

“Assessing the association between electronic invoicing and regional tax revenues in Kazakhstan”

AUTHORS	Zamzagul Tursynkulova 
	 Aizhan Abishova 
	 Gulbana Maulenkulova 
	Zarema Bigeldiyeva 
	Gulnur Baidautetova 
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Zamzagul Tursynkulova, Master of Economics, Department of Management and Marketing, Higher School of Management and Business, M. Auezov South Kazakhstan University, Kazakhstan.

Aizhan Abishova, Ph.D. in Economic Sciences, Associate Professor, Department of Economic Theory, Higher School of Management and Business, M. Auezov South Kazakhstan University, Kazakhstan. (Corresponding author)

Gulbana Maulenkulova, Ph.D. in Economic Sciences, Associate Professor, Department of Finance, Higher School of Management and Business, M. Auezov South Kazakhstan University, Kazakhstan.

Zarema Bigeldiyeva, Ph.D. in Economic Sciences, Associate Professor, Higher School of Management and Business, Department of Finance, M. Auezov South Kazakhstan University, Kazakhstan.

Gulnur Baidautetova, Master of Economics, Department of Economics, Higher School of Management and Business, M. Auezov South Kazakhstan University, Kazakhstan.



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Zamzagul Tursynkulova (Kazakhstan), Aizhan Abishova (Kazakhstan), Gulbana Maulenkulova (Kazakhstan), Zarema Bigeldiyeva (Kazakhstan), Gulnur Baidautetova (Kazakhstan)

ASSESSING THE ASSOCIATION BETWEEN ELECTRONIC INVOICING AND REGIONAL TAX REVENUES IN KAZAKHSTAN

Abstract

Electronic invoicing is an important component of digital tax administration that improves tax transparency and strengthens revenue administration. This study examines the association between electronic invoicing and regional tax revenues across Kazakhstan's regions. The analysis uses regional panel data for 16 regions covering 2010–2024 and employs fixed-effects panel regression models together with k-means cluster analysis. The empirical dataset was obtained from the reports of the State Revenue Committee of the Ministry of Finance of the Republic of Kazakhstan and the Bureau of National Statistics of the Republic of Kazakhstan. The results show that electronic invoicing is not significantly associated with regional tax revenues in either the baseline model ($\beta = 0.039$; $p = 0.538$) or the specification with a time trend ($\beta = -0.024$; $p = 0.690$). However, the specification using the shifted e-Inv indicator yields a positive and statistically significant association ($\beta = 0.302$; $p = 0.047$). Because e-Inv is a nationwide step dummy, this result reflects temporal robustness rather than evidence of a delayed fiscal effect. Across all model specifications, GRP per capita remains the strongest determinant of regional tax revenues ($\beta \approx 0.825$ – 1.102), highlighting the central role of regional economic capacity. The cluster analysis identifies three distinct groups of regions with different fiscal and digital characteristics, illustrating substantial regional heterogeneity in Kazakhstan. The findings suggest that the association between electronic invoicing and regional tax revenues depends on model specification and broader economic conditions. In contrast, regional economic capacity remains the most robust determinant of tax revenues.

Keywords

electronic invoicing, tax administration, tax revenues, regional development, digitalization, fiscal policy, regional economy

JEL Classification

H26, H71, O33

INTRODUCTION

Tax revenues are the primary source of public revenue and provide the financial foundation for effective fiscal policy. Stable tax revenues give governments the resources to finance public goods, develop infrastructure, and improve the population's living standards. The rapid development of digital technologies has also transformed tax administration. Against this background, Kazakhstan has actively introduced digital technologies into its tax administration system to increase the transparency of tax transactions, reduce tax evasion, and strengthen tax control. These tools include electronic invoicing, electronic tax filing, tax risk management systems, and digital platforms that facilitate interaction between taxpayers and tax authorities. A key milestone in the digitalization of tax administration in Kazakhstan was the introduction of the electronic invoicing system in 2014 (DSR, 2014). At the same time, Kazakhstan's national digital development strategy (Adilet, 2021) recognizes the development of digital infrastructure and the expansion of Internet penetration as important prerequisites for improv-

ing tax control and the efficiency of tax administration. Despite the active adoption of digital tax administration tools, their relationship with tax revenues remains insufficiently understood, particularly regarding whether this relationship differs across regions with different levels of digital development and economic structure. This issue is particularly relevant for Kazakhstan, where substantial regional differences exist in economic structure, tax capacity, and digital maturity.

1. LITERATURE REVIEW AND HYPOTHESES

Understanding the determinants of tax revenues has attracted considerable attention in the literature, as stable tax revenues are essential for effective fiscal policy and sustainable economic development. The literature examines tax revenues from macroeconomic, institutional, and technological perspectives. Despite this growing literature, the relationship between tax revenues, tax administration, and digitalization remains underexplored. The economic literature emphasizes that tax revenues depend on macroeconomic, structural, and institutional factors that reflect both the size of the economy and its functioning (Davoodi & Grigorian, 2007; Akitoby et al., 2020; Jalles, 2026; Lengaram et al., 2025). The main determinant of tax revenues is the structure of the territory's economy. Karagoz (2013) argues that tax revenues are higher in industrially developed regions, whereas they are lower in agricultural regions. Agbeyegbe et al. (2006) support this statement by examining the relationship between tax revenues and the industrial structure of the economy. Consequently, more developed regions, where industry and industrial production prevail, are characterized by a larger tax base and, therefore, higher tax revenues.

