

Technology and Tax Compliance Spillovers: Evidence from a VAT e-Invoicing Reform in Peru

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Abstract

Our study uses administrative data on firm-to-firm transactions and quasi-experimental variation in the rollout of electronic invoicing reforms in Peru to study the diffusion of e-invoicing through firm networks and its effect on tax compliance. We find that voluntary e-invoicing adoption is higher amongst firms with partners who have been mandated to adopt e-invoicing, implying positive technology adoption spillovers. Spillovers are stronger from downstream partners and from export-oriented firms, consistent with incentives in the VAT system. Trading partners of firms who have been mandated to adopt e-invoicing report lower taxable purchases. Transaction-level data suggest this decline comes from the termination of firm-supplier relationships. Lower purchases results in lower VAT credits, and higher VAT payments following the reform, suggesting positive spillovers in tax compliance.

Keywords: VAT, tax compliance, technology spillovers, firm transaction data

JEL: D22, H25, H26, L25, O17, L14

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1 Introduction

Digitalization of tax records and widespread adoption of digital technologies have been key features of tax administration modernization in many developing countries. One such technological innovation is the transfer of invoice information between firms and their suppliers through a digital medium (e-invoicing). Unlike traditional, paper-based invoices, e-invoices contain billing and payment data in a machine-readable format that can be imported directly into account payable systems and shared automatically with the tax authority. Drawn by the potential to strengthen tax compliance and reduce transaction and monitoring costs, more than 50 countries around the world have already implemented e-invoicing for the value added tax (VAT), including ten countries in Latin America and the Caribbean region (Barreix et al., 2018). While studies have found a direct impact of e-invoicing adoption on tax compliance and firm behavior, there is scant evidence of indirect impacts (spillovers) of e-invoicing adoption by firms on trading partners in the supply chain.¹

This study investigates spillovers in the adoption of e-invoicing and tax compliance within firm networks using administrative and transaction-level data from Peru. We examine a reform that sequentially mandated firms to adopt e-invoicing and analyze whether these mandates resulted in technology adoption spillovers among non-mandated trading partners in firm networks. We also examine spillovers in tax compliance of firms whose partners have been mandated to use e-invoicing, as measured by changes in firms' self-reported sales, purchases, and VAT payments. The presence of spillovers indicates that the overall impact of e-invoicing adoption is larger than implied by the direct effects of the e-invoicing reform on mandated firms alone. From a policy perspective, it also highlights whether targeted policy interventions diffuse through firm networks.

Network externalities exist when the number of agents using a product or service changes the value of the product/service for others (Katz and Shapiro, 1985). E-invoicing has the potential for generating network externalities in two ways. First, the costs of reporting transactions electronically may fall when your partner has already adopted e-invoicing. Such a network

¹Fan et al. (2020), Bellon et al. (2022) investigate direct effects. Bellon et al. (2022), covering the same period in Peru, finds that the direct effects are statistically significant among small and medium firms (with annual sales below \$2.5 million) and in some economic sectors characterized by traditionally higher tax non-compliance (services, transportation).

externality may be asymmetric in a VAT setting wherein VAT refund credits are increasing in reported taxable purchases but declining in reported taxable sales. This can create stronger incentives for firms to fully account for their purchase invoices from their upstream sellers, but creates no commensurate incentives for downstream partners. Therefore, firms are more likely to encourage their upstream partners to voluntarily adopt the e-invoicing technology, resulting in larger upstream spillovers.² Second, the costs of tax non-compliance may rise when a partner gets mandated into e-invoicing, because the enhanced monitoring of transactions with this partner renders the detection of misreporting more likely.

We examine the case of Peru, where e-invoicing was mandated for firms beginning in 2014. The implementation of the reform was staggered with the largest firms mandated to switch to e-invoicing first, followed by medium and small firms. This staggered implementation of the reform allows us to examine whether voluntary adoption among firms not directly mandated to adopt e-invoicing was influenced by their trading relationships with firms who were mandated to switch to e-invoicing. We further examine how this policy affects the volume of transactions between partner firms, as well as the spillover effects on sales and tax reporting behavior.

Firstly, our difference-in-differences analysis shows that the likelihood of voluntary e-invoicing adoption is higher among firms who have trading partners who have been mandated to adopt e-invoicing. This adoption spillover is asymmetric between upstream and downstream partners, with stronger spillovers generated by downstream partner firms. A firm with a downstream partner (buyer) who has been mandated to adopt e-invoicing is 26 percent more likely to voluntarily adopt e-invoicing in the year in which the downstream partner is mandated relative to a firm with no such partnership. Adoption spillovers are smaller when upstream partners are mandated to adopt e-invoicing, with voluntary adoption increasing by 7 percent relative to the rate of voluntary adoption for firms with no upstream partners mandated to adopt e-invoicing. This asymmetric spillover effect is consistent with VAT incentives as downstream partners collect purchase invoices from upstream firms and their VAT obligations are decreasing in their ability to report their purchase invoices. Adopting the same format of invoicing plausibly reduces the cost of reporting, hence downstream partners have a stronger incentive to lower

²Technology diffusion can also be the product of peer learning, which can operate both upstream and downstream. In our setting, we are unable to conclusively distinguish between the two channels, beyond highlighting the presence of spillovers in technology adoption and the presence of asymmetries in these spillovers in the supply chain.

their VAT reporting costs by drawing upstream firms into e-invoicing when they are mandated to switch. We similarly find larger adoption spillovers from exporting firms who receive a cash refund in the Peruvian VAT system and are similarly highly incentivized to participate in the VAT system.

Secondly, we evaluate whether mandating e-invoicing adoption among trading partners impacts a firm's tax compliance behavior as captured by self-reported sales, purchases and VAT reporting behavior. We find a reduction in both reported taxable sales and reported taxable purchases, but the reduction in purchases is larger and more robustly estimated. We also find a decline in VAT input credits among firms who have partners who have been mandated to adopt e-invoicing. While declines in overall sales and purchases could be driven by firms facing increased transaction costs of maintaining the same level activity with their trading partners when some partners are mandated to switch to the electronic system while other partners remain in the paper-based system, another possible explanation which is consistent with the asymmetry in results between taxable sales and taxable purchases, is an increase in tax compliance as a result of increased probability of VAT evasion-detection following the reform. Hence, a decline in reported purchases which is larger than the decline in reported sales is consistent with firms reducing their practice of filing false purchase invoices to lower their VAT obligations. This is also consistent with the observed decline in VAT input credits as a result of the reform, which have also been used as a form of evasion of VAT obligations in the Peruvian VAT system³. In practice, we expect that the observed effects of the reform are a result of both improved compliance and costs of transitioning between the e-invoicing and paper-based systems, but our data does not allow us to identify these two channels separately.

We use our tax compliance results to create a back-of-the-envelope estimate of the potential size of the spillover impact of the reform on tax compliance. Using the estimated effect on VAT payments in the first year following the reform, applied to the share of affected firms in the Peruvian VAT regime being analyzed, we find that spillover effects raise overall VAT payments by 2.3 percent. By comparison, [Bellon et al. \(2022\)](#) estimated that the direct effect of the same reform on firms that were mandated to adopt e-invoicing was an increase in their

³By over-reporting purchases based on fraudulent purchase invoices, firms are able to accumulate VAT input credits, allowing them to defray future VAT obligations as well. [Bellon et al. \(2022\)](#) found that while the direct impact of Peruvian e-invoicing reform was an increase in reported VAT liabilities, VAT payments did not increase among large firms, likely due to the existence of large stocks of VAT credits in the system

overall VAT liabilities by 6.7 percent in the first year of the reform⁴. Hence, the spillover effects of the reform on tax compliance of firms who were not yet in the e-invoicing system were about one fourth of the reform’s overall effects.

We also look at how the e-invoicing reform may be affecting firm networks, survival of firm partnerships, and overall likelihood of firms continuing to report in the VAT regime. Using transactions level data between a firm and its partners, we find suggestive evidence for disruption of firm networks on the extensive margin, with firms having a higher likelihood of losing their partnerships when their partners are mandated to adopt e-invoicing. This may be driven by higher transaction costs from having to operate in different systems or could be the result of firms trying to evade higher monitoring resulting from their partners adopting e-invoicing. However, at the aggregate level of firms, we find that firms connected to partners who are already in the e-invoicing system are significantly less likely to disappear from the VAT general regime of taxation and are more likely to report positive sales in the years following the reform, relative to firms who do not have such partners. So, while the reform may be resulting in reduced transactions volume, it is not driving an exit of firms from the VAT regime. This is a positive outcome from a policy perspective, since the introduction of a new, potentially costly, technology could have resulted in firm exit from the general tax regime into the simplified regime with less scrutiny or into informality.

Our work contributes to the small but growing literature that uses data on firm-to-firm transactions to evaluate how policies targeting firms can propagate through their trading networks. [Pomeranz \(2015\)](#) shows that improved VAT monitoring results in significant positive compliance spillovers in upstream firms in the supply chain. We similarly find evidence of propagation of tax compliance in a firm network but only in the case of small firms traditionally more likely to avoid monitoring, and thus more susceptible to behavioral change when monitoring technology is enhanced. [López-Luzuriaga and Scartascini \(2019\)](#) show that messaging regarding the consequence of non-compliance in property taxes results in increased reporting of gross sales tax and spillovers across different tax categories. [Boning et al. \(2020\)](#) find that the deterrence effect of IRS visits to taxpayers suspected of noncompliance spreads through the firms’

⁴[Bellon et al. \(2022\)](#) found that the direct effect of the reform on VAT payments was negative in the first year of implementation, even as VAT liabilities increased, because targeted firms used old VAT credits accumulated in the years before the reform to offset increased tax liabilities. Strong positive effects on VAT payments were found among small firms without a stock of old VAT credits.

tax preparer networks, resulting in higher tax payments among firms who share the same tax preparer as the firm facing the direct intervention.

A related literature shows the impact of tax regimes and reforms on segmentation of firm networks. [Gadenne et al. \(2019\)](#) demonstrate that tax reforms can reshape firm supplier networks and create market segmentation between firms in different VAT regimes in India. Similarly, [Gerard et al. \(2018\)](#) use administrative tax data from Brazil to show that tax regimes influence trading networks among firms, with segmentation between VAT and non-VAT registered firms. We find similar evidence in the case of adoption of a firm-level technology which causes a rupture in firm networks only partially reversed by firms' partners voluntarily adopting the same technology. This points to segmentation over time between firms who adopt e-invoicing and those who do not.

Our paper also relates to a diverse literature on the role of networks in the diffusion of technology, much of which is dominated by research on agricultural technologies (see, for instance, [Foster and Rosenzweig \(1995\)](#) on the learning spillovers of new seed technology; [Conley and Udry \(2010\)](#) on social learning from neighbors regarding new crops; and, more recently, [Beaman et al. \(2021\)](#) on using network information to spur technology diffusion. See [Cheng \(2021\)](#) for a detailed review). The increase in availability of administrative data has also been used to examine firms' production networks ([Bernard et al. \(2019\)](#)) and how production networks influence firm size ([Carvalho et al. \(2021\)](#)). Our work relies on similar administrative data on supply chains of individual firms but explores the propagation of technology between firms and spillover effects of this technology along different dimensions of the firm's network.

Finally, we contribute to the growing literature that examines the impact of digital technologies on tax administration, including e-invoicing (see [Fan et al. \(2020\)](#) and [Bellon et al. \(2022\)](#), and references therein), the electronic submission of tax returns or e-filing ([Yilmaz and Coolidge, 2013](#); [Okunogbe and Pouliquen, 2018](#)) and the use of electronic sales registry machines ([Mascagni et al., 2021](#)). In contrast to these papers, our paper focuses on spillovers of e-invoicing adoption by firms on trading partners in the supply chain.

The remainder of the paper is arranged as follows: Section 2 presents the main features of the e-invoicing reform in Peru; Section 3 outlines our empirical approach; Section 4 discusses the data used in this study; Section 5 presents our results, and the final section presents our conclusions.

2 The e-Invoicing Reform in Peru

E-invoicing was available to firms in Peru since the mid-2000s, but voluntary adoption of e-invoicing remained low. This led the Peruvian tax authority (SUNAT) to announce a multi-stage plan in 2013 to permanently switch from paper to e-invoicing, which is the reform we study in this paper.

For firms, the transition to e-invoices offered several potential benefits. First, e-invoices could be handled and processed more efficiently than paper invoices. As in other countries, paper invoices in Peru were associated with significant costs, including printing, postage, delivery and archiving physical copies, and possibly fines issued during tax audits for non-compliant paper records. Hence, e-invoices brought savings and allowed for a better integration of invoicing with accounting, procurement, and payment systems, reducing mistakes from processing paper invoices.

