Digitalization to Improve Tax Compliance: Evidence from VAT e-Invoicing in Peru

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Abstract

This paper examines the impact of switching from paper to e-invoicing on firm tax compliance and performance using quasi-experimental variation in the roll-out of VAT e-invoicing in Peru. We find that e-invoicing increases reported firm sales, purchases and value added by over 5 percent in the first year after adoption. The impact is concentrated among small firms and sectors with traditionally higher rates of noncompliance, suggesting that e-invoicing enhances compliance by lowering compliance costs and strengthening deterrence. The reform's positive effects on tax collection are hindered by shortcomings in the VAT refund mechanism in Peru, suggesting that digital tools such as e-invoicing should be complemented by other reforms to improve revenue collection.

Keywords: electronic invoicing, VAT, tax compliance, digitalization

JEL: D22, H25, H26, L25, O17

1   Introduction

Increasing revenue collection to finance their sizeable developmental needs remains a critical challenge for developing and emerging economies. Digitalization is transforming how tax administrations operate by enhancing their capacity to deter tax noncompliance while also helping to improve process efficiency and service delivery (Gupta et al., eds, 2017). A striking example is the adoption of electronic invoicing (e-invoicing), which allows for the automatic transfer of billing information between firms and the tax authority. Drawn by its potential to strengthen tax compliance and reduce costs, more than 50 countries around the world have already implemented e-invoicing, including ten countries in Latin America and the Caribbean region (Barreix and Zambrano, eds, 2018).

By replacing more cumbersome paper-based processes, e-invoicing promises multiple benefits for firms and the tax authorities alike, including lower administrative and compliance costs, better integration of billing and payment systems, and improved accuracy and information security. For tax administrations, e-invoicing also delivers real-time information that could be used to strengthen and automate compliance checks. However, despite its widespread adoption, there is still limited empirical evidence on how e-invoicing affects firm compliance and performance. This paper contributes to the literature on digitalization and tax compliance by using administrative tax data and quasi-experimental variation in the mandatory roll out of value-Added Tax (VAT) e-invoicing in Peru.

The electronic transmission of invoice information in Peru required a substantial overhaul of tax administration and taxpayer IT capabilities. As a result, e-invoicing was introduced gradually, with the first reform waves focusing on larger firms and priority sectors, while smaller firms were given more time to adopt the new electronic system. Our identification strategy exploits this sequential introduction of the reform to estimate the causal impact of VAT e-invoicing on firm performance and compliance.

We use confidential administrative data provided by the Peruvian tax authority (SUNAT) to conduct our analysis. Our monthly panel dataset covers all small, medium and large (formal) private-sector firms operating in Peru between 2010 and 2017, and includes detailed information on firm sales, purchases, employment, wages, capital, profits, and taxes. This allows us to distinguish between productivity and compliance gains associated with e-invoicing,

and its heterogeneous impact across firms. To avoid composition biases, our analysis focuses on a balanced sample panel consisting of 78 thousand firms that were mandated to adopt e-invoicing between 2014 and 2018, which account for over 85 percent of domestic VAT collections in Peru.

We conduct the analysis in three steps. First, we estimate the impact of the e-invoicing reform on sales, value added and tax liabilities across all firms. We find that being mandated to adopt e-invoicing (an "intent-to-treat" effect) increases reported taxable sales and purchases by 7 and 6 percent in the first year, respectively. This impact grows over time, starting from the mandatory date of adoption. The increase in reported value added does not seem to be associated with a commensurate increase in labor input, suggesting that it is likely driven by an increase in the share of output that is reported to the tax authorities. Furthermore, the increase in sales and purchases does not translate into a one-for-one increase in VAT collections. Instead, we find that large accumulations of past VAT credits allow some firms to offset VAT liabilities and, consequently, to lower VAT payments in the first year of e-invoicing.

Second, we examine how these estimated impacts vary across firms. We show that the positive impact of e-invoicing on reported sales and tax is driven primarily by relatively smaller firms. Specifically, we find that reported value added increases by about 6 percent in the first year after adoption among the relatively smaller firms, while the effect among large firms is close to zero and not statistically significant.

In addition, we find that the reform had a larger impact in sectors that traditionally suffer from low compliance, such as retail, business services and construction. Firms in these sectors respond more strongly to e-invoicing adoption, suggesting that e-invoicing affects firm behavior in part by fostering greater compliance, possibly because of the perceived threat of greater scrutiny. We also find that firms in these sectors are more likely to exit once the e-invoicing reform was announced, but before the deadlines for implementation are reached. This is consistent with e-invoicing reducing noncompliance and raising the effective tax rate on firms, leading less profitable firms to exit.

Finally, we find that the rate of e-invoicing adoption increases steadily around the mandatory dates of adoption in every mandated group. This suggests that being mandated into e-invoicing is a strong instrumental variable for studying the average treatment effect of e-invoicing adoption. The result of instrumental variable (IV) regressions are qualitatively simi-

lar and quantitatively stronger than the intent-to-treat effects. We find that actual e-invoicing adoption by firms increased their reported value added, VAT liabilities and VAT payments by over 10 percent.

To account for the possibility that omitted variable bias affects our difference-in-differences strategy, we employ firm fixed effects to control for time-invariant firm characteristics and quarter fixed effects to control for common shocks across all firms. Given the high frequency of our data, we are also able to control for firm-specific linear time trends, to allow for different growth trajectories across each individual firm. We also control for firm-level time varying characteristics such as the wage bill, capital stock and number of workers. Our dynamic specification allows us to evaluate the precise timing of the treatment effect relative to the time of being mandated to adopt e-invoicing, and establish quarterly parallel pre-trends, to ensure that results are not driven by other coincident changes in the economy. We also examine the behavior of treated firms around the dates when SUNAT announced the reform deadlines. We found no significant changes in firm-level sales, purchases and VAT following the announcement dates and in anticipation of the deadlines.

This paper contributes to several strands of the literature on tax compliance. First, our research contributes to the ongoing research on policy responses to tax evasion (see Slemrod (2019) for a review). In particular, our work reinforces the results from studies investigating the importance of third-party information reporting on tax compliance, whereby greater information on taxpayer transactions yield fewer avenues for tax noncompliance (Mittal and Mahajan, 2017; Slemrod et al., 2017; Naritomi, 2019; Pomeranz and Vila-Belda, 2019). Our work is also related to the impact of audit probability on taxpayer behavior (Slemrod et al., 2001; Alm et al., 2018), with the deterrence effect of e-invoicing deriving from higher threat of audit as a result of improved ability to identify noncompliance.

In addition, our research is linked to the broader study of how digital technologies can enhance governance and public sector efficiency. For instance, e-procurement has been shown to improve infrastructure provision in India and Indonesia through improvements in quality and reduction in delays respectively (Lewis-Faupel et al., 2016). Similarly, Banerjee et al. (2017) find sizeable reductions in leakages from the world's largest workfare program (NREGS in India) with the introduction of electronic funds flow management.

Finally, we contribute to the growing literature that examines the impact of digital technologies

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on tax administration, including not only e-invoicing (Ramirez et al., 2018; Bergolo et al., 2018; Artana and Templado, 2018; Castro et al., n.d.; Lee, 2016), but also the electronic submission of tax returns or e-filing (Yilmaz and Coolidge, 2013; Kochanova et al., 2016; Okunogbe and Pouliquen, 2018) and the use of electronic sales registry machines (Eissa and Zeitlin, 2014; Ali et al., 2015). Our work is closest to Fan et al. (2018), who find that the introduction of e-invoicing in China led to short-term tax revenue gains, which were partly reversed after a few years. While Fan et al. (2018) focus only on manufacturing firms, we use administrative data on all VAT paying firms, which allows us to evaluate both the average treatment effect across all economic sectors and heterogeneous effects across sectors with traditionally higher rates of tax noncompliance, such as construction and services. Moreover, our identification strategy relies upon the natural experiment created by the sequential manner in which e-invoicing was mandated across firms, as opposed to Fan et al. (2018) who utilize variation in VAT intensity at the industry level.

The remainder of the paper is organized as follows. Section 2 describes the reform timeline, while section 3 presents the dataset and stylized facts. Section 4 outlines the empirical approach, and section 5 discusses the main results. The last section concludes.

2   The e-Invoicing Reform in Peru

Electronic invoicing has been available to firms in Peru since the 2000s on a voluntary basis, allowing taxpayers to issue electronic invoices at their discretion.[1] The e-invoicing reform that we study in this paper began in 2013, with the aim of permanently switching away from paper-based invoices to electronic invoices. Firms were required to issue electronic invoices by default, while paper-based invoices are permitted only in exceptional circumstances (e.g., if there is an internet outage).[2]

E-invoicing can bring several benefits to taxpayers, including cost savings (such as lower printing, storing and administrative costs), more secure and accessible information storage, and

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[1]Initially, e-invoices could only be issued through a web portal. Starting in 2012, taxpayers could develop their own e-invoicing systems, provided they met certain technical and regulatory specifications. This encouraged some taxpayers, especially large firms, to adopt e-invoicing voluntarily early on.

[2]In these cases, firms are required to regularize paper-based invoices on a timely basis (RS 113-2018/SUNAT).

integration of invoice issuance with other internal (accounting, payment, billing) and external processes (such as accounting, payment and procurement systems of suppliers, clients and the public sector).[3] At the same time, by improving control over the invoicing process and allowing for real-time monitoring of taxable transactions, tax administrations may also be able to reduce sales omission, purchase over-invoicing (including the reporting of purchases that are not related to business operations), fraudulent transactions, and general tax submission errors, thus reducing tax noncompliance and informality at a lower cost. SUNAT's stated motivation for the e-invoicing system was to improve the competitiveness of domestic firms by encouraging their digital transformation; strengthen monitoring and control to reduce the VAT noncompliance; and increase the tax base by bringing more transactions into the formal sector.

Switching to e-invoicing can create significant adjustment costs for taxpayers and the tax administration alike, including updating IT capacity and staff training.[4] Although many of these are one-off costs, they can nonetheless impact tax collections and firm performance. Therefore, e-invoicing requirements in Peru were introduced in a gradual and staggered manner, whereby firms were assigned into reform waves with different deadlines for e-invoicing adoption. Selection of firms into waves was based on administrative classifications and was related to size and compliance factors. Larger firms were required to adopt e-invoicing earlier, as they represent a large share of VAT revenue and had more capacity to update their IT systems.[5] The tax administration also prioritized e-invoicing adoption by taxpayers with a record of poor tax compliance, since e-invoicing was believed to have a stronger deterrence effect and would facilitate the monitoring of their transactions.

The first reform wave began in 2014 and included 238 firms among the largest issuers of invoices

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[3]Anecdotal evidence from discussions with private-sector organizations suggests that e-invoicing helps firms reduce the likelihood of receiving substantial fines when audited. SUNAT can fine firms that do not organize invoices properly and the electronic format made it easier to comply with this requirement.

[4]For example, some firms complained about payment delays during the transition when buyers had not yet adapted their internal processes to receive e-invoices.

[5]Adoption by large firms can have positive network spillovers, if it encourages clients and suppliers to transition to e-invoicing as well. It can introduce a bias when comparing mandated to not-yet mandated firms if a non-negligible share of not-yet mandated firms voluntarily adopt e-invoicing in advance. However, the bias works against identifying any effects and our results should therefore be interpreted as a lower bound of the real effect of e-invoicing. Furthermore, we show that voluntary adoption before the slated deadlines was rare.

Figure 1: Timeline of e-Invoicing Adoption Waves in Peru
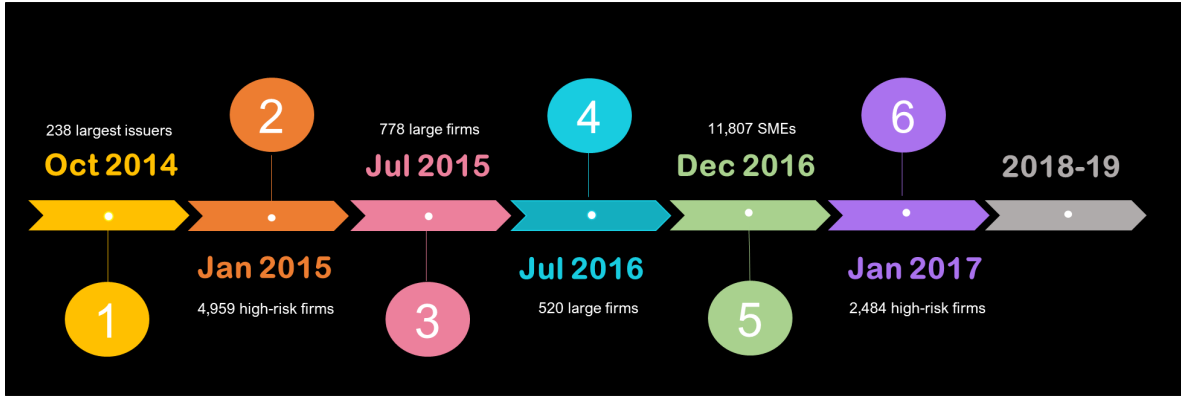
Note: This figure illustrates the stages of e-invoicing adoption in Peru. Reform waves are identified by their original adoption deadline.

in Peru, such as large manufacturing, mining and financial firms. The original deadline for this wave was October 2014, but it was later extended to April 2015 and then to August 2015 to give taxpayers additional time to comply.[6] The second wave comprised 4,959 firms that had been caught in fictitious or fraudulent transactions (Operaciones No Reales - ONR) during tax audits, and, therefore, were considered as high risk of tax evasion.[7] These firms were required to switch to e-invoicing starting from January 2015.