Additionally, the influence of the informal sector is noted, which reduces tax potential and limits the expansion of the tax base (Schneider, 2011; Medina & Schneider, 2019; Bulut, 2023). The prevalence of the shadow economy is negatively associated with tax revenues, suggesting that informal employment reduces tax revenues in the territory. Consequently, the informal economy narrows the tax base and constrains tax collection. The impact of the informal economy on tax revenues is accompanied by low institutional efficiency, underscoring the importance of tax policy management and tax control. Dabla-Norris et al. (2008) and Nadirov and Aliyev (2015) indicate that a weak

institutional environment can lead to weak tax administration, which in turn increases tax evasion. In this regard, tax administration is seen as a tool for increasing tax collection and strengthening fiscal discipline (Hoy et al., 2024; Nyamita & Kaunda, 2023; Ayoola et al., 2023; Mogollón García et al., 2025). Consequently, a relatively high level of economic development does not necessarily guarantee high tax revenues if tax administration remains ineffective. Recent studies have increasingly focused on the digitalization of tax administration. In particular, digitalization aims for openness and transparency, encouraging the state to actively introduce it into tax policy. In this regard, digitalization can be used in several ways (Tiwarei et al., 2023; Olaleye et al., 2023; Asmara et al., 2025). Digitalization of tax administration increases the efficiency of monitoring economic transactions in real time, allowing tax authorities to identify inconsistencies and risky transactions more effectively. Wibawan (2026) and Al-Khalaileh (2025) indicate that the use of digital tax administration tools and AI (e.g., EBMv2) has increased transaction transparency and that the introduction of AI has increased compliance with tax legislation. Digital tax administration tools also reduce administrative and transaction costs for both governments and taxpayers by simplifying reporting procedures and interactions with tax authorities. According to OECD (2025), the use of e-filing, e-payment, and e-registration simplifies payment procedures for tax subjects.

In addition, the automation of tax procedures and the use of AI reduce the role of the human factor in tax administration, thereby lowering the risk of errors and corruption (Serrano Antón, 2021; Belahouaoui & Alm, 2025). Consequently, the integration of digital tax administration tools into tax administration covers a wide range of research, but research on the impact of digitalization on tax revenues remains mixed. Several studies have noted the positive fiscal effect of digital instruments, manifested through increased tax discipline and

an expanded tax base (Bellon et al., 2022; Phinias et al., 2024). Other studies argue that digitalization by itself does not lead to an increase in tax revenues, but only improves the quality of administration, without changing the fundamental limitations of the tax base determined by the level of economic development and the structure of the economy (Efunboade, 2014; Olatunji & Ayodele, 2017; Dabla-Norris et al., 2020). Among the various digital tax administration instruments, electronic invoicing has received particular attention because it directly records and transmits information on economic transactions to tax authorities. Electronic invoicing is also important: this electronic tax administration tool increases transaction transparency and improves tax authorities' ability to monitor taxpayers. Empirical evidence suggests that electronic invoicing is associated with higher net tax payments and more efficient tax audits (Kotsogiannis et al., 2025). Similar results were obtained in Italy, where the introduction of electronic invoicing increased compliance with tax legislation and reduced opportunities for tax fraud (Heinemann & Stiller, 2025). However, the effects of e-invoicing are not uniform across firms and regional institutional environments. Tao and Li (2026) find that the compliance-enhancing effect of e-invoicing is stronger in regions with lower tax enforcement capacity, highlighting the importance of regional institutional conditions. Thus, existing studies generally show that electronic document management can improve tax administration efficiency, but its impact on tax revenues may depend on other institutional and financial factors. In addition, expanding digital instruments can improve tax administration efficiency, reduce administrative costs, and increase tax revenues (Nose & Mengistu, 2023; Khamithan et al., 2025). Overall, existing evidence remains inconclusive on the impact of digitalization on tax revenues. Although digitalization is widely recognized as improving tax administration, it remains unclear whether it independently contributes to higher tax revenues or primarily supports existing tax capacity determined by regional economic development and economic structure. Moreover, empirical evidence on whether this relationship varies across regions with different levels of economic development and economic structure remains limited, particularly in emerging economies such as Kazakhstan.

Against this background, Kazakhstan provides an informative case for examining whether electronic invoicing is associated with regional tax revenues and whether this relationship differs across regions with different levels of economic development.

Accordingly, the purpose of this study is to examine the association between electronic invoicing and regional tax revenues across Kazakhstan's regions. In this regard, the following hypotheses are put forward in the study:

- H1: *Electronic invoicing is associated with regional tax revenues in Kazakhstan.*
- H2: *The association between electronic invoicing and regional tax revenues differs across regions with different levels of economic development.*

2. METHOD

This study uses a quantitative approach based on fixed-effects regression analysis, covering panel data from 16 regions of the Republic of Kazakhstan for the period 2010–2024. The regions formed in 2022 (Abai, Zhetysu, and Ulytau), as well as Shymkent, which has data only from 2018, are excluded from the analysis due to insufficient observations for a robust econometric assessment. To ensure comparability of regional time series after the administrative reform of 2022, data for the three newly created regions (Abai, Zhetysu, and Ulytau) were combined with data from the corresponding regions (East Kazakhstan, Almaty region, and Karaganda) for 2022–2024 using summation of absolute values and population-weighted averaging for index variables. Absolute variables (tax revenues, GRP, and population) were aggregated by summation, whereas ratio variables (Internet users, inflation) were recalculated using population-weighted averages. The data were obtained from official sources, such as the State Revenue Committee of the Ministry of Finance of the Republic of Kazakhstan and the Bureau of National Statistics of the Republic of Kazakhstan. All calculations were performed in Stata 19.

