors are unpredictable and significantly affect tax revenue generation. However, with artificial intelligence and the application of data analytical tools, there are possibilities to consider taxpayers' behavior prediction in enhancing tax compliance. The taxpayer behavior predictive and adaptive behavior model deepen the efforts to eliminate disparities in interactions between taxpayers and government agencies, which can lead to increased compliance. According to Raikov (2021) taxpayers need to be understood as the understanding and opinions of both parties (Taxpayers and the tax authorities) and the government can be greatly influenced by their impressions of how the government treats them in comparison to others. Both the group benefiting and the people's relationship with the government may be impacted if a group is given preferential treatment by the government. Therefore, the treatment of a person by the government toward other members of the broader national community is just as significant as the government's treatment of the individual. Two examples that

demonstrate this perception are the treatment of each taxpayer and the connection between other people's tax burden and compliance behavior (Al-Sayyed, Hassan, & Yaseen, 2021; Rathi, Sharma, & Singh, 2021).

2.1.5. Taxpayers Database and Segmentation Analytics

Taxpayer database and segregation analytics in this instance entail a sufficient digital system that provides and updates a detailed breakdown of taxpayers' information as and when required (Iqbal, Hussain, & Khan, 2020). Globally, there is an increasing need for accurate and comprehensive taxpayer databases. Many forward-thinking governments in developing nations recognize that creating a robust database of this kind is equivalent to creating a goldmine for self-sufficient income generation (Hermanto, Nugroho, & Wicaksono, 2022). The foundation of tax data mining, improved insights into compliance trends, and computerized taxpayer services is an effective taxpayer database. The urgency of its implementation by subnational governments is reinforced by numerous other advantages. For example, centralization and communication with data banks regarding other facets of governmental decision-making would be necessary for an effective taxpayer database for data mining purposes (Kayser, Nehrke, & Zubovic, 2018). The achievements of other important metrics in the state or local government economy sectors can then be linked to tax compliance, and the level of availability, interaction, and connectivity between various hosted data is increased by database centralization. Increased attention is also necessary, especially in the areas of safety and security, as revenue agencies may easily and more effectively manage growing amounts of data with a properly configured taxpayer database (Jalles & Gupta, 2022; Jia, 2020).

2.1.6. Accuracy of Tax Revenue Projections

The accuracy of tax revenue projection is defined as the means by which the tax authorities' forecast or expected tax revenue generation aligns with the actual tax revenue collected during a specified fiscal year. Accuracy in tax revenue projection is essential for effective budgeting, fiscal planning, and ensuring the sustainability of government tax revenue programs. The lack of accurate tax projections has been a hallmark of challenges in tax revenue generation, creating an unhealthy landscape for accurate budget implementation when the government experiences poor tax revenue in Nigeria. Consistent with the foregoing, Najib and Badamasi (2021) stressed that If there is a chance for increased revenue, computer technology and political resolve to enforce tax collection must be united. Technology alone will not increase revenue unless it is accompanied by enforcement measures. A master file system can be developed with the aid of computer technology. Every taxpayer is given a unique number by the system, and the master file may thus develop into a crucial auditing tool.

2.1.7. Digital Data Processing and Reporting

Digital data processing and reporting is the process of collecting and translating raw data into information and reporting same on a timely manner (Hanrahan, 2021). Revenue agencies have made great strides in digitizing and reporting their long-standing procedures within the last ten years. New technologies, however, are opening the door to a far simpler and less onerous tax system for taxpayers. Digital data processing and reporting are new innovations in tax administration that entail tax revenue generation transformation, which will lead to a new understanding and a rethinking of the procedures required to compute and pay taxes that are integrated into the hardware and software that taxpayers use (Adu, Mensah, & Osei, 2019; Ahannaya, Obi, & Eze, 2022).

2.2. Theoretical Framework

2.2.1. Benefit Received Theory

The benefit-received theory, proposed by Hoffman (1961) is predicated on the idea that there ought to be a positive exchange relationship between the government's provision of services and the benefits that taxpayers can derive (Olschewski, Rieskamp, & Scheibehenne, 2018). According to Owens and Hodžić (2022) and Peng (2015) the