Reform waves in the next two years continued to focus on larger firms. A group of 778 large firms was required to adopt e-invoicing starting from July 2015 (later extended to January 2016), while a further 520 large taxpayers was given until July 2016 (later extended to July 2017) to make the switch. This staggered selection of firms reflected different vintages of the large firm database maintained by the tax administration, and in both cases the original deadlines for e-invoice adoption were also extended (see Figures A.1 and A.2 in appendix).[8]

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[6]See RS 374-2013/SUNAT for the original deadline, and RS 300-2014/SUNAT and RS 086-2015/SUNAT for deadline extensions.

[7]See RS 300-2014/SUNAT.

[8]The first group was drawn from the large firms register as of 30 September 2014 (Intendencia de Principales Contribuyentes Nacionales - IPCN) and was given an original deadline of 1st July 2015 (RS 300-2014/SUNAT), which was later extended until 1st January 2016 (RS 137-2015/SUNAT). The second group included new additions to the IPCN registry as of 31 July 2015. Its original deadline was 15th July 2016 (RS 203-2015/SUNAT), but this was later extended by six months (RS 328-2016/SUNAT).

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As shown in Table A.1, the first waves of e-invoice adoption included the largest contributors to sales, taxable value added and VAT collections. On average, firms in the October 2014 reform wave reported annual sales of $400 million and employed 1,700 workers each, while those in the July 2015 and July 2016 waves had sales of $50 million and $30 million, and employed 680 and 275 employees each, respectively. These firms were also more likely to be exporters and subject to special VAT withholding regimes.[9] Together, the firms in the first four waves represented just over 54 percent of total taxable value added and 27 percent of employment in our database.

The next wave (wave 5) focused on expanding e-invoicing to small and medium size firms. A group of 11,807 firms was drawn from the tax administration's registry of significant taxpayers at the regional and provincial levels and given until December 2016 to switch to e-invoicing. However, this deadline was subsequently extended to July 2017, and then to January 2018.[10] On average, these firms were smaller in size compared to firms in previous waves, with average annual sales of $5 million and about 100 workers each. However, it still included several larger firms with similar characteristics to firms in earlier waves. Thus, as a group, wave 5 firms account for a large share of economic activity, representing over 20 percent of value added and 30 percent of employment in the database.

A second group of 2,484 firms that had been caught in Operaciones No Reales (ONR) was also required to adopt electronic invoicing starting from January 2017, mainly consisting of firms that had shown poor tax compliance in subsequent audits. In the analysis of e-invoicing that follows, we exclude the ONR firms (waves 2 and 6) for two reasons. First, it is difficult to separate the impact of e-invoicing from the impact of the tax audits and increased monitoring these firms were subject to. Second, the observed e-invoicing adoption rates among these

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[9] Three special VAT withholding regimes are currently used in the Peru, aimed at improving tax compliance in certain industries or transactions. The "Retention" mechanism requires some taxpayers to collect part of the VAT liabilities of their suppliers, while the "Perception" mechanism works in reverse by forcing certain suppliers to pay additional tax as part of their customers' VAT liabilities. In both cases, suppliers or customers can later deduct the withheld amount from their tax liabilities. A third "Deposit" mechanism (SPOT) requires purchasers of specific goods and services to deposit a percentage of that transaction value into a bank account under the name of their supplier. Suppliers use these accounts to offset future tax liabilities.

[10]See RS 203-2015/SUNAT for the original deadline, and RS 311-2016/SUNAT and RS 155-2017/SUNAT for the subsequent extensions. This group was drawn from registries of small and medium-sized firms (Principales Contribuyentes - PRICOS) for Lima and other provinces in Peru, as of 31st July 2017.

FIGURE 2: e-Invoicing Adoption Rates Across Waves

(A) Original deadline   (B) Extended deadline
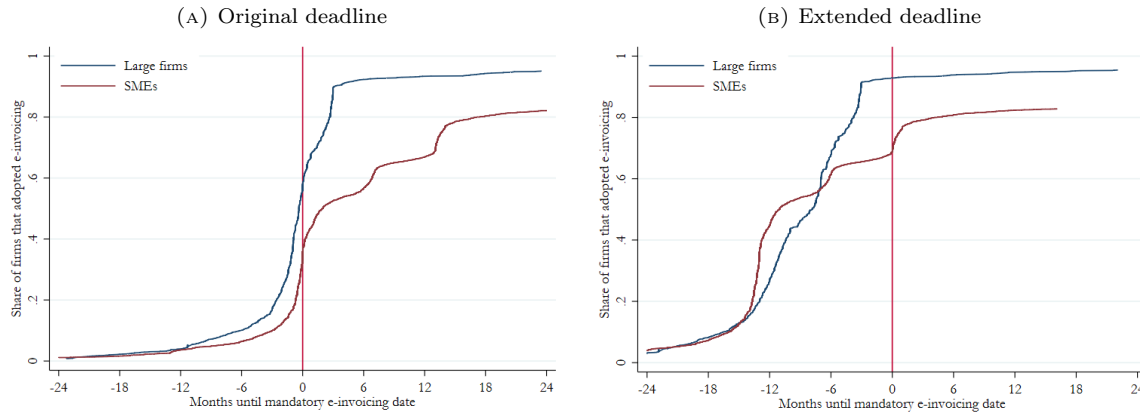
Note: This figure shows the e-invoice adoption rates across waves, using data from SUNAT. The left panel shows adoption rates relative to the original deadline, while the right panel shows adoption rates relative to the extended deadline (final deadline). The month in which e-invoicing would become mandatory is defined as time 0. The blue lines represent all the firms in wave 1, 3 and 4, while the red lines represent all wave 5 firms.

waves did not exceed 20 percent, as opposed to rates over 80 percent for the other waves, reflecting economic difficulties and very high exit rates after the requirement announcement.[11]

Starting in 2018, reforms focused on extending e-invoicing to a much larger number of small firms, the majority with annual sales between $0.2 and $5 million. Starting from January 2018, the e-invoicing requirement was extended to 4,741 high-risk firms, 4,550 agents of the Retention and Perception withholding regimes [12], and 943 larger firms.[13] In May, e-invoicing became mandatory for 11,573 small firms that were registered as government suppliers or included in the audited register of inspected goods. In August, the e-invoicing requirement began to apply to 13,837 firms in the manufacturing, construction, hotel and restaurant sectors, and from November onwards to all remaining 54,703 firms with annual sales over $0.2 million. The implementation of e-invoicing across other smaller firms is planned for 2019.

Figure 2 shows the rate of e-invoice adoption as firms reached the deadlines set by the tax administration. While adoption rates increase gradually and then spike just before the deadline

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[11]See Figure A.2 in appendix for more details.

[12]See footnote 9 for a brief description of these withholding regimes.

[13]See RS 192-2016/SUNAT. The latter group included all firms registered in the IPCN registry as of 29 June 2017, but that had not been included in previous waves (RS 155-2017/SUNAT).

was reached, they remained between 40 and 60 percent, suggesting that many taxpayers were unable or unwilling to comply with the e-invoicing requirement on time. Deadlines were then extended, by about one year on average, to give these firms additional time to comply.[14] The right panel of Figure 2 shows that this was a good strategy, since there was typically a high level of compliance by the time the final deadlines were reached. In fact, we see a gradual build up in adoption rates before the final deadline, as firms made the transition to e-invoicing in anticipation of this requirement becoming effective.[15]

While adoption rates are high after the e-invoicing deadline is reached, they never reach 100 percent for any of the reform waves. This reflects the difficulties faced by firms to complete the transition to e-invoicing, even among larger firms. In the analysis that follows, we therefore distinguish between the effects of the reform (mandating firms to adopt e-invoicing whether these firms complied or not) and the actual adoption of e-invoicing by mandated firms.

Finally, it is important to note that over the time period of our analysis (2013-2017) SUNAT had not yet adopted any significant changes in its compliance risk management strategy. Consequently, any effects of the reform observed during the period of the study are not confounded by changes in actual monitoring or audit activities of the tax authority. Instead, they would derive purely from the e-invoicing reform and the resulting increase in the probability of tax evasion detection by the tax authority.

3   Data and Stylized Facts

The VAT is the major source of revenue in Peru, accounting for over half of the country's gross tax revenue. The standard VAT rate was 18 percent during the period we analyze. As shown in Figure 3, the period during which e-invoicing was introduced was marked by a decrease in the VAT ratio from 8.8 percent of GDP in 2014 to 7.8 percent of GDP in 2017. This decline coincided with a slowdown in economic activity after 2014, an increase in the VAT compliance gap, and a marked decrease in the stock of outstanding VAT credits.[16] These credits are

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[14]See Figure A.2 in appendix for more details about the deadline extensions for specific waves.

[15]It is also likely that some firms made the switch voluntarily to take advantage of lower processing costs, or to facilitate transactions with their suppliers or clients that had already adopted e-invoices.

[16]The departure of VAT from a perfectly enforced tax levied at a uniform rate on all consumption can be measured by its "C-efficiency", the ratio of actual VAT revenue to the product of the standard rate and consumption as taken from national accounts. Keen (2013) decomposes this indicator further

(A) Gross VAT revenues and GDP growth

(B) VAT credits and compliance gap
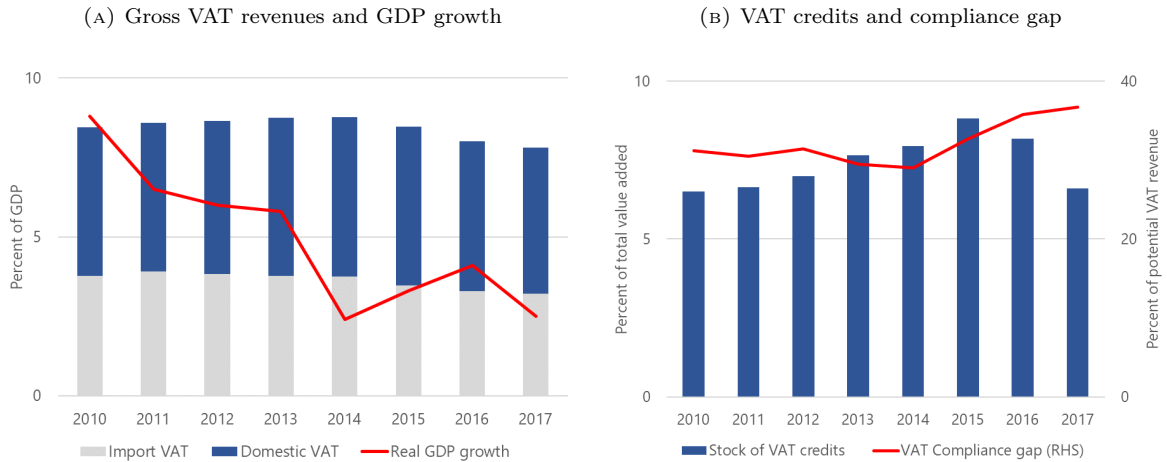
Note: The left panel plots gross VAT revenue in percent of GDP, distinguishing between domestic and import VAT. The growth rate of real GDP is shown in red. The right panel shows the total stock of VAT credits at the end of each year, expressed as share of total firm value added, and the red line shows the VAT compliance gap (Keen, 2013).

the result of VAT paid on inputs that was not refunded in the year they were incurred, and that are then carried over to subsequent years, when firms can use them to offset future tax liabilities.

We use monthly administrative tax data covering all small, medium and large formal Peruvian firms over the period 2010 to 2017. The dataset excludes two important groups of firms. First, micro firms with less than 150 UIT (about $175,000) in annual sales are excluded, as these firms were not targeted by the e-invoicing reform during the period we analyze.[17],[18] Second, it also excludes informal firms since these firms are not registered with the tax authority.

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into a policy gap, reflecting rate differentiation and exemptions, and a compliance gap, which measures imperfect implementation of the VAT. Since 2005, the compliance gap in Peru has ranged between 30 and 40 percent of potential VAT revenues, higher than the average across Latin American countries (IMF, 2015).

[17]The Unidad Impositiva Tributaria (UIT) is a monetary unit set every year by the tax authority to calculate tax and regulatory thresholds. For example, firms with less than 150 UIT in annual sales are defined as micro firms in the Peruvian legal system. In addition, firms with less than 96,000 soles (about $29,000) in annual sales were automatically excluded from our analysis because they are subject to a simplified tax regime in Peru (the Nuevo RUS), instead of the VAT regime.

[18]The dataset was constructed by including all the firms that reported annual sales above 150 UIT at least once over the 2010-2017 period.

Although there are many micro and informal firms in Peru, most of these firms are very small and together they make only a small contribution to aggregate value added.[19] Despite these exclusions, our dataset has a very large coverage and includes nearly 200,000 firms, representing 53 percent of GDP and 95 percent of VAT collections in 2013.

We exclude from our analysis firms that were caught in fraudulent transactions (waves 2 and 6) and the very small firms that were required to adopt e-invoicing only after 2018. Our sample selection strategy therefore ensures that we are comparing firms that are reasonably similar in terms of size and administrative characteristics by evaluating firms that are mandated against those that are yet to be mandated.

We collapse the dataset from monthly to quarterly frequency to facilitate the analysis. In addition, to focus on changes within firms and to avoid composition bias, we also create a balanced panel sample that excludes firms that enter or exit during the sample period (i.e., firms with no reported sales in a given quarter). This balanced dataset includes approximately 78,000 firms that account for 85 percent of the value added in the original dataset. As shown in Tables A.1-A.4 in appendix, the balanced sample remains representative of the original dataset, since average firm characteristics and the distribution of firms across sectors and risk categories by wave are similar across both datasets.