The empirical analysis consisted of descriptive analysis, panel estimation, robustness checks, and heterogeneity analysis. Descriptive statistics were analyzed to identify the main characteristics of the data. Diagnostic tests were conducted to justify the choice of the panel specification. Fixed-effects regression models were estimated to assess the relationship between electronic invoicing and regional tax revenues. Next, k-means cluster analysis was applied to identify regional heterogeneity. The optimal number of clusters was selected using the elbow method. To test *H2*, the three-cluster solution obtained from the k-means procedure was consolidated into two economically meaningful groups (high-income/resource-rich regions and other regions). Fixed-effects regressions were then estimated separately for these two groups to assess the heterogeneity of the association between electronic invoicing and regional tax revenues. The analysis focuses on the variables shown in Table 1.

The dependent variable is tax revenues per capita, calculated using the official indicator “tax revenues” reported by the Bureau of National Statistics and the State Revenue Committee for each region. The indicator follows the official budget classification. Comparability of the regional time series was preserved by reconstructing the 2022–2024 observations (Adilet, 2025). This procedure ensured a consistent panel structure throughout the study period despite the 2022 territorial reform. The primary explanatory variable is the electronic invoicing dummy (e-Inv), which equals 0 for all regions

before 2014 and 1 from 2014 onward, reflecting Kazakhstan’s nationwide implementation of the electronic invoicing information system. Thus, e-Inv varies only over time and does not capture interregional differences in e-invoicing intensity.

The baseline fixed-effects specification is formulated as follows:

$$\begin{aligned} \ln_tax_pc_it = & \alpha_i + \beta_1 \cdot e_Inv_t \\ & + \beta_2 \cdot INET_it + \beta_3 \cdot \ln(GRP_it) \\ & + \beta_4 \cdot IPC_it + \beta_5 \cdot oil_price_it \\ & + \beta_6 \cdot covid_it + \varepsilon_it, \end{aligned} \quad (1)$$

where $i = 1, \dots, 16$ region; $t = 2010, \dots, 2024$. *Oil_price* is included as a common macroeconomic control capturing nationwide commodity price fluctuations.

The choice of the fixed-effects model is driven by the need to control for unobserved regional characteristics that are constant over time, such as the sectoral structure of the economy, geographical features, and regional institutional differences. Since electronic invoicing was introduced nationwide in 2014, the estimated coefficient should be interpreted as a post-implementation association rather than as a causal effect of electronic invoicing itself. Moreover, the nationwide implementation does not allow the model to exploit interregional differences in treatment timing. Therefore, the e-Inv coefficient may also capture other na-

Table 1. Main variables

Indicator	Type of variable	Unit of measurement	Description	Source
ln_tax_pc	Dependent (in M1-M3)	Ln (thousand tenge)	The natural logarithm of tax revenues per capita in the region	State Revenue Committee (SRC, 2023)
e-Inv	Key independent	Step dummy 0 1	0 = before 2014; 1 = from 2014 onward	Department of State Revenue (DSR, 2014)
e_Inv_org	Regionally varying e-invoicing adoption measure	Number of organizations	Number of organizations using electronic invoices in the region	Bureau of National Statistics (BNS, 2024d)
int_users	Control	%	The proportion of Internet users in the region’s population	Bureau of National Statistics (BNS, 2024a)
ln_GRP_pc	Control	Ln (mln tenge)	Natural logarithm of gross regional product per capita, used as a proxy for regional economic development	Bureau of National Statistics (BNS, 2024b)
IPC_adj	Control	%	Inflation rate in the region – price dynamics monitoring	Bureau of National Statistics (BNS, 2024c)
Oil_price	Control	USD/ barrel	World Brent oil price – commodity cycle control	Macrotrends (2024)
Covid	Control	Dummy 0 1	1 – for 2020 (COVID-19 pandemic)	Our calculations

tionwide institutional or macroeconomic changes that occurred after 2014.

The second specification adds a linear time trend (year) to control the overall growth trend over time:

$$\begin{aligned} \ln_tax_pc_it = & \alpha_i + \beta_1 \cdot e_Inv_t \\ & + \beta_2 \cdot INET_it + \beta_3 \cdot \ln(GRP_it) \\ & + \beta_4 \cdot IPC_it + \beta_5 \cdot oil_price_it \\ & + \beta_6 \cdot covid_it + \beta_7 \cdot year_t + \varepsilon_it. \end{aligned} \quad (2)$$

This specification assesses whether the estimated association between e-invoicing and tax revenues remains after accounting for the common underlying time trend.

In the third specification, the contemporaneous e-Inv indicator is replaced with its one-period lag (L.e-Inv). Because e-Inv is a nationwide time-varying indicator, this specification does not identify a one-year delayed causal effect. Rather, it examines whether the estimated association changes when the post-implementation indicator is shifted by one year:

$$\begin{aligned} \ln_tax_pc_it = & \alpha_i + \beta_1 \cdot L.e_Inv_t \\ & + \beta_2 \cdot INET_it + \beta_3 \cdot \ln(GRP_it) \\ & + \beta_4 \cdot IPC_it + \beta_5 \cdot oil_price_it \\ & + \beta_6 \cdot covid_it + \varepsilon_it. \end{aligned} \quad (3)$$

Therefore, this specification is treated as a temporal robustness check rather than as evidence of a one-year delayed fiscal effect.