State is a supplier of certain products and services to the general public; however, its share of the cost of these supplies may not always match the benefits to the public. Framing tax efficiency through the lens of benefits received provides a pathway for improving taxpayer relations and engagement. The benefit received theory was considered the underpinning theory for value-added tax revenue generation in this study because the entire concept of governance and tax principles is to benefit from tax revenue performance and for the government to maximize tax revenue for the benefit of taxpayers and the entire citizens. This is based on firms, corporate taxpayers, and businesses effectively using the opportunities created by the government for profit maximization and the benefit of the firms and all stakeholders. In this regard, tax revenue generation is obedience to civil duties and for the benefit of taxpayers and all stakeholders who are directly or indirectly affected by the extent of tax revenue generation and the economic fortunes or misfortunes of the taxpayers. Additionally, the benefit received theory offers a perspective on the signal of civil responsibility, emphasizing the linked interactions between voluntary or enforced tax compliance and the creation of enabling incentives and simplified tax laws capable of generating sufficient tax revenue.

2.2.2. Theory of Disruptive Innovation

The Theory of Disruptive Innovation is founded on the principle that technological advancements can reshape markets by creating new consumer demand while challenging established incumbents. According to Gupta, Jalles, and Liu (2022) disruptive innovations are generally lower-cost and simpler solutions that initially serve niche markets or underserved consumers. Over time, they improve and often displace established competitors. Supporters have credited the distinctiveness of innovation as natural and expected since there is no stagnation line and humans are insatiably seeking new ways of doing things (Abugu, 2015; Yokoyama, 2023). In contrast, the applicability of disruptive innovation has been questioned in highly regulated sectors, where the barriers to entry are substantial, such as in public taxation systems (Ogunmakin & Owoniya, 2022). The Theory of Disruptive Innovation is relevant in highlighting how data-driven technologies can challenge traditional revenue collection methods. Taxation authorities have historically relied on outdated, less integrated systems, which can hinder efficiency. The introduction of data analytics tools such as Taxpayers Behavior Prediction Analytics and Digital Data Processing could disrupt conventional systems by enhancing accuracy, streamlining processes, and potentially reaching underserved or non-compliant taxpayer segments. This alignment with disruptive innovation theory suggests a potential paradigm shift in revenue generation efficiency within Nigeria, a shift that is critical for modernizing tax systems in a digital age.

2.3. Empirical Review

Sadiq (2024) examined how digital accounting affected Nigeria's tax revenue. The study's design and relevant secondary data came from publications published by the Federal Inland Revenue Service (FIRS), the World Bank, and the OECD, as well as from statistical bulletins issued by the Central Bank of Nigeria (CBN) between 2002 and 2021. Digital accounting was represented by pre- and post-digitalization periods, while oil and non-oil taxes were used as stand-ins for tax revenue. The findings demonstrated a positive and significant correlation between Nigeria's oil and non-oil taxes during the study period and the pre- and post-digitalization eras. We therefore draw the conclusion that digital tax accounting has advanced. Similarly, Ajuonu (2023) investigated the impact of internet taxes as an accountability tool on Abia State's internally generated revenue. To determine the relationship between online tax adoption and internally generated income, online road taxes (ORT) and online direct tax assessment (ODTA) were employed as study proxies for online tax adoption. The National Bureau of Statistics (NBS) provided the data for the study, which employed an ex post facto design. Online road taxes (ORT), online direct tax assessment (ODTA), and internally generated revenue in Abia State are positively and significantly correlated, according to the study's findings, which were derived using the Wilcoxon statistical test tool.

Additionally, Mbise and Baseka (2022) assessed the impact of the digital tax administration system used by the Tanzania Revenue Authority's Tanga regional office on the compliance of SMEs. The researchers employed a case

study research design and a quantitative technique. Questionnaires were used to collect data from SME taxpayers. The study's analysis employed both descriptive and regression analysis to determine the connection between digital tax and compliance. The study used 133 randomly selected samples from 254 small taxpayers to represent the population. With a P value of 0.000, the regression analysis's findings demonstrated how important the digital tax administration system is to SMEs' compliance. Since studies showed a significant effect, the results also suggest that using technology in a digital tax administration system improves tax compliance. In the same manner, Ihenyen et al. (2022) investigated the effective use of information technology (IT) and tax administration at the Bayelsa State Board of Internal Revenue in Yenagoa, Nigeria. The study employed a descriptive research design. Only 65, or 93%, of the 70 tax officers who were polled via an online questionnaire responded. The data was analyzed using frequency counts, percentages, and the test statistic from the Statistical Package for Social Sciences (SPSS) version 23. The study found a strong and significant relationship between the Bayelsa State Board of Internal Revenue's use of information technology and its effective tax administration.