4 Empirical Approach

We exploit the staggered adoption of e-invoicing to assess the impact of electronic invoicing on firm performance and VAT collections. This approach compares the change in outcomes for firms that have been mandated to adopt e-invoicing (the treated group) relative to firms that have not yet been mandated (the control group). Since there were no significant changes in SUNAT's compliance risk management strategy during the years we study, this approach will isolate the impact of the e-invoicing reform separately from any changes due to increased monitoring and audit effort. We specify our panel difference-in-differences model as a fixed effects linear regression:

$$Y_{i,t} = \alpha_i + \delta_t + \eta_i t + \beta \times I\left(\text{Treat}_{i,t} = 1\right) + \gamma X_{i,t} + \varepsilon_{i,t} \tag{1}$$

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[19]As shown in Table A.1 in the appendix, firms excluded from our analysis account for less than five percent of total value added.

The dependent variable is a firm-level outcome such as sales, value added or tax payments, and the coefficient β captures the treatment effect of being mandated to adopt e-invoicing. The indicator variable $I\left(\text{Treat}_{i,t} = 1\right)$ takes on a value of one in the quarter that a firm is mandated to adopt e-invoicing, and the first four quarter after that. We focus on the first year after treatment since we observe all treated groups for at least the first four quarters. Our specification also includes as a control variable an indicator for the fifth and following quarters after the date of mandatory e-invoicing adoption. The model also includes time fixed effect δ_t to control for shocks common to all firms, such as changes in commodity prices or monetary policy, a firm fixed effect α_i to control for time invariant firm characteristics, a firm-specific linear time trend $\eta_i t$ to control for heterogeneity in growth paths across firms, and $X_{i,t}$ is a vector of control variables, including the wage bill, fixed capital stock, and the number of workers. Standard errors are clustered at the firm level.

Even though the original deadlines for mandated adoption were later extended, we use the original deadlines for our identification strategy. From the firms' perspective, the original deadline was the relevant constraint, as reflected by the fact that a large proportion of firms adopted at the time of the original deadline. Moreover, given that the transition to e-invoicing requires substantial administrative and procedural changes within the firm, even those firms that had not begun to issue e-invoices at the time of the original deadline would have made significant progress towards operationalizing e-invoicing, particularly if they are unable to anticipate the provision of an extension. Focusing on the original deadlines allows to capture all these changes.

The identifying assumption in this specification requires parallel trends between the control and treated groups prior to treatment, such that the β coefficient represents the impact of treatment as opposed to differential pre-trends. To test this assumption, we also estimate a dynamic panel difference-in-differences specification which allows us to conduct a pre-trend analysis for treated and control groups and explore the evolution of the treatment effect over the quarters following the mandated date of adoption:

$$Y_{i,t} = \alpha_i + \delta_t + \eta_i t + \sum_t \beta_t \times I\left(\text{Treat}_{i,t} = 1\right) + \gamma X_{i,t} + \varepsilon_{i,t} \tag{2}$$

In this specification, the β_t coefficients capture the dynamic impact of treatment in 6 quarters before and 4 quarters after the mandated date of e-invoicing adoption for a firm, setting the

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reference period as the quarter before the reform was mandated (i.e. $t = -1$). Parallel pretrends require that the β_t in the pre-treatment period be statistically insignificant, implying no observed differences between the control and treated groups prior to the treatment date. However, given that the date of mandated adoption is pre-announced, some anticipation effects in the quarter leading up to mandated adoption cannot be ruled out.

Since there is imperfect compliance to the e-invoicing reform among mandated firms, the β_t estimates represent the "intent to treat" (ITT) effect. Moreover, firms that are not mandated into e-invoicing may still adopt e-invoicing voluntarily. While the ITT is considered the policy-relevant parameter given that policy makers cannot force or prevent adoption, we also estimate the Local Average Treatment Effect (LATE) which represents the impact of being mandated into e-invoicing by compliers only.

To estimate the LATE, we use an indicator for being mandated into e-invoicing as an instrumental variable for predicting actual compliance to treatment. Specifically, we estimate a two-stage least squares model where the first stage uses treatment assignment to predict compliance and the second stage uses fitted estimates from the first stage to predict treatment effects:

$$A_{i,t} = \tilde{\alpha}_i + \tilde{\delta}_t + \tilde{\eta}_i t + \theta \times I\left(\text{Treat}_{i,t} = 1\right) + \tilde{\gamma} X_{i,t} + u_{i,t} \tag{3}$$

$$Y_{i,t} = \alpha_i + \delta_t + \eta_i t + \beta \hat{A}_{i,t} + \gamma X_{i,t} + \varepsilon_{i,t} \tag{4}$$

where $A_{i,t}$ and $\hat{A}_{i,t}$ represent respectively an e-invoicing adoption indicator and the probability of adoption estimated in the first stage. One note of caution with respect to our LATE estimates is that we do not differentiate between noncompliers and late compliers and assume no change in behavior along other dimensions (reporting of sales, purchases) among this latter group at the time of treatment. However, firms could change their behavior at the time of their mandated date of adoption, even in the absence of having adopted the e-invoicing mechanisms. This could be in anticipation of the eventual switch or owing to the higher threat of audit for being noncompliant. This could bias the LATE downwards assuming the behavior of noncompliers after the treatment date is like the behavior of compliers. The ITT estimate does not suffer from this bias since all firms are considered treated following the mandated date of adoption, regardless of actual adoption, although it might suffer from another bias by not accounting for compliance among untreated firms. However, regardless of

the estimator considered, our model is biased against finding a treatment effect and therefore is a conservative lower bound on the potential treatment effect.

5 Results

5.1 Baseline

We start by estimating the difference-in-differences specification in Equation 1 using the balanced panel sample. All dependent variables are expressed in log constant national currency units (Peruvian soles). The main regressor is a treatment indicator that is equal to one in the quarter that e-invoicing became mandatory and in the following four quarters, so that the estimated coefficients represent the average percentage change in the first year of e-invoicing.

The results are presented in Table 1. The first two columns show that taxable sales and purchases are significantly higher among treated firms after the e-invoicing reform, with an average increase of 7.4 and 5.6 percent, respectively. As seen in the second row, this remains true even when controlling for firm employment, wage bill and its capital stock, which suggests that these impacts are not driven by a change in firm-level inputs. Consistent with these proportional percentage increases in sales and purchases, the third column shows a similar increase in reported taxable value added of 6.5 percent, which is also statistically significant.[20]

The next columns in Table 1 examine the impact of e-invoicing on VAT collections. Similar to other countries, Peruvian firms accumulate VAT credits when their taxable sales are lower than their taxable purchases, and can use these credits to offset existing or future VAT liabilities (except for exporters, firms cannot obtain cash refunds). We therefore construct two new variables, the first capturing the VAT liability of firms reporting positive taxable value added (and zero otherwise), and the second representing the new VAT credits earned by firms reporting negative taxable value added (and zero otherwise). We find that e-invoicing is associated with increases in both reported VAT liabilities and new VAT credits, although only the former is statistically significant. Consistent with these results, we also find that an

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[20]About 17 percent of firm-quarter observations in our sample report negative taxable value added, and these observations are assigned missing values when taking a log transformation. We have examined alternative transformations of the dependent variable that preserve those observations, and find quantitatively similar results. These results are available upon request.

TABLE 1: Impact of Mandatory e-Invoicing

	Taxable sales	Taxable purchases	Taxable value added	VAT liabilities	New VAT credits	VAT payments	Firm Employment	Firm TFP
A. Without firm variable controls								
Treatment (first year)	0.0744*** (0.0127)	0.0556*** (0.0139)	0.0653*** (0.0123)	0.0808*** (0.0203)	0.0475 (0.0366)	0.0537* (0.0316)	-0.0011 (0.0009)	0.0483*** (0.0093)
B. With firm variable controls								
Treatment (first year)	0.0657*** (0.0124)	0.0453*** (0.0135)	0.0589*** (0.0120)	0.0722*** (0.0202)	-0.0432 (0.0366)	0.0445 (0.0314)	...	0.0604*** (0.0091)
Obs	1,010,439	1,010,439	843,159	1,010,439	1,010,439	1,010,439	1,010,439	842,199

Note: Results for the balanced sample of firms mandated to adopt e-invoicing before 2019. Dependent variables are expressed in log constant 2014 soles (local currency). The treatment indicator is equal to one in the quarter of mandatory e-invoicing adoption and the following four quarters. All specifications include a variable controlling for the fifth and following quarters after the date of mandatory e-invoicing adoption, and the bottom row also includes controls for firm employment, wage bill and capital stock. Appendix table A.5 additionally shows estimates for controls. Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

increase in VAT payments to the tax authority, which represent the actual VAT collected after accounting for VAT credits, tax arrears and other tax offsets.

The two last columns in Table 1 examine the effect of e-invoicing on the number of workers employed by firms and on firm productivity, which we proxy by the residual of a regression of firm value added on firm employment and capital with time fixed effects.[21] We find that the e-invoicing reform on average had no impact on firm employment, but that there was a significant increase in reported productivity. Taken together, these results show that the e-invoicing reform was associated with higher reported taxable value added and increased VAT collections, and that this was driven by higher firm productivity as opposed to changes in firm labor inputs.

In Figure 4, we confirm our findings using the dynamic panel specification in Equation 2, which is estimated using the same sample as before. This specification allows us to rule out the presence of differential trends between the treated and control firms before the e-invoicing reform, as the estimated coefficients in the six quarters prior to the mandated date of adoption

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[21]Firm capital stock is measured on an annual basis in our dataset, and we are therefore unable to assess changes in capital inputs at a quarterly frequency.

FIGURE 4: Impact of e-Invoicing Around the Mandatory Date of Adoption
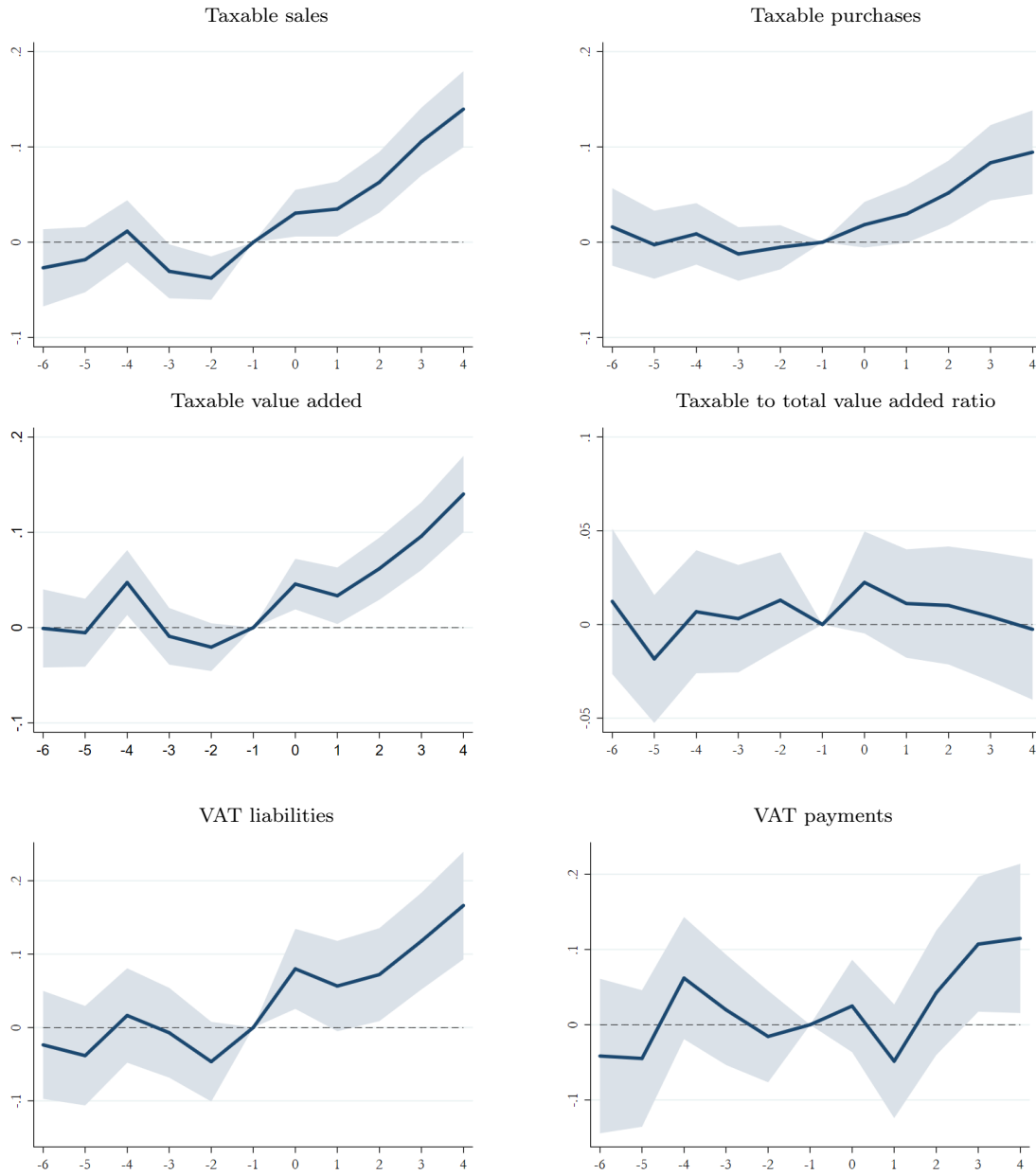
Note: This figure plots the point estimates (solid line) and the 95 percent confidence intervals (shaded area) of the β_t coefficients in Equation (2), estimated using the balance sample of firms mandated to adopt e-invoicing before 2019. The responses represent the percent change in the dependent variable relative to the mandatory adoption quarter.

are not significantly different from zero.

