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Modernizing Digital Tax Administration and Its Influence on Compliance Behavior: A Comprehensive Empirical Assessment of G20 and EU Economies Using the INDITEC Digitalization Index

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Abstract
This study provides an in-depth empirical investigation into the impact of digital transformation—measured through the INDITEC Digitalization Index—on tax compliance within G20 and European Union countries. Using panel data for the year 2021, the analysis evaluates three core dimensions of modernization: operational digitalization, technological innovation, and the efficiency of public resource allocation. The results reveal that technological innovation exerts a statistically significant positive impact on compliance behavior, while operational digitalization and resource allocation efficiency do not show significant influence. These indicate that advanced technologies such as AI, blockchain, and automated verification systems play a decisive role in improving transparency and administrative performance. The study concludes that governments should prioritize innovation-driven digital reforms and strengthen governance frameworks to enhance compliance outcomes. Future research is advised to explore mediating variables such as institutional trust, regulatory quality, and digital literacy, which may further explain cross-country differences in compliance behavior.

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1. Introduction

All expenditures incurred by the state in its sovereign capacity, as well as expenditures incurred by its institutions in the economic sphere, require financing. Taxes are one of the resources used by the state to

cover these expenditures. Therefore, governments strive to provide an appropriate climate to increase and improve tax compliance. In recent years, digitization, technological innovation, and strategic management of public resources have become fundamental to how governments manage taxes. These developments have reformed the structure of tax systems by introducing smarter tools, reducing inefficiencies, and promoting improved compliance. However, the extent to which each of these components adds a value to compliance remains academically controversial.

While prior studies have documented the potential of digital and technological reform in boosting compliance and minimizing evasion, the results are still inconclusive results in the literature. Therefore, it's an opportunity for this study to empirically test how these factors interact, especially within jurisdictions that have adopted modernization programs at scale, such as G20 and EU countries.

This study seeks to fill that gap by examining how operational digitalization, technological innovation, and the efficient use of resources and budget influence tax compliance in 2021. By focusing on a diverse sample of economies that reflect multiple levels of digital infrastructure and fiscal policy orientation, the research aims to offer an explanation of what motivates compliance in today's tax environment.

To achieve this objective, the following hypotheses are proposed:

H_{01}: Technological innovation (TI) has no significant effect on compliance improvement (CI).

H_{a1}: Technological innovation (TI) significantly influences compliance improvement (CI).

H_{02}: Operational digitalization (OD) has no significant effect on compliance improvement (CI).

H_{a2}: Operational digitalization (OD) significantly influences compliance improvement (CI).

H_{03}: Resource and budget allocation (RB) has no significant effect on compliance improvement (CI).

H_{a3}: Resource and budget allocation (RB) significantly influences compliance improvement (CI).

2. Literature review

1. Definition of Tax Compliance: Legal and Behavioral Perspectives

One word may have different connotations and can be viewed from different perspectives, and so is the case with tax compliance. Tax compliance can be approached from both legal and behavioral dimensions. From the legal perspective, it requires taxpayers to fulfill their duties and obligations in accordance with the enacted tax laws and regulatory framework. This includes the accurate and timely submission of payments and tax returns, as mandated by the valid national tax codes (Nhundu & Matamande, 2023, p. 64).

On the other hand, tax compliance does not rely exclusively on punitive enforcement measures; rather, it often operates within a framework of voluntary cooperation. The behavioral standpoint portrays the voluntary nature of compliance, formed by factors such as trust in public institutions, societal norms and how taxpayers perceive fairness of the tax system. In this context, beyond legal obligation goes compliance to include the aspects that may affect whether individuals willingly or unwillingly engage with tax responsibilities, such as personal convictions and civic values (Torgler, 2007, p. 3).

2. Major Theories of Tax Compliance

2.1 Economic Deterrence Theory

Under economic deterrence theory, rational taxpayers carefully weigh the benefits of tax avoidance against the probability of being caught and the extent of punishment. The general argument is that individuals won't evade taxes as long as the probability of being audited and the non-compliance penalty is high. Thus, strict enforcement procedures bear a critical role in reducing tax evasion (Allingham & Sandmo, 1972; Alm et al., 1995).

2.2 Social Norms Theory

This theory is based on how social norms and community values influence taxpayer behavior. People may act in accordance with tax laws not solely because they fear being penalized, but because they want to behave in a way that is socially acceptable and morally right by the standards of their culture. Community solidarity and human interest to keep a positive self-image are also strong motivations for compliance (Cahyonowati et al., 2022, pp. 411–412).

2.3 Slippery Slope Framework

The slippery slope model combines coercion of the tax authorities with the degree of trust that taxpayers have in the tax authorities. It suggests that, independent of forced compliance, long-term voluntary compliance is determined more by the existence and perceptual quality of the system's legitimacy and fairness. When government is perceived as fair and transparent, people willingly pay their dues and adhere to the law without being forced to (Kirchler et al., 2008; Oladele et al., 2020, p. 119).

