## Introduction:

Developing countries seeking new ways to finance development increasingly turn to digitalization, using technology to modernize weak bureaucracies. In El Salvador, where the Ministry of Finance lacks the technical and administrative depth of agencies like the U.S. IRS, digital tools offer a substitute for low state capacity. Among digital initiatives, e-invoicing stands out for offering administrative benefits like lower costs, faster refund processing, and improved data security. Yet implementation imposes burdens such as IT upgrades and staff training, especially for weak tax administrations (Bellon et al., 2020, p. 5).

Prior studies find largely positive fiscal impacts of e-invoicing reforms. In Brazil, reported earnings increased by 22% over four years (Naritomi, 2015). In Ecuador, assessed tax rose 18–25% following phased adoption (Ramírez et al., 2017). Mexico and Argentina documented gains of 6–11% in declared income or revenue (Fuentes et al., 2016; Artana and Templado, 2017). Uruguay saw a smaller 3.7% gain in tax payment amounts (Bergolo et al., 2017). In contrast, China’s early gains from e-invoicing later faded (Fan et al., 2018, cited in Bellon et al., 2020). These results suggest that well-implemented e-invoicing can raise revenue, particularly where tax evasion is common and administrative enforcement is weak. However, these studies should be interpreted cautiously: none applied modern DiD methods to measure causality, and some may have weighted treatment effects inaccurately.

Firm effects are similarly heterogeneous. Peru saw 7–12% increases in reported VAT in the first year of its mandatory e-invoicing rollout, and these effects were strongest among small firms and in low-compliance sectors like retail and construction. However, firms in these sectors also experienced temporary declines in survival rates as increased scrutiny led to firm exits (Bellon et al. 2020, p. 2-3). Small and medium firms may face steep adjustment costs and require support, underscoring the importance of gradual rollout (Review on pros and cons).

Existing literature shows that technology and human enforcement are complementary. Digital systems reduce time spent on routine tasks, allowing tax authorities to focus limited resources on audits and investigations (Okunogbe and Tourek, 2024, p. 84). Many empirical studies link increases in tax revenue to combinations of digital reforms with staffing increases and performance incentives (Basri et al., 2017; Khan et al., 2015, 2018; cited in Okunogbe and Tourek, 2024). El Salvador’s rollout attempts to capitalize on technological and human complementarities through the creation of e-invoicing help centers.

El Salvador is a promising case study. With VAT accounting for 38% of public revenue, the tax base remains underutilized due to high informality (~two-thirds of the workforce). The 2023 World Bank Enterprise Survey shows 80.3% of formal firms pay taxes electronically, yet internet access remains limited (68%). While over 70% of firms report the tax process as overly complex, only 10% cite tax administration as a major obstacle, suggesting openness to digital reforms.

This paper provides the first firm-level, causal analysis of e-invoicing in El Salvador. To date, no published studies have evaluated this reform in the Salvadoran context, despite its ambitious national rollout and political salience. I leverage the policy’s staggered implementation across ten treatment cohorts and apply modern difference-in-differences (DiD) methods to measure its impact on two outcomes: log reported VAT revenue and the probability that a firm remits VAT in a given month. While previous studies often rely on two-way fixed effects or discontinuities, I use the Callaway and Sant’Anna (2021) estimator, which produces unbiased estimates in staggered rollout settings by avoiding negative weighting and cohort contamination. These results contribute to a growing literature on tax digitalization in low-capacity settings and offer insight for policymakers considering similar enforcement technologies.

## Context:

### A. Historical Context:

After a civil war ended in 1992, decades of increasing poverty and gang violence preceded the election of President Nayib Bukele in 2019, who campaigned as a “non-party” candidate promising to end corruption and modernize the state. His decisive COVID-19 response — declaring repeated states of emergency and allocating emergency funds for new hospitals — paved the way for virtually unopposed one-party rule. Within months, the legislative majority replaced Supreme Court judges and the attorney general with Bukele loyalists, eliminating any judicial check on his decrees and even permitting him to seek re-election past the constitutional term limit.