In addition, for the years 2006–2017, Nimer, Uyar, Kuzey, and Schneider (2022) looked into whether e-government services reduced the prevalence of tax evasion in the UK. Time fixed-effects panel data analysis was used to examine the data, and the results confirmed the value of e-government services in reducing tax evasion. The study looked at information technology's potential and limitations in terms of tax mobilization. The results showed that, in addition to reducing taxpayer compliance costs, e-government and technology had a substantial impact on tax payments and unofficial payments by changing the interactions between taxpayers and tax officials. Adegbie and Akinyemi (2020) examined the effects of electronic payment systems on Lagos State's revenue generation. The study's main objective was to ascertain how electronic payment systems affected Lagos State's ability to generate revenue. Data was collected using a questionnaire distributed to 366 workers of the six (6) selected revenue-generating companies in Lagos State. Data were analyzed using descriptive statistics, and hypotheses were tested using a multiple regression model with a 5% significance level. According to the analysis's findings, personal income tax was significantly and favorably impacted by the two electronic payment variables—automated teller machines and electronic fund transfers. The results of the multiple regression analysis demonstrated a significant influence on the amount of money that businesses with TIN were able to generate. The study found that e-payments had an effect on Lagos State's ability to generate revenue. As a result, they recommended, among other things, that a government agency's leadership style should be flexible and open to encourage further advancements.

Consistently, Ihenyen et al. (2022) investigated along with the design and problems they raise randomized control trials for tax policy which are similar to those frequently used for medical treatments. The research then examined studies that did not affect the overall amount of tax paid when compared to a control group but instead provided benefits for specific taxpayers.

The paper further explored several key aspects of experimentation, such as assessment techniques, as well as potential issues, most notably the difficulty in concealing a subject's placement in a treatment group, which may influence their behavior. The study found that many policies were scaled up for adoption using revenue-neutral tax experiments.

It is clear from the previous empirical reviews that none of these studies specifically examined how data analytics affected the effectiveness of value-added tax revenue generation in Nigeria, using the selected explanatory variables of digital data processing and reporting (DDPR), taxpayers behavior prediction analytics (TBPA), taxpayers database and segmentation analytics (TDSA), accuracy of tax revenue projections (ATRP), and data integration capability analytics (TDSA), as identified and used in our study. While earlier studies focused on value-added tax revenue, they did not investigate the implications and impact of data analytics in enhancing the efficiency of value-added tax revenue generation in Nigeria.

3. METHODOLOGY

A survey research design was employed in the study. As of October 2024, there were 11,181 employees of the Federal Inland Revenue Service (FIRS). Taro Yamane's formula was used to determine the sample size, which was calculated to be 400. Respondents with data analytics experience were selected using purposive sampling. A structured, validated questionnaire was utilized to collect data. The reliability coefficient of Cronbach's alpha for the constructs ranged from 0.80 to 0.88. The response rate was 94.34%. Data analysis involved both descriptive and inferential statistics, including multiple regression, conducted at a significance level of 5%. Data analytics served as the independent variable, while the efficiency of businesses in generating income tax revenue was the dependent variable.

3.1. Model Specification

The study of the functional relationship between data analytics and the efficiency of value-added tax revenue generation in Nigeria is considered as:

$$EVAT = f(DICA, TBPA, TDSA, ATRP, DDPR) \quad (1)$$

Econometric model is formulated as follows:

$$EVAT_i = \alpha_0 + \beta_1 DICA_i + \beta_2 TBPA_i + \beta_3 TDSA_i + \beta_4 ATRP_i + \beta_5 DDPR_i + \mu \quad (2)$$

Where: EVAT = Efficiency in value-added tax revenue generation, DICA = Data Integration Capability Analytics, TBPA = Taxpayers Behavior Prediction Analytics, TDSA = Taxpayers Database and Segmentation Analytics, ATRP = Accuracy of Tax Revenue Projections, and DDPR = Digital Data Processing and Reporting. i = Cross-section, α = Constant, β1-β5 = Coefficients of the model, μ = Error term.

The four hundred (400) members of staff, as obtained using Yamane (1967), was adopted to determine the sample size proposed for this study.

n= N/(1+n (α)^2)

Where:

n = Sample size.

N = Population size.

α = Level of significance.

n= 2,000,000/(1+2,000,000 (0.05) ^2).

n= 2,000,000/(1+5,000).

n= 399.92 ≃400 Respondents.