The tax authority also expected e-invoicing to improve tax compliance. There was a strong belief that e-invoicing would reduce opportunities for VAT fraud, including from under-reported sales (e.g., not reporting transactions or presenting the same invoice to more than one buyer) or overstated deductions (e.g., issuing fake invoices to simulate purchases or reporting purchases unrelated to business operations). These types of fraud were prevalent with paper invoicing, since it was challenging for the tax authority to cross-check the more than 300 million invoices issued every year in Peru.

To facilitate the transition to e-invoicing, the tax authority gave firms several options on how to issue e-invoices, with larger issuers given the option for developing their own e-invoicing systems, and all firms having the ability to contract with authorized third-party systems or use a free software application developed by the tax authority. For small and micro-enterprises dealing with few invoices, an online platform was made available to submit invoices easily one by one. Once they transitioned to e-invoices, all firms were expected to remain e-issuers permanently, with paper-based invoices allowed only in exceptional circumstances (e.g., if there was an internet outage).⁵ As of 2020, a majority of taxpayers were using SUNAT platforms (61 percent), a third was using in-house systems while the rest was using third-party solutions.

⁵Even in these cases, firms were required to regularize paper invoices on a timely basis (RS 113-2018/SUNAT).

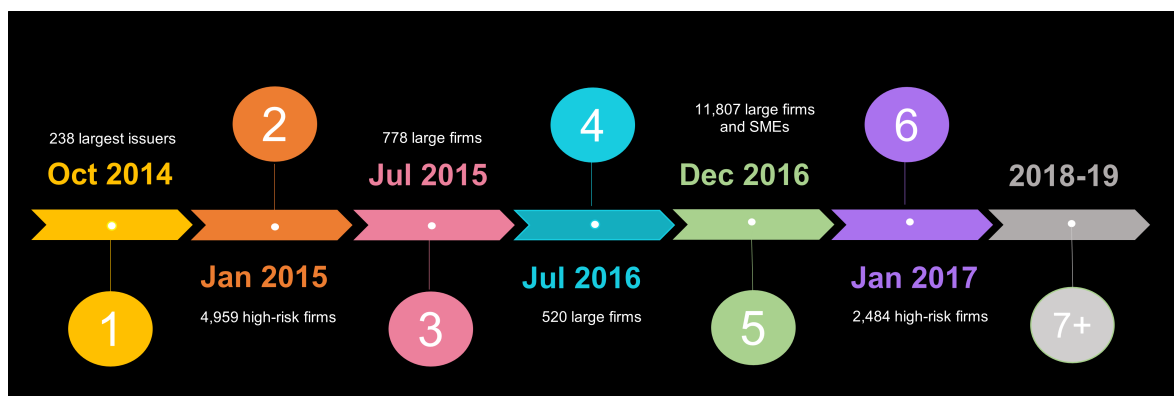
Since it was recognized early on that switching to e-invoicing would create significant adjustment costs for taxpayers and the tax administration, including updating IT capacity and staff training, the e-invoicing transition was introduced in a gradual and staggered manner. Firms were assigned into reform waves with different deadlines for e-invoicing adoption, with selection criteria based on administrative classifications related to size and compliance factors. Larger firms were required to adopt e-invoicing earlier, as they represented a larger share of VAT revenue and had more capacity to update their IT systems. 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 deterrent effect and would facilitate the monitoring of their transactions.

Over the main period of study from 2013 to 2017, there were six waves of requirements into e-invoicing targeting six different groups of firms (Figure 1). Those six waves mainly consisted of two types of firms. First, SUNAT targeted 13,343 firms using different administrative classifications with the objective of focusing on relatively larger firms across all sectors (waves 1, 3, 4, and 5). These firms included the largest contributors to value added and VAT collections but also comprised many small and medium enterprises (69 percent were SMEs). Second, SUNAT additionally focused on 7,443 firms that had been caught in fraudulent transactions (Operaciones No Reales - ONR) during tax audits, and, therefore, were considered as high risk.

The first six reform waves mandated firms to adopt e-invoicing in October 2014, January 2015, July 2015, July 2016, December 2016 and January 2017 respectively. For many groups, the original deadlines for adopting e-invoicing were subsequently extended by a few quarters (between 2 and 5 quarters) to give taxpayers more time to comply.⁶ A previous study (Bellon et al., 2022) showed that the original deadlines for adopting e-invoicing were effective in initiating adoption among targeted groups: for most waves, adoption rates were insignificant before the original deadlines and rose very rapidly immediately after. This is particularly true for the firms in waves 1, 3, 4, and 5, with a majority of firms having adopted 6 months after the

⁶See RS 374-2013/SUNAT, RS 300-2014/SUNAT and RS 086-2015/SUNAT for the original deadline and deadline extensions of wave 1; see RS 300-2014/SUNAT for the deadline of wave 2; see RS 300-2014/SUNAT and RS 137-2015/SUNAT for the original deadline and deadline extensions of wave 3; See RS 203-2015/SUNAT and RS 328-2016/SUNAT for the original deadline and deadline extensions of wave 4; see RS 203-2015/SUNAT, RS 311-2016/SUNAT and RS 155-2017/SUNAT for the original deadline and deadline extensions of wave 5; see RS 192-2016/SUNAT for the deadline of wave 6.

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. Large firms are defined as firms with sales >2300 UIT, medium with sales between 2300 UIT and 1700 UIT and small firms with sales below 1700 UIT. UIT (Unidad Impositiva Tributaria) is a monetary unit set every year by the tax authority to calculate tax and regulatory thresholds. In 2014 one UIT was equal to \$1,140.

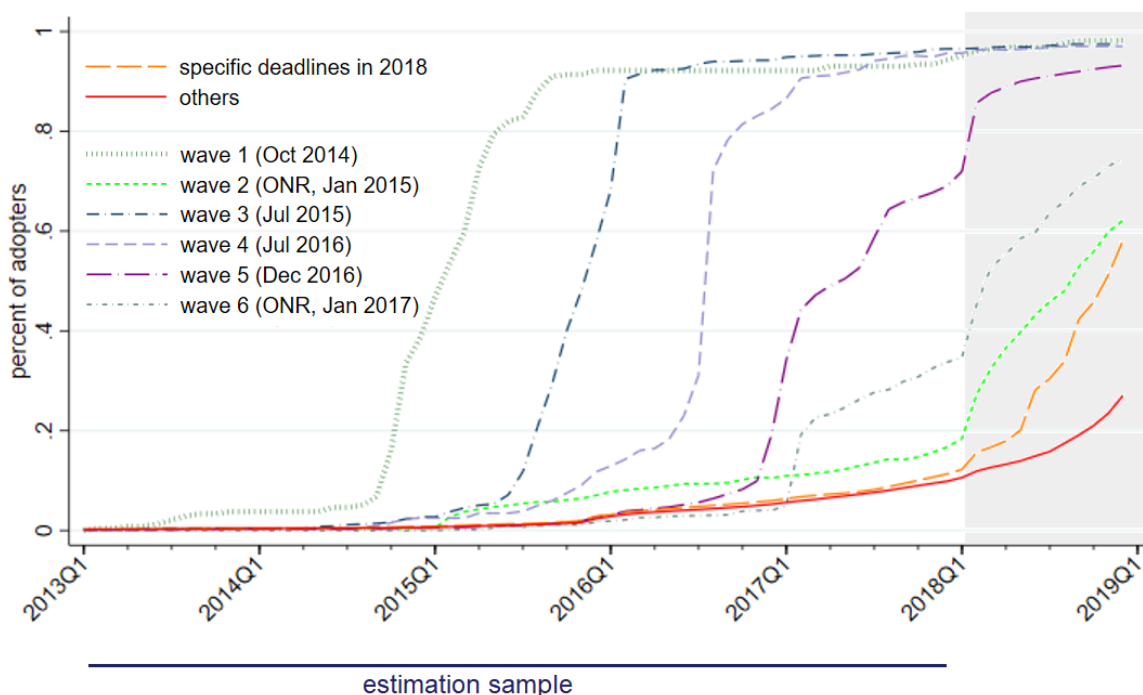
deadline (Figure 2). The firms in waves 2 and 6 that were caught in fraudulent transactions responded much less after their respective deadlines. For these firms, e-invoicing uptake was much more gradual and did not exceed 20 percent by end-2017, as opposed to adoption rates over 80 percent for the others. By end-2017, there was also some voluntary adoption by firms that were yet not mandated into e-invoicing: the adoption rate among these firms was slightly above 10 percent on average.

While adoption rates were high after e-invoicing deadlines, they never reached 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 focus on the effects of the reform (mandating firms to adopt e-invoicing irrespective of whether these firms complied or not) because the actual adoption rate of e-invoicing by mandated firms is very high and since the few mandated firms that did not adopt are nevertheless likely to expect higher scrutiny from SUNAT compared to before.

By 2017, SUNAT had already communicated plans to extend the usage of e-invoicing among firms. Four groups comprising a total of 90,347 firms, including 4,550 firms who committed some tax fraud, were mandated to adopt e-invoicing at different deadlines in 2018.⁷ These

⁷See RS 155-2017/SUNAT RS 155-2017/SUNAT and RS 155-2017/SUNAT: Anexo I-IV

FIGURE 2: 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 and deadlines are indicated in brackets. By the end of 2017, SUNAT had already announced specific deadlines in 2018 for some firms (the "specific deadlines in 2018" wave) while other firms might become required to adopt e-invoicing in 2018 or later once they meet some criteria (the "others" wave). "ONR" waves consist of firms that were caught in fraudulent transactions before their assignment to a wave.

firms were typically SMEs with a few exceptions (5 percent of large firms). After 2017, SUNAT also started to require firms to adopt e-invoicing once they meet specific criteria. For example, firms were required to adopt e-invoicing as soon as they started exporting, firms that registered under three of the four possible tax regimes were required to adopt e-invoicing in the 3 months following their registration, and firms that grew and sold above a certain threshold in a given calendar year were required to adopt e-invoicing in January of the following year.⁸ In the latter case, that threshold in 2018 corresponded to the cut-off used by SUNAT to distinguish between micro and small firms, implying that all but micro firms were mandated into e-invoicing by 2019. Subsequently, SUNAT announced plans to continue expanding the

⁸see RS 155-2017/SUNAT, RS 155-2017/SUNAT, RS 020-2018/SUNAT and RS 312-2017-SUNAT

coverage of e-invoicing by lowering this threshold.

During the period we analyze (2013-2017), the tax authority did not adopt any long-term changes in its compliance risk management strategy but several short-term supervisory activities were changed. In order for these changes to bias our difference-in-differences estimation results, their targeting and timing would have to be coincident with the timing and targeting of the reform. Hence, the changes in tax control activities would have to target firms according to the same classification by wave as the e-invoicing reform, and the timing of changes in control activity would also have to coincide with the deadlines by wave of the e-invoicing reform. We observe that this is not the case for change in tax control activities. Therefore, 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 and derive from the e-invoicing reform and the resulting increase in the probability of tax evasion detection.

SUNAT's e-invoicing requirements led to a steady increase in the usage of e-invoicing. By 2019, 775 thousand firms were using e-invoicing and 1.8 million electronic invoices were issued in that year. SUNAT estimated that 84 percent of formal sales were processed with e-invoices.

3 Empirical Specification

Our empirical analysis focuses on the spillover effects from mandated partner firms on non-mandated firms during the period 2013-17. Specifically, we exploit the staggered implementation of e-invoicing mandates for different groups of partner firms and compare firms with partners who were mandated to adopt e-invoicing (treated firms) against firms whose partners were not mandated to adopt e-invoicing (untreated firms).

3.1 Spillovers in e-Invoicing Adoption

Our primary specification evaluates spillovers in the adoption of e-invoicing technology. Because we focus on firms that were not yet mandated into e-invoicing, their adoption of e-invoicing is referred to as 'voluntary adoption'⁹. We examine whether having a trading relationship with firms mandated to adopt e-invoicing results in a higher likelihood of voluntary

⁹This could equally be considered 'early' adoption given that the mandate would have been extended to these firms in later years

adoption. Since VAT incentives differ based on a firm's position in the supply chain relative to trading partners, we distinguish between the effects from downstream partners (also referred to as "buyers") and the effects from upstream partners (also referred to as 'suppliers'). Our empirical specification is a panel difference-in-differences (DID) linear probability model at the firm level:

$$\begin{aligned}
 Prob(adopt)_{i,t} = & \sum_{s=0}^T \beta_s^S \cdot I(MandatedSupplier_{t-s} = 1) \\
 & + \sum_{s=0}^T \beta_s^B \cdot I(MandatedBuyer_{t-s} = 1) + \delta_i + \gamma_{gt} + \varepsilon_{i,t} \quad (1)
 \end{aligned}$$

where the dependent variable captures whether firm i has voluntarily adopted e-invoicing at time t ; the indicator $I(MandatedSupplier_{t-s} = 1)$ takes the value one when, for the first time at time $t - s$, at least one of the firm's suppliers get mandated to adopt e-invoicing. The indicator $I(MandatedBuyer_{t-s} = 1)$ is similar but for the firm's buyer.

