THE IMPACT OF TAX SERVICE DIGITALIZATION ON TAX REVENUE: EVIDENCE FROM THE INDONESIAN SUBNATIONAL DATA

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Abstract:

Background: The implementation of digital tax administration in Indonesia, through digital service channels such as e-filing, e-registration, e-billing, e-invoice, and e-bupot, aims to increase tax compliance and optimize tax revenue collection. However, empirical research on the effects of these digital services on total tax revenue remains limited.
Purpose: The purpose of this study is to analyze the impact of digital tax service implementation on tax revenue and explain the differences in effectiveness between digital service channels at the regional level.
Design/methodology/approach: This study uses panel data from 21 provinces for the period 2017–2023 and applies a Two-Way Fixed Effects model to control for provincial and annual heterogeneity. The model robustness is then tested using the ARDL method, which separates short-term and long-term effects.
Findings/Results: E-bupot, e-registration, and e-billing services have positive, statistically significant effects on total tax revenue, while e-filing and e-invoice have no significant effect. Cross-province analysis shows a high degree of heterogeneity in the effect of digitalization, with higher performance in Java than outside Java.
Conclusion: The digital tax administration plays an important role in increasing national tax revenue, but effectiveness varies across channels and regions.
Originality/value (State of the art): This study is the first to evaluate five digital tax channels using TWFE and ARDL panel data and explains the variation in the effectiveness of tax digitalization across Indonesian regions.

Keywords: digital tax administration, electronic tax services, Indonesian fiscal administration, tax digitalization, tax revenue performance

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INTRODUCTION

The phenomenon of digitalization has permeated all aspects of life (Yoo, 2013). In this context, digital transformation has become an unavoidable necessity across both economic sectors and public service delivery systems, including tax administration (Avianto et al. 2024; Fauzi et al. 2023). Prior studies have shown that digital transformation can enhance organizational performance, including financial outcomes, although its effectiveness depends on the quality of implementation (Tamami et al. 2025). Accordingly, the use of digital technologies in tax administration has increased to improve tax compliance, reduce administrative burdens, and modernize tax service systems (Nose & Mengistu, 2023; Tambunan & Anwar, 2019). In Indonesia, digital tax administration is implemented through several electronic service channels, including e-filing, e-registration, e-billing, e-invoice, and e-bupot (Ningsih et al. 2024). These systems are intended to improve tax compliance, reduce administrative burdens, and increase tax revenue collection (OECD, 2022). From a macroeconomic perspective, taxation plays a crucial role in fiscal policy and economic stability (Siregar & Ward, 2001; Tanjung & Siregar, 2012). Therefore, understanding the effectiveness of digital tax services is essential for improving fiscal performance and sustaining economic development.
Based on the Director General of Taxes Regulation Number KEP-173/PJ/2004 dated November 29, 2004, the Directorate General of Taxes (DGT) began implementing digitalization of taxpayer registration through the e-registration application. The e-registration system is an online system for registering, updating taxpayer data, and confirming and revoking the confirmation of taxable entrepreneurs, which came into effect on December 7, 2004.

Then, the DGT gradually began implementing e-filing in 2012 through the Director General of Taxes Regulation Number PER-39/PJ/2011. E-filing is the electronic submission of annual tax returns, done online and in real time via the internet on the DGT website or through an application service provider (ASP). Furthermore, the DGT implemented electronic tax payments via e-billing in 2014 through the Director General of Taxes Regulation Number PER-26/PJ/2014. E-billing is an electronic tax payment system that uses an identification code (billing code).

In addition, DGT stipulates the implementation of e-invoice under the Director General of Taxes Regulation Number PER-16/PJ/2014. An e-invoice is a tax invoice created through applications or electronic systems specified and/or provided by DGT. The implementation of electronic withholding slips (e-bupot) began in 2017 through the Director General of Taxes Regulation Number PER-4/PJ/2017. The e-bupot application is software available on the DGT website or on certain channels designated by the DGT that can be used to create withholding slips and to prepare and file, in electronic form, periodic income tax returns under Articles 23 and 26. With a digital tax administration system, it is hoped that taxpayers will find it easier to file reports, thereby increasing their compliance with tax reporting and payment requirements (Alamri & Widyatama, 2019).

Although the digital tax system has been implemented nationally, empirical research on the impact of digital tax services at the national level remains limited. In the context of national tax revenue collection, where socioeconomic characteristics vary significantly across provinces, it is important to assess whether digitalization has led to equitable fiscal impacts across regions.