3.2. Reliability of the Research Instrument

To ascertain the reliability of the research instrument for this study, an internal consistency test was conducted on the questionnaire using Cronbach's Alpha reliability analysis with a suitable statistical tool, such as the Statistical Package for the Social Sciences (SPSS).

Additionally, the reliability of the instrument was verified by distributing a few questionnaires to the pilot sample and computing the coefficient alpha of the collected data. Before the questionnaires were distributed to the respondents, a sample was sent to the study supervisors for approval and review to ensure that the relevant and essential data had been collected.

Table 1 presents the results of the reliability test.

Table 1. Results of the reliability test.

Variables	No of items	Cronbach's alpha
Efficiency in value-added tax revenue generation	5	0.923
Data analytics	5	0.843
Taxpayers' behavior prediction analytics	5	0.915
Taxpayers database and segmentation analytics	5	0.954
Accuracy of tax revenue projections	5	0.877
Digital data processing and reporting	5	0.911

All of the variables' Cronbach's Alpha coefficients were found to be above the acceptable limit of 0.7 after the data was entered into the IBM Statistical Package for the Social Sciences (IBM SPSS), as 0.7 has long been recognized as a suitable reliability coefficient by Warithaka (2012). Consequently, the pilot test results indicated that the instrument is reliable because the Cronbach's Alpha value for each variable exceeds 0.70.

Table 2 presents the validity test (Factor analysis).

Table 2. Validity test (Results of the factor analysis test).

Variables	No of items	KMO	Bartlett Test *Chi² (Sig.)*
Efficiency in value-added tax revenue generation	5	0.837	331.022 (0.000)
Data analytics	5	0.882	277.142 (0.000)
Taxpayers' behavior prediction analytics	5	0.795	298.136 (0.000)
Taxpayers database and segmentation analytics	5	0.812	395.461 (0.000)
Accuracy of tax revenue projections	5	0.745	380.141 (0.000)
Digital data processing and reporting.	5	0.891	391.123 (0.000)

The variables used and the results of the KMO and Bartlett tests were displayed in Table 2. The tests showed that 0.7 > 0.7 and that all of the results were significant at the 5% significance level (Sig. < 0.05), confirming the sufficiency of the data. The Kaiser-Meyer-Olkin (KMO) test was considered valid if it was greater than 0.7 and the p-value was less than 0.05, as stated by Yoon, Kim, and Kim (2015). The supervisor of the researcher reviewed the research instrument to confirm the validity of the data.

4. DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.1. Descriptive Statistics

This section presents the descriptive statistics of the study, and the Table 3 displays the respondents' work experience and qualifications.

Table 3. Respondents work experience/Qualification.

Working experience		
Less than 5 years	255	9.7
5 - 10 years	134	16.7
10 & above years	11	16.9
Total	400	56.7
Educational qualification		
Diploma/ND/NCE	257	64.3
HND/BSc	132	33.0
MSc/M Phil	11	2.8
Total	400	100.0

4.1.1. Respondents Demographic Analysis

This distribution suggests inclusivity in responses and ensures that the perspectives analyzed are not skewed by gender imbalance. In terms of work experience, the majority of respondents (255 individuals) have less than two years

of experience, representing a significant portion of the sample population. Respondents with 5-10 years of experience account for 33.5% (134 individuals), while those with 10 or more years of experience constitute 2.8% (11 individuals). Regarding educational qualifications, 64.3% of respondents hold a Diploma, ND, or NCE, while 33.0% possess a Higher National Diploma (HND) or Bachelor's degree. A smaller proportion (2.8%) have attained postgraduate qualifications (MSc/MPhil). The demographic composition underscores the diversity within the sample while ensuring a broad representation of relevant perspectives.

Figure 1 presents the results of the histogram of standard residuals and normality test plots for the dependent variable of efficiency, as well as the normal P-P plot of the regression standard residual of tax-added tax (EVAT).