The coefficients of interest β_0^S and β_0^B capture the effect on a firm's voluntary adoption of e-invoicing in the first year that one or more of their partners is mandated into e-invoicing. If there are spillovers, that is a firm is more likely to adopt e-invoicing when one of its partners is mandated into e-invoicing, then β_0^S or β_0^B should be positive. The coefficients β_s^S and β_s^B for $s = 1..T$, capture the effects of having a partner being mandated into e-invoicing for the first time s years before year t . Because the earliest adoption deadline is in 2014 and our estimation period ends in 2017, a partner can be mandated at most 3 years ago. Therefore, we choose $T = 3$. When comparing β_0^S with β_s^S (or β_0^B with β_s^B) for any $s > 0$, differences may be attributable to two effects. It may be that spillovers take time to unfold or grow larger over time ($\beta_0^S < \beta_s^S$). Alternatively, differences could arise from composition effects as the set of firms that have partners mandated for a year or more can be smaller than the set of firms that have partners that are mandated for the first year. Indeed, some firms might be treated for the first time at the end of the sample. Hence, different coefficients could reflect differences in the fundamental characteristics of the two sets of firms. Because we cannot separate between time and composition effects, we will focus our analysis on β_0^S and β_0^B .

Equation (1) introduces a number of controls: δ_i is a firm fixed effect capturing time-invariant firm characteristics which can influence voluntary e-invoicing adoption; γ_{gt} is a vector of group-year fixed effects, where a groups g is defined as a unique combination of export status, sector, number of suppliers, number of buyers, and sales quartile at the beginning of the sample. The group-year fixed effects control for time-variant group characteristics which may otherwise bias the treatment effect, given that firm networks and initial conditions are not randomly assigned.

3.2 Spillovers in Tax Compliance

We next evaluate the impact of technology adoption on tax compliance of non-mandated firms. Specifically, we explore the indirect effect of the reform on reported taxable sales, purchases, VAT credits and VAT payments among firms who have not been mandated to adopt e-invoicing but have trading relationships with firms that have been mandated as part of the reform.

$$Y_{i,t} = \sum_{s=0}^T \beta_s I(\text{MandatedPartner}_{t-s} = 1) + \delta_i + \gamma_{gt} + \varepsilon_{i,t} \quad (2)$$

where $Y_{i,t}$ alternately captures a firm’s reported taxable sales, purchases, VAT liabilities, new VAT credits and VAT payments on an annual basis. For tractability, we abstract from heterogeneity between treated suppliers and buyers since we do not observe meaningful differences in this type of outcome¹⁰ All controls are defined in the same way as before.

We can also explore whether compliance behavior is further impacted if the firm voluntarily adopts e-invoicing, following its partner being mandated into e-invoicing adoption, by adding an interaction term that captures voluntary adoption on the firm level. Given that the choice of voluntary adoption is subject to self-selection, these results are suggestive but do not have a causal interpretation.

¹⁰Results available upon request.

3.3 Market Segmentation: Transactions between firms

We investigate the effect of the reform on a firm’s transactions with its partners following a partner being mandated into e-invoicing, to shed further light onto potential channels through which aggregate firm outcomes such as reported sales and purchases may be affected. This analysis is conducted at the partnership level between every firm i and each of its individual partners, p :

$$Y_{i,p,t} = \sum_{s=0}^T \beta_s \cdot I(\text{MandatedPartner}_{p,t-s} = 1) + \delta_{i,p} + \gamma_{i,t} + \varepsilon_{i,p,t} \quad (3)$$

where $Y_{i,p,t}$ alternately captures whether there are transactions between a firm i and its partner p (the extensive margin) and the log of the transaction values between them (the intensive margin). The dummy variable $I(\text{MandatedPartner}_{p,t-s} = 1)$ indicates if partner p has been mandated to adopt e-invoicing in year $t - s$; $\delta_{i,p}$ captures firm-partner pair fixed effects to control for time-invariant characteristics of partnerships; γ_{it} captures firm-year fixed effects to control for time-variant features of the firm that may influence transactions in the partnership. Hence, β_0 captures the impact on the intensive and extensive margin of transactions between a firm and its partners in the year that the partners are mandated to adopt e-invoicing. We estimate this specification separately for upstream and downstream partners (suppliers and buyers).

We can further explore whether firm-partner transactions are impacted by whether a firm voluntarily adopts e-invoicing by adding an interaction term, but these results are illustrative and cannot be causally interpreted since the voluntary adoption sub-sample is subject to self-selection bias.

3.4 Difference-in-differences with staggered treatment

Recent developments in the difference-in-differences literature have noted that in the case of a panel with multiple time periods (as opposed to a canonical two-period model) and multiple treatments cohorts with different treatment dates, the standard DID setup may pro-

duce erroneous results if treatment effect are heterogeneous across time or across treatment cohorts. This arises from the fact that a standard DID specification will estimate average treatment effects based on 'correct' comparisons between units who have been treated relative to untreated or not-yet-treated units, as well as 'incorrect' comparison between units who are already treated (Roth et al., 2022). As a result, the standard DID coefficient can have an incorrect sign in the presence of treatment effect heterogeneity between different treatment groups.

To ensure that our results are not subject to error arising from applying a standard difference-in-differences specification to a setting with staggered treatment timing, we test for the robustness of our results to the use of an alternate procedure proposed by Callaway and Sant'Anna (2021). This doubly-robust difference-in-differences estimation procedure calculates average treatment effects at the treatment group level, where a treatment group is defined by the period in which it is first treated, and ensures that the resulting estimate is based only on correct comparisons of treated units with not-yet treated and untreated units. The procedure also has the attractive property of allowing for the inclusion of covariates to control for observable characteristics which may create violations in the parallel pre-trends assumption required for the application of the difference-in-differences model. This allows us to closely replicate our original specification while using an estimator which is more robust to potential errors that may affect the standard difference-in-differences estimator in the presence of staggered treatment timing ¹¹. By ensuring consistency of our results between application of the two different estimation procedures, the standard difference-in-differences specification and well as the doubly-robust difference-in-differences procedure, we are assured of the robustness of our estimation.

A key condition for validity of the difference-in-differences approach is the presence of parallel pre-trends across treated and untreated groups. In a staggered difference-in-differences approach, the analysis of pre-trends is complicated by the fact that different groups of firms are exposed to the treatment at different times. Consequently, we also use the robust difference-in-differences procedure of Callaway and Sant'Anna (2021) to analyze pre-trends in our variables of interest. Since this procedure relies on the estimation of group-time treatment effects, by aggregating these group-time treatment effects for different periods of exposure to the treatment, the procedure allows the construction of event studies surrounding the date of first

¹¹We implement this procedure in Stata using the module *csdid* (Rios-Avila et al., 2022)

treatment for multiple treatment groups.

4 Data

Our dataset is constructed by drawing from three administrative tax datasets, on firm VAT payments, on firm total transactions, and on firm-to-firm transactions.¹² All the datasets have annual information covering the 2013-2017 period, but some have a slightly longer coverage.

We obtain firm-level information about total sales, total purchases, total VAT liabilities and total VAT credits from a database of firm-level VAT declarations. This first dataset reports total sales and total purchases across all buyers and suppliers. We supplement this data with information from a second dataset on total VAT payments with data on e-invoicing requirements and e-invoicing adoption. While the data in these two datasets is restricted to formal small, medium and large firms, the coverage is comprehensive. It follows nearly 200,000 firms accounting for 53 percent of GDP and 95 percent of domestic VAT collections in 2013.

The combined firm-level dataset does not cover two groups of firms. First, it does not cover micro firms with less than 150 UIT (about \$175,000) in annual sales.^{13,14} Second, it does not cover informal firms since these firms are not registered with the tax authority. Because of these coverage restrictions, the estimated impacts of e-invoicing are not directly applicable to informal and micro firms. Nonetheless, most of these firms in Peru are very small and the dataset only misses firms that make small contributions to aggregate value added.

We obtain partnership-level information from a third dataset that compiles firm annual accounting records. For every firm in the database, there is a list of the total transaction values sold to each of the firm's buyers and the total transaction values purchased from each sup-

¹²Confidentiality of the disaggregated tax data was strictly maintained throughout the study. All data processing and analysis was carried out on SUNAT's servers. Researchers only had access to the results from the empirical estimation, which contains no unique identifiers at the firm level.

¹³The Unidad Impositiva Tributaria (UIT) is a monetary unit set every year by the tax authority to calculate tax and regulatory thresholds (see figure 1 notes). 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 excluded from our analysis because they are subject to a simplified tax regime in Peru (the Nuevo RUS) instead of the VAT regime.

¹⁴The dataset was constructed by including all the firms that reported annual sales above 150 UIT at least once over the 2013-2017 period.

plier.¹⁵ For tractability, we limit the size of the supplier and buyer network to the top-five partners of each type (suppliers and buyers): for each firm in the database, we examine their links with (up to) their five largest suppliers and buyers. Combining this network information with the firm-level data, we find that the top five suppliers and buyers account for about 30 percent of total purchases and sales respectively in a given year (Tables A.1-A.2 in the appendix).

Similarly to the first two datasets, the partnership database only has a partial coverage of Peruvian firms. By 2013, only large firms were required to report partnership information.¹⁶ Nevertheless, this information includes partnerships with all firms, including with small and medium firms. Therefore, we recover transaction-level information on the medium and small firms that trade with large firms using the data from these large firms. In 2014 (the first year of the e-invoicing reform implementation), we obtain transaction data on 4.7 suppliers and 3.5 buyers on average for the firms in our estimation sample (Table A.2 in the appendix). This is obtained after we restrict the data only to top-five suppliers and top-five buyers. Therefore, these numbers suggest that we capture most of the true top-five partners and likely the most important by their size. While we argue that the size of the data coverage is not an issue, we acknowledge that changes in coverage over the years could lead to issues.

Thus, we construct a specific panel of firm-partner transactions for the purpose of our analysis. Given that firm networks can be endogenously determined and impacted by data collection issues and by the policy itself, we freeze the firm network in 2014 (the first year of the policy). In other words, we only consider the transactions between a firm and its top-five suppliers and top-five buyers according to the 2014 ranking of partners. We then follow the evolution of transaction values between firms and their 2014 top partners throughout the years. In particular, we continue collecting information on transaction values with a partner even if this partner's ranking falls below five in another year. This allows us to know whether the reform led to the termination of firm-partner relationships and to accurately measure changes in transaction values between partners.

We focus our analysis on the indirect effects of the reform on the firms that were not yet mandated into e-invoicing by 2017. Therefore, we restrict our estimation sample to firms that

¹⁵Totals by partner are computed from the exhaustive list of all the transactions with each partner.

¹⁶See RS 286-2009/SUNAT, RS 008-2013/SUNAT and their annexes for details about the legal requirements.

were not themselves mandated by 2017 while considering all partners of these firms regardless of when the partners were mandated to adopt. After merging information from all sources and eliminating firms with inconsistent information across sources, the dataset covers about 150 thousand firms every year (Table A.1 in the appendix) and their 25,000 top-five partners.¹⁷

The not-yet-mandated firms in our sample are mostly small- and medium-sized (only 3 percent are large enterprises). On average, their annual sales are just below \$0.5 million (see Table A.1 in the appendix for details). However, because of their large number, they account for about 12 percent of GDP and 22 percent of domestic VAT collections. Despite the fact that they have not been required to adopt e-invoicing, 1 percent of firms in our sample already adopted e-invoicing in 2014 and 9 percent did so in 2017.

In 2014, the firms in our sample had 4.2 suppliers and 2.5 buyers on average, implying that some of these firms had fewer than 5 formal business suppliers and buyers (Table A.1 in the appendix).¹⁸ The number of buyers is lower, likely reflecting the fact that some firms mainly sell to final customers and are therefore not captured in our data. We also observe that many partnerships do not survive from one year to the next. In 2015, firms maintained positive transactions with only 2.3 of their 2014 top-5 suppliers and with only 1.5 of their 2014 top-5 buyers on average. By 2017, these numbers were down to 1.5 for suppliers and 0.8 for buyers. Yet, this implies that some of the 2014 top partners remain important throughout the period of study, thereby allowing for the possibility of capturing spillover effects from 2014 partners. We also observe that the number of top-5 partners mandated into e-invoicing increases steadily over the period under study, from an average of 0.9 for suppliers and 0.3 for buyers in 2014 to 2.8 for suppliers and 1.5 for buyers in 2017.