Previous studies have examined the effect of digitalization on tax revenue and economic performance (Fajrina & Setiawan, 2023; Myovella et al. 2020). Other studies focus on how digital tax services influence taxpayer compliance (Panjaitan & Rialdy, 2024; Sutisna & Fachril, 2023). However, most of the literature evaluates the effects of several channels of digitalization on tax revenue through national case studies (Adesoga et al. 2024; Frățilă et al. 2023) or cross-country data (Hanrahan, 2021). Therefore, there is still a research gap in understanding the combined effects of multiple digital tax service channels within a single national context. Moreover, limited attention has been given to regional heterogeneity in digital tax effectiveness, particularly at the sub-national level. This study addresses this gap by simultaneously analyzing five digital tax service channels and examining their heterogeneous effects across provinces in Indonesia using panel data.

To address the research gap, this study applies a provincial panel-data approach using the Two-Way Fixed Effects (TWFE) model. This model controls for unobserved heterogeneity across provinces and years,

enabling the analysis to capture both regional and temporal variations in the effectiveness of the digital tax service. In addition, an Auto Regressive Distributed Lag (ARDL) with an Error Correction Model (ECM) robustness test is employed to assess the consistency of the results in both the short- and long-run. This combined approach enables the study to provide a more reliable estimation of the relationship between digital tax services and tax revenue. Therefore, the methodological strategy is designed to explain not only whether digital tax services affect tax revenue, but also how their effects differ across channels and regions.

The purpose of this study is to analyze the effect of five digital tax service channels on tax revenue in Indonesia and to compare their effectiveness across provincial groups. Specifically, this study aims to examine the effects of e-filing, e-billing, e-invoice, e-registration, and e-bupot on tax revenue. It also aims to identify whether the effect of digital tax services varies across provinces. By achieving these objectives, this study provides empirical evidence for the design of more targeted and regionally adaptive digital tax policies. The findings are expected to contribute to the literature on digital tax administration and support fiscal policy formulation in Indonesia and other developing countries.

METHODS

This study employs three types of variables: dependent, independent, and control variables, as presented in Table 1. The dependent variable is tax revenue, measured in rupiah. The independent variables represent digital tax service channels, including e-registration, e-filing, e-billing, e-invoice, and e-bupot. Data on tax revenue and digital tax services are obtained from the Directorate of Tax Data and Information, Directorate General of Taxes (DGT), Indonesia. In addition, this study incorporates several control variables to account for socioeconomic factors beyond digital tax adoption that may influence tax revenue. These variables are sourced from Statistics Indonesia (BPS) and include average years of schooling, hotel occupancy rate, gross regional domestic product per capita (GRDP per capita), motor vehicle sales, population growth rate, and unemployment rate. The inclusion of these variables is supported by prior literature demonstrating that economic activity and social conditions are closely associated with regional tax revenue performance.

This study utilizes provincial panel data in Indonesia covering the period from 2017 to 2023, as shown in Table 2. This approach is appropriate because fiscal dynamics and tax performance may vary significantly across sub-national regions, requiring detailed analysis at the provincial level (Wahyudi et al. 2009; Wibowo et al. 2022). The dataset consists of 21 cross-sectional units, representing either individual provinces or combinations of two to three provinces with relatively similar economic characteristics. This grouping is implemented to ensure consistency and comparability of the tax revenue data across regions. In addition, seven years (2017-2023) were chosen to represent the crucial phase of implementation and maturation of the digital tax system in Indonesia.

The control variables are available in annual provincial-level data. In contrast, the cross-sectional units in this study are grouped by provincial tax offices (regional offices of the DGT). To ensure consistency, the provincial-level control variables are aggregated according to the same grouping structure. Since the control variables consist of ratios, proportions, and absolute values (e.g., GRDP per capita and motor vehicle sales), all variables are aggregated using the average value across provinces within each group. This approach ensures that each cross-sectional unit reflects the overall socioeconomic characteristics of the grouped provinces while maintaining comparability and avoiding bias from scale differences. The use of panel data enables a more comprehensive analysis by capturing both inter-provincial variation and temporal dynamics. This structure enhances the ability to estimate the effect of digital tax services on tax revenue more accurately across regions and over time.

To analyze the effect of digital tax services on tax revenue, this study employs a Two-Way Fixed Effects (TWFE) panel regression model. The model selection is based on the panel data structure and the need to control for unobserved heterogeneity across provinces and over time (Kropko & Kubinec, 2020). The data panel comprises observations from 21 provinces in Indonesia over 7 years (2017-2023). Digital tax services are being implemented gradually, though the nationwide launch of each service channel occurs simultaneously. The intensity of digital tax service adoption varies across provinces and over time, allowing for the exploitation of variation in units and time.