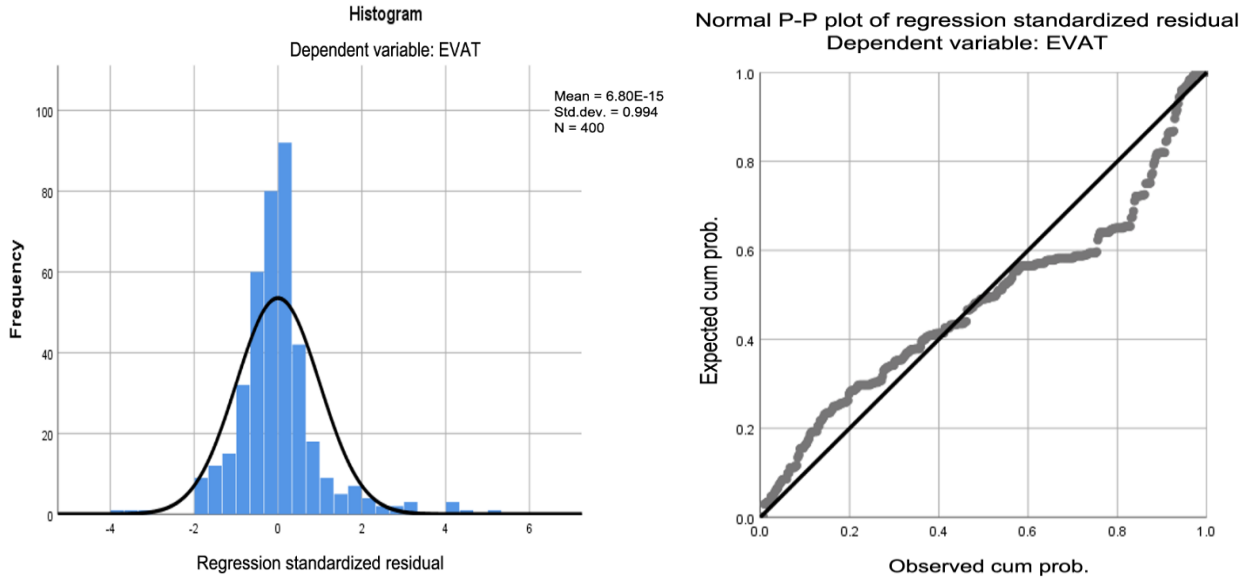

Figure 1. Histogram of Standard residual and Normality test plots.

4.1.2. Results of Normality Test

The normality tests conducted using histograms of standardized residuals and normal P-P plots for the models indicate that the regression residuals approximate a normal distribution. The histograms exhibit a bell-shaped curve, with residuals symmetrically distributed around the mean, suggesting minimal skewness or kurtosis issues. The P-P plots further confirm this observation, as the residuals closely follow the diagonal reference line, indicating that the assumption of normality is not significantly violated.

4.1.3. Result of Multicollinearity Test

The multicollinearity assessment in Table 4 employs Variance Inflation Factor (VIF) and Tolerance values to evaluate the degree of interdependence among the independent variables.

Table 4 presents the result of multicollinearity test.

Table 4. Result of multicollinearity test.

Variables	Collinearity statistics	
	Tolerance	VIF
Data integration capability analytics (DICA)	0.592	1.689
Taxpayers' behaviour prediction analytics (TBPA)	0.568	1.760
Taxpayers database & segmentation analytics (TDSA)	0.594	1.684
Accuracy of tax revenue projections (ATRP)	0.751	1.332
Digital data processing & reporting (DATR)	0.619	1.615
Average	**0.6248**	**1.616**
Dependent variable: Efficiency of value-added tax revenue generation.		

The results indicate that all VIF values range between 1.332 and 1.760, remaining well below the conventional threshold of 10, while Tolerance values exceed the critical limit of 0.1. These findings suggest the absence of severe multicollinearity among the predictors. Taxpayers' Behaviour Prediction Analytics (TBPA) exhibits the highest VIF (1.760) and the lowest Tolerance (0.568), implying a relatively stronger association with other independent variables. Conversely, Accuracy of Tax Revenue Projections (ATRP) has the lowest VIF (1.332), indicating minimal collinearity. The average VIF (1.616) further confirms that multicollinearity is not a concern in this model, ensuring the stability of coefficient estimates in subsequent regression analysis. Consequently, the predictors can be reliably included in the econometric estimation without the risk of distorted inference due to collinearity.

4.1.4. Result of Homoscedasticity Test

The scatterplots illustrate the relationship between the regression standardized predicted values of all the models. The distribution of data points in each plot provides insights into potential patterns of heteroscedasticity.

Figure 2 presents Respondents' responses to questions on efficiency in value-added tax.