For the small firms that we study, compliance variables (sales, VAT liabilities, etc.) can often be null. This means that the average of any variable in log terms in a given year is a function of the varying set of active firms with non-zero values and that the composition of this set can be affected by the reform effects. To avoid composition bias, we construct our estimation sample as the balanced sample of firms with positive sales in every year from 2013 to 2017. We

¹⁷There are less partners than firms because of the specific construction of the dataset which focuses on top-five partners. Large enterprises are over-represented among partners and tend to be the top-five partners of multiple firms.

¹⁸The average number of partners is slightly lower than in the estimation sample that is obtained after dropping firms with missing or zero sales as explained in the next paragraph (Table A.1).

also transform all nominal variables using the $x \rightarrow \ln(x + 1)$ transformation. The balanced sample has half as many firms as in the full sample (approximately 74,616 firms) and these firms tend to be somewhat larger on average but otherwise retain similar characteristics (Table A.1 and Table A.2).

Finally, we use the partnership-level data when examining the reform effects on firm-to-partner transactions. In 2014, we observe 641 thousand links between firms and their top-five suppliers and 364 thousand links between firms and their top-five buyers (see Table A.5 in the appendix for details).¹⁹ In 2014, the average annual transaction between a firm and one of its partners is around \$40,000. Unsurprisingly, large enterprises are over-represented among top-five partners: they account for three fourths of the firms' top-five suppliers and two-thirds of the firms' top-five buyers. Exporters are also well-represented with above one fourth of partners being export-oriented. As for the firm-level data, we also construct a balanced sample of partnership data with only non-zero non-missing transactions. This allows us to estimate reform effects on transaction values after controlling for composition effects. This sample is about ten times smaller but its characteristics are reasonably similar (Table A.6 in the appendix).

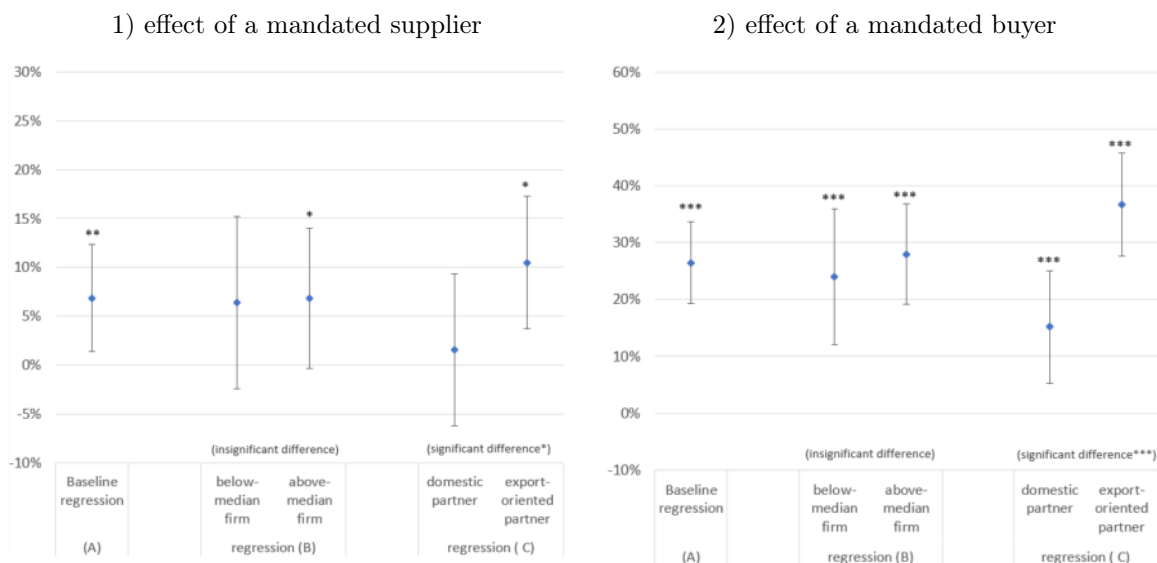
5 Results

5.1 Spillovers in Technology Adoption

Table A.7 shows the spillover effect of e-invoicing on a treated firm from its mandated partners for the balanced sample of firms. We find that in the year when a firm's supplier or buyer is mandated to adopt e-invoicing, there is a highly statistically significant increase in the probability of the treated firm voluntarily adopting e-invoicing as well. Since the overall level of voluntary adoption is low, and therefore the coefficients estimates of the marginal increase due to treatment are also small in absolute term, we interpret the size of this spillover relative to the average level of voluntary adoption among untreated firms (Figure 3). Voluntary adoption among treated firms with mandated suppliers increases by 7 percent in the year in which the partner was mandated to adopt, relative to untreated firms that do not have suppliers

¹⁹The numbers of links in other years are slightly lower as some firm exit the sample.

FIGURE 3: Impact of Having a Partner Mandated into e-Invoicing on e-Invoicing Adoption



Note: The central blue dots indicate the estimated percentage increase in the probability of adopting e-invoicing, and the bars represent 95% confidence intervals. Results are obtained from 3 regressions based on equation (1). In regressions (B) and (C), the coefficients of interest are interacted with mutually exclusive dummy variables: in (B), they are interacted with dummy variables indicating if the firm had sales above or below median sales in 2013; in (C), they are interacted with dummy variables indicating if the firm exported in 2013. The significance of the difference between coefficient estimates is indicated in brackets (* 0.10, ** 0.05, *** 0.01.). All estimates are from Table A.7 in appendix (see table notes for estimation details) and are scaled up by the average probability of adoption in the control group of firms with no mandated partners as indicated by the constant estimate.

mandated to adopt e-invoicing.²⁰ On the other hand, if the mandated partner is a buyer (downstream partner), we find a significant and larger spillover on their untreated partner in the year of the mandate. Hence, firms who transact with mandated buyers are 26 percent more likely to voluntarily adopt e-invoicing in the first year that their partner has been mandated to adopt, relative to untreated firms.

Asymmetric spillover effects between upstream and downstream mandated partners (suppliers and buyers) are consistent with VAT incentives. When the mandated firm is downstream (buyer), its VAT obligations are decreasing in the number of purchase invoices that it can

²⁰To calculate this relative treatment effect, we evaluate the treatment coefficient from the regression as a proportion of the constant, since the constant represents the mean of the dependent variable in the untreated group. Hence in Table A.7, column A, the treatment effect from suppliers is = $0.00166/0.0242*100= 6.86\%$ and from buyers is = $0.00639/0.0242*100= 26.41\%$.

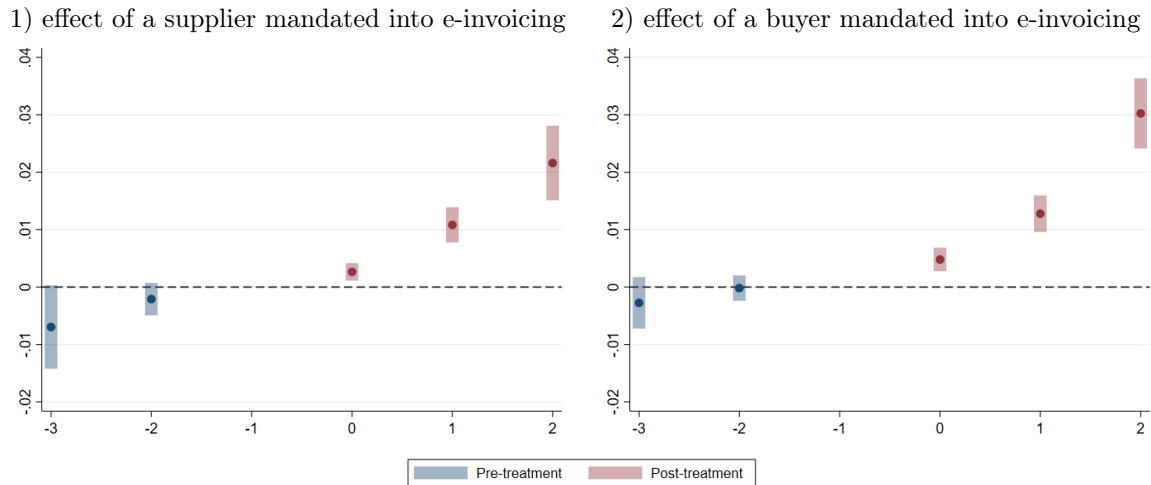
collect and file from the treated firm. If transactions costs are lowered from both firms belonging to the same e-filing regime, downstream firms have a strong incentive to draw their upstream partners into the same system of filing taxes as themselves. Hence, there is a strong adoption spillover incentive generated by downstream mandated firms (buyers). This incentive is missing between a treated firm and its upstream mandated partner since upstream partners (suppliers) collect sales invoices from treated firms and VAT obligations are increasing in recorded sales, giving upstream partners no strong incentives for ensuring complete accounting of their transactions with downstream firms. Consequently, we see much stronger spillovers from downstream partners (buyers) than from upstream partners (sellers).

We find further evidence of VAT incentives driving heterogeneity in spillovers by examining spillovers created by exporting partner firms, relative to non-exporting firms. In the case of exporters, since the majority of their sales are not subject to VAT, VAT obligations are negative, and they are in a position to receive VAT credits from the government in cash under the Peruvian tax system. Consequently, they have a strong incentive for high levels of VAT reporting and compliance. This can generate adoption spillover effects on their trading partners, likely deriving from the exporting firms' interest in lowering reporting costs. The results in Figure 3 show that partners who are exporters create significantly larger spillovers in our sample, both as buyers and sellers. The size of the spillover is twice as large when the mandated partner is an exporter relative to when the partner is not an exporter, though non-exporters continue to generate positive spillovers overall. On the other hand, we do not find strong evidence for heterogeneity in spillovers by size of treated partner, where the size is measured in terms of median sales in the firm sample.

Our specification allows us to unpack how spillovers evolve following the year in which the partner is mandated to adopt e-invoicing. In Table A.7 we show that spillovers increase over time, both for upstream and downstream partners. The spillover effect in the second year more than doubles with buyers and increases four-fold with sellers, although the latter is from a significantly lower baseline effect in the first year. Overall, spillovers from buyers remain significantly higher than from sellers regardless of the numbers of years since the partner was mandated. Hence, while spillovers appear to get stronger over time, they remain asymmetric.

The spillover coefficients for lags of greater than one year are illustrative and should be interpreted with caution since they are subject to composition bias. Given that partner firms can

FIGURE 4: Event Study of Having a Mandated Partner on Voluntary e-Invoicing Adoption



Note: The central dots indicate the difference-in-differences estimate of the change in the probability of voluntary e-invoicing adoption for treated firms and the bars represent 95% confidence intervals. The horizontal axis shows the number of years relative to the e-invoicing adoption deadline of the first partner being mandated. Results are obtained from the doubly robust estimation procedure of [Callaway and Sant'Anna \(2021\)](#), using the 2013-2017 balanced sample. The first panel only considers the partners that supply the firms in the estimation sample, while the second only considers the partners that buy from these firms. All estimates are reported in Appendix in Table A.8 in appendix (see table notes for estimation details).

be drawn from any of the treatment waves, our dataset includes more post-treatment years for partners who belong to earlier treatment waves and fewer post-treatment years for partners drawn from waves that were treated closer to 2017. As such, we are guaranteed one year of treatment outcomes for all partners, and this coefficient is not subject to composition bias. However, the spillover coefficient for longer lags is determined by the subset of firms have partners who are drawn from earlier treatment waves, and is therefore not representative of the full sample of firms.

We confirm the validity of our result by implementing the doubly robust difference in differences estimation procedure of [Callaway and Sant'Anna \(2021\)](#) detailed in Section 3. The magnitude of the estimated spillovers from buyers and suppliers are remarkably similar across methodologies (see column A in Table A.7 and Table A.8), reinforcing our earlier results. Figure 4 presents event study estimates around the treatment date, to rule out the presence of non-parallel pre-trends in the estimation sample. We fail to find statistically significant

TABLE 1: Impact of Having a Partner Mandated into e-Invoicing on Firm Compliance

	(A) Taxable sales	(B) Taxable purchases	(C) VAT liabilities	(D) New VAT credits	(E) VAT payments
treatment year when partner is mandated	-0.0151** (0.00622)	-0.0399*** (0.00866)	0.000872 (0.0109)	-0.0956*** (0.0246)	-0.00457 (0.0239)
first year after treatment	-0.0299*** (0.0108)	-0.0625*** (0.0150)	-0.0158 (0.0174)	-0.164*** (0.0369)	0.112*** (0.0376)
Observations	373,080	373,080	373,080	373,080	373,080

Note: Results are estimated based on equation (2) using the balanced sample of firms with positive sales from 2013 to 2017. The dependent variables are expressed in constant soles and we apply the transformation $y \rightarrow \log(y + 1)$. The first explanatory variables indicate whether a firm has one mandated partner for the first time in the current year. The second explanatory variable is a dummy indicating the year after a partner was mandated for the first time. All specifications include control variables capturing additional years of treatment as well as group-year fixed effects, where a group is defined as a unique combination of export status, sector, number of suppliers, number of buyers, and sales quartile at the beginning of the sample. Coefficient estimates of controls are reported in Table A.9. Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

differences in adoption rates between the treated and untreated groups in pre-treatment years at the 5 percent level, with highly statistically significant differences emerging in the year of treatment and beyond. Figure 4 additionally reinforces our earlier result of the magnitude of spillovers amplifying over time.