Table 1. Description of variables used in the analysis of digital tax services and tax revenue in Indonesia

Variables	Symbol	Type of Variables	Unit measurements	Sources
Tax Revenues	Y	Dependent	Value (Rp)	DGT
E-filing	X1	Independent	Number of returns	DGT
E-billing	X2	Independent	Growth yoy of the number of e-billing	DGT
E-invoice	X3	Independent	Number of e-invoices	DGT
E-registration	X4	Independent	Number of taxpayers	DGT
E-bupot	X5	Independent	Number of e-bupot	DGT
Education	Z1	Control variable	Years_schooling	BPS (2025)
Hotel occupancy	Z2	Control variable	% of hotel occupancy	BPS (2025)
GRDPpc	Z3	Control variable	Value (Rp)	BPS (2025)
Motor vehicle sales	Z4	Control variable	Number of vehicles	BPS (2025)
Population	Z5	Control variable	% of growth	BPS (2025)
Unemployment	Z6	Control variable	% of unemployment	BPS (2025)

Table 2. Cross-section units based on grouped provincial tax regions in Indonesia (2017–2023)

Aceh	Kalimantan Timur and Utara
Bali	Kep. Riau
Banten	Nusa Tenggara
Bengkulu and Lampung	Papua, Papua Barat and Maluku
Di Yogyakarta	Riau
DKI Jakarta	Sulsel, Barat and Tenggara
Jawa Barat	Sulut Tenggo and Malut
Jawa Tengah	Sumatera Barat and Jambi
Jawa Timur	Sumatera Utara
Kalimantan Barat	Sumsel and Kep. Babel
Kalimantan Selatan and Tengah	

Provincial fixed effects are included to control for time-invariant characteristics such as institutional capacity, tax base structure, and digital readiness. Time fixed effects capture common shocks, including macroeconomic fluctuations and regulatory changes that affect all provinces simultaneously. The results of the Hausman specification test support the fixed-effects approach over the random-effects approach (Hausman, 1978; Wooldridge, 2010). In addition, the joint significance test (F-test) confirmed the suitability of the province and year effects (Greene, 2012). Overall, the TWFE model is theoretically and statistically appropriate for isolating the effect of digital tax adoption on national tax revenue, while controlling for confounding heterogeneity and national trends (Imai & Kim, 2021). The linear regression panel data research model is as follows:

$$\hat{Y}_{i,t} = \alpha_i + \lambda_t + \beta 1X1_{i,t} + ... + \beta 5X5_{i,t} + \beta 6Z1_{i,t} + ... + \beta 11Z6_{i,t} + \varepsilon_{i,t}$$

Where $\hat{Y}_{i,t}$ represents tax revenue in province i and year t; X1-X5 denote digital tax service variables (e-filing, e-billing, e-invoice, e-registration, and e-bupot); Z1-Z6 represent control variables. (education, hotel occupancy rate, GDRBpc, motor vehicle sales, population, and unemployment rate). The index α_i captures provincial fixed effects; λ_t captures time fixed effects; and $\varepsilon_{i,t}$ is the error term.

To ensure the robustness of the results, an additional analysis is conducted using the ARDL-ECM framework (Pesaran et al. 2001). This approach allows for the examination of both short-run dynamics and long-run relationships between digital tax services and tax revenue.

Existing studies predominantly examine individual digital tax channels (Adesoga et al. 2024; Frățilă et al. 2023) or rely on cross-country analyses (Hanrahan, 2021), leaving a gap in understanding the combined effect of multiple digital tax services within a single

national context. Moreover, limited attention has been given to regional heterogeneity in digital tax effectiveness, particularly in developing countries such as Indonesia. From a theoretical perspective, digital tax services are expected to improve tax revenue through several mechanisms, including enhanced administrative efficiency, reduced compliance costs, improved reporting accuracy, and strengthened enforcement capacity (Nose & Mengistu, 2023). These mechanisms suggest that the effectiveness of digitalization depends on the functional role of each system within the tax administration process. Specifically, e-filing and e-invoice are designed to improve reporting quality and data availability, which, in turn, can support tax compliance. In contrast, e-billing and e-bupot are more directly linked to payment and withholding mechanisms, making them more effective in influencing actual tax collection.

Meanwhile, e-registration helps expand the taxpayer base by facilitating registration and updating taxpayer data. Furthermore, differences in economic structure, digital readiness, and administrative capacity across regions may lead to variations in the effectiveness of digital tax services. Therefore, the effect of digitalization is expected to be heterogeneous across provinces. Based on these arguments, this study proposes the following hypotheses:

H1: E-filing has a positive effect on tax revenue.
H2: E-billing has a positive effect on tax revenue.
H3: E-invoice has a positive effect on tax revenue.
H4: E-registration has a positive effect on tax revenue.
H5: E-bupot has a positive effect on tax revenue.
H6: The effect of digital tax services on tax revenue varies across provinces in Indonesia.

This study is based on the conceptual framework that digital tax services influence tax revenue by improving compliance, efficiency, and administrative effectiveness. The framework integrates multiple digital service channels (e-filing, e-registration, e-billing, e-invoice, and e-bupot) as independent variables, with tax revenue as the dependent variable and socioeconomic factors as control variables. Figure 1 illustrates the research framework, showing the relationship between digital tax services and tax revenue, as well as the role of regional heterogeneity. This framework guides the empirical analysis conducted in this study.