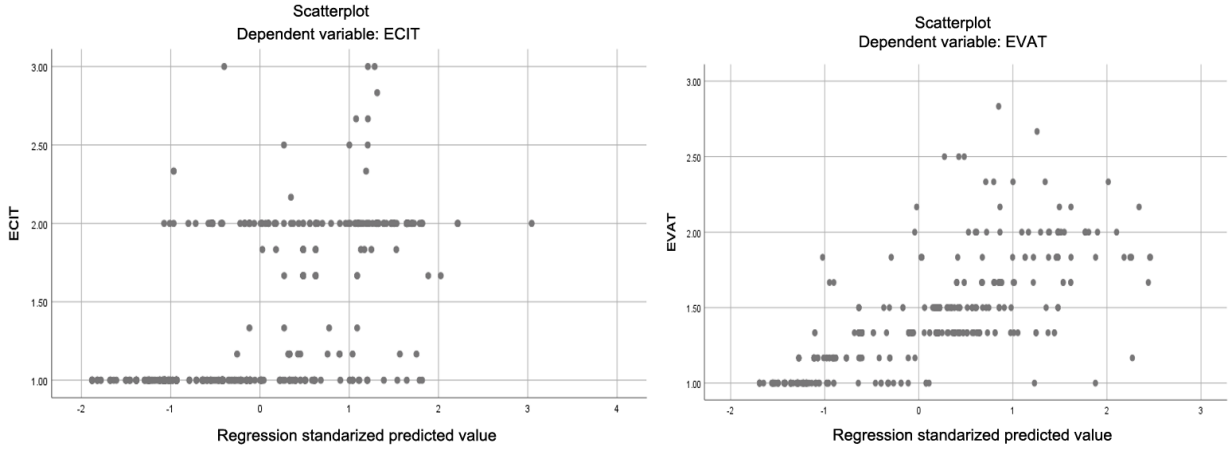

Figure 2. Respondents' responses to questions on efficiency in value-added tax.

Table 1 presents respondents' perceptions of the efficiency of VAT administration in Nigeria. The table highlighted the extent to which VAT processes, including collection, compliance, and enforcement, contribute to revenue generation. It examined whether improvements in VAT efficiency can enhance overall tax revenue performance.

Table 5 presents the respondents responses on efficiency in value-added tax.

Table 5. Respondent responses on efficiency in value-added tax.

Questions	SD		D		U		A		SA		Mean/SD	
	C	%	C	%	C	%	C	%	C	%	Mean	SD
Extent of data integration capability analytics tends to enhance the efficiency in VAT revenue generation in Nigeria.	0	0%	0	0%	10	3%	121	30%	269	67%	4.65	0.53
Tax collectors' knowledge of taxpayers' behaviour prediction can improve the efficiency in VAT revenue generation in Nigeria.	0	0%	0	0%	8	2%	157	39%	235	59%	4.57	0.53
Enhanced taxpayer's database and segregation analytics affect the efficiency in VAT revenue generation in Nigeria.	0	0%	0	0%	9	2%	132	33%	259	65%	4.63	0.53
Accuracy of tax revenue projection influences efficiency in VAT revenue generation in Nigeria.	0	0%	0	0%	6	2%	170	43%	224	56%	4.55	0.53
Digital data processing and reporting have the ability to enhance efficiency in VAT revenue generation in Nigeria.	0	0%	0	0%	5	1%	169	42%	226	56%	4.55	0.52
Data analytics could influence efficiency in VAT revenue generation in Nigeria.	0	0%	0	0%	7	2%	132	33%	261	65%	4.64	0.52

Table 5 demonstrates that respondents strongly agreed on the significance of digital processing, predictive modeling, and data analytics in enhancing the effectiveness of Value-Added Tax (VAT) revenue collection in Nigeria. With 67% of respondents strongly agreeing and 30% agreeing, the statement regarding data integration capability analytics received the highest level of agreement (Mean = 4.65, SD = 0.53). Similarly, 65% of respondents strongly agreed with the impact of taxpayer database segregation (Mean = 4.63, SD = 0.53) and the influence of data analytics on VAT efficiency (Mean = 4.64, SD = 0.52). Although slightly lower, other factors such as the accuracy of tax revenue projections (Mean = 4.55, SD = 0.53) and digital data processing (Mean = 4.55, SD = 0.52) also garnered high levels of agreement. The high degree of consensus among respondents is indicated by the consistently high mean values, ranging from 4.55 to 4.65, with relatively low standard deviations (0.52–0.53). The robustness of these findings is further supported by the absence of disagreement or strong disagreement. These results suggest that integrating advanced data analytics into VAT collection processes could significantly improve efficiency and revenue mobilization.

Table 6 presents the summary of multiple regression between data analytics and the efficiency of value-added tax revenue generation.

Table 6. Summary of multiple regression between data analytics and efficiency of value-added tax revenue generation.