Following the introduction of e-invoicing, we find that taxable sales, purchases and value added rise steadily, in line with the gradual increase in actual e-invoicing adoption rates documented in Figure 2. Four quarters after the mandatory date of adoption, e-invoicing is associated with an average increase of 14 percent in taxable sales and 10 percent in taxable purchases. These effects are larger than the estimated effects shown in Table 1 because those results represent the average impact over the entire first year of e-invoicing adoption, and not just the fourth quarter. The impact of e-invoicing does not appear to be driven by a re-classification of tax-exempt sales or purchases, as would happen if firms began reporting as taxable certain transactions that they had previously reported as nontaxable. As shown in the middle right panel, there is no change in ratio of taxable value added to total value added in the period around the e-invoicing reform. In the bottom two panels, we see that the response of reported VAT liabilities mirrors the impact on taxable value added, while actual VAT payments also move up gradually, with a statistically significant increase of 10 percent in the fourth quarter after e-invoicing was made mandatory.[22]

As a robustness check, we also examine the behavior of firms around the time when the e-invoicing adoption deadlines were first announced. Once again, we use the specification in Equation 2, and we set the quarter before announcement as the reference period. As shown in Figure A.4 in the appendix, there are no systematic and significant differences in sales, purchases and VAT between the firms in the treated and control group in the periods immediately following the announcement dates. These results suggest that treated firms waited until the deadline to implement changes in their reported value added and their VAT declarations and payments.

5.2 Heterogeneity by Firm Size and Creditor Status

We next assess the potential heterogeneity in treatment effects, starting by examining the role of firm size. Much of the existing research on the impact of tax audits finds larger

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[22]Figure A.3 in the appendix shows a statistically significant increase in employment in the later quarters, suggesting that e-invoicing may have been associated with an increase in firm employment after some quarters. However, the scale of increase in employment is small (just over 2 percent), relative to the increase in value added (on the order of 15 percent).

FIGURE 5: Impact of e-Invoicing on Taxable Value Added by Firm Size
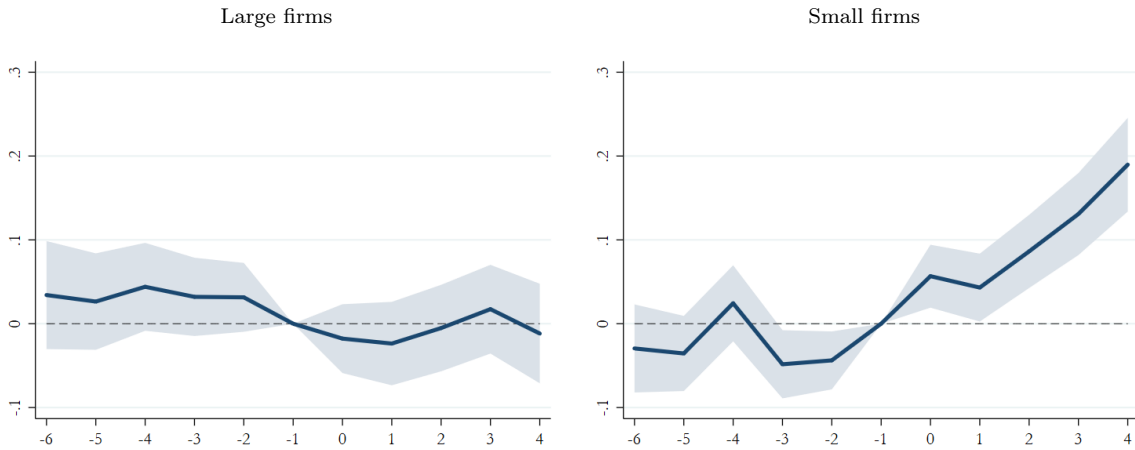
Note: This figure plots the point estimates (solid line) and the 95 percent confidence intervals (shaded area) of the β_t coefficients in Equation (2), estimated using the balance sample of firms mandated to adopt e-invoicing before 2019. Small firms are defined as having sales lower than 1,700 UIT (about $2 million) in 2013Q2. The responses represent the percent change in the dependent variable relative to the mandatory adoption quarter.

treatment effects among smaller firms (e.g., Kleven et al., 2016). Small firms are less likely to be subject to tax audits, since individually they make only a marginal contribution to overall tax collections. They also tend to conduct more transactions in cash, which makes them more difficult to record and track. Smaller firms are thus more likely to engage in tax noncompliance, and an increase in the threat of audit should disproportionately affect their behavior (Slemrod, 2019).

We start by re-estimating our dynamic difference-in-differences specification in Equation 2, but this time focusing on the response of taxable value added separately for small and large firms. We define small firms as those having annual taxable sales below 1,700 UIT (about $2 million) at the beginning of our sample period, as this threshold is also the legal definition of a small or medium firm in the Peruvian legal system. As Figure 5 makes clear, the significant increase in taxable value added following the introduction of e-invoicing is entirely driven by the response of small and medium firms, whereas larger firms are essentially unaffected.

In Table 2, we formally test the hypothesis that e-invoicing had a different impact on smaller firms relative to larger firms by interacting the treatment indicator with an indicator of firm

Table 2: Heterogeneity by Firm Size and Creditor Status

	By Firm Size				By Firm Size and Creditor Status			
	Taxable value added	VAT liabilities	New VAT credits	VAT payments	Taxable value added	VAT liabilities	New VAT credits	VAT payments
Treatment (first year)	0.0270 (0.0168)	0.0379 (0.0321)	0.00521 (0.0573)	-0.103** (0.0423)	0.0337* (0.0182)	0.0869*** (0.0291)	-0.230*** (0.0602)	0.0338 (0.0454)
Interacted with:								
× Small firm indicator	0.0581** (0.0228)	0.0645* (0.0382)	0.0771 (0.0690)	0.276*** (0.0584)	0.0576** (0.0228)	0.0556 (0.0377)	0.120* (0.0687)	0.251*** (0.0585)
× VAT credit stock indicator					-0.0304 (0.0277)	-0.155*** (0.0519)	0.746*** (0.0811)	-0.436*** (0.0720)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	843,147	1,010,400	1,010,383	1,010,400	843,147	1,010,400	1,010,383	1,010,400

Note: Results for the balanced sample of firms mandated to adopt e-invoicing before 2019. Dependent variables are expressed in log constant 2014 soles (local currency). The treatment indicator is equal to one in the quarter of mandatory e-invoicing adoption and the following four quarters. This treatment indicator is interacted with two dummy variables indicating if a firm had sales lower than 1,700 UIT (about $2 million) or a positive stock of VAT credits in 2013Q2, respectively. All specifications include controls for the effects in the fifth and following quarters after the date of mandatory e-invoicing adoption, and controls for firm employment, wage bill and capital stock. Appendix table A.6 additionally shows estimates for these controls. Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

size. As the first columns show, the increase in taxable value added, VAT liabilities and actual VAT payments are entirely driven by smaller firms, and the firm size interaction coefficients are statistically different from zero. Likewise, one can also infer that e-invoicing had no discernible impact on the taxable value added or VAT liabilities reported by large firms in Peru. These results are robust to using firm sales at the beginning of the sample as an alternative measure of firm size, as we report in appendix Table A.7.

In the remaining columns of Table 2, we examine the role played by the stock of VAT credits a firm has, which is a potential confounder in the relation between e-invoicing and firm size. About one-third of the firms in our sample carried a stock of VAT credits at the beginning of our sample period, which they could use to offset VAT liabilities (see Table A.4 in appendix). To understand how these outstanding VAT credits might affect the impact of the e-invoicing reform, we interact the treatment variable with an indicator for whether firms had a positive

positive stock of VAT credits at the beginning of the sample period. The results are shown in last four columns of Table 2, where once again we find large and significant differences across firms with and without past credits. Firms without VAT credits experience a stronger increase in VAT liabilities, accumulate fewer new VAT credits and pay more VAT after e-invoicing was made mandatory. By contrast, firms with existing VAT credits not only avoided paying additional VAT after e-invoicing was introduced, but also managed to accumulate new credits, essentially offsetting the positive impact on e-invoicing on VAT liabilities and payments we found for the average firm.

5.3   Heterogeneity by Economic Sector

Next, we evaluate how different economic sectors responded to the e-invoicing reform. We focus on the impact on the reform in the six main sectors of the Peruvian economy, namely construction, manufacturing, transportation, retail, hospitality and business and professional services.[23]. We start by examining the dynamics of taxable value added across sectors in Figure 6. Following the reform, we observe a large increase in reported taxable value added in the construction sector, reaching about 50 percent after four quarters, and smaller though still significant increases in transportation, retail and professional and business services ranging between 10 to 20 percent. The impact on construction and services is particularly noticeable, since these sectors were previously identified as having large VAT compliance gaps in Peru, which suggests that mandatory e-invoicing may induce changes for firms with low compliance (Keen, 2013; IMF, 2015). However, we see little impact of e-invoicing in manufacturing or in the hospitality sector, even though manufacturing is also found to have a large VAT compliance gap.

These findings are confirmed in Table 3, which also examines the response of other variables by sector. It is instructive to contrast the response of firms in the retail and business and professional services sectors, as there seem to be striking differences in the impact of e-invoicing across the two sectors. In the case of the retail sector, we find a strong and significant increase

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[23]This last category includes financial, consulting, IT, marketing, accounting and legal, rental, architecture, research, and engineering services. We exclude agriculture, fishing, utilities, telecommunication and public administration from the analysis because these sectors accounted for less than 5 percent of the observations or the total value added in our sample. We also exclude mining since it is dominated by a few large firms that are primarily exporters.

FIGURE 6: Impact of e-Invoicing on Taxable Value Added by Sector
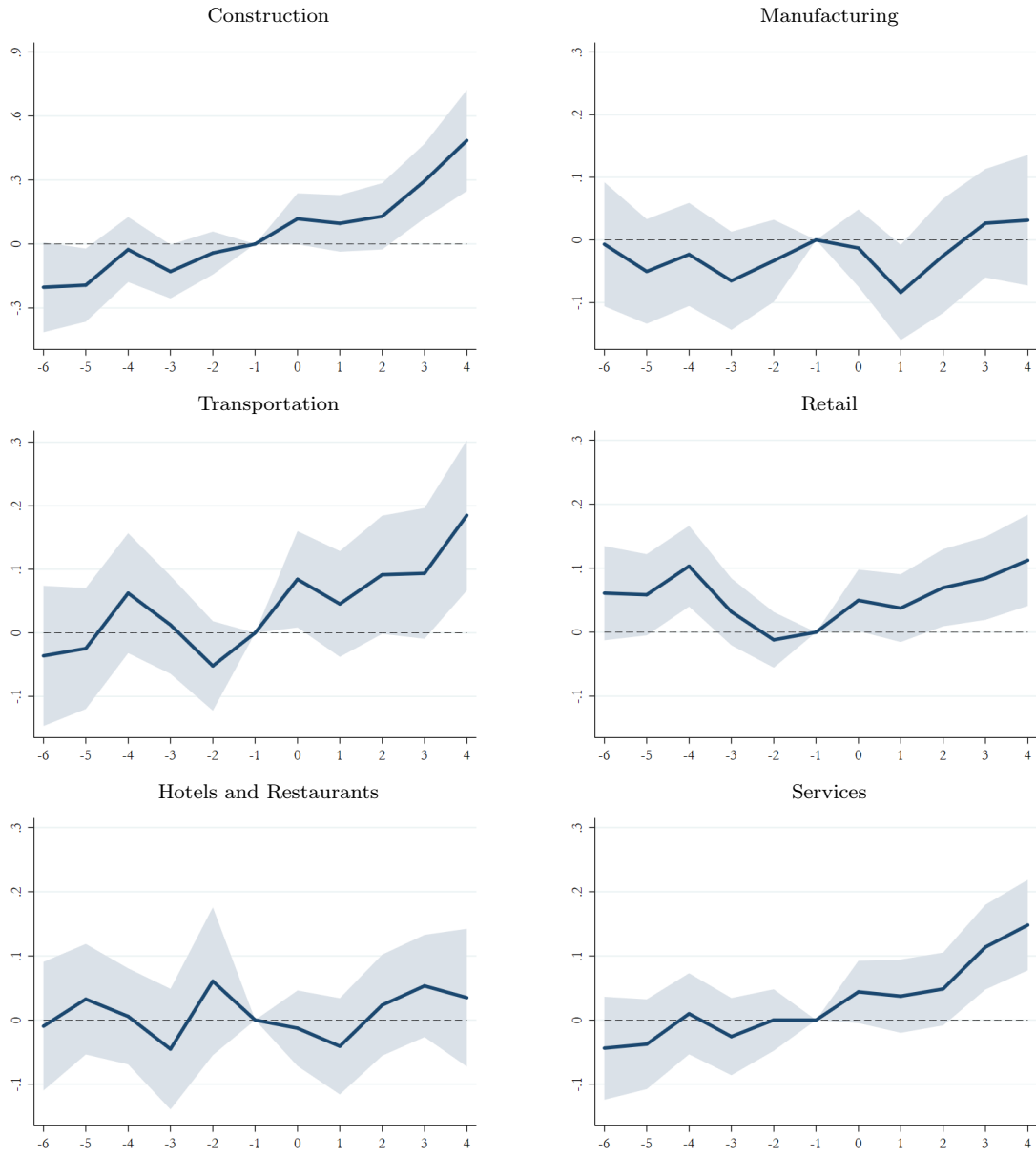
Note: This figure plots the point estimates (solid line) and the 95 percent confidence intervals (shaded area) of the β_t coefficients in Equation (2), estimated using the balance sample of firms mandated to adopt e-invoicing before 2019. Each panel corresponds to a separate regression by sector. The responses represent the percent change in the dependent variable relative to the mandatory adoption quarter.