RESULTS

Descriptive Statistics

The results of the statistical analysis of the sample data, comprising 147 observations, are shown in Table 3. Tax revenue averaged 44,07 million rupiah, ranging from 3,49 million to 671,61 million rupiah. The median value of 9,97 million rupiah, which is substantially lower than the mean, indicates that most regions have tax revenues below the overall average. The e-filing variable has an average of 1,89 million rupiah and a standard deviation of 4,29 million rupiah. Its maximum value reaches 26,07 million rupiah, while the median is only 0,59 million rupiah. Furthermore, e-billing has an average of 3,05 million rupiah and a standard deviation of 2,90 million rupiah. The median value is 1,75 million rupiah, with a maximum of 12,98 million rupiah.

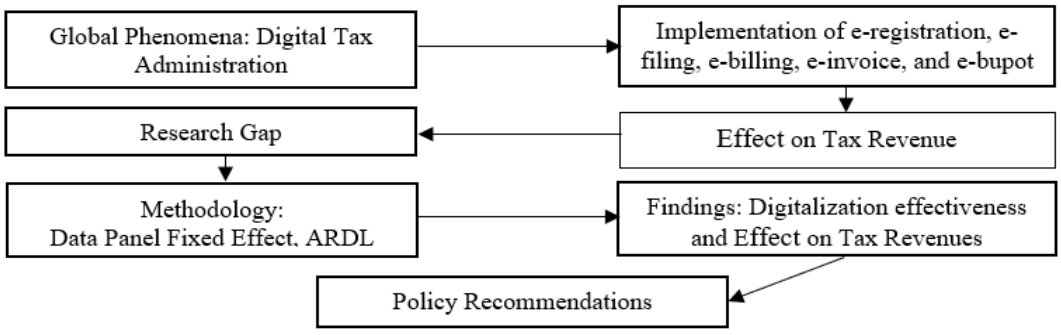


Figure 1. Conceptual framework of the effect of digital tax services on tax revenue in Indonesia

Variable Selection and Multicollinearity Test

Correlation analysis among model variables is performed using a correlation matrix to address multicollinearity. The test used the Variance Inflation Factor (VIF), which assesses the extent to which the correlation among variables affects the variance of the estimates. VIF values between 5 and 10 are used as a threshold to determine the presence of multicollinearity (Kim, 2019; Wirtz & Daiser, 2018). The VIF test results for the model ranged from 1,06 to 3,2, indicating that all independent variables had relatively low VIF values below the threshold of 5 (Table 4). A low VIF value suggests that there are no serious multicollinearity issues between independent variables in the regression model (De Villiers & Marques, 2016). Thus, it can be concluded that all variables in this model are suitable for further regression analysis, as no multicollinearity will affect the stability and validity of the regression coefficient estimates.

Two-Way Fixed Effects (TWFE) Model Analysis

The baseline estimation employs a TWFE model to control for unobserved heterogeneity across provinces and over time. The regression results, presented in Table 5, examine the effect of digital tax service channels on tax revenue. Among the eleven independent variables included in the model, seven—vehicle sales, GRDP per capita, hotel occupancy rate, education, e-bupot, e-registration, and e-billing—exhibit statistically significant effects. Specifically, e-bupot ($\beta = 0,27$; $p < 0,01$), e-registration ($\beta = 0,06$; $p < 0,01$), and e-billing ($\beta = 0,69$; $p < 0,01$) have positive and statistically significant effects on tax revenue. These findings suggest that digital tax systems, particularly those linked to payment, withholding, and taxpayer registration, contribute to improved administrative efficiency and compliance, thereby increasing tax revenue. This result is consistent with Ramzi (2024), who reports a positive and statistically significant effect of digital tax systems on tax revenue in Algeria.

Table 3. Descriptive statistics of tax revenue, digital tax services, and control variables across provincial units

Variable	Mean	Standard deviation	Min	Max	Range
Y	44,069,242	111,423,773	3,496,556	671,614,942	668,118,386
X1	1,891,271	4,287,455	161,534	26,066,448	25,904,914
X2	3,052,558	2,895,753	940,313	12,975,044	12,034,731
X3	46,393,836	110,239,282	424,210	6,381,052,020	6,381,000,000
X4	269,122	430,060	22,097	3,025,830	3,003,733
X5	81,451	2,757,962	11	22,114,919	22,114,908
Z1	8.68	0.91	7.03	11.49	4.46
Z2	36.24	8.55	9.45	70.46	61.01
Z3	46,452	36,212	15,147	192,134	176,987
Z4	5,648,157	6,826,170	321,112	24,023,666	23,702,554
Z5	1.53	0.58	0.38	3.48	3.1
Z6	5.55	1.78	1.14	11.46	10.32

Table 4. Variance Inflation Factor (VIF) results for testing multicollinearity among variables