Under Bukele, public debt has soared to more than USD 30 billion, or 87.6% of the country’s gross domestic product (GDP) — much higher than its neighbors, which all have debt under 50% of GDP. To fund his ambitious infrastructure agenda (e.g., high-speed rail and a new international airport), inherited anti-poverty programs, and sizable COVID-19 relief, Bukele has pursued high-profile technological reforms. One such initiative — the sale of Bitcoin-denominated bonds — failed; another, which this study examines, is the tax authority’s rollout of a mandatory e-invoicing program.

### B. E-invoicing:

El Salvador’s Ministry of Finance identified e-invoicing as a “high impact” project — central to modernizing state administration and improving revenue collection. Prior to its rollout, tax policy had not been overhauled since the 1990s. The standard 13% VAT generates 38% of public revenue, yet approximately 70% of the workforce is informal. Heavy reliance on remittances — about a quarter of the country’s gross national product —supports household incomes but may reduce incentives or capacity for small and rural firms to adopt electronic billing.

Most countries, including El Salvador, levy VAT at each stage of production and distribution. Producers pay VAT on sales to retailers, who in turn apply the same rate to consumer sales. Many public, financial, and insurance services are exempt (PwC). In contrast, U.S. states typically rely on a single-stage retail sales tax. While both can raise equivalent revenue, VAT’s invoicing trail and detailed reporting mechanisms enhance enforcement and reduce evasion.

More than 50 countries around the world, including ten countries in Latin America and the Caribbean region, had implemented e-invoicing by 2018 ­­— four years before El Salvador’s initial reform legislation. Like El Salvador’s plan, e-invoicing in Peru required an overhaul of their tax administration and taxpayer IT capabilities. As such, e-invoicing was introduced gradually, with initial reform waves focusing on larger firms, while smaller firms were given more time to adopt.

Prior to the reform, tax enforcement in El Salvador relied on paper-based invoicing and ex-post audits, with limited cross-checking and no real-time monitoring. Tax and customs inspections were paper-intensive and slow, confirming low administrative capacity. Mandatory e-invoicing, however, enabled real-time monitoring of commercial transactions, aiming to boost transparency and enforcement efficiency.

In 2019, El Salvador launched a voluntary e-invoicing pilot targeting roughly 50 large VAT taxpayers, but the program was delayed by the COVID-19 pandemic and lacked public documentation (VATCalc, EDICOM). In July 2023, El Salvador began mandating e-invoicing for the first rollout group, replacing paper invoices with fully electronic invoices via the Finance Ministry’s eFacturaSV. Suppliers use the Ministry’s free web portal or approved accounting software to create each invoice in a standard computer-readable format. The platform then automatically checks the file, verifies the supplier’s digital credentials and the VAT calculation, and issues an official authorization code before returning the approved invoice. The supplier forwards this to the buyer, and because every step happens in real time on a government-controlled system, tax authorities can monitor compliance instantly. Unlike the more decentralized models in parts of Europe, El Salvador’s e-invoicing is fully government-mediated and archives every VAT invoice as it is issued.

Notifications began in February 2023, and the ten-group rollout has not been completed at the time of writing. Firms may opt-in early but must comply by their assigned date. In 2018, the Inter-American Development Bank contributed USD 3 million to modernize tax administration — USD 170,000 funded crucial steps in the e-invoicing rollout in 2023-2024, such as a mobile app, project website, and six support centers that have trained over 50,000 users. According to the Ministry of Finance, the transition to e-invoicing contributed to a USD 2 billion increase in VAT revenue between 2022 and 2023, reduced evasion, streamlined processes, and shortened service times; by September 2024 it also saved 29,157 trees and cut water use by 208.6 million liters (IADB 2024).

This ten-group rollout let the tax authority onboard firms in manageable batches, stress-test eFacturaSV and the help centers, and tailor training before each new wave. Phasing with cohorts of increasing numbers of firms concentrated resources on each group’s needs, avoided overwhelming the platform or small firms unfamiliar with e-invoicing, and mirrored pilots in other Latin American countries (e.g., Peru).