TABLE 3: Heterogeneity by Sector

	Taxable sales	Taxable purchases	Taxable value added	VAT liabilities	New VAT credits	VAT payments
Construction	0.200***	0.118*	0.192***	0.0503	0.00538	0.176
	(0.0607)	(0.0619)	(0.0556)	(0.126)	(0.196)	(0.156)
Manufacturing	0.0499*	0.0508**	0.0184	0.104	-0.0760	0.247***
	(0.0279)	(0.0233)	(0.0281)	(0.0676)	(0.122)	(0.0773)
Transportation	0.0657*	0.0155	0.0737**	0.138***	-0.0122	0.155
	(0.0348)	(0.0391)	(0.0357)	(0.0529)	(0.114)	(0.113)
Retail	0.0485**	0.0429*	0.0446**	0.0332	0.227***	-0.223***
	(0.0209)	(0.0232)	(0.0216)	(0.0317)	(0.0646)	(0.0582)
Hotels and Restaurants	-0.0240	0.0125	-0.0553*	0.101	0.185	0.0692
	(0.0271)	(0.0280)	(0.0334)	(0.107)	(0.132)	(0.101)
Services	0.0459**	0.0401	0.0604***	0.0757**	-0.139**	0.160***
	(0.0218)	(0.0268)	(0.0213)	(0.0354)	(0.0663)	(0.0496)
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents estimated treatment effect for separate difference-in-difference regressions for different economic sectors. All regressions use the balanced sample of firms mandated to adopt e-invoicing before 2019. Dependent variables are expressed in log constant 2014 soles (local currency). The treatment indicator is equal to one in the quarter of mandatory e-invoicing adoption and the following four quarters. All specifications include a variable controlling for the fifth and following quarters after the date of mandatory e-invoicing adoption and controls for firm employment, wage bill and capital stock. Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

in new VAT credits, whereas the new VAT credits decline in the services sector after e-invoicing was introduced. As a result, we find a significant increase in VAT payments in the services sector, but an average decline in VAT payments in among retail firms. The positioning of these firms in their value chains could offer some explanation for this pattern. Firms providing professional and business services are more often upstream industries that do not require many inputs from other sectors. Conversely, retail requires sourcing from many industries and selling to final consumers. Therefore, retail firms are more likely to accumulate large stocks of VAT credits that they could use to offset their VAT liabilities.

5.4 Firm Survival

We also examine the impact of e-invoicing on the extensive margin of firms. If e-invoicing reduces noncompliance, thereby increasing the effective tax rate on firms, one would expect some firms to exit if they cannot maintain profitability under a higher tax burden. We test this hypothesis by examining changes in the survival rate of firms over time.

We start by defining survival as as having positive sales in the next quarter. Consistent with our hypothesis, Figure 7 shows that there is a drop in the survival rate. However, the timing differs from what we observed for other firm variables, since the decline in survival rates occurs in the three to five quarters preceding the e-invoicing adoption deadline. This period corresponds roughly to the gap between the announcement of the e-invoicing reform and the original deadlines for adoption, which suggests that some firms stopped reporting to the tax authorities or ended activity altogether in response to these announcements. This behavior would be consistent with noncompliant firms expecting increased scrutiny from the tax authorities once they start e-invoicing. In panel (B), we use again Equation 2, but alternatively set the reference period as the quarter before the deadline was announced. The results confirm that the survival rates of treated firms drop significantly in the five quarters following the announcement dates.

In appendix Figure A.5, we also examine heterogeneity in survival around announcement dates between different sectors. Once again, the sectors that were previously identified as having large VAT compliance gaps in Peru firms features the strongest response. Firms in construction, in services and now in manufacturing have the largest drop in survival probability in the quarters following the announcement dates.

In panel (A), we also find a rise in the survival rate after the mandatory date of adoption. A potential explanation is that the more profitable firms that did not decide to exit between the announcement date and the mandatory date of adoption also exhibit higher survival rates. On the other hand, firms in the control group may be pressured to adopt e-invoicing after the mandatory date because they are trading with mandated firms that are adopting e-invoicing. As a result, some noncompliant firms in the control group may exit, thereby generating an increase in the difference in survival rates between the treated and the control group.

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FIGURE 7: e-Invoicing Impact on Firm Survival Rates

(A) Around the mandatory dates of adoption

(B) Around the announcement dates of deadlines
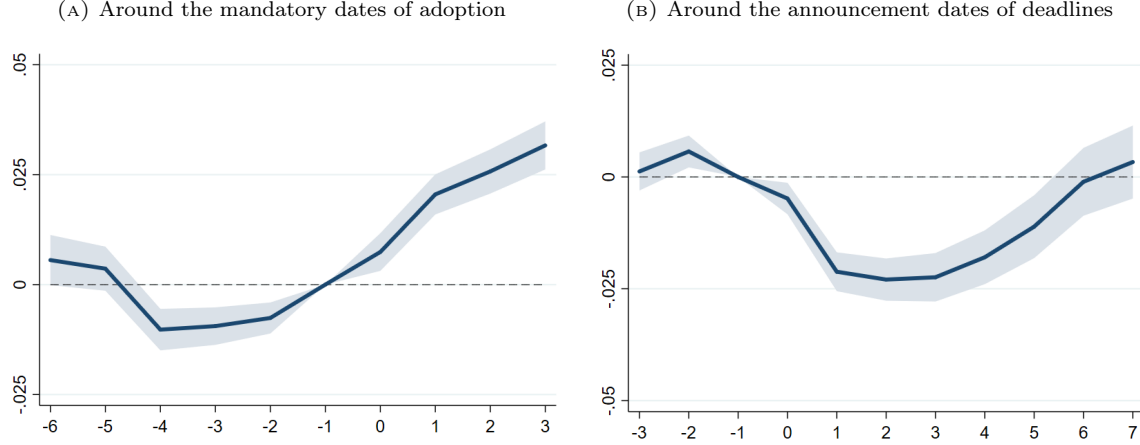
Note: In Panel (A), the reference period -1 corresponds to the quarter before the deadline for adopting e-invoicing. In Panel (B), instead of using the deadlines for adoption as before, the graph shows the relatives changes of the treated around the *announcement dates*, that is when deadlines were announced. This figure plots the point estimates (solid line) and the 95 percent confidence intervals (shaded area) of the β_t coefficients in Equation (2), estimated using the 2013Q2-2017Q3 sample of all firms mandated to adopt e-invoicing before 2019. 2017Q4 is dropped because survival next quarter cannot be calculated.

5.5   IV Estimation of the Effects of e-Invoicing Adoption

The results shown in the previous sections focus on the impact of directing firms to adopt e-invoicing. However, some firms delayed adoption for a few quarters, and others kept using paper invoices for more than a year after the deadline had passed. Therefore, the magnitude of these effects may be different from the effect of actually adopting e-invoicing. In Table 4, we estimate the effects of actual adoption by comparing mandated adopters with non-mandated non-adopters using the instrumental variable approach described in Equations 3 and 4.

The first column of Table 4 shows that assignment to treatment strongly predicts actual adoption across all treatment groups. The Kleibergen-Paap F-statistic for the first-stage regression is 1.3e+04, indicating that there is no concern about weak instruments. We find that adopting e-invoicing is associated with statistically significant increases in taxable sales, purchases and value added of about 15, 10 and 13 percent, respectively, and also a 16 percent increase in reported VAT liabilities. The impact on new VAT credits and actual VAT payments is also positive, as before, although not statistically significant. The larger magnitude of these

TABLE 4: Instrumental Variable Results

	1st Stage	2nd Stage					
	Adoption	Taxable sales	Taxable purchases	Taxable value added	VAT liabilities	New VAT credits	VAT payments
Treatment (first year)	0.448*** (0.00396)						
Adoption		0.147*** (0.0276)	0.101*** (0.0302)	0.132*** (0.0269)	0.161*** (0.0451)	0.105 (0.0817)	0.0993 (0.0700)
Robust F-stat	1.3e+04						
Obs	1,010,400	1,010,398	1,010,400	843,147	1,010,400	1,010,400	1,010,400

Note: Regression results for the balanced sample of firms mandated to adopt e-invoicing before 2019. Dependent variables in the second-stage regression are expressed in log constant 2014 soles (local currency). The treatment indicator is equal to one in the quarter of mandatory e-invoicing adoption and the following four quarters. All specifications control for firm employment, wage bill and capital stock, and also include a variable controlling for the fifth and following quarters after the date of mandatory e-invoicing adoption. Appendix table A.8 additionally shows estimates for controls. Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

impacts suggests our ITT estimates are smaller due to noncompliance among the mandated firms, or voluntary compliance among firms in the control group, and that the effects of the reform on firms that have indeed adopted e-invoicing are substantially larger.

6 Conclusion

This paper investigates the effect of e-invoicing adoption on firm performance and tax compliance using administrative tax data on all VAT paying firms in Peru. We show that e-invoicing increases reported firm sales, purchases and value added by over 5 percent on average in the first year after adoption. These effects are heterogeneous across firms, with larger impacts for small firms and firms in sectors with a higher risk of tax noncompliance. In addition, we find that the announcement of the e-invoicing reform is associated with a temporary decline in the firm survival rate, particularly in higher risk sectors. Together, this suggests that the impact of e-invoicing is operating primarily through the deterrence channel of reduced noncompliance.

Our results show that the response of VAT payments was weaker than the response of reported value added, possibly due to shortcomings in the credit refund mechanism in Peru. This issue

undermines the self-enforcing characteristic of the VAT and weakens the relationship between reported taxable value added and VAT payments. Improved strategies to enforce control of VAT credits, in combination with the improved monitoring capabilities of the e-invoicing system, could strengthen the impact of the e-invoicing reform by reducing evasion through misreporting of credits.

The effects of e-invoicing build up gradually over time, implying that the full effect of the reform is not yet fully accounted for. Moreover, by the end of 2017 SUNAT had not yet made significant changes to its risk management strategy to make use of the flow of information generated by the e-invoicing system. Therefore, our results identify changes in firm behavior in response to a perceived increase in the threat of audit, which is likely a lower bound for the full effect of an e-invoicing reform once improved monitoring and enforcement are in place based on this new technology.

we also find that e-invoicing adoption appears to have had a stronger impact on VAT collections in upstream industries. A useful avenue for future research would be to study the spillover effects of e-invoicing adoption on upstream and downstream firms, as digitalization in some firms can strengthen the incentives for connected firms to also digitalize and improve compliance (e.g., Keen and Lockwood, 2010; Pomeranz, 2015).

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A   Additional Tables and Figures

FIGURE A.1: e-Invoicing Adoption Rates by Wave
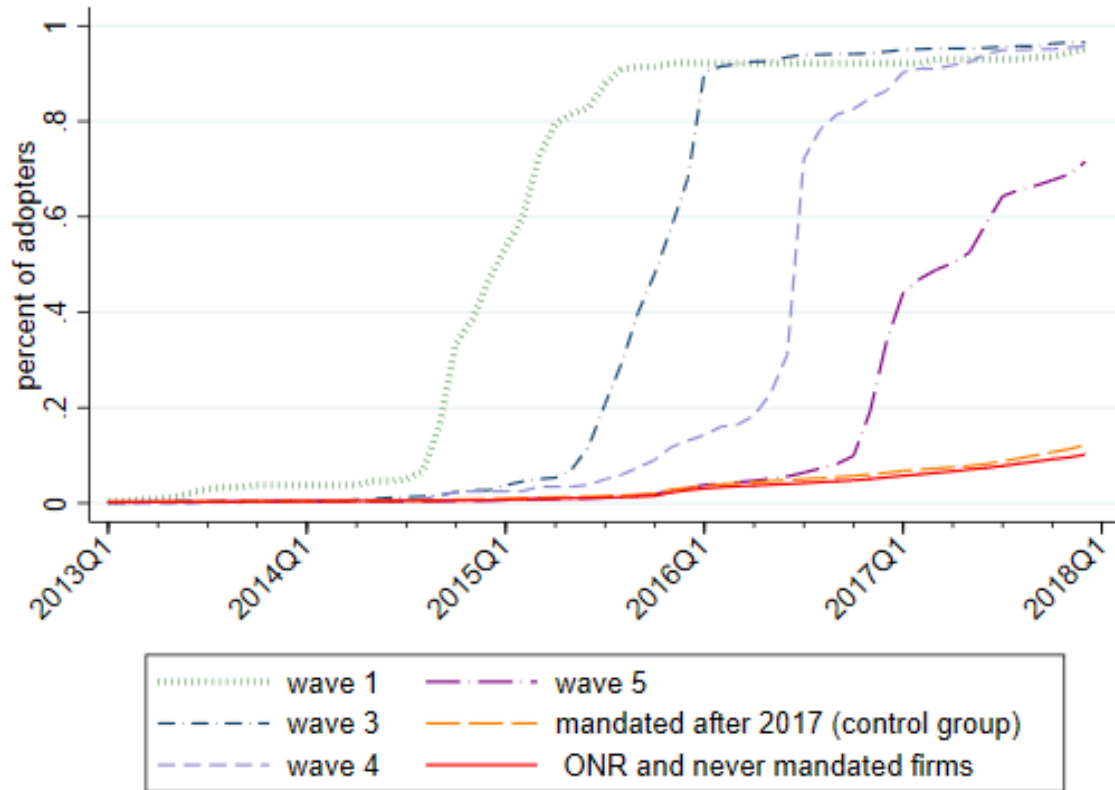
Note: This figure shows the rate of e-invoicing adoption by wave using data from SUNAT. Firm waves are defined based on adoption deadlines imposed by SUNAT. The control group consists of firms that were assigned adoption deadlines after 2017. The last group consist of wave 2 and wave 6 "ONR" firms that were caught in fictitious or fraudulent transactions before their assignment to a wave and of firms that were not yet assigned a specific deadline by 2017.