Variable	Symbol	VIF
E-filing	X1	1.11
E-billing	X2	1.09
E-invoice	X3	1.08
E-registration	X4	1.67
E-bupot	X5	2.35
Education	Z1	1.06
Occupancy_rate_hotel	Z2	1.49
GRDPpc	Z3	2.21
Motor vehicle sales	Z4	3.2
Population	Z5	2.62
Unemployment Rate	Z6	1.63

Meanwhile, the e-invoice and e-filing variables do not have a statistically significant effect on tax revenue (p-value > 0,05). The finding indicates that these systems are more closely related to administrative reporting functions and, on their own, do not increase tax revenue without complementary measures, such as effective law enforcement and behavioral changes in taxpayer compliance. These findings differ from those of Usman et al. (2025), who found that e-filing, e-payment, and other digital platforms have a significant positive effect on tax revenue. Differences in data types and sources may explain such discrepancies. While this study relies on objective quantitative data on national tax revenue and system usage, Usman et al. (2025) use survey data from tax administration employees, which may reflect subjective perceptions and be subject to social desirability bias. Similarly, Irawati et al. (2022) find that e-invoices and tax compliance significantly affect tax revenue. However, their study focuses on Value Added Tax revenue within a single tax office, while the present study examines the aggregate effect of multiple digital service channels on total national tax revenue.

In terms of hypothesis testing, the findings support H2, H4, and H5, but not H1 or H3. This result suggests that systems directly linked to payment and enforcement mechanisms, such as e-billing and e-bupot, play a more substantial role in generating tax revenue. Conversely, reporting-based systems such as e-filing and e-invoice primarily serve administrative functions and do not directly translate into higher revenue. These findings confirm that the effectiveness of digital tax services varies depending on their functional role within the tax system. This result is consistent with Nose and Mengistu (2023), who show that digital technologies can enhance tax revenue, although their effect depends on the type of system implemented. These findings further highlight that not all digital tax services contribute equally to tax revenue. Overall, this distinction highlights the importance of aligning digital tax strategies with enforcement and compliance mechanisms to maximize fiscal outcomes.

The effect of the digital tax services across 21 provincial groups in Indonesia is illustrated in Figure 2. The results reveal significant variation in the effectiveness of digital services, with some channels demonstrating strong regional effects, while others exhibit weak or even negative effects. E-registration and e-bupot show the greatest variation across provinces. Notably, DKI Jakarta stands out as an outlier in e-bupot, indicating that digital tax system adoption and compliance in this region are substantially higher than in other areas. E-filing and e-invoice display negative or insignificant coefficients in most provinces. In contrast, provinces such as Banten and DKI Jakarta consistently exhibit positive results across all digital channels.

Table 5. Results Two-Way Fixed Effects (TWFE) regression analysis of digital tax services on tax revenue

Variables	Estimate	Std. Error	T-value	P-value	Results
E-filing	-0.01	0.01	-0.88	0.38	Not significant
E-billing	0.69	0.11	6.37	0.00	Significant
E-invoice	0.00	0.01	-0.60	0.55	Not significant
E-registration	0.06	0.01	4.13	0.00	Significant
E-bupot	0.27	0.02	12.67	0.00	Significant
Education	-0.03	0.01	-3.53	0.00	Significant
Hotel occupancy rate	0.11	0.02	4.77	0.00	Significant
GRDPpc	0.31	0.15	2.07	0.04	Significant
Motor vehicle sales	0.58	0.17	3.44	0.00	Significant
Population	0.02	0.02	0.95	0.34	Not significant
Unemployment rate	0.00	0.02	-0.07	0.94	Not significant