3. Determinants of Tax Compliance

3.1 Institutional Factors

The quality of state institutions strongly influences how taxpayers choose to act. Tax systems which operate efficiently and transparently with sufficient resources decrease the expenses of aligning with regulations, thus leading more taxpayers to comply with their tax obligations. The way tax officials manage their duties and tasks with clear procedures and service quality availability strengthens the likelihood of tax compliance (Bird, 2008, p. 6; Bobek et al., 2013, p. 22).

3.2 Behavioral Factors

The behavioral determinants which influence tax compliance consist of individual perceptions and moral reasoning, together with prior experiences with tax authorities. The likelihood of compliance increases when taxpayers perceive the system as fair and when they maintain a strong sense of civic duty. Taxpayers who have experienced negative treatment or discrimination through past interactions with tax authorities tend to avoid complying with tax regulations (Torgler, 2007, pp. 9–11; Kirchler, 2007, p. 21).

3.3 Digital Factors

The administration of taxes has undergone a major transformation because of technological progress. The combination of digital systems with e-filing capabilities, electronic invoicing, and big data analytics helps tax authorities monitor operations better while simplifying compliance procedures. These technological advancements lead to better efficiency, together with decreased possibilities of fraud and established mechanisms for compliance (Nhundu & Matamande, 2023, p. 65; Muita, 2011, p. 14).

3.4 Cultural Factors

Cultural factors such as valuing authorities, alongside religious doctrines and dominant ethical principles, establish a significant influence on tax payment practices. Communities which prioritize social welfare in addition to ethical duties demonstrate enhanced voluntary tax adherence. When citizens doubt government institutions, or when public trust is low, their willingness to pursue tax regulations tends to decrease significantly (Torgler, 2003, p. 289; Alm & Torgler, 2006, p. 225).

2. Operational Digitalization in Tax Administration

2.1 Concept and Role in Digital Transformation

The implementation of modern operational tools in tax administration marks a purposeful move toward complete digital governance systems and integrated technological frameworks. The fundamental mechanisms of tax collection, along with assessment and service delivery, become digitally integrated through this transformation process. Tax administrations enhance precision, reduce processing delays, and

improve taxpayer experience through the implementation of automated real-time systems that replace traditional paper-dependent procedures. The World Bank (2022) emphasizes digitalization needs more than technical upgrades, because successful implementation demands complete changes to legal frameworks, organizational structures, and procedural workflows for permanent institutional reform (Junquera-Varela et al., 2022, p. 6). Domestic revenue mobilization receives critical support from digital transformation because it enhances transparency, reduces corruption risks, and builds public confidence through easier procedures with decreased compliance requirements.

2.2 Components of Operational Digitalization

The operational digitalization process in tax administration relies on multiple essential technological elements, which are interconnected to boost efficiency while reinforcing compliance mechanisms. The three fundamental pillars—which are electronic invoicing, digital signatures, and integrated taxpayer service platforms—establish a modernized administrative framework that enhances transparency while lowering both purposeful and accidental non-compliance cases.

a. Electronic Invoicing (e-Invoicing)

Electronic invoicing systems enable the immediate exchange and verification of transactional data between businesses and tax authorities through their operation. E-invoicing systems provide instant access to invoice data, which leads to better traceability while simultaneously reducing fraud risk compared to conventional paper-based methods. The OECD (2022) states that tax authorities achieve better risk assessment through structured transaction data access, which helps reduce value-added tax gaps via e-invoicing implementation (OECD, 2022, p. 19).

b. Digital Signatures and Trust Services

Digital signatures play an essential role in protecting electronic documents through security measures which maintain their integrity. Digital signatures use encrypted certificates to authenticate signer identities, which makes electronic transactions legally valid. The European Union's eIDAS Regulation establishes a strong legal system for electronic identification and trust services across its member states, which enables safe international digital transactions (European Commission, 2021, pp. 3–5).

c. Taxpayer Service Platforms

Taxpayer service platforms combine vital functions, which include registration and return filing, together with payment processing and customized support. These platforms simplify government processes and ameliorate user accessibility while enabling smooth communication between taxpayers and tax administration officials. The World Bank (2022) identifies these systems as essential tools for reducing compliance costs and enabling immediate data analysis, which leads to better enforcement strategies and resource distribution (Junquera-Varela et al., 2022, pp. 11–12).

2.3 Impact of Operational Digitalization on Tax Compliance

Digital technologies implemented in tax operations transformed how taxpayers view and comply with regulations. Operational digitalization simplifies standard procedures while minimizing administrative complexity to decrease taxpayer transaction expenses and reduce procedural mistakes. Automated systems remove most of the subjective elements which exist in manual operations, thus delivering consistent, predictable outcomes for tax enforcement.

Digitalization delivers its greatest impact through its capacity to increase transparency. Digital tax systems allow full tracking, auditing, and verification of every transaction, which eliminates opportunities for corruption and misreporting. The system becomes fairer, more efficient, and impartial to taxpayers because digital processes create clear conditions for voluntary compliance. According to the World Bank, robust digital infrastructures establish administrative accountability and build public trust in tax institutions by delivering equal and just service with prompt delivery (Junquera-Varela et al., 2022, p. 2).