To complement the nationwide implementation indicator, we use the number of organizations using electronic invoices as a regionally and temporally varying measure of e-invoicing adoption:

$$\begin{aligned} \ln_tax_pc_it = & \alpha_i + \beta_1 \cdot e_Inv_org_it \\ & + \beta_2 \cdot INET_it \\ & + \beta_3 \cdot \ln(GRP_it) + \beta_4 \cdot IPC_it \\ & + \beta_5 \cdot oil_price_it + \beta_6 \cdot covid_it + \varepsilon_it. \end{aligned} \quad (4)$$

Unlike the nationwide e-invoice model, e-Inv_org indicator varies by region and over time, providing additional information about regional differences.

To assess the appropriateness of the panel specification, the Hausman test, the *F*-test for fixed effects, and the modified Wald test for heteroscedasticity were performed. All models were estimated using robust standard errors (vce(robust)) to account for potential heteroscedasticity.

3. RESULTS

Given the peculiarities of regional development in Kazakhstan, the analyzed panel data show significant regional heterogeneity, as confirmed by Table 2. According to descriptive statistics, the average value of the logarithm of tax revenues per capita was 5.824 (SD = 0.961), with a minimum of 3.609, observed in the Zhambyl region in 2010, and a maximum of 8.418, observed in Atyrau in 2022. Such a wide range reflects the deep structural heterogeneity of Kazakhstan's regions, from agricultural regions with a low tax base to oil-producing regions with a high concentration of tax revenues. A similar pattern is observed in the indicator: the level of Internet penetration ranges from 33.9% to 97.9%, indicating a significant digital divide across regions, which is important for interpreting the effects of e-Inv.

To provide a visual assessment of the dynamics of regional tax revenues in Kazakhstan for the period 2010–2024, Figure 1 shows the time trajectory

Table 2. Descriptive statistics

Variables	(1)	(2)	(3)	(4)	(5)
	N	mean	sd	min	Max
int_users	224	78.73	14.03	33.94	97.91
e_inv	240	0.733	0.443	0	1
oil_price	240	78.95	23.04	41.96	111.6
ln_tax_pc	240	5.824	0.961	3.609	8.418
ln_grp_pc	240	1.090	0.750	−0.839	3.090
ipc_adj	240	8.51	3.901	3.4	24
covid	240	0.0667	0.250	0	1

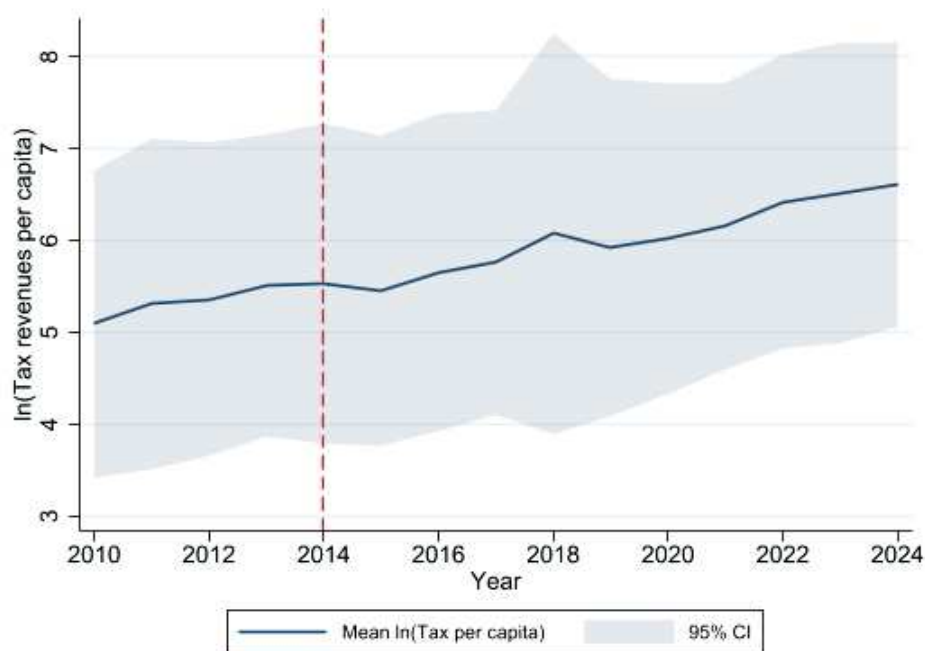


Figure 1. Dynamics of regional tax revenues in Kazakhstan, 2010–2024

of average tax revenues per capita. The shaded area represents the 95% confidence interval of the mean regional tax revenues across the 16 regions. The dotted red vertical line indicates the launch of the mandatory electronic billing system (e-Inv) in 2014.

The trend line for tax revenues shows a positive trend throughout the entire period. After the introduction of e-Inv, the growth trajectory remains unchanged, but the confidence interval width remains significant, confirming the ongoing regional heterogeneity. To justify the choice of a specification with fixed effects and to verify the model's assumptions, a diagnostic test was performed (Table 3).