5.2 Spillovers in Tax Compliance

After showing evidence of spillovers in e-invoicing adoption, we evaluate whether there are spillovers on a firm’s sales, purchases and VAT reporting as a result of their partners being mandated to adopt e-invoicing.

Table 1 shows that the impact on a firm’s reported taxable sales of a partner being mandated into e-invoicing is statistically significant and negative. In the year when a partner is mandated to adopt e-invoicing, treated firms report 1.5 percent lower taxable sales (Column A), with the negative spillover effect increasing in subsequent years. The average effect on reported taxable purchases (Column B) is also negative and even larger, with treated firms reporting 4 percent

lower taxable purchases in the year when their partner is mandated.

There are two possible explanations these outcomes. First, the decline in firm sales could be the result of increased transaction costs. The cost of switching to the electronic system could be prohibitive for some firms and the partners that had to adopt e-invoicing could find it costly to maintain the same level of activity with the firms outside of the electronic system.

Another possible explanation for our findings, which is consistent with an increase in tax compliance, is that the reduction in reported sales and purchases is a result of a reduction in firms filing false invoices. This explanation is consistent with the negative coefficient being much larger for purchases than sales, since VAT obligations are decreasing in purchases and since false purchase invoices are a form of misreporting/evasion. However, without additional data, we cannot rule out that the other explanation plays a role.

While we do not find significant effects on VAT liabilities (Column C), we do find that the reduction in reported purchases translates into a sizeable and significant reduction in the filing of new VAT credits (Column D). The magnitude of the decline is estimated to be 9.6 percent in the treatment year and 16.4 percent the year after. This would also suggest that avenues for misreporting which allow firms to accumulate more VAT credits to offset their tax liabilities have been reduced. Consequently, we estimate a significant increase in VAT payments by 11.2 percent, but only in the year after a partner is mandated into e-invoicing. The absence of any significant effect in the treatment year could be the result of some delay by the treated firm in acknowledging and processing the new VAT payment obligations. We also explore heterogeneity in behavior between upstream and downstream mandated partners, but find no meaningful distinction in impact on VAT (results available upon request).

We evaluate the robustness of our tax compliance results using the doubly robust difference in differences estimation procedure (Table A.10). Figure 5 and Table A.10 show that the parallel pre-trends assumption is valid at the 5 percent level for all variables, with the exception of taxable sales. Our regression estimates for taxable purchases, VAT credits and VAT payments are consistent between both specifications, painting a similar narrative of increased VAT payments deriving from lower reporting of purchases and input credits, with the treatment effects on VAT credits and VAT payments increasing over time. Our results on sales, however, are not robust to the specification change, with evidence of violation of parallel trends in the pre-treatment period and weak coefficient estimates in the years following the treatment year,

so we exercise caution with respect to this result.

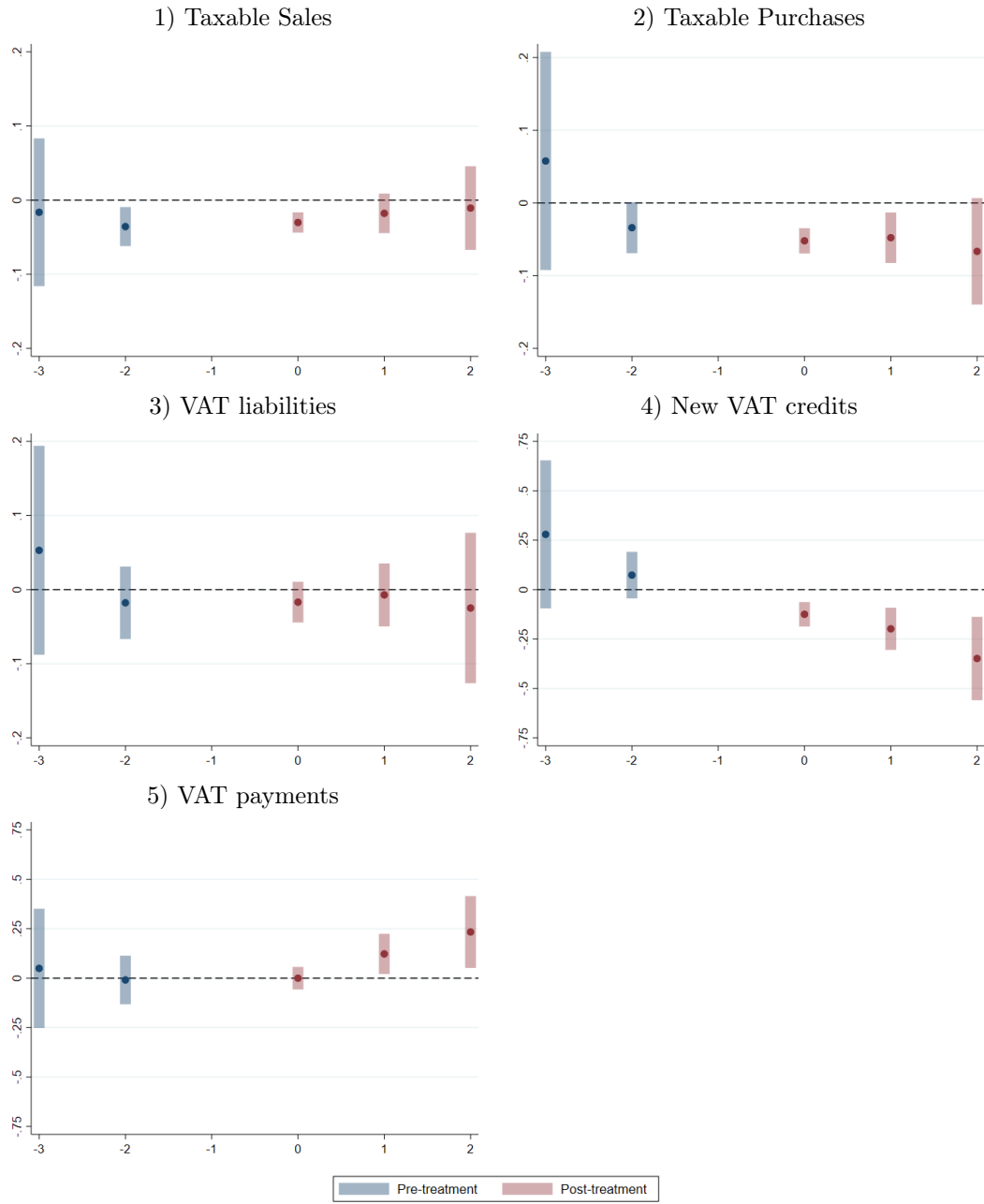
Because we are also interested in the spillover effects of the reform on tax compliance through its impact on voluntary e-invoicing adoption, we explore the interaction of treatment with voluntary adoption. The interaction term allows us to compare treated firms that decide to adopt e-invoicing when their partners are targeted by the reform against treated firms who do not themselves adopt e-invoicing. Results in Table A.11 suggest that voluntary adoption is not the driver behind the shrinkage of firms or the increase in VAT payments. Interaction terms are mostly insignificant, but they would on the contrary suggest that e-invoicing leads to increased reporting of sales and purchases. However, these results do not have a causal interpretation as voluntary adoption could be driven by self-selection, for example in the cases where firms anticipating future growth are more likely to adopt e-invoicing.

In Table A.9, we additionally explore whether having a mandated partner affects the likelihood of firm survival. Here, we define firm survival as observing a firm making positive sales in years subsequent to their partners being mandated into e-invoicing, which implies that the firm is still filing VAT in the general regime. Firms not surviving could be a result of either the firm ceasing operations, the result of the firm switching out of the general tax regime and into the simplified tax regime for smaller firms, or not filing taxes on account of becoming informal or hiding its activities in the shadow economy. In column F, we find that relative to firms who do not have mandated partners in the general regime, firms who are connected to mandated partners are significantly more likely to survive and report positive sales in the year that their partner is mandated, as well as in subsequent years following the reform. This is also a positive indirect effect of the reform, since it suggests that merely being connected to a treated firm increases the likelihood of firms filing under the general regime in all years following the reform. Hence, we find that spillovers in compliance operate not only on the intensive margin in terms of *how much* firms report in sales, purchases and VAT, but also on the intensive margin of *whether* firms continue to report VAT in the general regime.

5.3 Market Segmentation: Transactions between firms

Turning our attention to the partnerships between firms and their top-five partners, we estimate the consequences of having a partner mandated into e-invoicing at the level of each partnership. We consider the extensive margin effects of the reform on partnership survival and

FIGURE 5: Event Study of Having a Partner Mandated on Tax Compliance



Note: The central dots indicate the difference-in-differences estimate of the change in the outcome variable for treated firms relative to untreated and not-yet treated firms and the bars represent 95% confidence intervals. The horizontal axis shows the number of years relative to the e-invoicing adoption deadline of the first partner being mandated. Results are obtained from the doubly robust estimation procedure of Callaway and Sant'Anna (2021), using the 2013-2017 balanced sample. All estimates are reported in Tables A.10 in appendix (see table notes for estimation details).

the intensive margin effects of the reform on partnership strength in surviving partnerships.

We start with the extensive margin by examining the probability of maintaining a partnership active, that is to have positive purchases from a supplier or positive sales to a buyer. Results in Columns A and B in Table 2 show that the probability of maintaining a partnership active declines when a partner is mandated into e-invoicing.

We investigate changes at the intensive margin by looking at changes in transaction values between firms and partners. To this end, we seek to isolate our findings from variations at the extensive margin. Therefore, we estimate the effect of the partner being mandated into e-invoicing on a balanced sample of partnerships that only have positive values in all years. The results in Column C and D in Table 2 are not significantly different from zero.

As before, we examine whether our results are robust to the use of the doubly robust difference in differences estimation procedure. The estimates in Table A.13 confirm the treatment effect on the extensive margin of a reduction in firm partnership survival. They also broadly point to the absence of significant changes at the intensive margin, with the exception of purchases (transaction with suppliers) in the case of the second estimation method. While there is no consistent pre-treatment trend, the pre-treatment period estimates are very noisy and significant in this specification. The presence of this noise in the pre-treatment period necessitates that we treat these results as suggestive and not strictly causal.

Overall the partnership-level results suggest that most of the adjustments occur at the extensive margin. Conditional on a partnership remaining active, the requirement for a partner to adopt e-invoicing has no significant impact on how much is purchased or sold between partners. However, partnerships become increasingly at risk of being terminated when a partner is mandated into e-invoicing. This indicates that our findings at the firm level, which show a reduction in firm total sales and purchases (summed across all partners), could be occurring due to this reduction in partnerships.

While transactions costs can be one possible reason for reduction in transactions between firms in different systems, paper vs. electronic, another possible reason is a reduction in the presence of fraudulent invoices in the VAT system. Mandated adoption of e-invoicing could lead to a decline in misreporting of transactions, which may show up in our data as a termination in firm relationships. This effect would be larger for upstream than downstream partners. Consistent

with this hypothesis, we find that when an upstream partner (seller) is mandated to adopt e-invoicing, there is a larger reduction in the probability of the partnership surviving in the year of the mandate (14 percent) compared when the partner is downstream (11 percent).

If the transaction cost channel were relevant, we would expect the decline in partnership survival to be mitigated when firms voluntarily adopt e-invoicing along with their partner. We investigate this hypothesis with the introduction of an interaction term with an adoption dummy. Results are reported in Table A.14 in the appendix. In columns A and B, voluntarily adopting e-invoicing when its partner is mandated to adopt reduces the negative impact on partnership survival. The net reduction in partnerships with suppliers and buyers is approximately 7 percent. Hence, the impact of voluntary adoption is positive but not large enough to reverse the overall negative impact on the extensive margin.

This result lends credibility to our earlier assertion that there could be transaction costs for trading firms from operating in different systems which results in partnership termination and segmentation between invoicing systems. When firms switch to the same system, these costs are alleviated as evidenced by a higher likelihood of maintaining the partnership but are not altogether eliminated.

6 Robustness checks

Our main results are robust to a number of additional robustness checks. We split our sample, separating the firms that belong to the large groups mandated to adopt e-invoicing in 2018 and the other firms with later deadlines. This allows us to check whether our results could be biased by some firms' expectations about imminent e-invoicing requirements by the tax authority. We find that all our results are qualitatively and quantitatively similar, indicating that our results are not driven by a correlation between expectations about imminent requirements and the treatment (whether you have partners mandated into e-invoicing).