FIGURE A.2: Adoption Rates around First Announcement Dates, Initial and Final Deadlines

(A) non ONR waves
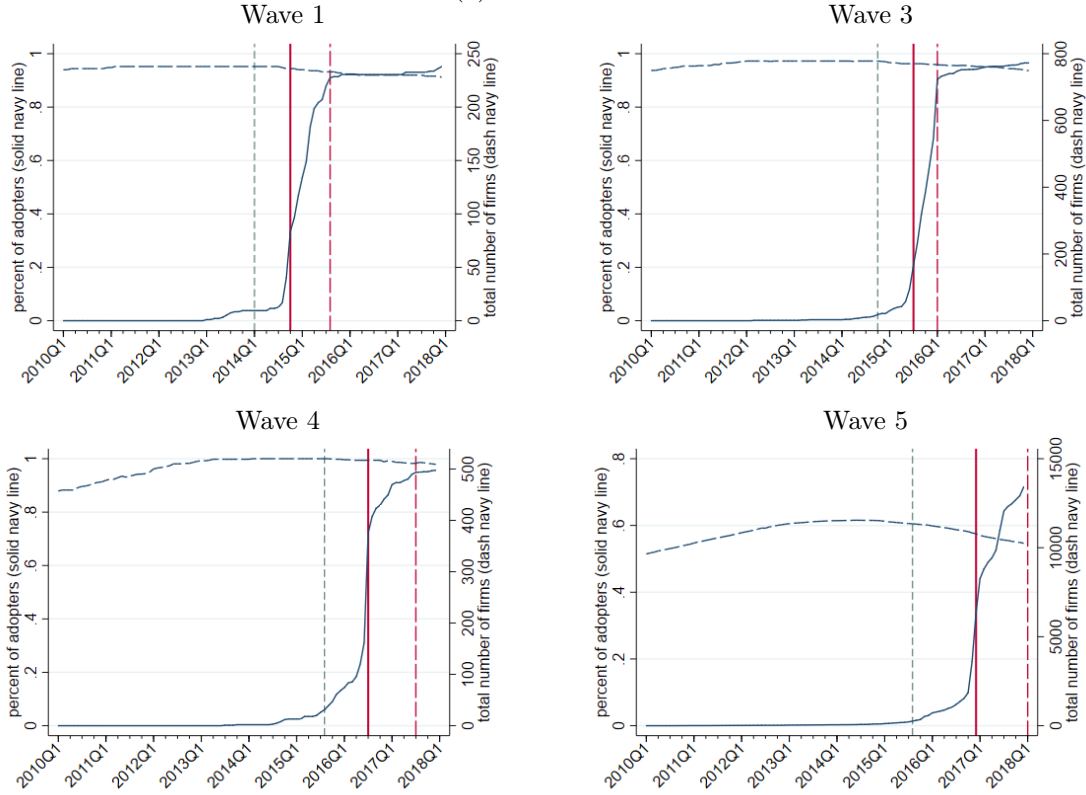
(B) ONR waves excluded from the analysis
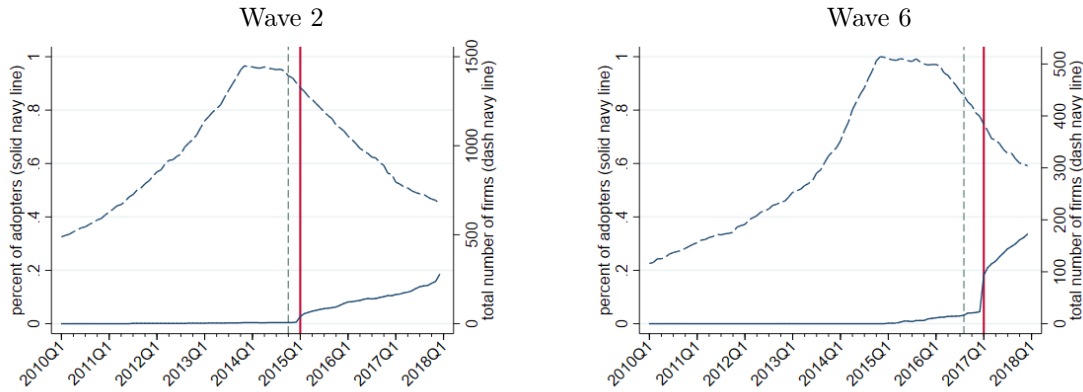
Note: The number of firms (dash curve) and the fraction of them (solid curve) that adopts e-invoicing are plotted over time. For each wave, dash vertical grey lines indicate the first announcement date. The solid red lines indicate the deadline announced initially. The dash red lines indicate the final revised adoption deadlines. ONR firms are firms that were caught in fictitious or fraudulent transactions.

FIGURE A.3: Impact of e-Invoicing on Firm Employment and TFP
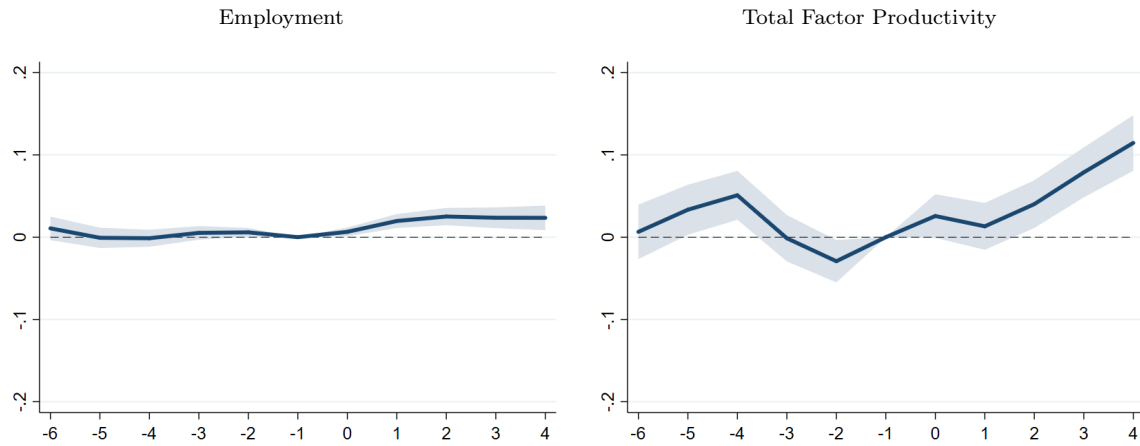
Employment   Total Factor Productivity

Note: This figure plots the point estimates (solid line) and the 95 percent confidence intervals (shaded area) of the β_t coefficients in Equation (2) without firm time-varying controls, estimated using the balance sample of firms mandated to adopt e-invoicing before 2019. The responses represent the percent change in the dependent variable relative to the mandatory adoption quarter.

FIGURE A.4: Impact of e-Invoicing Around the Announcement dates
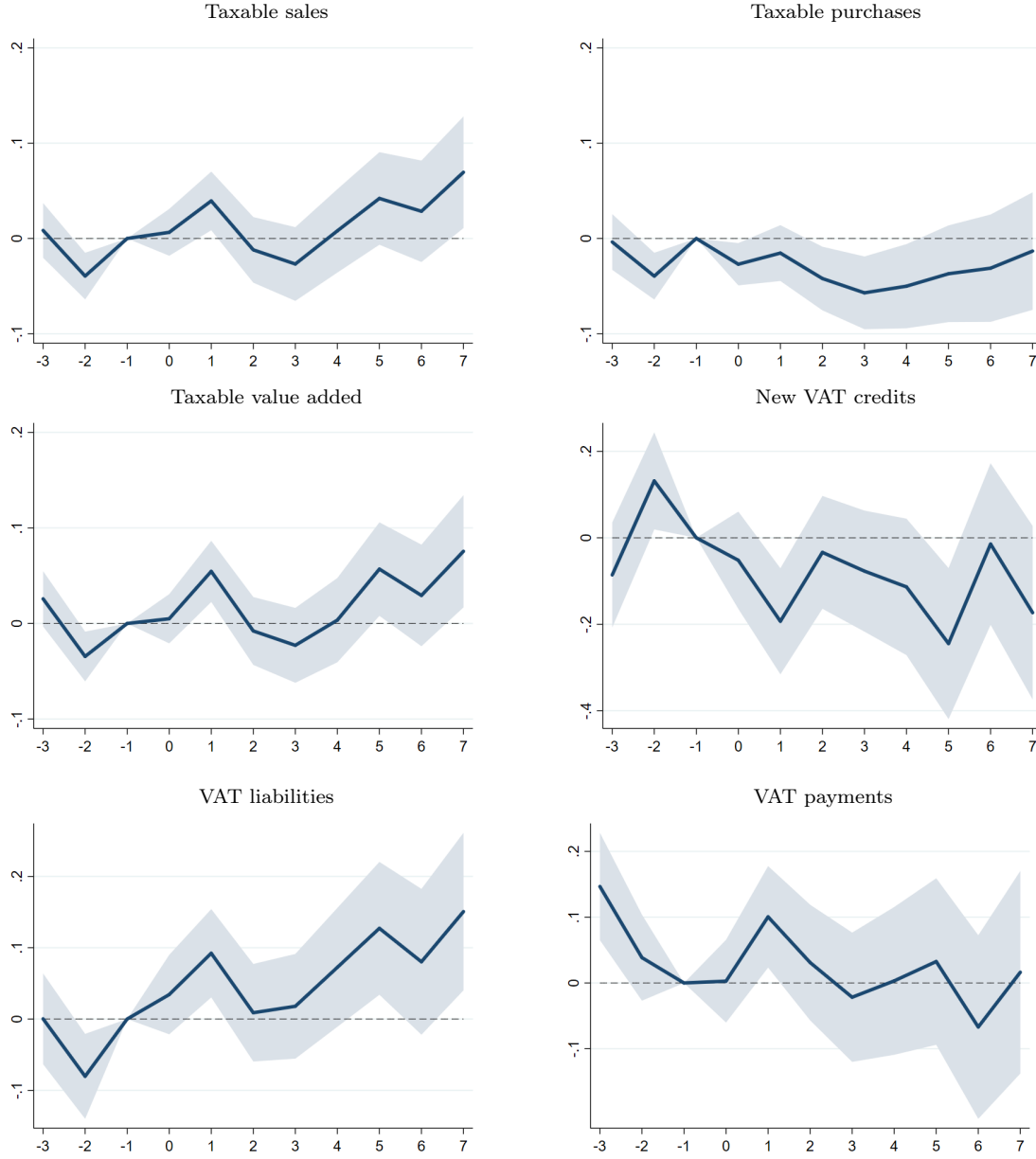
Note: Instead of using the deadlines for adoption as in the main text, these graphs show the relatives changes of the treated around the *announcement dates*, that is when deadlines were announced. This figure plots the point estimates (solid line) and the 95 percent confidence intervals (shaded area) of the β_t coefficients in Equation (2), estimated using the balance sample of firms.

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FIGURE A.5: Impact of e-Invoicing on Survival Rates by Sector
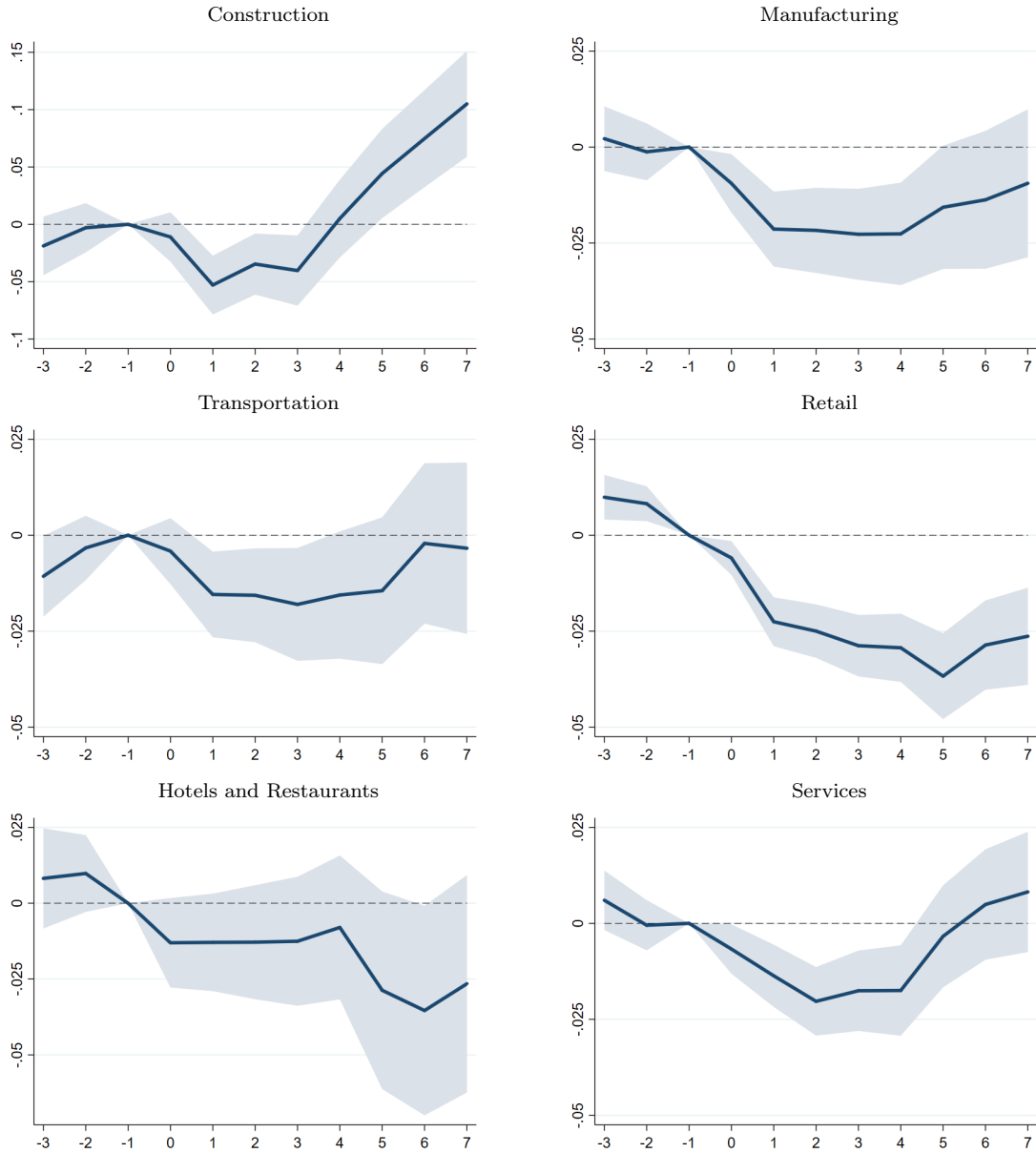
Note: Instead of using the deadlines for adoption as in the main text, these graphs show the relatives changes of the treated around the *announcement dates*, that is when deadlines were announced. This figure plots the point estimates (solid line) and the 95 percent confidence intervals (shaded area) of the β_t coefficients in Equation (2), estimated using the sample of all firms mandated to adopt e-invoicing before 2019. Each panel corresponds to a separate regression by sector.