The Hausman test does not reject the null hypothesis of no systematic difference between the FE and RE estimators ($\chi^2(6) = 2.03$; $p = 0.917$). However, the F -test strongly rejects the null hypothesis that all regional effects are jointly zero ($F(15,202) = 28.19$; $p < 0.001$), confirming the presence of statistically significant unobserved regional heterogeneity. Given that the analysis covers the population of Kazakhstan's regions rather than a sample drawn from a larger population of regions, the fixed-effects specification is retained as the primary specification. The FE and RE estimates are nevertheless highly similar, which provides additional reassurance regarding the robustness of the results (Arellano, 1987; Cameron & Miller, 2015).

Table 3. Diagnostic test

Test	The null hypothesis	Statistic	p-value	Result
Hausman test	There is no systematic difference between FE and RE	$\chi^2(6) = 2.03$	0.917	It is not rejected. However, FE is used: the sample covers the entire general population of regions, rather than a random sample (Mundlak, 1978). The results of FE and RE are almost identical
F-test: all $u_i = 0$	The regional FE are collectively zero	$F(15, 202) = 28.19$	0.000	Rejected. Fixed effects are jointly significant. Regions systematically differ in their invariable characteristics. The use of FE is meaningfully justified
Modified Wald (xttest3)	$H_0: \sigma_i^2 = \sigma^2$ for all i – checks the equality of error variances across regions	$\chi^2(16) = 264.80$	0.000	Rejected. Group heteroskedasticity has been confirmed. Robust standard errors are used in all models (Arellano, 1987)
VIF	There is no multicollinearity	Max VIF = 3.92	–	mean VIF = 2.25

Given the confirmed correctness of the FE specification, three panel regression models were estimated and are presented in Table 4.

Table 4. Panel regression results

Variables	M1: Base FE	M2: FE+Trend	M3: Lagged e-Inv
e-Inv	0.039 (0.062)	-0.024 (0.06)	
INET_users	-0.002 (0.004)	-0.006 (0.004)	-0.003 (0.004)
ln_GRP_pc	1.102*** (0.114)	0.825** (0.212)	1.01*** (0.133)
ipc_adj	-0.0002 (0.004)	-0.003 (0.004)	-0.008 (0.005)
Oil_price	0.001 (0.001)	0.001 (0.0008)	0.005** (0.002)
covid	-0.004 (0.06)	-0.028 (0.07)	0.08 (0.072)
year		0.047 (0.023)	
L1_e-Inv			0.302* (0.140)
_cons	4.63*** (0.272)	-89.612 (46.19)	4.460*** (0.280)
N	224	224	224
r2_w	0.810	0.819	0.815

Note: Robust SE clustered at region level in parentheses.
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$.

Given the appropriateness of the fixed-effects (FE) specification, three panel regression models were estimated (Table 4). In the baseline model (M1), the coefficient for electronic invoicing (e-Inv) is statistically insignificant ($\beta = 0.039$; $p = 0.538$), while Internet penetration is also insignificant ($\beta = -0.002$; $p = 0.702$). These results indicate that, within the baseline FE specification, digital indicators are not significantly associated with regional tax revenues. The COVID-19 dummy is insignificant in all specifications. In Model M2, which additionally controls for a linear time trend, the coefficients for both electronic invoicing ($\beta = -0.024$; $p = 0.690$) and Internet penetration ($\beta = -0.006$; $p = 0.123$) remain statistically insignificant. Thus, H1 is not supported in the baseline specification (M1) or in the specification including a time trend (M2). In Model M3, which replaces the contemporaneous e-Inv indicator with its one-period lag (L1_e-Inv), the coefficient is positive and statistically significant at the 5% level ($\beta = 0.302$; $p = 0.047$). However, given that e-Inv is a nationwide step dummy, this result should not be

interpreted as evidence of a one-year delayed fiscal effect. The lagged specification shifts the post-implementation breakpoint from 2014 to 2015 and is therefore interpreted as a temporal robustness check. Although M3 yields a positive and statistically significant coefficient, this result should be interpreted as a temporal robustness finding. Across all three models, GRP per capita remains a positive and statistically significant determinant of tax revenues ($\beta = 0.825$ -1.102; $p < 0.01$), highlighting the important role of regional economic development in explaining fiscal performance.

The absence of a stable association between the nationwide e-Inv indicator and regional tax revenues may also reflect substantial regional heterogeneity. The results indicate substantial heterogeneity across regions in terms of digital development and tax revenues. To provide a more detailed interpretation of this heterogeneity, regions were clustered using the k-means method.

Clustering by the k-means method ($k = 3$) using standardized $\ln_tax_pc$ and int_users values revealed three distinct typological groups of regions (Table 5). The choice of $k = 3$ is supported by both the elbow criterion and the economic interpretability of the resulting clusters. Statistically: a 30% decrease in WSS during the transition from $k = 2$ to $k = 3$ (from 17.34 to 12.14); with further increases in k , the increase in explained variance becomes less significant. However, in terms of content: $k = 2$ unites 13 regions into one group, which makes it impossible to distinguish urban and resource regions; and $k = 4$ divides homogeneous groups without meaningful justification. Further, allocating the Atyrau region to a separate cluster at $k = 3$ reflects its exceptional fiscal specifics. The highest tax revenues per capita ($\ln_tax_pc = 7.43$), twice the sample average (5.82), makes this typology economically meaningful.