We also investigate the robustness of our results by interacting the treatment variable with measures of treatment intensity. To capture treatment intensity, we use the number of partners that are mandated into e-invoicing and the share of transactions that are associated with mandated partners. The main coefficient estimates remain qualitatively the same as reported in the main specification. The effect of treatment intensity is broadly associated with a strength-

TABLE 2: Impact of Having a Mandated Partner on Firm-Partner Transactions

	Extensive margin (active partnership)		Intensive margin (log transaction values)	
	(A) supplier links	(B) buyer links	(C) supplier links	(D) buyer links
treatment year when partner is mandated	-0.139*** (0.0145)	-0.110*** (0.00695)	0.00616 (0.0169)	-0.0233 (0.0190)
Observations	3,008,216	1,722,928	291,900	194,120

Note: Results are estimated based on equation (3). The dependent variable in columns (A) and (B) is a dummy variable indicating whether we observe a positive transaction value between a firm and its partner. The dependent variable in columns (C) and (D) is the log of the transaction value between a firm and its partner. For (C) and (D), we restrict the sample to links with positive transaction values throughout sample period. Only the top-5 suppliers and top-5 buyers of every firms in 2014 are considered. The explanatory variable indicates whether the partner was mandated into e-invoicing in the current year. All specifications include firm-year and firm-partner fixed effects, as well as control variables indicating whether the partner was already mandated in previous years. Table A.12 shows the coefficient estimates of the controls. Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

ening of the main effects. For example, having more mandated partners or transacting more with mandated partners tends to translate into a greater likelihood of e-invoicing adoption. Similarly, an increase in treatment intensity is associated with a greater increase in taxable sales at firms that adopt e-invoicing.

7 Conclusion

This paper investigates the spillover effects of a reform requiring firms in Peru to adopt e-invoicing, a technology that enhances tax administration capacity. To this end, we examine the non-targeted firms that are in the networks of firms directly targeted by the reform. We find that the reform has *indirect* effects on these non-targeted firms leading to improved voluntary adoption of e-invoicing and improved tax compliance. Our results indicate that evaluations of the true effects of the reform need to account for *indirect* effects and cannot be captured by only accounting for the *direct* effects of the reform on the firms mandated to adopt e-invoicing.

We find strong evidence for positive technology adoption spillovers. Among the firms that were not targeted by the reform, the propensity to adopt e-invoicing increases substantially when

one of a firm’s main partners is mandated into e-invoicing. Consistent with VAT incentives, the spillovers are stronger when the mandated partner is a buyer, having incentives to get purchase invoices more efficiently. While the overall level of voluntary adoption during the time period considered in this study is low, and therefore the size of spillovers small in absolute terms, data indicates that the pace of voluntary adoption accelerated significantly in the later years of the reform.

We also find spillover effects on tax compliance. We find evidence that the firms with mandated partners experience a decrease in reported taxable sales and purchases, but the decline is more pronounced and more robustly estimated for taxable purchases. The larger reduction in reported taxable purchases is consistent with a significant reduction in the reported VAT credits and a significant increase in VAT payments. This suggests that the transition costs arising from the reform lead indirectly affected firms to scale down or cut other costs, thereby generating more value-added, or that deterrence effects lead them to reduce over-reporting of purchases, or both. Additional evidence on voluntary adoption suggests that the firms that decide to adopt e-invoicing along with their mandated partners do not scale down, implying that compliance costs may have less of a negative effect when both a firm and its main partners are in the same reporting system.

Applying our regression estimates from Table 1, a back of the envelope calculation suggests that the reform spillovers have a sizeable impact on tax compliance both when compared with total VAT revenue and with the reform direct effect estimated in [Bellon et al. \(2022\)](#). To facilitate the comparison with [Bellon et al. \(2022\)](#), we focus on the indirect effect in the first year after a partner was mandated. Using the estimated effect on VAT payments and the share of affected firms, we find that spillover effects raise overall VAT payments by 2.3 percent, implying that net VAT liabilities also increase by the same amount. By comparison, [Bellon et al. \(2022\)](#) estimated that the direct effect in the first year of implementation raises overall VAT liabilities by 6.7 percent.²¹ Therefore, our results would imply that about one fourth of the reform overall effects are indirect.

Our results also suggest that e-invoicing adoption can lead to disruption of firm networks, with many firms losing their partnerships with mandated trading partners. This may be driven by

²¹However, [Bellon et al. \(2022\)](#) also estimated that the direct effect of the reform on VAT payments was negative in the first year of implementation because targeted firms used old VAT credits accumulated in the years before the reform to offset increased tax liabilities.

higher transaction costs from having to operate in different systems, paper versus electronic. Alternatively, this effect could be driven by firms trying to evade higher monitoring resulting from their partners adopting e-invoicing, which lowers their ability to evade VAT obligations in that partnership. However, at the firm level we find that firms connected to partners who are already in the e-invoicing system are significantly less likely to disappear from the VAT general regime of taxation and are more likely to report positive sales in the years following the reform, relative to firms who do not have such partners. This is a positive outcome from a policy perspective, since the introduction of a new, potentially costly, technology could have resulted in firm exit from the general tax regime into the simplified regime with less scrutiny or into informality. Yet, our results also highlight the need to minimize disruptions as new technologies are adopted. Exploring the source of these transition costs and measures to alleviate them is an important area for future research.

References

- Barreix, Alberto Daniel, Raul Zambrano, and Costa**, “Factura electronica en america latina,” *Inter-American Development Bank*, 2018, vol. 595.
- Beaman, Lori, Ariel BenYishay, Jeremy Magruder, and Ahmed Mushfiq Mobarak**, “Can network theory-based targeting increase technology adoption?,” *American Economic Review*, 2021, 111 (6), 1918–43.
- Bellon, Matthieu, Era Dabla-Norris, Salma Khalid, and Frederico Lima**, “Digitalization to improve tax compliance: evidence from VAT e-Invoicing in Peru,” *Journal of Public Economics*, 2022, forthcoming.
- Bernard, Andrew B, Emmanuel Dhyne, Glenn Magerman, Kalina Manova, and Andreas Moxnes**, “The origins of firm heterogeneity: A production network approach,” Technical Report, National Bureau of Economic Research 2019.
- Boning, William C, John Guyton, Ronald Hodge, and Joel Slemrod**, “Heard it through the grapevine: The direct and network effects of a tax enforcement field experiment on firms,” *Journal of Public Economics*, 2020, 190, 104261.
- Callaway, Brantly and Pedro HC Sant’Anna**, “Difference-in-differences with multiple time periods,” *Journal of Econometrics*, 2021, 225 (2), 200–230.
- Carvalho, Vasco M, Makoto Nirei, Yukiko U Saito, and Alireza Tahbaz-Salehi**, “Supply chain disruptions: Evidence from the great east japan earthquake,” *The Quarterly Journal of Economics*, 2021, 136 (2), 1255–1321.
- Cheng, Hoi Wai Jackie**, “Factors Affecting Technological Diffusion Through Social Networks: A Review of the Empirical Evidence,” *The World Bank Research Observer*, 2021.
- Conley, Timothy G and Christopher R Udry**, “Learning about a new technology: Pineapple in Ghana,” *American economic review*, 2010, 100 (1), 35–69.
- Fan, Haichao, Yu Liu, Nancy Qian, and Jaya Wen**, “Computerizing VAT Invoices in China,” Working Paper 24414, National Bureau of Economic Research April 2020.

- Foster, Andrew D and Mark R Rosenzweig**, “Learning by doing and learning from others: Human capital and technical change in agriculture,” *Journal of political Economy*, 1995, *103* (6), 1176–1209.
- Gadenne, Lucie, Tushar K Nandi, Roland Rathelot et al.**, “Taxation and Supplier Networks: Evidence from India,” Technical Report, JSTOR 2019.
- Gerard, François, Joana Naritomi, and Arthur Seibold**, “Tax systems and inter-firm trade: evidence from the VAT in Brazil,” Technical Report, Tech. rep., Mimeo London School of Economics 2018.
- Katz, Michael L and Carl Shapiro**, “Network externalities, competition, and compatibility,” *The American economic review*, 1985, *75* (3), 424–440.
- López-Luzuriaga, Andrea and Carlos Scartascini**, “Compliance spillovers across taxes: The role of penalties and detection,” *Journal of Economic Behavior & Organization*, 2019, *164*, 518–534.
- Mascagni, Giulia, Andualem T Mengistu, and Firew B Woldeyes**, “Can ICTs increase tax compliance? Evidence on taxpayer responses to technological innovation in Ethiopia,” *Journal of Economic Behavior & Organization*, 2021, *189*, 172–193.
- Okunogbe, Oyebola Motunrayo and Victor Maurice Joseph Pouliquen**, “Technology, taxation, and corruption: evidence from the introduction of electronic tax filing,” Policy Research Working Paper Series 8452, The World Bank May 2018.
- Pomeranz, Dina**, “No Taxation without Information: Deterrence and Self-Enforcement in the Value Added Tax,” *American Economic Review*, August 2015, *105* (8), 2539–2569.
- Rios-Avila, Fernando, Pedro Sant’Anna, and Brantly Callaway**, “CSDID: Stata module for the estimation of Difference-in-Difference models with multiple time periods,” 2022.
- Roth, Jonathan, Pedro HC Sant’Anna, Alyssa Bilinski, and John Poe**, “What’s Trending in Difference-in-Differences? A Synthesis of the Recent Econometrics Literature,” *arXiv preprint arXiv:2201.01194*, 2022.
- Yilmaz, Fatih and Jacqueline Coolidge**, “Can e-filing reduce tax compliance costs in developing countries?,” Technical Report, World Bank 2013.

A Appendix

TABLE A.1: Main Firm Variables Summary Statistics over 2013-2017 (Full Sample)

Values in thousand 2014 soles	2013		2014		2015		2016		2017	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
total sales	1,623	(17,890)	1,555	(9,904)	1,602	(8,438)	1,577	(10,210)	1,518	(9,893)
share of top-5-buyer sales (%)	16.6	(29.5)	25.7	(32.4)	20.4	(31.1)	16.5	(28.4)	14.2	(27.7)
total purchases	1,348	(14,450)	1,285	(7,993)	1,330	(10,990)	1,276	(10,600)	1,226	(11,190)
share of top-5-supplier purchases	19.7	(26.5)	32.8	(29.1)	20.7	(26.3)	19.2	(25.3)	17.3	(136.7)
taxable sales	1,221	(3,735)	1,204	(5,219)	1,249	(7,227)	1,217	(8,182)	1,166	(8,221)
taxable purchases	1,113	(13,140)	1,074	(7,174)	1,093	(8,286)	1,038	(8,662)	993	(8,802)
VAT liabilities	62	(207)	63	(456)	68	(517)	67	(446)	63	(384)
new net VAT credits	43	(2,087)	39	(988)	40	(1,001)	35	(903)	32	(771)
VAT payments	33	(135)	37	(411)	40	(322)	41	(336)	39	(269)
e-invoicing adoption (%)	0.4	(6.3)	0.7	(8.2)	2.4	(15.2)	4.8	(21.3)	8.6	(28.0)
large enterprises (%)	2.8	(16.4)	2.5	(15.7)	2.5	(15.7)	2.5	(15.7)	2.5	(15.7)
exporters (%)	4.5	(20.8)	4.5	(20.7)	4.2	(20.0)	4.0	(19.7)	3.9	(19.4)
active top-5 2014 suppliers	2.1	(1.4)	4.2	(1.6)	2.3	(1.7)	2.2	(1.7)	2.0	(1.6)
mandated suppliers	0.0	(0.0)	0.9	(1.0)	0.6	(0.8)	0.9	(1.0)	1.4	(1.4)
active top-5 2014 buyers	1.0	(1.3)	2.5	(2.1)	1.5	(1.7)	1.1	(1.5)	0.9	(1.4)
mandated buyers	0.0	(0.0)	0.3	(0.7)	0.4	(0.9)	0.4	(0.9)	0.6	(1.1)
observations	134,555		146,953		147,219		147,347		147,348	

Note: The mean and standard deviations are derived from the full sample of firms that were not mandated to adopt e-invoicing by 2017. 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. The second (fourth) line reports statistics related to the sum of the transaction values with the 2014 top-5 buyers (top-5 suppliers) expressed as a share of total sales (purchases).