Alongside the e-invoicing mandate, El Salvador introduced complementary tax measures that may also influence VAT outcomes. As of January 2025, e-tickets became mandatory for business-to-consumer transactions, expanding digital traceability in retail sectors (IADB, 2023). Unlike e-invoices, which apply to business-to-business transactions and require stricter documentation, e-tickets are simplified digital receipts. The end of tax amnesty programs in late 2024 may also signal a shift toward stricter enforcement (Auxadi, 2024). While this study isolates the impact of staggered e-invoicing, these concurrent reforms may reinforce compliance trends. As the primary mechanism for recording VAT liabilities, e-invoicing remains the most consequential reform and a valid focus of analysis.

## Data:

This study uses monthly firm-level tax remittance data from 2022 to 2025, publicly available through El Salvador’s *Fiscal Transparency Portal*, maintained by the Ministry of Finance. These datasets contain declassified information for each firm’s monthly payments, including the remittance amount, payment type, as well as their economic activity and municipality.The number of unique firms (30,167) is slightly below the official number of firms notified (approximately 37,000), likely due to delayed entry into the dataset, as there is a notable increase in new firm appearances in the most recent months.

Firm identifiers are unavailable, so firms are approximated using unique combinations of municipality and economic activity codes. A balanced monthly panel is constructed by merging tax data from January 2022 to May 2025. For example, a firm with code 410106 (metal treatment and coating) in 0614 (San Salvador) is assigned firm\_id 410106\_0614. Municipality and activity codes are matched to names using official code dictionaries provided on the Fiscal Transparency portal. Each firm’s industry is classified by the first two digits of its activity code (e.g., 40 corresponds to the information and communications industry), enabling industry-level analysis.

The analysis is restricted to VAT revenue, identified using tax codes from the Portal’s public dictionary, which includes:

* VAT Internal Transactions
* VAT on Imports
* VAT Transactions via Withholding and Collection
* VAT Withholding Non-Residents
* VAT Advance Payment (e.g., 2% on credit card purchases)

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Because e-invoicing rollout dates were not publicly documented, direct contact with the Ministry of Finance and the Transparency portal support office was necessary to obtain official notification and implementation dates, as well as the firm count per cohort. While assignment criteria are classified, the increasing cohort sizes and legal mandate to begin with large taxpayers suggest that firms were sorted by decreasing pre-treatment size. Firms with no reported revenue one month prior to the first rollout group’s notification date (February 2023) are excluded to ensure comparability and valid estimation of dynamic treatment effects.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Group 1** | **Group 2** | **Group 3** | **Group 4** | **Group 5** | **Group 6** | **Group 7** | **Group 8** | **Group 9** | **Group 10** |
| **Notification Date** | 2/1/2023 | 5/1/2023 | 8/1/2023 | 12/1/2023 | 2/1/2024 | 5/1/2024 | 8/1/2024 | 12/1/2024 | 2/1/2025 | 5/1/2025 |
| **Treatment Date** | 7/1/2023 | 10/1/2023 | 1/1/2024 | 4/1/2024 | 7/1/2024 | 10/1/2024 | 1/15/2025 | 4/1/2025 | 7/1/2025 | 10/1/2025 |
| **Firm Count** | 233 | 239 | 249 | 345 | 657 | 701 | 704 | 4982 | 14286 | 15000 |

Firms are classified as large (over USD 1 million/year in total tax remittances), medium (USD 100,000—1 million), or small taxpayers (under USD 100,000) based on their average pre-treatment VAT revenue. [SLIDESHOW SOURCE] Firms were notified approximately five months before their assigned implementation dates.

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Remittance plots are calculated by a binary variable that takes the value 1 for when a firm remits, and 0 for when a firm does not.

A known limitation of the data is an under-reporting error affecting October 2023, corresponding to the second cohort’s treatment month. This month is excluded from the sample. Other limitations include the absence of firm-level covariates (e.g., firm age, digital readiness, or tax history) and the inability to observe firms that voluntarily adopted e-invoicing before the mandate.

## Methods:

To identify the causal effects of e-invoicing on firms’ tax behavior, I use a difference-in-differences (DiD) for multiple time periods — an event study design proposed by Callaway and Sant’Anna (2021) — exploiting the staggered adoption of e-invoicing. DiD compares changes in outcomes before and after treatment between a treated and control group, given similar pre-treatment trends for both groups. Since the e-invoicing program was the only major tax-related overhaul affecting VAT revenue, any difference in outcomes between the two groups after the policy can be attributed to the intervention, assuming both would have otherwise followed similar trends.