Cluster analysis identified three distinct typological groups of Kazakhstan's regions with different patterns of fiscal capacity and digital development. Cluster 1 ("Low Level", $n = 10$) includes the majority of regions and is characterized by the lowest tax revenues per capita ($\ln_tax_pc = 5.46$) together with relatively low Internet penetration (76.79%). Cluster 2 ("Oil leader", $n = 1$) consists solely of the Atyrau region, which records

Table 5. K-means cluster analysis results

Cluster	Regions	ln_tax_pc (mean)	INET_users (mean)
1 – Low level	Akmola, Kyzylorda, Turkestan, Zhambyl, Almaty, East Kazakhstan, Karaganda, North Kazakhstan, Mangystau, West Kazakhstan	5.46	76.79
2 – The oil leader	Atyrau	7.43	78.43
3 – City leaders	Almaty city, Astana city, Aktobe, Kostanay, Pavlodar	6.23	82.65
Total	16 regions	5.82	78.73

the highest tax revenues per capita ($\ln_tax_pc = 7.43$) despite only moderate Internet penetration (78.43%). This exceptional fiscal performance is largely attributable to the concentration of oil-producing enterprises rather than to the level of digitalization. Cluster 3 (“City leaders”, $n = 5$; Almaty city, Astana city, Aktobe, Kostanay, and Pavlodar) exhibits the highest Internet penetration (82.65%) and relatively high tax revenues per capita ($\ln_tax_pc = 6.23$), reflecting comparatively advanced levels of both economic and digital development. Overall, the clustering results demonstrate substantial regional heterogeneity and provide the empirical basis for the subsequent heterogeneity analysis.

To further study the regional heterogeneity, the sample was divided into two significant groups: high-income regions (Almaty, Astana,

and Atyrau region) and the rest of the regions. Separate fixed-effects regressions were calculated for each group (Table 6). The estimated association between the lagged e-Inv indicator and tax revenues is positive in both regional groups, but statistically insignificant in each group. The e-Inv lag coefficient is not statistically significant in high-income regions. In other regions, the coefficient remains positive, but falls short of the generally accepted levels of significance ($\beta = 0.277$; $p = 0.105$). Internet penetration is negatively related to tax revenues per capita and is marginally significant in the high-income group ($\beta = -0.017$; $p = 0.051$). On the contrary, GRP per capita remains a positive and statistically significant factor determining tax revenues in both groups ($p < 0.05$ and $p < 0.001$, respectively), which underlines the importance of regional economic potential regardless of regional classification.

Table 6. Subgroup analysis: High-income vs. Other regions

Variables	(4)	(5)
	Rich regions	Other regions
L1_e_Inv	0.462 (0.260)	0.277 (0.158)
int_users	-0.0174* (0.00410)	-0.00165 (0.00386)
ln_grp_pc	1.305** (0.145)	0.959*** (0.156)
ipc_adj	-0.00269 (0.0131)	-0.00885 (0.00598)
oil_price	0.00528 (0.00400)	0.00491** (0.00227)
covid	0.139 (0.115)	0.0821 (0.0939)
e_Inv_org		
Constant	5.229*** (0.314)	4.289*** (0.343)
Observations	42	182
R-squared	0.877	0.801
Number of region_id	3	13
Fixed effects	Yes	Yes

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

To assess the robustness of the main findings, several additional analyses were conducted (Table 6). First, the year 2020 was excluded to account for the potential influence of the COVID-19 pandemic. The coefficient of the lagged e-Inv variable remained positive and statistically significant ($\beta = 0.286$; $p = 0.053$), indicating that the main finding is not driven by the pandemic year. Second, the oil-producing regions of Atyrau and Mangystau were excluded from the sample. The estimated coefficient remained positive ($\beta = 0.251$; $p = 0.10$), although its statistical significance declined slightly, likely due to the smaller sample size. Third, the binary e-Inv indicator was replaced with an alternative continuous measure: the number of organizations using electronic invoicing by region (2018–2023). Although this specification produced an insignificant coefficient ($\beta = -0.333$; $p > 0.10$), the shorter time period and substantially smaller number of observations ($N = 105$) reduce the statistical power of the fixed-effects model.

Table 7. Robustness and sensitivity analyses

Variables	(1)	(2)	(3)	(4)
	Baseline	Excl. 2020	Excl. oil regions	E_inv organis
L1_e_Inv	0.302** (0.140)	0.286* (0.136)	0.251 (0.144)	
int_users	-0.00350 (0.00394)	-0.00265 (0.00386)	-0.000815 (0.00412)	-0.006 (0.006)
ln_grp_pc	1.006*** (0.133)	0.992*** (0.131)	0.943*** (0.148)	1.366*** (0.219)
ipc_adj	-0.00758 (0.00513)	-0.00739 (0.00513)	-0.00556 (0.00571)	0.006 (0.004)
oil_price	0.00491*** (0.00182)	0.00476** (0.00176)	0.00487** (0.00209)	
covid	0.0843 (0.0716)		0.103 (0.0813)	-0.009 (0.056)
e_Inv_org				-0.333 (0.263)
Constant	4.460*** (0.279)	4.431** (0.277)	4.297*** (0.339)	7.473 (2.194)
Observations	224	208	196	105
R-squared	0.815	0.824	0.825	0.578
Number of region_id	16	16	14	15
Fixed effects	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Several robustness checks were conducted to examine whether the estimated association is sensitive to changes in the sample or model specifi-