TABLE A.2: Main Firm Variables Summary Statistics over 2013-2017 (Balanced Sample)

Values in thousand 2014 soles	2013		2014		2015		2016		2017	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
total sales	1,949	(7,110)	2,145	(6,952)	2,206	(6,934)	2,202	(8,658)	2,109	(7,896)
share of top-5-buyer sales (%)	20.5	(31.1)	29.3	(31.9)	24.5	(31.7)	19.8	(29.3)	17.0	(29.2)
total purchases	1,617	(8,055)	1,748	(6,613)	1,773	(6,581)	1,729	(6,765)	1,666	(7,324)
share of top-5-supplier purchases	21.8	(26.9)	35.3	(27.8)	22.6	(25.9)	21.0	(24.9)	19.5	(99.6)
taxable sales	1,666	(4,055)	1,839	(5,629)	1,898	(5,822)	1,877	(5,975)	1,808	(6,764)
taxable purchases	1,426	(4,336)	1,548	(5,565)	1,565	(5,656)	1,514	(5,571)	1,463	(6,459)
VAT liabilities	85	(218)	95	(293)	101	(268)	103	(306)	98	(308)
new net VAT credits	42	(401)	43	(403)	41	(337)	37	(285)	36	(348)
VAT payments	45	(139)	54	(166)	61	(194)	64	(234)	62	(257)
e-invoicing adoption (%)	0.5	(6.8)	0.7	(8.6)	2.9	(16.7)	5.8	(23.3)	11.2	(31.5)
large enterprises (%)	3.9	(19.2)	3.9	(19.2)	3.9	(19.2)	3.9	(19.2)	3.9	(19.2)
exporters (%)	5.0	(21.8)	5.3	(22.4)	5.3	(22.3)	5.3	(22.4)	5.3	(22.4)
active top-5 2014 suppliers	2.4	(1.4)	4.7	(0.9)	2.8	(1.5)	2.9	(1.4)	2.7	(1.5)
mandated suppliers	0.0	(0.0)	1.0	(1.0)	0.8	(0.9)	1.2	(1.1)	2.0	(1.3)
active top-5 2014 buyers	1.4	(1.4)	3.5	(1.9)	2.2	(1.7)	1.8	(1.6)	1.4	(1.5)
mandated buyers	0.0	(0.0)	0.5	(0.9)	0.7	(1.1)	0.7	(1.1)	1.0	(1.3)
observations	74,616		74,616		74,616		74,616		74,616	

Note: The mean and standard deviations are derived from the balanced sample of firms that were not mandated to adopt e-invoicing by 2017 and had positive sales every year from 2013 to 2017. 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. The second (fourth) line reports statistics related to the sum of the transaction values with the 2014 top-5 buyers (top-5 suppliers) expressed as a share of total sales (purchases).

TABLE A.3: Comparisons Across Treated Groups in 2013 (Full Sample)

Values in thousand 2014 soles	Treated in 2014		Not treated by 2014		Treated by 2015		Not treated by 2015	
	mean	sd	mean	sd	mean	sd	mean	sd
	total sales	1,828	(21,820)	1,257	(6,339)	1,778	(19,630)	1,001
top-5-buyer sales (%)	20.3	(31.6)	9.5	(23.2)	18.7	(30.6)	7.1	(21.0)
total purchases	1,483	(17,480)	1,105	(5,933)	1,469	(15,770)	863	(6,899)
top-5-supplier purchases (%)	21.3	(27.3)	16.6	(24.6)	21.0	(27.0)	13.7	(23.3)
nb. of top-5 suppliers	2.4	(1.4)	1.5	(1.4)	2.3	(1.4)	1.2	(1.3)
nb. of top-5buyers	1.2	(1.4)	0.7	(1.1)	1.2	(1.4)	0.4	(0.9)
observations	86,361		48,194		107,709		26,846	
2010-2013 growth rate	0.26	(0.815)	0.16	(0.893)	0.26	(0.824)	0.04	(0.904)
observations	56,947		27,775		69,915		14,807	

	Treated by 2016		Not treated by 2016		Treated by 2017		Not treated by 2017	
	mean	sd	mean	sd	mean	sd	mean	sd
	total sales	1,757	(19,220)	935	(8,044)	1,678	(18,340)	957
top-5-buyer sales (%)	18.3	(30.4)	6.6	(20.7)	17.4	(29.9)	5.0	(18.7)
total purchases	1,454	(15,450)	798	(7,329)	1,392	(14,750)	812	(10,010)
top-5-supplier purchases (%)	20.9	(26.9)	12.5	(22.8)	20.5	(26.7)	8.1	(19.4)
nb. of top-5 suppliers	2.3	(1.4)	1.1	(1.2)	2.2	(1.4)	0.8	(1.1)
nb. of top-5buyers	1.2	(1.4)	0.4	(0.8)	1.1	(1.4)	0.2	(0.6)
observations	112,732		21,823		124,279		10,276	
2010-2013 growth rate	0.27	(0.825)	-0.02	(0.908)	0.26	(0.829)	-0.25	(0.881)
observations	72,853		11,869		78,789		5,933	

Note: In each of the 4 panels, the full sample of firms that were not required to adopt e-invoicing by 2017 is split based whether a firm's treatment year is before or after a reference year. In the top-left panel for example, the first 2 columns are derived from the subsample of firms that had a partner that was mandated into e-invoicing in 2014 or before while the last 2 columns are derived from the rest of the full sample. All statistics are derived for the year 2013 (unless otherwise noted) and sales and purchases are expressed in thousands of soles. The second (fourth) line reports statistics related to the sum of the transaction values with the 2014 top-5 buyers (top-5 suppliers) expressed as a share of total sales (purchases). Stars in the first columns of each panel indicate the significance level in a regression of the left-hand-side variable on a dummy indicating whether the firm had been treated by the reference year and including controls for group effects where groups are defined as in Table A.7.

TABLE A.4: Comparisons Across Treated Groups in 2013 (Balanced Sample)

Values in thousand 2014 soles	Treated in 2014		Not treated by 2014		Treated by 2015		Not treated by 2015	
	mean	sd	mean	sd	mean	sd	mean	sd
	total sales	2,075	(7,895)	1,630	(4,525)	2,028	(7,358)	1,286
top-5-buyer sales (%)	23.9	(32.7)	12.0	(24.6)	21.9	(31.7)	8.8	(22.1)
total purchases	1,692	(9,094)	1,426	(4,426)	1,674	(8,399)	1,135	(4,103)
top-5-supplier purchases (%)	22.5	(27.5)	19.8	(25.1)	22.3	(27.1)	17.6	(24.5)
nb. of top-5 suppliers	2.6	(1.3)	1.9	(1.3)	2.5	(1.3)	1.6	(1.3)
nb. of top-5buyers	1.6	(1.5)	1.0	(1.3)	1.5	(1.4)	0.7	(1.1)
observations	53,543		21,073		66,712		7,904	
2010-2013 growth rate	0.33	(0.745)	0.36	(0.787)	0.34	(0.754)	0.34	(0.776)
observations	37,798		13,587		46,564		4,821	

	Treated by 2016		Not treated by 2016		Treated by 2017		Not treated by 2017	
	mean	sd	mean	sd	mean	sd	mean	sd
	total sales	2,009	(7,320)	1,140	(3,018)	1,954	(7,123)	1,031
top-5-buyer sales (%)	21.5	(31.5)	8.19	(21.700)	20.7	(31.1)	1.1	(8.6)
total purchases	1,664	(8,313)	986	(2,746)	1,621	(8,074)	865	(3,185)
top-5-supplier purchases (%)	22.2	(27.0)	16.1	(24.2)	21.9	(26.9)	1.9	(8.4)
nb. of top-5 suppliers	2.4	(1.3)	1.5	(1.3)	2.4	(1.3)	0.2	(0.5)
nb. of top-5buyers	1.5	(1.4)	0.7	(1.1)	1.4	(1.4)	0.1	(0.3)
observations	69,460		5,156		74,209		407	
2010-2013 growth rate	0.34	(0.756)	0.33	(0.765)	0.34	(0.756)	0.33	(0.831)
observations	48,342		3,043		51,153		232	

Note: In each of the 4 panels, the balanced sample of firms that were not required to adopt e-invoicing by 2017 is split based whether a firm's treatment year is before or after a reference year. In the top-left panel for example, the first 2 columns are derived from the subsample of firms that had a partner that was mandated into e-invoicing in 2014 or before while the last 2 columns are derived from the rest of the full sample. All statistics are derived for the year 2013 (unless otherwise noted) and sales and purchases are expressed in thousands of soles. The second (fourth) line reports statistics related to the sum of the transaction values with the 2014 top-5 buyers (top-5 suppliers) expressed as a share of total sales (purchases). Stars in the first columns of each panel indicate the significance level in a regression of the left-hand-side variable on a dummy indicating whether the firm had been treated by the reference year and including controls for group effects where groups are defined as in Table A.7.

TABLE A.5: Firm-Partner Links Summary Statistics over 2013-2017 (Full Sample)

	Firm links with suppliers				
	2013	2014	2015	2016	2017
number of links	595,945	641,543	624,525	594,079	552,124
links where the firm is large	7%	8%	6%	6%	6%
links where the partner is large	75%	75%	75%	75%	75%
links where the partner exports	27%	27%	27%	27%	27%
links where the firm adopted	0%	1%	3%	5%	10%
number of treated links	0	131,907	207,774	232,659	386,218
treated links where the firm adopted		1%	3%	6%	11%
links with non-zero transactions	274,833	606,929	311,692	292,395	264,288
mean transaction values	162	117	158	151	155
standard deviation	(2,153)	(1,673)	(2,096)	(2,347)	(3,153)
	Firm links with buyers				
	2013	2014	2015	2016	2017
number of links	345,868	363,775	356,670	340,056	316,559
links where the firm is large	17%	9%	7%	7%	7%
links where the partner is large	65%	65%	65%	65%	66%
links where the partner exports	28%	28%	28%	28%	29%
links where the firm adopted	0%	0%	1%	3%	6%
number of treated links	0	44,128	89,309	102,777	208,997
treated links where the firm adopted		1%	4%	8%	12%
links with non-zero transactions	131,298	351,265	202,800	149,982	119,160
mean transaction values	240	141	214	230	256
standard deviation	(1,294)	(958)	(1,206)	(1,338)	(1,809)

Note: The table reports on the links between the firms that were not required to adopt e-invoicing by 2017 and their top-5 suppliers (top panel) and their top-5 buyers (bottom panel) according to rankings in 2014. Firm-partner links are excluded when a firm exit the database and are included otherwise even if there are no positive transaction value between a firm and its partner. Adoption refers to the adoption of e-invoicing. A treated link is a link with a partner that was required to adopt into e-invoicing in the current year or before. Transaction values correspond to annual totals and are expressed in thousands of 2014 soles. In 2014, the exchange rate was approximately 0.34 US\$ per soles.

TABLE A.6: Firm-Partner Links Summary Statistics over 2013-2017 (Balanced Sample)

	Firm links with suppliers				
	2013	2014	2015	2016	2017
number of links	58,380	58,380	58,380	58,380	58,380
links where the firm is large	3%	4%	3%	2%	3%
links where the partner is large	75%	75%	75%	75%	75%
links where the partner exports	26%	26%	26%	26%	27%
links where the firm adopted	0%	0%	2%	4%	9%
number of treated links	0	9,761	23,489	28,400	55,100
treated links where the firm adopted		0%	2%	5%	9%
links with non-zero transactions	58,380	58,380	58,380	58,380	58,380
mean transaction values	236	267	266	257	248
standard deviation	(1,656)	(3,630)	(3,760)	(3,821)	(5,125)
	Firm links with buyers				
	2013	2014	2015	2016	2017
number of links	38,824	38,824	38,824	38,824	38,824
links where the firm is large	7%	4%	3%	3%	4%
links where the partner is large	63%	63%	63%	63%	64%
links where the partner exports	27%	27%	27%	27%	28%
links where the firm adopted	0%	1%	2%	6%	14%
number of treated links	0	10,756	19,246	21,673	36,956
treated links where the firm adopted		1%	3%	7%	14%
links with non-zero transactions	38,824	38,824	38,824	38,824	38,824
mean transaction values	288	310	345	333	319
standard deviation	(1,218)	(1,548)	(1,493)	(1,447)	(1,674)

Note: The table reports on the links between the firms that were not required to adopt e-invoicing by 2017 and their top-5 suppliers (top panel) and their top-5 buyers (bottom panel) according to rankings in 2014. Firm-partner links are excluded when a firm exit the database and are included otherwise even if there are no positive transaction value between a firm and its partner. Adoption refers to the adoption of e-invoicing. A treated link is a link with a partner that was required to adopt into e-invoicing in the current year or before. Transaction values correspond to annual totals and are expressed in thousands of 2014 soles. In 2014, the exchange rate was approximately 0.34 US\$ per soles.