However, standard DiD methods using two-way fixed effects (TWFE) — which include group and time dummies in a single regression — can give misleading results when treatment timing varies. Callaway and Sant’Anna (2021) reveals that TWFE may even produce wrong-signed treatment effects, since some treated units are incorrectly used as controls for other treated units. This contamination leads to invalid comparisons and, in some cases, biases the estimated treatment in the opposite direction of the true effect.

To avoid these issues, I implemented the doubly robust event study method developed by Callaway and Sant’Anna (2021). Their approach builds upon separate estimations of group-time average treatment effects (ATTs), denoted:

which is the expected difference in outcomes at time for units in one of the ten treatment groups . By fixing units, or firms, to a group and varying time , it is possible to extrapolate how average treatment effects evolve over time for that specific group. In other terms, this equates the expected difference for treated groups compared to how they would have remitted without treatment, which is done by comparing each treated group only to firms that had not yet been treated at time , ensuring that the control group is always untreated.

Identifying assumptions for Callaway and Sant’Anna (2021) event studies are key. The “Limited Treatment Anticipation” assumption allows for more robust treatment effects, incorporating firm’s behavior given the consistent five-month gap between each group’s notification and implementation dates.

Since my dataset lacks firm-level covariates such as employment, age, or digital readiness, I do not adjust for observed heterogeneity. Treatment effects are identified solely through variation in treatment timing across cohorts. While the estimator supports conditional parallel trends given covariates, I rely on the stronger assumption that, in the absence of treatment, firms in different groups would have followed similar outcome trajectories on average.

Treatment effects are measured using the log of firms’ monthly VAT revenue. However, because some firms do not remit every month, their revenue values are zero in some periods. Since is undefined, I follow a standard practice by adding one dollar to each firm’s monthly revenue before logging. This transformation preserves zero values while enabling logarithmic comparison across firms and time. While this introduces slight bias when revenue values are small, it avoids the loss of observations or systematically dropping certain observations correlated with a valid outcome. This approach aligns with guidance from Dzielinsky et al. (2023), who recommend the adjustment when modeling economic variables subject to censoring.

In addition to my firm-level analysis, I estimate treatment effects at a more aggregated level using a balanced panel of 189 group-industry-month units, where each unit captures all firms within a taxpayer size group and industry in a given month. This aggregation reduces firm-level noise and smooths irregular reporting behavior, particularly among smaller firms. Since treatment timing is assigned at the group level, this structure preserves the staggered rollout design while allowing for sector-level heterogeneity in policy response. Compared to my firm-based panel with units grouped at the industry-municipality level, the group-industry aggregation trades off granularity for greater stability and interpretability in aggregate fiscal behavior. These aggregate results are more directly relevant for policymakers seeking to understand how the e-invoicing mandate affects revenue and compliance across broader economic sectors.

To understand how the treatment effect evolves over time, I construct an event study, which re-indexes treatment effect by time relative to each group’s treatment date. Letting represent event time (i.e., how many periods before or after treatment), I estimate the average treatment effect at each event time:

This aggregates group-time effects across all groups that are observed periods after treatment, weighting by the size of each group. Negative values of correspond to pre-treatment periods (used to check if trends were parallel before the policy), while positive values track the policy’s effect over time.

I implement this estimator in two steps using the did package in R.[[1]](#footnote-1) This modern DiD method provides more credible estimates in staggered rollout settings like this one (NAME DROP PERU STUDY). By focusing on only valid comparisons and modeling treatment dynamics explicitly, Callaway and Sant’Anna (2021) event studies overcome key limitations of traditional regressions and gives a clearer picture of the policy’s timing and impact.

## Results:

The Callaway and Sant’Anna (2021) event study model fits the data well and confirms parallel pre-treatment trends. I find no evidence that El Salvador’s e-invoicing mandate significantly or rapidly increased VAT remittance or compliance during the initial rollout period. However, long-term effects — particularly among smaller firms — remain unknown and appear likely to improve as firms adapt and enforcement scales. I reject the hypothesis that the policy produced immediate gains in public revenue collection.