Moreover, research conducted by the OECD demonstrates how digital tax services lead to better taxpayer attitudes. A combination of user-friendly interfaces, real-time assistance, and rapid feedback mechanisms creates an improved tax compliance experience. Taxpayers become more active participants in tax systems through these elements, which results in increased compliance and better revenue mobilization outcomes (OECD, 2021, p. 27).

3.1 Emerging Technologies and Their Role in Tax Administration Modernization

Tax administrations throughout the world have adopted advanced technologies as part of their recent reform strategies for improved efficiency, enhanced compliance, and service delivery. Modern tax governance relies on fundamental technologies, including artificial intelligence (AI), together with cloud computing, big data analytics, and blockchain, which have moved beyond their initial testing phases. The adoption of these technologies by authorities has transformed institutional capacity through new data collection and processing methods that move organizations from reactive to proactive administrative frameworks (Mazur, 2022, p. 528).

These technologies function beyond their automation capabilities to drive transformations across organizational structures. The technologies enable organizations to perform immediate analytics alongside risk-based enforcement activities, which use data to drive their decision-making processes. The International Monetary Fund states that modern technology implementation proves vital for resolving institutional problems which stem from system complexity, integrity issues, and administrative capacity constraints, especially in environments with limited resources (IMF, 2024, p. 6).

3.2 Key Technologies in Tax Administration

a. Artificial Intelligence (AI)

AI functions as a significant transformative force which modern tax administrations use for their operations. Tax agencies utilize AI to handle extensive, complex data sets, which helps detect patterns that indicate non-compliance. AI-driven predictive analytics helps agencies make better audit decisions, and intelligent systems, including chatbots and virtual agents, provide immediate support to taxpayers during their interactions (IBM, 2023, p. 4). AI-driven automation, according to Kengaaju and Solayen (2024, p. 134), decreases administrative work while improving transparency because it reduces both human mistakes and discretionary decisions.

b. Cloud Computing

Cloud-based infrastructure enables tax administrations to deploy scalable, secure, and cost-efficient systems for managing taxpayer data and services. Cloud platforms enable multiple departments to work together while making it possible to implement rapid policy or operational changes throughout the entire system. The adoption of cloud technology leads to better data accessibility, together with improved system resilience, and promotes inter-agency cooperation, according to Deloitte (2022, p. 7). According to Microsoft (2023, pp. 3–5), cloud environments provide direct integration capabilities between AI and mobile applications, which forms an adaptable, responsive service delivery ecosystem.

c. Big Data Analytics

Tax authorities can obtain practical knowledge from all types of information through their implementation of big data systems. The combination of advanced algorithms with real-time dashboards helps agencies identify anomalies and build behavioral profiles so they can better direct their audit resources. According to PwC (2020, p. 2), data lakes and analytics platforms serve as critical tools for better indirect tax oversight and for pinpointing non-compliant sectors. According to the OECD (2016, pp. 13–14), advanced analytics serve as essential tools for developing evidence-based compliance strategies and improving policy refinement.

d. Blockchain Technology

The implementation of blockchain technology brings fundamental changes to transaction security and integrity in taxation processes. The decentralized ledger system operates as a tamper-proof system that maintains complete transparency of entries while making them verifiable and immutable, which are critical features for tax systems vulnerable to fraud or administrative misconduct. According to PwC (2016, p. 5), blockchain technology has the potential to automate VAT collection while providing secure documentation for customs operations and establishing systems for taxpayer identification. The research conducted by Kim (2022, pp. 70–72) demonstrates that blockchain reduces administrative expenses while stopping duplicate invoicing and developing trust through smart contract traceability.

3.3 Technological Impact on Tax Compliance

The implementation of contemporary technologies produces significant effects on tax compliance patterns. Modern technologies strengthen tax administrations' ability to detect non-compliance while forecasting and deterring it, which supports trust-based compliance models and enforcement-based compliance models. Through its risk identification capabilities, blockchain provides transactional transparency, while cloud systems create an environment of real-time interaction, and big data enables customized compliance approaches.

Mazur (2022, p. 530) argues that digitalization facilitates the evolvement of organizations from reactive enforcement toward predictive compliance models, which use behavioral insights to improve their effectiveness. The new approach minimizes tax evasion while providing taxpayers better access to services and fair treatment in a responsive system. Digital tools provide personalized communication to taxpayers while using behavioral nudges to promote timely filing and payment through feedback mechanisms.

4.1 The Role of Human Capital in Tax Administration Modernization

Human capital is deemed to be the strongest asset of any reform initiative in tax administrations. When we consider whether tax governance is a key part of digital transformation, the way that human resources are strategically developed becomes more than just a necessity; rather, it is an essential matter. The OECD (2024) argues that a human-centered approach to reform enhances institutional resilience, increases operational integrity, and enables organizations to achieve modernization goals in a time-efficient manner (OECD, 2024, pp. 8–9). Bensaci (2023, p. 12) notes that well-trained and competent people are important to innovation and performance within organizations.

Modernization initiatives require individuals who can use sophisticated digital systems while at the same time being knowledgeable about complex tax data and providing high-quality services. Therefore, we have to regard the human resources function as critical in generating efficiencies and future-proofing tax administrations.