cation (Table 7). In Models (1)–(3), the coefficient on the shifted e-Inv indicator remains positive across alternative samples. Since L1_e-Inv is a one-year shift of the nationwide implementation dummy, these specifications should be interpreted as temporal robustness checks rather than evidence of a delayed fiscal effect. The baseline model (1) shows a positive and statistically significant lagged effect of electronic invoicing ($\beta = 0.302$; $p = 0.047$). Excluding the COVID-19 year (2020) in Model (2) does not alter this conclusion: the coefficient remains positive and statistically significant at the 10% level ($\beta = 0.286$; $p = 0.053$). Similarly, excluding the oil-producing regions of Atyrau and Mangystau (Model 3) leaves the coefficient positive ($\beta = 0.251$; $p = 0.10$), although its statistical significance declines slightly, reflecting the smaller sample size. Across all three specifications, oil prices remain a significant determinant of tax revenues, highlighting the importance of resource-sector dynamics in Kazakhstan's fiscal system. Model (4) uses an alternative measure of electronic invoicing by replacing the binary policy indicator with the regional number of organizations using e-Inv (2018–2023) (BNS, 2024d). The estimated coefficient is not statistically significant ($\beta = -0.333$; $p > 0.10$). In Model (4), the nationwide e-Inv indicator is replaced by the regionally varying number of organizations using electronic invoices for 2018–2023. The estimated coefficient is negative but statistically insignificant ($\beta = -0.333$; $p > 0.10$). Thus, this specification does not provide evidence of a positive association between regional e-invoicing adoption and tax revenues. The result should be interpreted with caution given the shorter observation period and smaller number of observations ($N = 105$), but it also indicates that the positive association observed with the nationwide implementation indicator is not robust to this alternative, regionally varying measure. Overall, Models (1)–(3) show that the positive association associated with the shifted nationwide implementation indicator is not sensitive to excluding 2020 or oil-producing regions. However, Model (4) provides a more cautious interpretation: when a regionally varying measure of e-invoicing adoption is used, the coefficient is negative and statistically insignificant. Therefore, the evidence for a positive association is not robust across alternative measures of e-invoicing.

H1 is partially confirmed, as the basic fixed-effects model shows a statistically significant relationship between the national indicator for the introduction of electronic billing and regional tax revenues. A positive and statistically significant coefficient is obtained only when the indicator is shifted by one period. Because electronic billing has been introduced nationwide, this conclusion should be interpreted as temporary sustainability rather than evidence of a delayed financial impact. Thus, the overall data do not allow us to establish a strong positive relationship between electronic invoicing and regional tax revenues. The *H2* hypothesis has not received sufficient statistical confirmation. Although the estimated coefficients for the lagged indicator of electronic billing are positive in regions with high incomes and significant natural resources, as well as in other regions, none is statistically significant at the 5% level. At the same time, the results confirm the important role of the region's economic potential in generating tax revenues: the coefficient on GRP per capita is positive and statistically significant in both groups of regions. However, the results do not allow us to determine whether the relationship between electronic invoicing and regional tax revenues differs by a region's level of economic development.

4. DISCUSSION

The baseline fixed-effects model (M1) and the specification including a time trend (M2) do not reveal a statistically significant association between electronic invoicing and regional tax revenues ($p = 0.538$ and $p = 0.690$ respectively). However, the lagged specification (M3) shows a positive and statistically significant coefficient for the shifted electronic invoicing indicator ($\beta = 0.302$; $p = 0.047$). Given that *e-Inv* is a nationwide step dummy, this result should not be interpreted as evidence of a one-year delayed fiscal effect. Rather, M3 provides a temporal robustness check indicating that the estimated post-implementation association is sensitive to shifting the implementation breakpoint by one year. An important result is that the coefficient on the shifted *e-Inv* indicator becomes statistically significant only after controlling for oil-price dynamics. In resource-dependent economies such as Kazakhstan, fluctuations in commodity prices can substantially affect regional tax revenues, making associations between administrative reforms and fiscal outcomes more difficult

to detect in simpler model specifications. After accounting for oil-price dynamics, the coefficient on the shifted *e-Inv* indicator becomes positive and statistically significant. This result suggests that the estimated post-implementation association changes once resource-related macroeconomic conditions are taken into account, but it should not be interpreted as causal evidence of a fiscal effect of electronic invoicing. This underlines the importance of considering resource-related macroeconomic conditions when evaluating digital tax administration reforms (Keller, 2022). The lack of a statistically significant coefficient in the contemporaneous specifications may also reflect the broader institutional and economic context in which the reform was implemented. At the initial stage, electronic invoicing primarily covered large and medium-sized enterprises that already had relatively high levels of tax compliance. At the same time, the presence of a sizeable informal sector may limit the extent to which digital instruments can expand the tax base. This suggests that the potential contribution of electronic invoicing may be reflected more in tax administration and compliance within the existing tax base than in an immediate increase in measured tax revenues. Across all model specifications, GRP per capita remains the strongest and most stable determinant of regional tax revenues. This suggests that the economic capacity of a region continues to be the primary driver of fiscal performance, while digital tax administration plays a supporting rather than a leading role. This interpretation is consistent with the arguments of Bird and Zolt (2005) and Pessino and Fenochietto (2010), who identify economic development as the main determinant of tax capacity. To examine regional heterogeneity, a cluster analysis was conducted using tax revenues per capita and Internet penetration. The purpose of this analysis was descriptive rather than causal: it was intended to identify groups of regions with similar fiscal and digital characteristics. Three distinct clusters were identified. The first consists of regions with relatively low tax revenues and lower Internet penetration. The second includes only the Atyrau region, where exceptionally high tax revenues are primarily associated with oil production rather than digitalization. The third comprises economically more advanced regions with the highest levels of Internet penetration and relatively high tax revenues per capita. These patterns illustrate the considerable diversity of Kazakhstan's regions in terms of both economic