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### A. Effects on VAT Remittance:

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Overall summary of ATT's based on event-study/dynamic aggregation:

ATT Std. Error [ 95% Conf. Int.]

0.0116 0.0407 -0.0681 0.0913

The estimated average treatment effect on the treated (ATT) for log VAT revenue at the firm level is 0.012 (SE = 0.041), with a 95% confidence interval of [-0.068, 0.091]. These results indicate that, through the end of 2024, the e-invoicing mandate had no statistically significant impact on firms’ reported VAT revenue. The dynamic event study plot confirms parallel pre-treatment trends and shows no sharp or sustained revenue increase in the initial months.

### Changes in Remittance Probability

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Overall summary of ATT's based on event-study/dynamic aggregation:

ATT Std. Error [ 95% Conf. Int.]

-6e-04 0.0037 -0.0078 0.0066

The estimated ATT for the probability of VAT remittance at the firm level is -0.0006 (SE = 0.0037), with a 95% confidence interval of [-0.0078, 0.0066]. This estimate is statistically indistinguishable from zero, indicating that e-invoicing had no measurable short-run effect on the probability that firms remit VAT during the study period ending in 2024. The event study plot shows stable pre-treatment trends and no discernible break in the post-treatment period.

### Aggregate Revenue and Compliance Effects

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Overall summary of ATT's based on event-study/dynamic aggregation:

ATT Std. Error [ 95% Conf. Int.]

-0.0594 0.0996 -0.2546 0.1358

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Overall summary of ATT's based on event-study/dynamic aggregation:

ATT Std. Error [ 95% Conf. Int.]

0.0092 0.0112 -0.0128 0.0311

To assess broader fiscal impacts, I estimate event studies on industry-level monthly aggregates within each treatment group. Panel A reports dynamic treatment effects on log total VAT revenue, while Panel B reports the probability of any firm in the group remitting VAT in a given month.

While group sizes, with units that are clusters of firms based on their economic activity and mandated rollout group, vary significantly, the ATT estimates are consistently computed using within-group comparisons against not-yet-treated controls. To mitigate the risk of overweighting larger cohorts, I interpret the agg

For log total VAT revenue (Panel A), the estimated ATT is -0.059 (SE = 0.100), with a 95% confidence interval of [-0.255, 0.136]. This estimate is not statistically significant, and the dynamic event study plot shows no clear deviation from pre-treatment trends. These results indicate the total VAT collected within treated group-industries did not increase in the short run.

Panel B shows the effect on the probability that at least one firm in the group remits VAT. The estimated ATT is 0.009 (SE = 0.011), with a 95% confidence interval of [-0.013, 0.031]. This too is statistically indistinguishable from zero, and the plot reveals no discernible shift in compliance behavior following treatment.

Taken together, these aggregated results reinforce the firm-level findings: El Salvador’s e-invoicing mandate did not produce measurable improvements in revenue or compliance at the group-industry level through the end of 2024.

### Industry-Specific Treatment Effects

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(Public administration and defense; compulsory social security plans)

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(Agriculture, livestock, forestry and fishing)

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(Human health care and social care activities)

Industry-level event studies reveal that only three sectors — health care and social assistance; agriculture, livestock, forestry and fishing; and public administration and social security — indicate statistically significant positive effects in one or more post-treatment periods. These sectors stand out among the top twenty by firm count, where most industries show no measurable response to the e-invoicing mandate. The concentration of positive effects in these areas suggests that the policy’s initial fiscal impact is strongest where firms are either already rooted in formal regulatory systems (e.g., public contracts, health licensing) or where informal firms interact regularly with the state, such as agricultural producers involved in exports or cooperative arrangements. These results align with the hypothesis that e-invoicing is more likely to raise compliance and VAT remittance in sectors operating at the boundary of informality and state oversight.

### Recent Cohorts and Possible Late-Stage Treatment Effects

While early findings suggest potential upward trends in VAT remittance for later cohorts, I refrain from interpreting these as causal due to possible changes in firm classification and reporting practices in 2025. The integrity of the event study relies on stable units over time—a condition that may not hold in the final months of the panel. Instead, I interpret revenue patterns descriptively.