	Model	B	SE	t-stat	Sig.	ANOVA (Sig.)	R	Adjusted R^2	F (5,355)
400	(Constant)	0.152	0.070	2.162	0.031	0.000	0.742	0.544	96.266
	DICA	0.205	0.041	5.051	0.000				
	TBPA	0.456	0.040	11.405	0.000				
	TDSA	0.022	0.033	0.675	0.500				
	ATRP	0.031	0.042	0.741	0.459				
	DDPR	0.103	0.040	2.579	0.010				

Note: Predictors: (Constant), DICA, TBPA, TDSA, ATRP, DDPR.
Dependent variable: EVAT.
EVAT = Efficiency in value-added tax revenue generation, DICA = Data integration capability analytics, TBPA = Taxpayers behaviour prediction analytics, TDSA = Taxpayers database and segmentation analytics, ATRP = Accuracy of tax revenue projections, and DDPR = Digital data processing and reporting. A significance threshold of 5% has been chosen.

4.2. Regression Analysis

The results indicate that some components of data analytics had a significant positive effect on VAT revenue efficiency, while others had an insignificant impact. Notably, all the significant coefficients were positive, aligning with a priori expectations that data analytics should enhance the efficiency of VAT collection. A positive and statistically significant impact on VAT revenue efficiency is suggested by the Data Integration Capability Analytics (DICA) coefficient ($\beta = 0.205$, $p = 0.000$). This suggests that by simplifying data sources, reducing duplication, and improving accuracy in taxpayer records, enhanced data integration improves VAT collection. Smooth data sharing between tax authorities is facilitated by a well-integrated tax database, which reduces errors, detects fraud, and enhances compliance. These results demonstrate the importance of robust data integration systems in strengthening VAT administration.

In terms of VAT efficiency, Taxpayers Behaviour Prediction Analytics (TBPA) had the strongest positive and statistically significant impact ($\beta = 0.456$, $p = 0.000$). This finding implies that detecting trends in taxpayer compliance and potential hazards through predictive analytics is essential for increasing VAT revenue. Tax authorities can proactively implement policies to promote voluntary compliance and reduce tax evasion by utilizing behavioral insights. The significant impact of TBPA suggests that predicting taxpayer behavior with machine learning and data-driven models is an effective strategy for enhancing VAT revenue generation. The impact of Taxpayers Database and Segmentation Analytics (TDSA) on VAT revenue efficiency was positive but statistically insignificant ($\beta = 0.022$, $p = 0.500$). The lack of significance of TDSA might indicate that other factors, such as enforcement and compliance strategies, are more critical for ensuring VAT effectiveness than merely classifying

taxpayers. The accuracy of tax revenue projections (ATRP) had a positive but statistically insignificant impact on VAT efficiency (β = 0.031, p = 0.459). This suggests that although precise tax revenue forecasting is vital for government planning and budgeting, the effectiveness of VAT collection is not directly influenced by forecasting alone. The negligible effect raises the possibility that increasing VAT revenue may require more than just revenue forecasting without accompanying enforcement actions.

The impact of Digital Data Processing and Reporting (DDPR) on VAT revenue efficiency was positive and statistically significant (β = 0.103, p = 0.010). This research implies that by improving record-keeping, decreasing errors, and boosting transparency, digital tax processing and reporting systems increase VAT collection. Because automated systems reduce fraud, increase compliance rates, and streamline VAT reporting, the DDPR's substantial impact emphasizes the value of digital transformation in tax administration.

The predictive multiple regression model can be expressed as follows:

$$EVAT = 0.152 + 0.205DICA + 0.456TBPA + 0.022TDSA + 0.031ATRP + 0.103DDPR \quad (3)$$

Since TDSA and ATRP were insignificant, the prescriptive model can be expressed as:

$$EVAT = 0.152 + 0.205DICA + 0.456TBPA + 0.103DDPR \quad (4)$$

This model suggests that, when holding all variables constant, the baseline level of tax revenue efficiency is 0.152. The results indicate that Taxpayer Behaviour Prediction Analytics (TBPA), Data Integration Capability Analytics (DICA), and Digital Data Processing and Reporting (DDPR) are the most critical components in improving tax revenue efficiency. The model summary shows a strong correlation (R = 0.742) between data analytics and VAT efficiency, with an adjusted R^2 of 0.544, indicating that 54.4% of the variations in efficiency in value-added tax can be explained by the predictors, while the remaining 45.6% are factors explaining changes in VAT efficiency in Nigeria that were not captured in the model. The overall model is statistically significant (F = 96.266, p = 0.000), confirming the relevance of data analytics in improving VAT revenue generation.