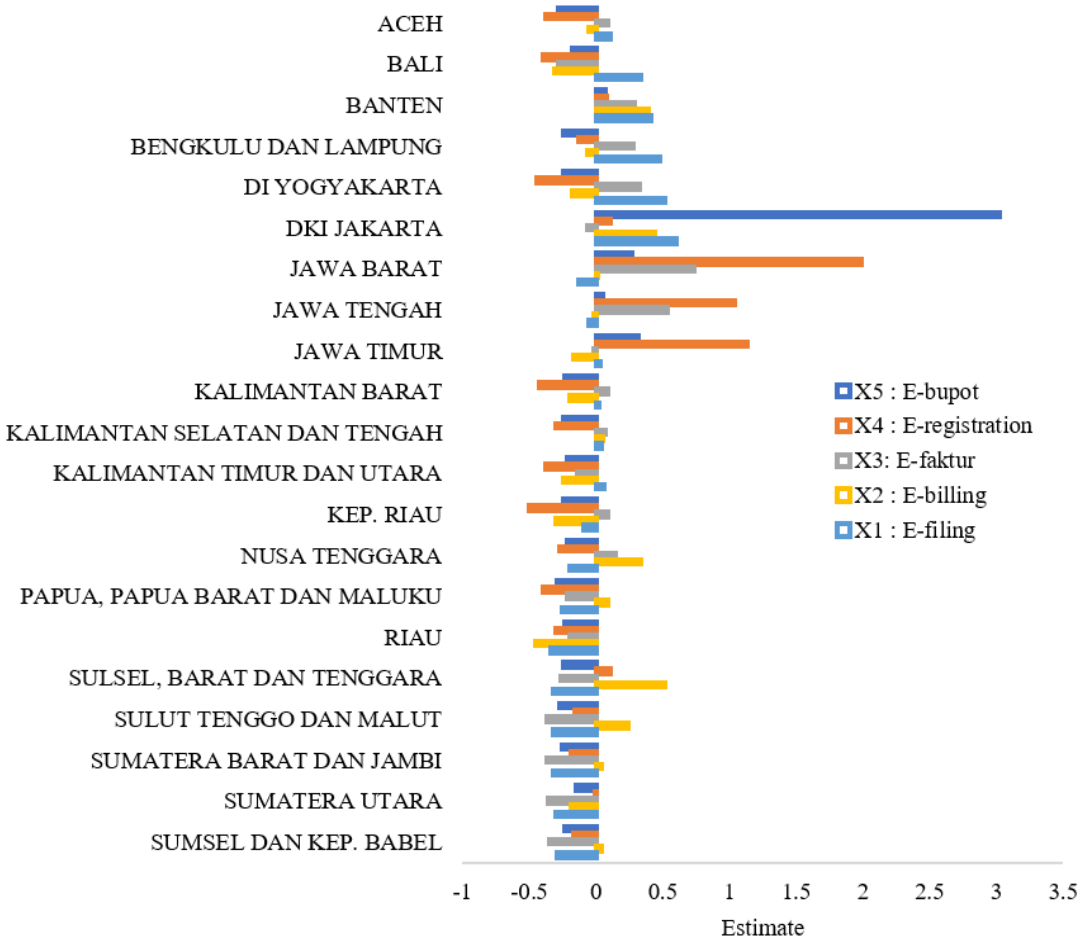


Figure 2. Cross-provincial variation in the effect of digital tax service channels on tax revenue in Indonesia

Meanwhile, provinces outside Java, including Papua and Sulawesi, tend to demonstrate weaker or negative performance. This disparity underscores the need for a tax digitalization strategy that is tailored to regional socioeconomic characteristics, as well as the importance of strengthening support systems in low-performing regions. These findings support H6, indicating that the effect of digital tax services on tax revenue varies significantly across provinces in Indonesia. The observed heterogeneity reflects differences in economic structure, digital readiness, and institutional capacity between regions, particularly between Java and non-Java provinces. The support for H6 reinforces the importance of contextual factors in digital transformation, which emphasize that digital system effectiveness depends on organizational and environmental readiness (Tamami et al. 2025).

Robustness Test

Robustness tests are conducted to assess whether the estimation results remain consistent when alternative methods are applied to address potential heteroscedasticity, autocorrelation, and cross-sectional dependence. In this study, the analysis includes panel unit root tests to examine stationarity, the construction of lagged and differenced variables to approximate the ARDL framework, and the estimation of dynamic panel models with fixed effects. This approach enables the simultaneous evaluation of both short-run dynamics and long-run relationships, thereby strengthening the reliability of the results. The estimation results in Table 6 show that the lagged dependent variable (Y_lag1) has a negative and statistically significant coefficient of -1,0955 ($p < 0,001$), indicating the presence of a mean-reversion effect in tax revenue. Specifically, increases in tax revenue in the previous period tend to be downwardly adjusted toward a long-run equilibrium level. In the long run, only e-bupot and e-registration remain statistically significant positive effects on tax revenue, with coefficients of 0,3100 and 0,0807, respectively ($p < 0,001$). This finding suggests that these digital systems contribute to sustained improvements in tax revenue over time. In contrast, other lagged variables—such as e-invoice, e-billing, and e-filing—do not show statistically significant long-term effects.

In the short term (measured as Δ changes), several variables were found to have a statistically significant effect. The Δe-bupot variable shows a significant negative coefficient (-0,1043; $p < 0,05$), indicating that changes to the e-bupot administration system require a period of adaptation before they have a positive effect. Conversely, Δe-registration and Δe-billing showed positive and significant effects (0,0795 and 0,3844, respectively; $p < 0,001$), which reinforced the important role of the digital tax system in short-term tax revenue growth. Meanwhile, other variables, such as Δe-invoice and Δe-filing, are not statistically significant, indicating that changes in these variables do not yet explain short-term variations in tax revenue. Overall, the results of this robustness test show that the fixed-effects panel dynamic model is robust to temporal variation, and that the e-bupot, e-registration, and e-billing systems have a significant positive contribution to tax revenue in both the long and short term.