TABLE A.1: Full Sample Summary Statistics over 2014-2017: main variables

| Values in thousand 2014 soles	Wave 1 (October 2014)		Wave 2 (January 2015)		Wave 3 (July 2015)		Wave 4 (July 2016)	
	mean	sd	mean	sd	mean	sd	mean	sd
total sales	1,316,000	(1,768,000)	659	(5,551)	158,100	(183,100)	102,400	(262,500)
total purchases	1,047,000	(1,733,000)	606	(5,334)	114,000	(142,900)	87,220	(215,800)
value added	268,900	(944,700)	53	(309)	44,120	(126,900)	15,220	(154,100)
gross VAT	165,400	(243,200)	115	(999)	22,000	(23,290)	13,820	(20,860)
gross VAT credits	164,000	(243,200)	107	(960)	17,360	(23,060)	13,210	(34,990)
VAT due	34,280	(60,830)	13	(62)	7,167	(8,670)	3,723	(5,587)
new net Vat credits	32,840	(101,800)	4	(39)	2,531	(11,340)	3,115	(27,120)
total VAT collection	37,360	(72,380)	6	(20)	7,127	(9,189)	3,032	(5,610)
2018 e-invoices*	0.85	(0.32)	0.63	(0.41)	0.91	(0.24)	0.94	(0.20)
VAT credit stock	20,540	(100,800)	4	(76)	2,433	(19,950)	3,523	(16,240)
exporting firms**	0.63	(0.48)	0.00	(0.05)	0.45	(0.50)	0.34	(0.47)
number of workers	1,729	(2,766)	4	(15)	710	(1,280)	287	(474)
wage bill	11,410	(19,500)	4	(16)	2,319	(3,036)	938	(1,082)
capital	480,100	(892,800)	32	(96)	66,220	(230,700)	143,500	(974,200)
profits	123,600	(315,700)	21	(48)	14,630	(53,740)	19,810	(138,600)
observations	934		4,734		3,078		2,073	
percent of total V-A	32%		0%		17%		4%	

Values in thousand 2014 soles	Wave 5 (December 2016)		Wave 6 (January 2017)		Wave 7 (many 2018 deadlines)		Firms never mandated or mandated after	
	mean	sd	mean	sd	mean	sd	mean	sd
total sales	15,450	(125,700)	700	(1,181)	2,678	(13,890)	759	(3,634)
total purchases	11,430	(87,320)	643	(1,183)	2,213	(14,730)	629	(4,243)
value added	4,024	(70,050)	57	(263)	466	(8,287)	131	(3,667)
gross VAT	1,721	(8,805)	112	(196)	372	(1,875)	102	(516)
gross VAT credits	1,567	(13,980)	104	(195)	327	(2,122)	88	(599)
VAT due	501	(1,883)	12	(29)	111	(640)	30	(232)
new net Vat credits	347	(10,500)	5	(32)	66	(1,308)	16	(433)
total VAT collection	525	(9,799)	7	(22)	69	(480)	17	(194)
2018 e-invoices*	0.93	(0.21)	0.82	(0.32)	0.34	(0.37)	0.18	(0.34)
VAT credit stock	477	(27,400.00)	3	(28.00)	90	(8,625.00)	27	(568.00)
exporting firms**	0.10	(0.30)	0.01	(0.09)	0.07	(0.25)	0.02	(0.15)
number of workers	103	(601.00)	2	(5.00)	14	(44.00)	6	(32.00)
wage bill	292	(4,151)	2	(7)	26	(94)	12	(65)
capital	6,650	(91,900)	50	(133)	1,025	(16,720)	799	(20,840)
profits	1,055	(11,920)	25	(53)	200	(2,545)	102	(2,735)
observations	45,075		1,950		294,434		309,498	
percent of total V-A	23%		0%		18%		5%	

Note: Waves correspond to groups of firms and are identified by initial deadline for e-invoicing adoption. Adoption deadlines are indicated in brackets at the column tops. Values correspond to annual averages and are expressed in thousands of 2014 soles, unless otherwise noted. In 2014, the exchange rate was approximately 0.34 US$ per soles. Shaded columns indicate the waves with firms that were caught in fictitious or fraudulent transactions before their assignment to a wave. * indicates that numbers correspond to the share of invoices issued electronically. ** indicates that numbers correspond to a dummy variables indicating if a firm exports.

TABLE A.2: Full Sample Summary Statistics over 2014-2017: Group Distributions

| | Wave 1 | | Wave 2 | | Wave 3 | | Wave 4 | |
	obs.	value added	obs.	value added	obs.	value added	obs.	value added
(in % of total)								
Agriculture	1.3	1.0	1.7	1.4	0.8	0.6	0.6	0.5
Fishing	0.6	0.4	1.1	0.3	0.4	0.3	0.5	0.4
Extraction	18.7	31.3	0.9	0.9	8.4	6.9	7.7	38.0
Manufacturing	20.0	7.7	12.8	20.6	17.9	14.5	13.5	8.0
Utilities	4.7	5.8	0.1	0.1	1.4	1.7	1.6	-4.6
Construction	3.5	3.1	9.7	23.8	9.3	8.8	13.8	13.2
Retail	32.4	3.2	47.0	21.2	21.7	2.8	24.7	-4.2
Hotel-restaurant	0.2	0.1	0.0	0.0	1.5	0.6	1.9	2.0
transportation	2.9	0.8	4.7	6.0	4.0	7.5	5.4	5.4
Telecommunication	1.9	3.0	0.7	0.2	1.0	0.4	1.9	-5.0
Other services	13.6	43.6	21.3	25.4	33.7	55.8	28.2	46.4
Public admnistration	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0
Small (150-1700 UIT*)	0.7	0.0	99.5	91.7	6.8	-1.9	9.6	-8.6
Medium (1700-2300 UIT*)	0.1	0.0	0.3	2.5	0.6	0.0	0.9	0.0
Large (>2300 UIT*)	99.1	100.0	0.3	5.7	92.6	101.9	89.6	108.7
2013Q2 VAT credit stock**	45.7	39.8	30.5	30.1	29.6	20.1	43.4	5.5
(V-A in million soles)								
Total	934	262,332	4,734	256	3,078	141,144	2,073	32,852

| | Wave 5 | | Wave 6 | | Wave 7 | | Not yet assigned | |
	obs.	value added	obs.	value added	obs.	value added	obs.	value added
(in % of total)								
Agriculture	3.4	4.6	4.8	-1.1	2.6	2.6	2.8	4.4
Fishing	1.7	1.4	2.1	3.5	0.6	0.8	0.9	1.1
Extraction	2.3	7.0	2.1	8.2	1.3	4.1	1.7	5.1
Manufacturing	9.0	13.5	11.2	18.4	10.5	10.0	8.9	8.9
Utilities	0.7	2.5	0.0	0.0	0.2	-3.7	0.2	-5.3
Construction	9.4	5.1	9.4	9.2	9.8	16.4	14.3	18.8
Retail	33.4	10.3	45.9	33.2	36.6	13.9	36.1	17.6
Hotel-restaurant	3.4	1.8	0.1	0.1	3.6	4.0	2.2	2.5
transportation	12.3	6.4	6.4	11.6	8.6	4.2	7.8	8.3
Telecommunication	0.6	0.5	0.4	0.3	0.9	0.7	0.7	1.0
Other services	22.8	36.9	17.6	16.5	25.2	46.8	24.4	38.8
Public admnistration	1.1	10.0	0.0	0.0	0.1	0.1	0.2	-1.2
Small (150-1700 UIT*)	63.1	5.0	99.2	102.0	92.9	49.5	98.1	41.7
Medium (1700-2300 UIT*)	6.5	3.1	0.5	3.7	2.3	8.2	0.5	4.9
Large (>2300 UIT*)	30.3	91.8	0.3	-5.7	4.8	42.3	1.4	53.4
2013Q2 VAT credit stock**	27.7	38.5	19.6	24.6	31.9	28.1	33.3	24.7
(V-A in million soles)								
Total	45075	189,278	1,950	115	294,434	143803	309,498	41,905

Note: For every wave, the first column shows the percent of observations that belongs to the corresponding industry, size or VAT credit group. Waves correspond to groups of firms and are identified by initial deadline for e-invoicing adoption. Value added totals correspond to annual averages and are expressed in thousands of 2014 soles. In 2014, the exchange rate was approximately 0.34 US$ per soles. Shaded columns indicate the waves with firms that were caught in fictitious or fraudulent transactions before their assignment to a wave. * UIT are "Unidad Impositiva Tributaria", inflation-adjusted tax units. ** indicates the share of firms with a positive stock of VAT credit in 2013Q2.

TABLE A.3: Balanced Sample Summary Statistics over 2014-2017: main variables

Values in thousand 2014 soles	Wave 1 (October 2014)		Wave 3 (July 2015)		Wave 4 (July 2016)		Wave 5 (December 2016)		Wave 7 (many 2018 deadlines)	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
total sales	1,315,000	(1,755,000)	168,300	(182,900)	101,800	(217,900)	18,780	(138,300)	2,883	(8,641)
total purchases	1,049,000	(1,735,000)	121,100	(144,200)	83,200	(143,900)	13,700	(92,370)	2,262	(7,534)
value added	266,000	(940,600)	47,140	(125,700)	18,610	(156,400)	5,080	(79,820)	622	(4,506)
gross VAT	164,400	(241,800)	23,470	(23,360)	14,450	(20,820)	2,051	(7,394)	411	(997)
gross VAT credits	164,000	(242,500)	18,410	(23,310)	12,430	(20,890)	1,873	(14,550)	340	(1,009)
VAT due	33,890	(60,620)	7,644	(8,766)	3,718	(5,085)	602	(2,072)	120	(292)
new net Vat credits	33,510	(102,500)	2,584	(11,350)	1,700	(6,559)	424	(11,960)	49	(486)
total VAT collection	36,750	(71,970)	7,604	(9,314)	3,062	(5,331)	646	(11,180)	76	(217)
2018 e-invoices*	0.85	(0.32)	0.91	(0.24)	0.94	(0.20)	0.93	(0.21)	0.32	(0.36)
VAT credit stock	20,980	(101,600)	1,810	(11,300)	2,035	(10,010)	590	(31,330)	68	(10,410)
exporting firms**	0.63	(0.48)	0.49	(0.50)	0.37	(0.48)	0.12	(0.33)	0.07	(0.26)
number of workers	1,756	(2,796)	742	(1,311)	303	(489)	119	(665)	15	(44)
wage bill	11,490	(19,660)	2,378	(3,043)	943	(1,062)	348	(4,662)	27	(75)
capital	475,300	(893,700)	58,940	(187,100)	76,880	(562,400)	6,882	(79,090)	754	(7,531)
profits	117,600	(306,200)	14,630	(48,070)	9,470	(59,930)	1,270	(13,430)	182	(2,000)
observations	900		2,756		1,768		33,792		173,508	
percent of total V-A	35%		19%		5%		25%		16%	

Note: The balanced sample is constructed from the full sample by excluding Wave 2 and Wave 6 high-risk firms as well as firms that have no sales in at least on quarter over 2013Q2-2017Q4. Waves correspond to groups of firms and are identified by initial deadline for e-invoicing adoption. Adoption deadlines are indicated in brackets at the column tops. Values correspond to annual averages and are expressed in thousands of 2014 soles, unless otherwise noted. In 2014, the exchange rate was approximately 0.34 US$ per soles. Shaded columns indicate the waves with firms that were caught in fictitious or fraudulent transactions before their assignment to a wave. * indicates that numbers correspond to the share of invoices issued electronically. ** indicates that numbers correspond to a dummy variables indicating if a firm exports.