5. DISCUSSION OF FINDINGS

The findings suggest that data analytics plays a crucial role in enhancing VAT revenue efficiency, although its effectiveness varies across different components. The significant positive effects of DICA and TBPA underscore the importance of data integration and predictive analytics in improving VAT collection. These results imply that a well-structured data integration system and predictive models can enhance tax compliance and revenue generation. Conversely, the insignificant effects of TDSA and ATRP indicate that while taxpayer segmentation and revenue forecasting are useful, they do not directly translate to VAT efficiency improvements in the Nigerian context. The significant impact of DDPR emphasizes the role of digital transformation in modern tax administration. These results are consistent with some previously documented research outcomes (Adegbie & Akinyemi, 2020; Adeyemo, 2020; Ashafoke & Obaretin, 2023; Hamisu & Akintoye, 2023; Karuru, 2022; Latif, 2019; Mukolu & Ogodor, 2021; Ogunnode & Akintoye, 2023; Okeke, 2018; Oladele, Salami, & Ogunyemi, 2022; Pohan, Rahmi, Arimbhi, & Junaidi, 2022; Uyar, Kuzey, & Güngörmüs, 2021).

For instance, Komolafe and Chukwuani (2020) the Nigeria Finance Act 2020 represents a paradigm shift for a new government, in addition to resolving the debate over taxing the country's digital economy. The regression conducted showed that the new Finance Act significantly impacted resolving the problem of tax revenue generation in Nigeria. The results reported are similar to some prior studies that have found similar significant effects. However, some other prior studies found contradictory results, as some of them documented inverse results of negative and insignificant effects (Audu & Ishola, 2021; Oreku, 2021).

5.1. Conclusion

The study examined the effect of data analytics on efficiency in value-added tax revenue generation in Nigeria, and the study revealed mixed results. The descriptive statistics results revealed a strong consensus among

respondents on the role of data analytics, predictive modeling, and digital processing in enhancing the efficiency of Value-Added Tax (VAT) revenue generation in Nigeria. The highest agreement was observed for the statement on data integration capability analytics (Mean = 4.65, SD = 0.53), where 67% of respondents strongly agreed and 30% agreed.

Additionally, the regression showed that while all of the DICA, TBPA, and DDPR variables demonstrated positive and significant effects, the TDSA and ATRP variables showed positive but insignificant effects. The study concluded that data analytics significantly impacted the effectiveness of value-added tax revenue generation in Nigeria, as the joint statistics utilizing all explanatory variables also indicated a significant effect.

5.2. Implications for Practice

For the government, the implications become crystallized when the application of data analytics enhances accuracy and speed in data analyses, and tax data integration capacity is improved. One of the major challenges of Nigeria in tax revenue generation is tax administration ineptness, incompetence, and diversion of collected tax revenue. The significance of data integration capacity has critical implications for the government, suggesting improvement from the manual data analysis model, which had hitherto contributed to huge errors, confusions, and inaccuracies that slowed down the process in the past. Besides, it increases accountability in public service and at the same time improves Nigeria's global tax compliance rating, attracting foreign direct investments to Nigeria. Furthermore, in contributing to knowledge, the efficiency of VAT revenue generation has significant implications for policymakers in Nigeria, as it enhances the government's capacity to fund public services, reduce fiscal deficits, and support economic development without over-reliance on oil revenues. Policymakers must prioritize tax system reforms, digitalization of VAT collection, and improved compliance enforcement to curb leakages and expand the tax base. By strengthening institutional capacity and ensuring transparency, efficiency in VAT administration can boost revenue performance, foster investor confidence, and contribute to a more sustainable and diversified Nigerian economy.

5.3. Recommendations

The study found some significant results useful for interested stakeholders. The study found that taxpayer database and segmentation analytics and digital data processing exerted significant effects on efficiency in value-added tax revenue generation in Nigeria. Consequently, based on these findings, the study recommends that tax administrators like the Federal Inland Revenue Service (FIRS) should leverage digitalization of the tax system in all of its locations, both in urban and rural areas in Nigeria. In addition, the study recommends, where practicable, to improve tax computation accuracy, a robust compilation of eligible taxpayers' database, and improvement on tax computation inaccuracies that have long undermined the efficiency of the tax system in Nigeria.

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Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Data Availability Statement: Upon a reasonable request, the supporting data of this study can be provided by the corresponding author.
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