Model Goodness Test

The model goodness-of-fit test evaluates the extent to which the specified model explains variation in the dependent variable. In this study, the analysis is conducted using a TWFE model and complemented by a robustness test based on the ARDL-ECM framework to ensure the consistency of the results. The ARDL approach enables the distinction between long-run effects, captured through lagged variables, and short-run dynamics, reflected in changes or first differences of the variables. Thus, the addition of an ARDL specification serves to verify that the TWFE coefficient estimates remain valid when accounting for temporal dynamics and short-term relationships between variables. The combination of these two approaches ensures that the estimated model not only fits the panel data but is also robust to short-term and long-term variations between provinces.

Table 6. Results Robustness Test Using ARDL-ECM Model for digital tax services and tax revenue

Variables	Estimate	Std. Error	T-value	P-value	Result
Y_lag1	-1.0955	0.0824	-132.955	0.0000	Significant
X1_l1	0.0042	0.0095	0.4432	0.6588	Not significant
X2_l1	0.0635	0.0940	0.6762	0.5008	Not significant
X3_l1	0.0033	0.0103	0.3208	0.7492	Not significant
X4_l1	0.0807	0.0137	58.723	0.0000	Significant
X5_l1	0.3100	0.0222	139.342	0.0000	Significant
Z1_l1	-0.0039	0.0098	-0.3973	0.6922	Not significant
Z2_l1	0.0030	0.0139	0.2145	0.8307	Not significant
Z3_l1	-0.0976	0.1157	-0.8438	0.4012	Not significant
Z4_l1	-0.0834	0.1619	-0.5151	0.6078	Not significant
Z5_l1	-0.0249	0.0165	-15.058	0.1360	Not significant
Z6_l1	0.0191	0.0160	11.903	0.2374	Not significant
dX1	-0.0048	0.0066	-0.7277	0.4689	Not significant
dX2	0.3844	0.0899	42.784	0.0001	Significant
dX3	-0.0039	0.0053	-0.7389	0.4621	Not significant
dX4	0.0795	0.0139	57.304	0.0000	Significant
dX5	-0.1043	0.0431	-24.184	0.0178	Significant
dZ1	-0.0222	0.0071	-31.506	0.0023	Significant
dZ2	0.0432	0.0137	31.454	0.0023	Significant
dZ3	0.4446	0.1545	28.785	0.0051	Significant
dZ4	0.5157	0.3620	14.244	0.1581	Not significant
dZ5	-0.0004	0.0114	-0.0386	0.9693	Not significant
dZ6	-0.0018	0.0097	-0.1841	0.8544	Not significant

Based on the results in Table 7, the TWFE and ARDL models exhibit strong explanatory power, as evidenced by high R-squared values. In terms of R-Squared, the TWFE model yields 0,83, while the ARDL model yields 0,91. This result indicates that the ARDL model explains approximately 91% of the variation in the dependent variable through its independent variables, whereas TWFE explains only 83%. Finally, the F-statistic in the TWFE model is 47,40 ($p < 0,001$), while in the ARDL model it is 35,85 ($p < 0,001$). Both are statistically significant, indicating that simultaneously the independent variables have a significant effect on the dependent variable. Overall, both models are significant and feasible to use.

This study identifies several important findings regarding the effectiveness of digital tax services in Indonesia, which provide deeper insights into how digital transformation contributes to tax revenue performance.

First, the results show that not all digital tax services have the same effect on tax revenue. Specifically, e-billing, e-bupot, and e-registration demonstrate a positive and significant effect, while e-filing and e-invoice do not show a significant direct effect. This finding suggests that digital systems directly linked to payment processes and tax withholding mechanisms tend to yield stronger fiscal outcomes. In contrast, systems that primarily serve reporting functions, such as e-filing and e-invoice, play a more supportive administrative role and may require complementary enforcement mechanisms to influence revenue. This finding is consistent with prior studies showing that digital transformation improves organizational efficiency and performance, including in financial and service sectors (Shanti et al. 2024).

Second, the findings highlight the importance of compliance enforcement and system integration in determining the effectiveness of digital tax services. The significant effect of e-billing and e-bupot indicates that digital tools closely integrated with tax payment and withholding processes are more effective at improving tax collection. Therefore, the effectiveness of digital transformation is not solely determined by the availability of digital systems, but also by how well these systems are integrated into compliance monitoring and enforcement frameworks.

Third, the analysis reveals substantial heterogeneity in the effect of digital tax services across provinces. Regions such as DKI Jakarta and Banten show consistently strong positive results, while provinces outside Java tend to exhibit weaker or even negative effects. The result reflects differences in regional economic structures, digital infrastructure, and administrative capacity. It also suggests that the benefits of digital tax systems are not automatically realized across all regions, but depend on the level of regional readiness and institutional support.