4.2 Training Programs: Emphasis on Technology, Analytics, and Data Management

As tax systems transition into data-rich environments, there will need to be a significant, revamped training effort to meet this need. The capacity-building programs that are structured today now contain key areas of emphasis on technical skills involving digital platforms, tax analytics, and data-informed decisions. As stated in the World Bank (2022, pp. 7–10), the outcome of the success of any automated tax system is ultimately dependent upon the staff assigned to operate the system being properly equipped with the specific skills necessary to navigate digital experiences and read analytic outputs.

Modern-day training programs are being designed to include new and current training modules focused on topics like artificial intelligence, cloud architecture, and integrated digital services, so that staff can perform their tasks in increasingly iterative and on-demand environments. Microsoft (2023, pp. 4–6) shed light on the importance of education being aligned with technology's numbers within an organization's training and education approach to help tax administrations prepare for the inevitable future environment. Furthermore, the OECD's VITARA framework provides critical advice in developing strategies which address how these competencies are integrated into larger human resource strategies like job design, performance frameworks, and alignment with any strategic direction (OECD, 2024, pp. 18–21).

4.3 Training and Tax Compliance: A Functional Link

There is a growing body of evidence linking staff training with improved compliance outcomes. Well-trained personnel are better positioned to conduct audits, interpret legislation, and deliver taxpayer services that are both targeted and effective. Gitaru (2017, p. 15) found that training programs—especially those supported by digital tools—significantly enhance taxpayers' willingness to comply voluntarily.

Furthermore, continuous development of personnel creates a solid platform for a workforce that has the ability to adapt to any changes, is less prone to commit operational errors, and is more knowledgeable in addressing problems. These qualities are advantageous in setting higher levels of transparency, consistency in enforcement, and overall institutional credibility (World Bank, 2022, p. 11).

4.4 Aligning Human Capital Development with Budget Planning

The ability of training programs to remain continuously effective, relevant, and supported over time requires being fused into the institutional budget. By considering human resource development through budget priorities, tax administrations will have a clearer capability to distribute their available assets more strategically and maintain training sustainability. The OECD (2024, p. 22) suggests the use of performance-based budget processes to connect training expenditure to outputs that can be measured on a regular basis, while continuing to maintain an accountability framework.

The Asian Development Bank (2022, p. 9) similarly highlights the need to embed HR development within budget processes, especially in developing countries where funding is limited and thus the potential for training may be less flexible. Making strategic alliances and gaining targeted external funding can be essential in overcoming these limitations. No matter what, HR development in budget formats always assures the future sustainability of human capital development in modernization agendas.

3. Methods and Materials

3.1 Study Population, Sample, and Sampling Techniques

3.1.1 Population

The study utilized a population that is composed of the world's richest economies and most digitally mature communities, which includes both developed economies and the most noteworthy emerging markets, representing about 85% of global GDP and a bit less than two-thirds of the world's populations. While there are economies within the selected population with very different levels of technology infrastructure, tax system complexity, and digital adoption levels, this is a great opportunity to theorize on the nexus between an economy's degree of digital transformation and its tax compliance levels.

Another notable aspect of the selected population is the degree of overlap between the G20 and EU member countries, including France, Germany, and Italy. This adds another analytic dimension, as it allows a comparison of countries that are part of global economic leadership with countries that share EU harmonized regulatory frameworks. This duality enhances the study's validity because the population represents a continuum between institutional, regulatory, and technological configuration credibility, which can provide further insights into tax compliance behavior amidst digital reforms.

3.1.2 Sample

The study sample consists of all G20 countries in addition to the 27 member states of the European Union. These countries collectively provide a wide range of economic and technological development levels, presenting an appropriate opportunity for analyzing how modern digital tools and operational reforms impact tax compliance. The G20 countries offer an illustration about multiple models of digital tax administration, enabling a more generalized interpretation of findings. Meanwhile, EU member states serve as exemplars of regulatory integration and digital modernization within tax systems, thus bolstering the robustness and credibility of the comparative analysis.

3.1.3 Sampling Technique

A purposive sampling method was adopted to ensure that the selected jurisdictions reflect a diverse blend of economic maturity and technological advancement. Moreover, this technique enabled the continuous maintenance of relevant and viable data throughout the study length. Most noteworthy, the richness of the chosen dataset allows a deep dive into the specific policy and technology measures taken during and after the COVID-19 pandemic, giving temporal relevance to the empirical aspect of this research and allowing for meaningful, context-sensitive conclusions to be drawn.

3.2 Data and Variables

3.2.1 Type and Source of Data

This research employs quantitative data sourced from the *Innovation, Digitalization, and Technology Index*, as introduced in the working paper by Morán and Díaz (2023). The index evaluates the digital transformation of tax administrations during the period impacted by the COVID-19 pandemic, based principally on the 2022 ISORA (International Survey on Revenue Administration) database, which is considered one of the most comprehensive and reliable sources on global tax administration practices.