Including the 2025 dataset, VAT remittance does not spike for early treatment groups in ways that diverge from historical seasonal variation. However, later cohorts composed of smaller firms show pronounced increases around treatment dates that mirror seasonal trends already observed in larger groups. By law, firms must track VAT collected throughout the month but are only required to remit it by the 10th business day of the following month. As a result, high-consumption periods such as December lead to higher VAT remittances in January or February. In addition, government spending on public and private contracts is often front-loaded at the start of the fiscal year. These factors help explain the consistent first-quarter revenue spikes across all groups and the increase in remittance behavior among smaller firms.

The spike in reported VAT remittance among smaller firms following treatment is notably sharper than that observed in larger firms and could suggest that the e-invoicing mandate had a stronger compliance effect on smaller firms. Larger firms, already more likely to remit consistently, show no discontinuity beyond historical patterns. However, interpretation of these late-stage effects is complicated by the inclusion of 2025 data, during which firm classifications and administrative practices may have shifted. Nonetheless, the data point toward potential long-run compliance gains for smaller firms: the estimated average treatment effect on remittance probability is 0.019 (SE = 0.0029), statistically significant at the 5% level. Still, this increased compliance does not translate into substantial revenue gains, as the estimated ATT on log VAT revenue is only 0.049 (SE = 0.0284) and not statistically significant. While these results are not causal, they suggest that although e-invoicing may help bring more small firms into the tax net, their contribution to total VAT revenue remains limited.

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Overall summary of ATT's based on event-study/dynamic aggregation:

ATT Std. Error [ 95% Conf. Int.]

0.0491 0.0284 -0.0066 0.1048

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Overall summary of ATT's based on event-study/dynamic aggregation:

ATT Std. Error [ 95% Conf. Int.]

0.0193 0.0029 0.0136 0.025 \*

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Overall summary of ATT's based on event-study/dynamic aggregation:

ATT Std. Error [ 95% Conf. Int.]

-0.011 0.1011 -0.2091 0.1872

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Overall summary of ATT's based on event-study/dynamic aggregation:

ATT Std. Error [ 95% Conf. Int.]

0.0151 0.0106 -0.0056 0.0358

## Conclusion:

This paper examines the effect of the initial stages of an e-invoicing mandate on reported VAT revenue and compliance using publicly available data on all taxpaying firms in El Salvador and private correspondence with their Ministry of Finance. I show that the policy does not significantly increase reported VAT revenue for large firms, likely due to their existing digital infrastructure and consistent compliance. These effects appear heterogeneous, with larger impacts for smaller firms and for firms in sectors with a lower risk of tax noncompliance. This suggests that the impact of e-invoicing is primarily through deterrence and improved traceability.

Treatment effects accumulate gradually over time, suggesting that the full effect of the reform may not yet be realized, as also noted in similar reforms such as Peru’s (CITE). The Ministry of Finance has indicated that more than ten rollout cohorts may follow and continues to invest in firm-level support via physical help centers. While such implementation support is widely considered necessary for successful adoption (CITE), my results show no improvement in compliance among large and medium firms, suggesting that the returns to these complementarities may be higher for small or digitally inexperienced taxpayers. A useful avenue for future research is to evaluate the mandate’s effects once rollout is complete — both to estimate causal impacts on smaller firms and to assess potential spillovers to other branches of government, such as public administration, social security, or health-related sectors, where early results suggest stronger compliance effects likely driven by closer ties with the state.

This study is among the first to apply modern difference-in-differences methods to measure firm- and group-level responses to staggered e-invoicing rollout in a low-capacity tax administration. By using the Callaway and Sant’Anna (2021) estimator, I ensure valid comparisons across treatment cohorts and avoid common biases that affect traditional DiD approaches. The findings offer early insight into how digital enforcement tools affect compliance in low state capacity settings and may help inform policy design in other developing or low-compliance countries pursuing similar digital reforms.

1. First, I compute the group-time ATTs using att\_gt(), comparing each treated cohort to appropriate not-yet-treated controls. Then, I apply aggte(type = “dynamic”) to produce an aggregate event-study graph, allowing for visual assessment of e-invoicing’s impacts following implementation. [↑](#footnote-ref-1)