TABLE A.4: Balanced Sample Summary Statistics over 2014-2017: Group Distributions

	Wave 1		Wave 3		Wave 4		Wave 5		Wave 7	
	obser-vation	value--added	obser-vation	value--added	obser-vation	value--added	obser-vation	value--added	obser-vation	value--added
(in % of total)										
Agriculture	1.3	1.0	0.6	0.4	0.5	0.4	3.2	4.3	1.9	2.8
Fishing	0.7	0.4	0.4	0.3	0.3	0.3	0.7	1.1	0.2	0.4
Extraction	18.6	32.4	7.8	8.9	5.7	37.5	1.6	7.2	0.5	1.7
Manufacturing	20.8	8.0	19.3	14.8	14.9	7.2	10.0	13.6	12.1	12.0
Utilities	4.0	5.1	1.5	1.6	0.7	0.3	0.9	3.4	0.2	0.3
Construction	3.4	3.2	7.5	8.8	12.0	10.7	5.4	4.0	4.8	9.3
Retail	33.0	3.0	22.8	2.9	27.3	-5.2	35.3	9.9	38.9	15.1
Hotel-restaurant	0.2	0.1	1.7	0.6	2.2	1.9	3.6	1.7	4.0	4.0
transportation	3.0	0.8	4.1	7.7	6.1	5.0	13.4	6.4	10.5	7.9
Telecommunication	1.8	1.3	1.0	0.4	2.0	-0.4	0.6	0.5	0.9	1.2
Other services	13.2	44.6	33.3	53.6	28.0	42.2	24.0	37.5	25.8	44.7
Public admnistration	0.0	0.0	0.0	0.0	0.2	0.0	1.2	10.4	0.1	0.5
Small (150-1700 UIT*)	0.1	0.0	1.2	-0.2	3.2	-1.0	55.0	4.6	91.4	44.8
Medium (1700-2300 UIT*)	0.1	0.0	0.5	0.0	0.8	0.0	7.6	2.7	2.9	6.4
Large (>2300 UIT*)	99.8	100.0	98.3	100.2	96.0	101.0	37.4	92.7	5.7	48.8
2013Q2 VAT credit stock**	46.2	41.2	27.7	21.9	42.3	15.3	27.1	39.6	38.9	30.1
(V-A in million soles)										
Total	900	252,965	2,756	136,541	1,768	34,552	33,792	181,131	173,508	113,637

Note: The balanced sample is constructed from the full sample by excluding Wave 2 and Wave 6 high-risk firms as well as firms that have no sales in at least on quarter over 2013Q2-2017Q4. For every wave, the first column shows the percent of observations that belongs to the corresponding industry, size or VAT credit group. Waves correspond to groups of firms and are identified by initial deadline for e-invoicing adoption. Value added totals correspond to annual averages and are expressed in thousands of 2014 soles. In 2014, the exchange rate was approximately 0.34 US$ per soles. Shaded columns indicate the waves with firms that were caught in fictitious or fraudulent transactions before their assignment to a wave. * UIT are "Unidad Impositiva Tributaria", inflation-adjusted tax units. ** indicates the share of firms with a positive stock of VAT credit in 2013Q2.

TABLE A.5: Impact of Mandatory e-Invoicing

	Taxable sales	Taxable purchases	Taxable value added	VAT liabilities	New VAT credits	VAT payments	Firm Employment	Firm TFP
A. Without firm variable controls								
Treatment (first year)	0.0744*** (0.0127)	0.0556*** (0.0139)	0.0653*** (0.0123)	0.0808*** (0.0203)	0.0475 (0.0366)	0.0537* (0.0316)	-0.0011 (0.0009)	0.0483*** (0.0093)
Dummy (a year after)	0.158*** (0.0269)	0.122*** (0.0281)	0.160*** (0.0287)	0.296*** (0.0760)	-0.277** (0.1330)	0.378*** (0.0677)	-0.0092*** (0.0028)	0.128*** (0.0285)
Constant	11.67*** (0.00072)	11.34*** (0.00079)	10.48*** (0.00071)	8.403*** (0.00120)	3.458*** (0.00215)	6.096*** (0.00180)	0.407*** (0.000053)	0.00103* (0.00055)
Observations	1,010,437	1,010,439	843,159	1,010,439	1,010,439	1,010,439	1,010,439	842,199
B. With firm variable controls								
Treatment (first year)	0.0657*** (0.0124)	0.0453*** (0.0135)	0.0589*** (0.0120)	0.0722*** (0.0202)	-0.0432 (0.0366)	0.0445 (0.0314)	... ...	0.0604*** (0.0091)
Dummy (a year after)	0.140*** (0.0259)	0.0989*** (0.0266)	0.146*** (0.0282)	0.278*** (0.0758)	-0.283** (0.133)	0.360*** (0.0660)	... ...	0.159*** (0.0274)
Number of workers	0.483*** (0.0110)	0.483*** (0.0114)	0.411*** (0.0102)	0.442*** (0.0185)	-0.190*** (0.0263)	0.688*** (0.0242)	... ...	-0.354*** (0.0082)
Wage bill	-0.0145*** (0.00308)	-0.00476 (0.00352)	-0.0147*** (0.00306)	-0.00613 (0.00472)	0.0290*** (0.00681)	-0.0472*** (0.00648)	... ...	-0.0230*** (0.0026)
Capital stock	0.00783*** (0.00117)	0.0130*** (0.00153)	0.00609*** (0.00115)	0.00383** (0.00184)	0.0109*** (0.00310)	0.00814*** (0.00296)	... ...	-0.0222*** (0.0011)
Constant	10.63*** (0.0259)	10.16*** (0.0320)	9.606*** (0.0259)	7.425*** (0.0398)	3.504*** (0.0589)	4.886*** (0.0574)	... ...	1.272*** (0.0231)
Observations	1,010,398	1,010,400	843,147	1,010,400	1,010,400	1,010,400	...	842,199

Note: Results for the balanced sample of firms mandated to adopt e-invoicing before 2019. Dependent variables are expressed in log constant 2014 soles. The treatment indicator is equal to one in the quarter of mandatory e-invoicing adoption and the following four quarters. All specifications include a variable controlling for the fifth and following quarters after the date of mandatory e-invoicing adoption, and the bottom row also includes controls for firm employment, wage bill and capital stock. Firm-clustered standard errors in brackets. * 0.10, ** 0.05, *** 0.01.

TABLE A.6: Heterogeneity by Firm Size and Creditor Status

	By Firm Size				By Firm Size and Creditor Status			
	Taxable value added	VAT liabilities	New VAT credits	VAT payments	Taxable value added	VAT liabilities	New VAT credits	VAT payments
Treatment (first year)	0.0270 (0.0168)	0.0379 (0.0321)	0.00521 (0.0573)	-0.103** (0.0423)	0.0337* (0.0182)	0.0869*** (0.0291)	-0.230*** (0.0602)	0.0338 (0.0454)
Interacted with:								
× SME indicator	0.0581** (0.0228)	0.0645* (0.0382)	0.0771 (0.0690)	0.276*** (0.0584)	0.0576** (0.0228)	0.0556 (0.0377)	0.120* (0.0687)	0.251*** (0.0585)
× VAT credit stock indicator					-0.0304 (0.0277)	-0.155*** (0.0519)	0.746*** (0.0811)	-0.436*** (0.0720)
Dummy (a year after)	0.111*** (0.0313)	0.245*** (0.0811)	-0.352** (0.143)	0.184** (0.0748)	0.101*** (0.0361)	0.386*** (0.0777)	-1.004*** (0.170)	0.373*** (0.0778)
Interacted with:								
× SME indicator	-0.231 (0.487)	-0.757 (0.860)	2.057** (0.923)	0.278 (0.608)	-0.239 (0.484)	-0.725 (0.857)	1.915** (0.879)	0.269 (0.615)
× VAT credit stock indicator					0.0413 (0.0572)	-0.428** (0.186)	1.983*** (0.276)	-0.590*** (0.150)
Number of workers	0.411*** (0.0102)	0.442*** (0.0185)	-0.190*** (0.0263)	0.688*** (0.0242)	0.411*** (0.0102)	0.442*** (0.0185)	-0.190*** (0.0262)	0.688*** (0.0242)
Wage bill	-0.0146*** (0.00306)	-0.00611 (0.00472)	0.0290*** (0.00681)	-0.0472*** (0.00648)	-0.0147*** (0.00306)	-0.00614 (0.00471)	0.0292*** (0.00681)	-0.0473*** (0.00648)
Capital stock	0.00610*** (0.00115)	0.00383** (0.00184)	0.0109*** (0.00310)	0.00817*** (0.00296)	0.00609*** (0.00115)	0.00381** (0.00184)	0.0111*** (0.00309)	0.00810*** (0.00296)
Constant	9.607*** (0.0259)	7.425*** (0.0398)	3.505*** (0.0589)	4.887*** (0.0574)	9.607*** (0.0259)	7.426*** (0.0398)	3.502*** (0.0589)	4.888*** (0.0573)
Observations	843,147	1,010,400	1010400	1,010,400	843,147	1,010,400	1,010,400	1,010,400

Note: Results for the balanced sample of firms mandated to adopt e-invoicing before 2019. Dependent variables are expressed in log constant 2014 soles. The treatment indicator is equal to one in the quarter of mandatory e-invoicing adoption and the following four quarters. This treatment indicator is interacted with two dummy variables indicating if a firm had sales lower than 1,700 UIT (about $2 million) or a positive stock of VAT credits in 2013Q2, respectively. All specifications include a variable controlling for the fifth and following quarters after the date of mandatory e-invoicing adoption, and the bottom row also includes controls for firm employment, wage bill and capital stock. Firm-clustered standard errors in brackets. * 0.10, ** 0.05, *** 0.01.

TABLE A.7: Heterogeneity by Initial sales and Creditor Status (Alternative Specification)

	By Firm Size				By Firm Size and Creditor Status			
	Taxable value added	VAT liabilities	New VAT credits	VAT payments	Taxable value added	VAT liabilities	New VAT credits	VAT payments
Treatment (first year)	0.0850*** (0.0167)	0.0865*** (0.0255)	0.0471 (0.0462)	0.187*** (0.0440)	0.0912*** (0.0176)	0.126*** (0.0268)	-0.140*** (0.0484)	0.297*** (0.0444)
Interacted with:								
× Initial sales	-0.0254** (0.00997)	-0.0138 (0.0204)	-0.00119 (0.0369)	-0.133*** (0.0236)	-0.0251** (0.00998)	-0.00907 (0.0201)	-0.0234 (0.0370)	-0.120*** (0.0238)
× VAT credit stock indicator					-0.0304 (0.0277)	-0.158*** (0.0517)	0.740*** (0.0810)	-0.434*** (0.0722)
Dummy (a year after)	0.273** (0.119)	0.490 (0.335)	0.176 (0.426)	0.665*** (0.221)	0.266** (0.120)	0.594* (0.333)	-0.314 (0.421)	0.824*** (0.218)
Interacted with:								
× Initial sales	-0.0647 (0.0419)	-0.0855 (0.123)	-0.164 (0.152)	-0.209*** (0.0755)	-0.0657 (0.0419)	-0.0707 (0.122)	-0.233 (0.151)	-0.195** (0.0763)
× VAT credit stock indicator					0.0417 (0.0570)	-0.430** (0.186)	2.013*** (0.278)	-0.585*** (0.151)
Number of workers	0.410*** (0.0102)	0.442*** (0.0185)	-0.190*** (0.0263)	0.687*** (0.0242)	0.411*** (0.0102)	0.442*** (0.0185)	-0.190*** (0.0262)	0.688*** (0.0242)
Wage bill	-0.0146*** (0.00306)	-0.00612 (0.00472)	0.0290*** (0.00681)	-0.0472*** (0.00648)	-0.0147*** (0.00306)	-0.00616 (0.00472)	0.0292*** (0.00681)	-0.0473*** (0.00648)
Capital stock	0.0061*** (0.0012)	0.0038** (0.0018)	0.0109*** (0.0031)	0.0082*** (0.0030)	0.0061*** (0.0012)	0.0038** (0.0018)	0.011*** (0.0031)	0.0081*** (0.0030)
Constant	9.607*** (0.0259)	7.426*** (0.0398)	3.505*** (0.0589)	4.888*** (0.0573)	9.607*** (0.0259)	7.426*** (0.0398)	3.502*** (0.0589)	4.890*** (0.0573)
Observations	843,147	1,010,400	1010400	1,010,400	843,147	1,010,400	1,010,400	1,010,400

Note: Regression results for the balanced sample of firms mandated to adopt e-invoicing before 2019. Dependent variables are expressed in log soles adjusted for inflation, and treatment, the main regressor, is equal to one in the quarter of mandatory e-invoicing adoption and the following four quarters. The treatment variable is interacted with log sales in 2013Q2 and with a variable indicating whether a firm had a positive stock of VAT credits in 2013Q2. The measure of initial sales was demeaned and normalized to facilitate interpretation. All specifications include a variable controlling for the fifth and following quarters after the date of mandatory e-invoicing adoption and controls for firm employment, wage bill and capital stock. Firm-clustered standard errors in brackets. * 0.10, ** 0.05, *** 0.01.

TABLE A.8: Instrumental Variable Results

	1st Stage	2nd Stage					
	Adoption	Taxable sales	Taxable purchases	Taxable value added	VAT liabilities	New VAT credits	VAT payments
Treatment (first year)	0.448*** (0.00396)						
Adoption		0.147*** (0.0276)	0.101*** (0.0302)	0.132*** (0.0269)	0.161*** (0.0451)	0.105 (0.0817)	0.0993 (0.0700)
Number of workers	-0.00183 (0.00124)	0.484*** (0.0110)	0.483*** (0.0114)	0.411*** (0.0102)	0.442*** (0.0185)	-0.190*** (0.0263)	0.688*** (0.0242)
Wage bill	0.000683** (0.000311)	-0.0146*** (0.00308)	-0.00483 (0.00352)	-0.0147*** (0.00306)	-0.00624 (0.00472)	0.0289*** (0.00681)	-0.0473*** (0.00648)
Capital stock	0.000349** (0.000174)	0.00778*** (0.00117)	0.0130*** (0.00153)	0.00603*** (0.00115)	0.00377** (0.00184)	0.0109*** (0.00310)	0.00810*** (0.00296)
Dummy (a year after)	0.463*** (0.00735)	0.0719*** (0.0205)	0.0521** (0.0203)	0.0857*** (0.0236)	0.204*** (0.0717)	-0.332*** (0.125)	0.314*** (0.0515)
Robust F-stat	1.3e+04						
Observations	1,010,400	1,010,398	1,010,400	843,147	1,010,400	1,010,400	1,010,400

Note: Regression results for the balanced sample of firms mandated to adopt e-invoicing before 2019. Dependent variables in the second-stage regression are expressed in log constant 2014 soles. The treatment indicator is equal to one in the quarter of mandatory e-invoicing adoption and the following four quarters. All specifications control for firm employment, wage bill and capital stock, and also include a variable controlling for the fifth and following quarters after the date of mandatory e-invoicing adoption. Firm-clustered standard errors in brackets. * 0.10, ** 0.05, *** 0.01.