The reason for choosing this data source lies in its standardization, objectivity, and completeness. It offers consistent indicators across multiple jurisdictions, allowing for comparative analysis and solid statistical testing. The data also offer indicators about the relevant measures of emerging technology integration, innovation adoption, and administrative digitalization. In addition to this source, the report of the Inter-American Center of Tax Administrations (CIAT) was consulted (2024) for updated accounts of digitals reforms and implications of COVID during the given period. Together these sources provide a rigorous empirical basis for evaluating the effects of digitization on tax compliance.

3.2.2 Variables Measurement

This study explores the nexus between digital transformation and tax compliance using a systematic measurement method derived from the INDITEC Index, developed by Morán et al. (2024). The variables set includes one dependent variable—**Compliance Improvement (CI)**—and three independent variables: **Technological Innovation (TI)**, **Operational Digitalization (OD)**, and **Resources and Budget (RB)**.

The INDITEC Index introduces a multidimensional assessment approach that associates both qualitative and quantitative indicators across four main domains. It evaluates the depth and how broad in terms of technology coverage and integration, the digital maturity of tax operations, the level of investment in ICT infrastructure, and the tangible outcomes of compliance initiatives. Each of these variables contributes to an overarching understanding of how innovation and modernization affect administrative performance in taxation contexts.

3.2.2.1 Technological Innovation (TI)

Technological innovation reflects the extent to which tax administrations have adopted and utilized advanced tools such as data science, artificial intelligence, and cloud-based systems.

- **Score 0** indicates an absence of technological integration, with tax processes still relying entirely on manual operations.
- **Score 0.5** represents partial implementation, where limited functionalities such as online tax filing are available, but core processing remains offline.
- **Score 1** denotes full-scale digital integration, characterized by end-to-end automation in data processing, risk analysis, and taxpayer engagement.

3.2.2.2 Operational Digitalization (OD)

This variable measures the digitization level of internal operations within tax administrations.

- **Score 0** is assigned where processes are entirely paper-based and conducted offline.
- **Score 0.5** reflects transitional digitalization, with some online services implemented but many functions still dependent on manual procedures.
- **Score 1** corresponds to fully digitized systems in which all administrative and taxpayer-facing functions operate through digital platforms.

3.2.2.3 Resources and Budget (RB)

Resources and budget pertain to the institutional commitment to financing digital transformation.

- **Score 0** applies where no specific budget is allocated for ICT or related infrastructure.
- **Score 0.5** indicates moderate investment, such as dedicating around 30% of the budget to technology resources.
- **Score 1** implies a high-priority approach, with over 70% of the operational budget allocated to digital systems and human capital development.

3.2.2.4 Compliance Improvement (CI)

This dependent variable assesses the effectiveness of measures designed to enhance taxpayer compliance.

- **Score 0** reflects no observable progress, with compliance rates stagnating at or below 40%.
- **Score 0.5** signifies moderate improvement, often resulting from targeted outreach and education programs, raising compliance levels to approximately 60%.
- **Score 1** is awarded when significant advancements are achieved, with compliance rates reaching or exceeding 80% as a result of integrated digital and behavioral interventions.

4. Results

4.1 Descriptive Statistics

Descriptive statistics were applied Before conducting the multiple regression analysis, to have an overview about the key characteristics of the variables included in research model. This preliminary analysis provides the distribution, central tendency, and variability of each variable: Compliance Improvement (CI), Technological Innovation (TI), Operational Digitalization (OD), and Resources and Budget (RB). Key indicators such as the mean, standard deviation, and range (minimum and maximum values) are reported to identify potential anomalies that could influence the regression outcomes. Table (1) presents the results of descriptive statistical analysis.

Table 1. Descriptive Statistics Results

	N	Minimum	Maximum	Mean	Std. Deviation
CI	42	0.170	1.000	0.62	0.215
TI	42	0.110	1.000	0.65	0.192

OD	42	0.240	1.000	0.78	0.175
RB	42	0.380	0.910	0.65	0.107
Valid N (listwise)	42				

Source: Proccessed Data On SPSS V 24

The table (1) shows several patterns. In general, the mean values range between 0.62 and 0.78, suggesting a generally positive inclination across all the study variables. Nevertheless, the standard deviations ranging between 0.107 and 0.215, indicates heterogeneity and variability in the research variables among the sampled entities.

Concerning CI, the mean score of 0.62 and a standard deviation of 0.215 pointing to a moderate levels of compliance improvement, with significant variation observed (ranging from 0.170 to 1.000). This dispersion sheds light on the contrasting levels of progress among jurisdictions, with some realizing full compliance while others still lagging.

TI demonstrates a slightly higher average of 0.65 and a relatively lower standard deviation of 0.192, indicating a consistent but not stable adoption of technological innovations across countries. The spread from 0.110 to 1.000 hints to the coexistence of early adopters and those still in early adoption stages.

OD appears as the most advanced aspect, with a mean of 0.78, reflecting strong integration of digital processes within tax administrations. However, the variability (standard deviation = 0.175) implies disparities in implementation, since the lowest score remains at 0.240.

RB exhibits a distribution without large fluctuations or outliers, with a mean of 0.65 and the lowest standard deviation (0.107). The low standard deviation values, suggests that resource allocation strategies, especially those directed at digital infrastructure are relatively adopted in a similar way by the different units of the sample. What supports this conclusion is the narrower range (0.380 to 0.910).