Fourth, the study finds that real economic factors such as vehicle sales, GRDP per capita, and hotel occupancy rates remain significant determinants of tax revenue. This finding indicates that digital tax systems function as complementary instruments that enhance revenue collection, rather than as standalone drivers. In other words, digitalization amplifies the effects of underlying economic activity but cannot fully substitute for a strong, growing tax base.

Taken together, these findings suggest that the effectiveness of digital tax transformation depends on three key dimensions: the functional role of the digital system (payment vs. reporting), the degree of integration with enforcement mechanisms, and the regional context in which the system is implemented. From a broader fiscal perspective, strengthening tax revenue is essential to reduce reliance on external debt and ensure sustainable public financing (Salsabila et al. 2023). Furthermore, micro-level dynamics, including service delivery and taxpayer interaction, play a crucial role in determining macroeconomic policy outcomes (Siregar, 2009). These insights provide an important foundation for deriving policy and managerial implications in the next section.

Table 7. Model Goodness-of-Fit Statistics for TWFE and ARDL Models

Test Statistics	TWFE	ARDL
Total Sum of Squares (TSS)	4.34	2.17
Residual Sum of Squares (RSS)	0.75	0.20
R-Squared	0.83	0.91
F-Statistic and p-value	47.40 (< 0.001)	35.85 (< 0.001)

Managerial Implications

The managerial implication of these findings is that the DGT and fiscal policy authorities should prioritize e-bupot, e-registration, and e-billing as strategic digital service channels for increasing tax revenue. These channels are more directly connected to taxpayer registration, payment, and withholding mechanisms, making them more effective at influencing compliance behavior and revenue collection. The uneven effectiveness of digitalization across provinces also indicates that DGT should avoid a uniform national strategy and instead adopt a regionally differentiated approach. Provinces outside Java require stronger support in digital infrastructure, taxpayer assistance, and administrative capacity to ensure that digital tax services generate comparable fiscal benefits. In addition, DGT needs to develop automated monitoring systems that connect tax return data, electronic invoices, withholding data, and payment records. Such integration would allow e-filing and e-invoice to move beyond administrative reporting and become effective tools for compliance monitoring and enforcement.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The results of this study indicate that the effect of digital tax services on tax revenue is heterogeneous across both service types and regions. Specifically, e-bupot, e-registration, and e-billing have a positive and significant effect on tax revenue, while e-filing and e-invoice do not show a significant direct effect. These findings confirm that digital transformation in tax administration contributes to revenue performance; however, its effectiveness depends on the type of digital service and its linkage to compliance enforcement mechanisms. The findings are consistent with prior studies (Nose & Mengistu, 2023) that highlight the role of digitalization in enhancing tax revenue. However, they differ from the findings of Usman et al. (2025), who report a significant positive effect of e-filing, indicating that the effectiveness of digital tax services may depend on the type of data and context used.

In addition, the study confirms that the effectiveness of digital tax services varies significantly across provinces, underscoring the importance of regional factors, such as economic capacity and digital readiness, in shaping policy outcomes. Real economic factors, including vehicle sales, GRDP per capita, and hotel occupancy rates, also have a significant positive effect on tax revenue. Overall, these findings suggest that the government should continue to strengthen and expand digital tax policies (e-bupot, e-registration, e-billing) as the backbone of national tax reform. At the same time, promoting growth in the real sector and tourism remains essential for expanding the tax base. The combination of inclusive economic growth and a digital, efficient, and transparent tax system will serve as a key foundation for the long-term sustainability of Indonesia's tax revenue.

Recommendations

Based on the TWFE estimation results and robustness tests, several strategic policy recommendations can be proposed to increase tax revenue in Indonesia in both the short and long term. First, the DGT should expand the implementation of digital tax systems across regions, strengthen system integration, and ensure adequate taxpayer training and assistance, especially for Micro, Small, and Medium Enterprises (MSMEs) and the informal sector, to facilitate a smooth transition to digital taxation.

Second, the government should strengthen policies that promote productive economic activity, such as increasing household purchasing power, improving access to vehicle financing, and promoting both domestic and international tourism. Strengthening the real sector will broaden the tax base, enhance revenue potential, and indirectly improve tax compliance by expanding formal economic activity.

Third, education policies should place greater emphasis on financial and tax literacy to increase taxpayer awareness and long-term compliance. The integration of digital-based tax education into school and university curricula can serve as a preventive strategy to foster a culture of tax compliance from an early age.

Fourth, although e-filing and e-invoicing do not show significant effects in this model, their roles remain important. Therefore, the government should continue to improve service quality, data security, and system reliability in these platforms. Furthermore, the development of tax big data and its integration with national financial transaction systems can strengthen compliance monitoring and reduce the risk of tax avoidance. Finally, fiscal policy should be implemented

proactively and adaptively, with careful attention to long-term stability to minimize fluctuations in tax revenue over time.

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