structure and digital development and provide a rationale for exploring heterogeneity in the estimated relationships. To investigate this issue further, the sample was divided into two economically meaningful groups: high-income regions (Almaty city, Astana city, and Atyrau region) and the remaining regions. The subgroup analysis suggests that the relationship between electronic invoicing and tax revenues is not uniform across regions. The coefficient on the shifted electronic invoicing indicator is statistically insignificant in the high-income group, while in the remaining regions it remains positive but only marginally significant. The subgroup estimates show some variation in the magnitude and statistical significance of the estimated association across the two groups, although the evidence is not sufficient to establish a statistically significant heterogeneous effect. Taken together, these findings indicate that digital tax administration alone cannot account for regional differences in tax revenues. Its contribution is likely to depend on broader economic conditions and the structure of regional economies. In Kazakhstan, where resource-rich regions generate a substantial share of tax revenues, electronic invoicing may be more closely associated with improvements in tax administration within the existing tax base than with a measurable expansion of that base.

This study has several limitations. First, digitalization is measured using proxy variables, including Internet penetration, the nationwide electronic invoicing dummy, and the regionally varying number of organizations using electronic invoicing.

These measures do not fully capture the broader intensity of digital tax administration. More direct regional indicators, such as the number of electronic invoice users or the volume of electronic invoices issued, were not available for the entire study period. Although regional data on organizations using electronic invoicing have been available since 2018, the analysis based on this alternative indicator relies on a shorter period and a smaller sample ($N = 105$). Therefore, the estimates from this specification should be interpreted with appropriate caution. Importantly, this alternative measure does not provide evidence of a positive association between e-invoicing adoption and regional tax revenues. Second, because electronic invoicing was introduced simultaneously across all regions of Kazakhstan, conventional causal identification strategies, such as difference-in-differences, could not be applied due to the absence of a valid control group (Angrist & Pischke, 2009). The empirical analysis therefore relies on fixed-effects models to estimate post-implementation associations, while the lagged specification is used only as a temporal robustness check. Finally, the study period coincided with several major economic shocks, including the COVID-19 pandemic and the inflationary surge in 2022, which may have influenced regional tax revenues despite the inclusion of relevant control variables. Future research could extend this analysis by using more detailed regional indicators of digital tax administration and longer time series as additional data become available.

CONCLUSION

The purpose of this study is to examine the association between electronic invoicing and regional tax revenues across Kazakhstan's regions. The empirical results show that electronic invoicing is not significantly associated with regional tax revenues in either the baseline fixed-effects model or the specification including a time trend. However, the specification using the shifted e-Inv indicator yields a positive and statistically significant coefficient. Given that e-Inv is a nationwide step dummy, this result should be interpreted as a temporal robustness finding rather than evidence of a delayed fiscal effect. Across all model specifications, GRP per capita remains the most robust determinant of regional tax revenues. At the same time, the cluster and subgroup analyses demonstrate substantial regional heterogeneity in both economic structure and digital development.

Overall, the findings suggest that the association between electronic invoicing and regional tax revenues is sensitive to model specification and broader regional economic conditions. In Kazakhstan, where differences in economic structure and resource endowment strongly influence regional tax capacity, digital tax administration appears more closely associated with existing tax capacity than with an in-

dependent increase in regional tax revenues. These results underline the importance of considering regional economic characteristics when evaluating the effectiveness of digital tax reforms. Importantly, the alternative regionally varying measure based on the number of organizations using electronic invoices provides no evidence of a positive association with regional tax revenues.

This study has several limitations. The analysis relies on indirect measures of digital tax administration, while more direct regional indicators were unavailable for the full study period. In addition, the simultaneous nationwide introduction of electronic invoicing limited the use of conventional causal identification approaches. Future research could extend this analysis by employing more direct indicators of digital tax administration, longer regional panel datasets, and alternative empirical strategies as more detailed regional data become available.

AUTHOR CONTRIBUTIONS

Conceptualization: Zamzagul Tursynkulova, Aizhan Abishova, Gulbana Maulenkulova.

Data curation: Zamzagul Tursynkulova, Gulbana Maulenkulova, Zarema Bigeldiyeva.

Formal analysis: Aizhan Abishova, Zarema Bigeldiyeva, Gulnur Bidauletova.

Funding acquisition: Zamzagul Tursynkulova, Aizhan Abishova, Gulbana Maulenkulova, Zarema Bigeldiyeva, Gulnur Bidauletova.

Investigation: Zamzagul Tursynkulova, Aizhan Abishova, Gulbana Maulenkulova.

Methodology: Zamzagul Tursynkulova, Aizhan Abishova.

Project administration: Zamzagul Tursynkulova, Aizhan Abishova.

Resources: Gulnur Bidauletova.

Software: Gulbana Maulenkulova, Zarema Bigeldiyeva, Gulnur Bidauletova.

Supervision: Zamzagul Tursynkulova, Aizhan Abishova.

Validation: Zamzagul Tursynkulova, Gulbana Maulenkulova.

Visualization: Zarema Bigeldiyeva, Gulnur Bidauletova.

Writing – original draft: Zamzagul Tursynkulova, Aizhan Abishova, Gulbana Maulenkulova, Zarema Bigeldiyeva, Gulnur Bidauletova.

Writing – review & editing: Zamzagul Tursynkulova, Aizhan Abishova.

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