Jointly, these findings signal a remarkable difference in digital maturity and institutional potentials. While OD seems most developed, the disparity in TI and CI points to probable leverage points for enhancing compliance through improved innovation and policy design.

4.2 Classical Assumptions

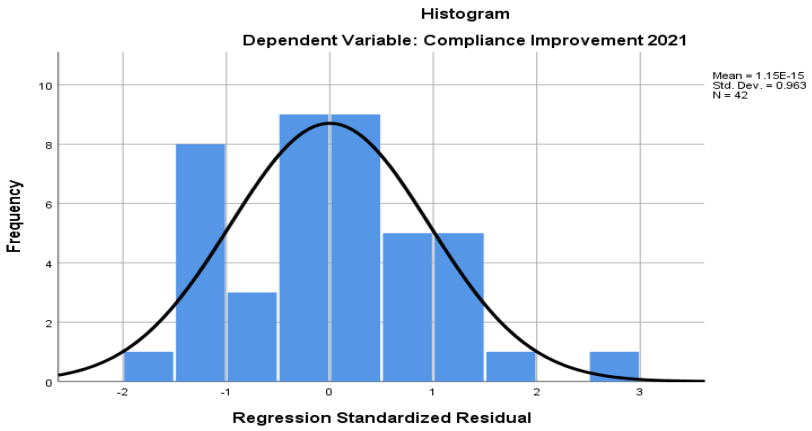
Before running the multiple regression analysis, it is important to check the validity of underlying assumptions of classical linear regression. These assumptions include:

- Linearity: a linear relationship between the independent and dependent variables;
- Independence of errors: residuals should not be correlated;
- Homoscedasticity: the variance of the residuals remains constant across observations; and
- No multicollinearity: the independent variables should not be highly correlated with each other.

4.2.1 Normality Test

To evaluate the assumption of normality in regression analysis, both a histogram and a Normal P-P plot were generated for the dependent variable Compliance Improvement (CI) (see Figures 1 and 2).

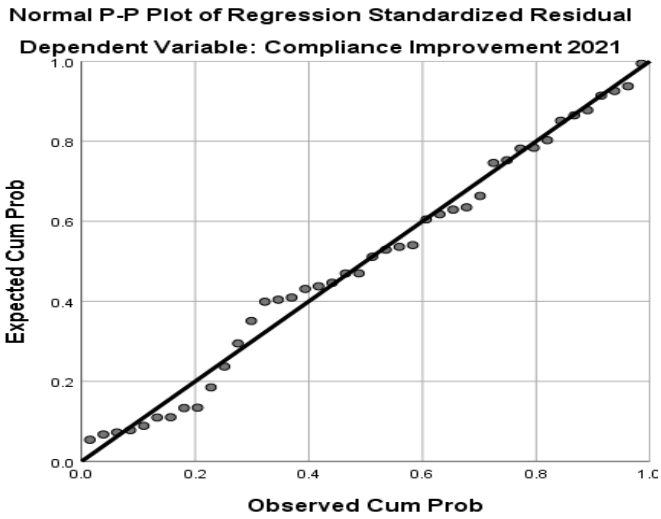
Figure 1. Result of Normality Test



Source: Proccessed Data on SPSS V 24

Figure 1 displays a bell-shaped histogram, with residuals symmetrically distributed on both sides centered around zero. This symmetry indicates that the residuals approximate a normal distribution, with no evident skewness or kurtosis abnormalities. The distribution of values near the center and the gradual decrescent of frequencies toward the tails reflect an alignment with the Gaussian curve.

Figure 2: QQ_plot



Source: Proccessed Data on SPSS V 24

Figure 2, the Normal P-P plot, supports this interpretation. The cumulative observed probabilities lie approximately along the diagonal line, which represents the expected values under a normal distribution. Minor deviations are observed but fall within acceptable bounds, which indicates there is no violation of normal distribution assumption, thereby justifying the use of regression analysis technique for the CI variable.

4.2.2 Multicollinearity Test

To ensure that there was no multicollinearity among the explanatory variables (TI, OD, RB), a correlation matrix was generated (see Table 2). According to established thresholds, multicollinearity is considered present if correlation coefficients between independent variables are above 0.7.

Table 2. Correlations matrix

	CI	TI	OD	RB
CI	1.000			
TI	0.497**	1.000		
OD	0.257*	0.096	1.000	
RB	0.268*	0.382**	0.177	1.000

Data processed by SPSS V26

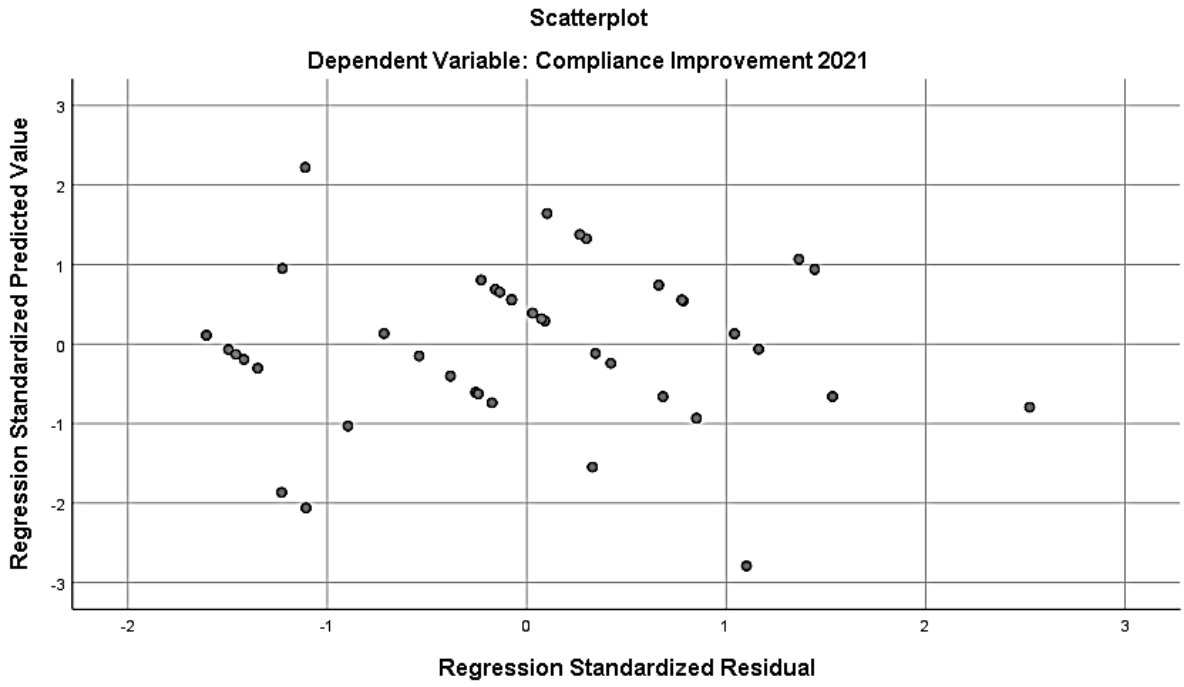
Table 2 shows that all correlation coefficients in the matrix fall below the 0.7 threshold, affirming the absence of multicollinearity. The highest observed correlation (r = 0.497) is between CI and TI, pointing to a moderate and statistically significant positive relationship. likewise, RB reflects a mild correlation with TI (r = 0.382). In the other hand, OD exhibits weaker relationship with other variables, ranging from 0.096 to 0.268.

These results confirm that each explanatory variable has its unique contribution in the regression model, improving the reliability of the analysis and supporting the assumption that multicollinearity is not violated.

4.2.3 Homoscedasticity Test

The homoscedasticity assumption which requires residuals variance to be consistent across all levels of values. This assumption was assessed through a scatterplot of standardized residuals versus standardized predicted values (see Figure 3).

Figure 3: Homoscedasticity results



Source: Proccessed Data on SPSS V 24

The visual inspection of the scatterplot reveals that the variance of the residuals was constant and no obvious pattern, which indicates that the assumption of Homoscedasticity was not violated. random dispersion of residuals around the zero line, with no regular shapes such as funnel forms or clustering. The dots seem evenly scattered, suggesting homogeneity in the variance of residuals across the predictive range.

4.2.4 Interdependency of Residuals Test

To assess the assumption of independence among residuals in the regression model, the Durbin-Watson (DW) statistic was calculated. This test whether the residual values of the independent variables are related in a systematic way, which can distort the validity of inferential results. The DW statistic ranges from 0 to 4, where a value close to 2.0 suggests no autocorrelation, values significantly below 2 indicate positive autocorrelation, and values above 2 suggest negative autocorrelation.

In this study, the results in the table (4) demonstrates that Durbin-Watson value computed was 1.808, a value that falls within the commonly accepted range for independence ($1.5 < DW < 2.5$). This indicates that this assumption also is met.

4.3 Hypothesis Testing Results

To test the hypotheses of the study, the regression model was performed. Table 3 summarizes the results of the multiple regression analysis, which examined the impact of the three independent variables, i.e., TI, OD, and RB—on CI at a 5% significance level.

Table 3 Multiple Regression Analysis Results

		Standardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	0.015	0.209		0.072	0.943	-0.409	0.439
	TI	0.511	0.165	0.456	3.091	0.004	0.176	0.845
	OD	0.250	0.170	0.203	1.466	0.151	-0.095	0.595
	RB	0.116	0.300	0.058	0.387	0.701	-0.492	0.724

a. Dependent Variable: CI

F test = 5.286**

Durbin-Watson = 1.808

Adjusted R^2 = .239

**. Coefficient is significant at the 0.01 level (2-tailed).

*. Coefficient is significant at the 0.05 level (2-tailed).

Source: Processed Data on SPSS V 24

Table 3 shows that the model is significant, F (5.286), P< .001, explaining 23.9%, (Adjusted R^2 = .239) of the variance in the dependent variable. This reflects the quality of the models' fit, which indicates its explanatory power for the independent variables on the dependent variable.

As for the effect of the explanatory variables on the outcome variable in the multiple regression model, it is noted that the Technological Innovation (TI) has a statistically significant positive effect on Compliance Improvement (CI) (β = 0.456), at a level of significance of 1% (P = 0.004 and t-value of 3.091). Therefore, it can be concluded that the null hypothesis for TI is rejected.

In contrast, Operational Digitalization (OD) does not demonstrate any a statistically significant impact on CI (β = 0.203), at a level of significance of 5% (P = 0.151 and t-value of 1.466), hence leading to the acceptance of the null hypothesis for OD.

Similarly, Resources and Budget (RB) shows no significant impact on CI (β = 0.058), at a level of significance of 5% (P = 0.701 and t-value of 0.387). Thus, it can be said that the null hypothesis for RB is accepted.

All in all, among the three explanatory variables, Technological Innovation (TI) is the only one with a significant positive impact on Compliance Improvement. This finding asserts the important role that innovation and advanced digital tools add in promoting higher levels of tax compliance. Conversely, while OD and RB may contribute operationally, their effects in this study are statistically insignificant.

5. Discussion

The results demonstrate a positive effect of Technological Innovation (TI) on Compliance Improvement (CI), which means a significant increase in the (CI) is a result of the increase in (TI) adoption. The values of the regression coefficients of (TI) is (0.456), which indicates that if (TI) adoption increase by one standard deviation, it will lead to an increase in the (CI) by (0.456) standard deviation. This finding goes in line with the empirical evidence introduced by (Odunayo et al. 2024, p. 311), highlighting that innovation in tax systems and specifically through digital tools, can decrease compliance costs, remove ambiguity, and limit evasion.

This supports the hypothesis that creating a room for advanced technologies into tax administration strategies is not merely helpful but essential. The result further substantiates the proposition that innovation act as a transformative agent in urging behavioral shifts among taxpayers, especially in digitally mature economies.

Compared to (TI), Operational Digitalization (OD), Resources, and Budget (RB) failed to show statistically significant effects on CI (β = 0.203, P = 0.151), meaning that digital systems, in isolation, may not promote compliance in an effective way. This result coincides with the conclusions of (Apollo 2024, p. 4), who argued that digitalization alone may increase procedural complexity, and without oversight, can inevitably facilitate loophole exploitation.

Similarly, the role of RB proved minimal, as demonstrated by the negligible beta coefficient (0.058) and a p-value of 0.701. This result is consistent with findings of (Mir Djawadi and Fahr 2013, p. 3), which emphasize that in well-functioning tax environments, financial inputs alone are not a sufficient tool to drive compliance. Instead, the reaction or responsiveness of taxpayer is often formed more significantly by enforcement measures such as audit probability and perceived fairness.

Taken together into consideration, these findings suggest that while resources and digital infrastructure are a corner stone, it is technological innovation that function as the decisive catalyst. However, even the creative innovation must be backed up by directed policy interventions, taxpayer education, and institutional reform to result into substantial compliance improvements.

6. Conclusion

The research objectives were threefold, first to check the impact of technological innovation on tax compliance improvement, to assess how operational digitalization influences tax compliance and finally to empirically explore the effect of resource and budget allocation on enhancing tax compliance. By realizing these three objectives which forms the three dimensions of tax administration modernization, this study explored the impact of tax administration modernization on tax compliance across the G20 and European Union countries in 2021. After running the multiple linear regression analysis, the results demonstrate that solely Technological Innovation is the dimension with a statistically significant and positive influence on tax compliance. This confirms the need for investing in creative technologies such as Artificial intelligence and blockchain to increase system efficiency, promote transparency, and reduce the incidence of tax evasion.

Conversely, Operational Digitalization and Resources and Budget did not show a statistically significant effect on compliance. Despite these agents remain important for administrative process, they cannot be sufficient on their own to make change in taxpayers' behavior. The findings imply that, if governments do not accompany traditional digitization by long term innovation, the results may be limited.

This study also provides some practical implications for policy makers. This study recommends a comprehensive modernization planification, one that takes into consideration innovation with operational frameworks and resource management. Future research is encouraged to delve deeper into mediating and moderating variables, such as law enforcement strength, taxpayer trust, and regulatory quality that may mediate or moderate the nexus between modernization and compliance in various economic contexts.

Methodology

This research adopts a quantitative empirical approach to evaluate the impact of digital tax administration modernization on tax compliance across G20 and EU countries for the year 2021. Data was sourced from international institutions including the OECD, World Bank, IMF, and European Commission. Three main explanatory variables were analyzed: operational digitalization, technological innovation, and resource allocation efficiency. The dependent variable was tax compliance, measured through compliance ratios and revenue performance indicators. Multiple linear regression was performed using ordinary least squares (OLS) with robust standard errors. Diagnostic tests were applied to ensure the validity of the model, including checks for heteroscedasticity, multicollinearity, and normality.

Ethical Considerations

This study complies with all international ethical standards. All data used were publicly available and did not involve private or personal information. No experiments on humans or animals were conducted. Academic integrity and transparency were maintained throughout the research process.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this research.

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