TABLE A.7: Impact of Having a Partner Mandated into e-Invoicing on e-Invoicing Adoption

	(A) Baseline	(B) Interaction with firm size		(C) Interaction with partner status	
		below-median	above-median	any	exporter
mandated supplier					
treatment year	0.00166** (0.000689)	0.00156 (0.00110)	0.00166* (0.000894)	0.000376 (0.000977)	0.00218* (0.00118)
first year after	0.00807*** (0.00133)	0.00875*** (0.00205)	0.00738*** (0.00173)	0.00746*** (0.00174)	0.000598 (0.00171)
second year after	0.0147*** (0.00203)	0.0160*** (0.00304)	0.0133*** (0.00267)	0.0125*** (0.00262)	0.00299 (0.00239)
third year after	0.0277*** (0.00306)	0.0311*** (0.00448)	0.0248*** (0.00408)	0.0240*** (0.00391)	0.00482 (0.00345)
mandated buyer					
treatment year	0.00639*** (0.000896)	0.00582*** (0.00149)	0.00680*** (0.00110)	0.00368*** (0.00124)	0.00522*** (0.00156)
first year after	0.0153*** (0.00147)	0.0158*** (0.00245)	0.0150*** (0.00179)	0.0136*** (0.00209)	0.00287 (0.00231)
second year after	0.0304*** (0.00214)	0.0295*** (0.00354)	0.0311*** (0.00264)	0.0226*** (0.00307)	0.0118*** (0.00325)
third year after	0.0691*** (0.00337)	0.0625*** (0.00550)	0.0732*** (0.00422)	0.0618*** (0.00517)	0.00872* (0.00528)
Constant	0.0242*** (0.00110)	0.0243*** (0.00109)		0.0243*** (0.00110)	
Observations	373,080	373,080		373,080	

Note: Results are for the 2013-2017 balanced sample of firms not mandated into e-invoicing by 2017. The specification in the column (A) follows equation (1). The explanatory variables indicate whether a firm has one mandated partner for the first time in the current year or in any of the past 3 years, and they indicate this separately for suppliers and buyers. The specifications in columns (B) and (C) build on the equation (1) as the coefficients of interest are interacted with mutually exclusive dummy variables. In column (B), the coefficients are interacted with dummy variables indicating if the firm had sales above or below median sales in 2013. In column (C), the coefficients are interacted with dummy variables indicating if the firm exported in 2013. All specifications include group-year fixed effects, where a group is defined as a unique combination of export status, sector, number of suppliers, number of buyers, and sales quartile at the beginning of the sample. Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

TABLE A.8: Event Study of Having a Partner Mandated on e-Invoicing Adoption

treatment = partner being mandated	(A) supplying partners	(B) buying partners
Pre-treatment average	-0.0045* (0.0025)	-0.0016 (0.0016)
Post-treatment average	0.0117*** (0.0017)	0.0174*** (0.0016)
3 years before treatment	-0.0070* (0.0037)	-0.0030 (0.0023)
2 years before treatment	-0.0021 (0.0015)	-0.0003 (0.0011)
Treatment year	0.0026*** (0.0008)	0.0054*** (0.0010)
1 year after treatment	0.0110*** (0.0016)	0.0141*** (0.0016)
2 years after	0.0215*** (0.0034)	0.0327*** (0.0029)
Observations	373,080	373,080

Note: Results are obtained from the doubly robust estimation procedure of [Callaway and Sant'Anna \(2021\)](#) (see Section 3) applied to the 2013-2017 balanced sample of firms, using the Stata command *csdid* ([Rios-Avila et al., 2022](#)). Results are illustrated in Figure (4). Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

TABLE A.9: Impact of Having a Partner Mandated into e-Invoicing on Firm Compliance

	(A) Taxable sales	(B) Taxable purchases	(C) VAT liabilities	(D) New VAT credits	(E) VAT payments	(F) Survival
treatment year when partner is mandated	-0.0151** (0.00622)	-0.0399*** (0.00866)	0.000872 (0.0109)	-0.0956*** (0.0246)	-0.00457 (0.0239)	0.0143*** (0.00173)
first year after	-0.0299*** (0.0108)	-0.0625*** (0.0150)	-0.0158 (0.0174)	-0.164*** (0.0369)	0.112*** (0.0376)	0.0251*** (0.00249)
second year after	-0.0353** (0.0154)	-0.0824*** (0.0216)	-0.0283 (0.0241)	-0.211*** (0.0493)	0.242*** (0.0511)	0.0308*** (0.00317)
third year after	-0.0495** (0.0213)	-0.0892*** (0.0299)	-0.0584* (0.0325)	-0.169** (0.0657)	0.315*** (0.0682)	0.0426*** (0.00406)
Constant	13.47*** (0.00850)	13.10*** (0.0118)	10.25*** (0.0136)	6.798*** (0.0278)	7.409*** (0.0286)	0.881*** (0.00165)
Observations	373,080	373,080	373,080	373,080	373,080	723,422

Note: Results are estimated based on equation (2). In columns (A)-(E), the dependent variables are expressed in constant soles and we apply the transformation $y \rightarrow \log(y + 1)$ and we use the balanced sample of firms with positive sales from 2013 to 2017. In column (F), the dependent variable is a dummy variable indicating whether we observe positive sales later in the sample and we use a sample with all firms appearing every year from the first year when we observe positive sales. The first four explanatory variables indicate whether a firm has one mandated partner for the first time in the current year or in any of the past 3 years. All specifications include group-year fixed effects, where a group is defined as a unique combination of export status, sector, number of suppliers, number of buyers, and sales quartile at the beginning of the sample. Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

TABLE A.10: Event Study of Having a Partner Mandated on Firm Compliance

treatment = partner being mandated	(A) Taxable sales	(B) Taxable purchases	(C) Taxable liabilities	(D) New VAT credits	(E) VAT payments
Pre-treatment average	-0.0260 (0.0292)	0.0118 (0.0427)	0.0176 (0.0435)	0.1764 (0.1071)	0.0201 (0.0918)
Post-treatment average	-0.0196 (0.0142)	-0.0555*** (0.0183)	-0.0163 (0.0250)	-0.2240*** (0.0523)	0.1185** (0.0488)
3 years before treatment	-0.0164 (0.0508)	0.0577 (0.0765)	0.0530 (0.0719)	0.2795 (0.1911)	0.0494 (0.1539)
2 years before treatment	-0.0357** (0.0134)	-0.0341* (0.0179)	-0.0178 (0.0249)	0.0733 (0.0601)	-0.0092 (0.0627)
Treatment year	-0.0301*** (0.0070)	-0.0521*** (0.0089)	-0.0169 (0.0140)	-0.1250*** (0.0315)	-0.0002 (0.0291)
1 year after treatment	-0.0178 (0.0136)	-0.0478*** (0.0177)	-0.0072 (0.0217)	-0.1984*** (0.0545)	0.1225** (0.0519)
2 years after	-0.0107 (0.0288)	-0.0666* (0.0374)	-0.0248 (0.0518)	-0.3486*** (0.1076)	0.2334*** (0.0928)
Observations	373,080	373,080	373,080	373,080	373,080

Note: Results are obtained from the doubly robust estimation procedure of [Callaway and Sant'Anna \(2021\)](#) (see Section 3) applied to the 2013-2017 balanced sample of firms, using the Stata command *csdid* ([Rios-Avila et al., 2022](#)). Results are illustrated in Figure (5). Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

TABLE A.11: Impact of Having a Partner Mandated into e-Invoicing on Firm Compliance: Heterogeneity by e-Invoicing Adoption

	(A) Taxable sales	(B) Taxable purchases	(C) VAT liabilities	(D) New VAT credits	(E) VAT payments
treatment year when partner is mandated	-0.0165*** (0.00621)	-0.0410*** (0.00863)	-0.000527 (0.0109)	-0.0976*** (0.0247)	-0.00691 (0.0239)
first year after	-0.0330*** (0.0108)	-0.0650*** (0.0150)	-0.0192 (0.0175)	-0.171*** (0.0371)	0.113*** (0.0377)
second year after	-0.0405*** (0.0155)	-0.0852*** (0.0216)	-0.0347 (0.0242)	-0.216*** (0.0495)	0.245*** (0.0513)
third year after	-0.0626*** (0.0214)	-0.102*** (0.0299)	-0.0700** (0.0326)	-0.178*** (0.0659)	0.310*** (0.0684)
e-invoicing adoption	-0.0144 (0.0507)	-0.0199 (0.0711)	0.0320 (0.0749)	-0.0948 (0.160)	0.244* (0.142)
adoption \times mandated partner treatment year	0.107** (0.0483)	0.0788 (0.0695)	0.0984 (0.0729)	0.153 (0.160)	0.133 (0.132)
first year after	0.124** (0.0500)	0.0996 (0.0714)	0.114 (0.0755)	0.277* (0.167)	-0.0901 (0.146)
second year after	0.122** (0.0512)	0.0794 (0.0717)	0.120 (0.0766)	0.164 (0.164)	-0.117 (0.145)
third year after	0.161*** (0.0520)	0.147** (0.0725)	0.123 (0.0766)	0.183 (0.164)	-0.0642 (0.145)
Constant	13.47*** (0.00852)	13.10*** (0.0118)	10.24*** (0.0136)	6.799*** (0.0279)	7.402*** (0.0287)
Observations	373,080	373,080	373,080	373,080	373,080

Note: Results are estimated based on equation (2) using the balanced sample of firms with positive sales from 2013 to 2017. The dependent variables are expressed in constant soles and we apply the transformation $y \rightarrow \log(y + 1)$. The first four explanatory variables indicate whether a firm has a mandated partner for the first time in the current year or in any of the past 3 years. These variables are then interacted with a variable indicating whether the firm adopted e-invoicing. All specifications include group-year fixed effects, where a group is defined as a unique combination of export status, sector, number of suppliers, number of buyers, and sales quartile at the beginning of the sample. Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

TABLE A.12: Impact of Having a Mandated Partner on Firm-Partner Transactions

	Extensive margin (active partnership)		Intensive margin (log transaction values)	
	(A) supplier links	(B) buyer links	(C) supplier links	(D) buyer links
treatment year when partner is mandated	-0.139*** (0.0145)	-0.110*** (0.00695)	0.00616 (0.0169)	-0.0233 (0.0190)
first year after	-0.302*** (0.0404)	-0.136*** (0.00529)	0.0131 (0.0278)	0.0256 (0.0233)
second year after	-0.193*** (0.0324)	-0.172*** (0.00727)	0.0364 (0.0362)	-0.0382 (0.0326)
third year after	-0.0654*** (0.0212)	-0.188*** (0.0126)	0.0848 (0.0531)	-0.00366 (0.0534)
Constant	0.639*** (0.00635)	0.589*** (0.00110)	10.45*** (0.00790)	10.71*** (0.0108)
Observations	3,008,216	1,722,928	291,900	194,120

Note: Results are estimated based on equation (3). The dependent variable in columns (A) and (B) is a dummy variable indicating whether we observe a positive transaction value between a firm and its partner. The dependent variable in columns (C) and (D) is the log of the transaction value between a firm and its partner. For (C) and (D), we restrict the sample to links with positive transaction values throughout sample period. Only the top-5 suppliers and top-5 buyers of every firms in 2014 are considered. The first set of explanatory variables indicate whether the partner was mandated into e-invoicing in the current year or in any of the past 3 years. These variables are then interacted with a variable indicating whether the firm adopted e-invoicing. All specifications include firm-year and firm-partner fixed effects. Standard errors that are clustered at the partner level are shown in brackets. * 0.10, ** 0.05, *** 0.01.

TABLE A.13: Event Study of Having a Mandated Partner on Firm-Partner Transactions

treatment = partner being mandated	Extensive margin (active partnership)		Intensive margin (log transaction values)	
	(A) supplier links	(B) buyer links	(C) supplier links	(D) buyer links
	Pre-treatment average	0.0005 (0.0012)	-0.0118 (0.0012)	0.0022 (0.0129)
Post-treatment average	-0.2053*** (0.0012)	-0.0761*** (0.0012)	0.0451*** (0.0103)	-0.0169 (0.0103)
3 years before treatment	-0.0531*** (0.0016)	-0.0852*** (0.0016)	0.0033 (0.0177)	-0.0693*** (0.0177)
2 years before treatment	0.0540*** (0.0012)	0.0616*** (0.0012)	0.0010 (0.0107)	0.0330** (0.0107)
Treatment year	-0.0982*** (0.0010)	-0.0621*** (0.0010)	0.0440*** (0.0105)	-0.0310** (0.0105)
1 year after treatment	-0.3281*** (0.0016)	-0.0809*** (0.0016)	0.0146 (0.0092)	0.0010 (0.0092)
2 years after	-0.1896*** (0.0017)	-0.0853*** (0.0017)	0.0767*** (0.0169)	-0.0207 (0.0169)
Observations	3,006,367	1,811,164	421,145	286,825

Note: Results are obtained from the doubly robust estimation procedure of [Callaway and Sant'Anna \(2021\)](#) (see Section 3) applied to the 2013-2017 balanced sample of firms, using the Stata command *csdid* ([Rios-Avila et al., 2022](#)). Results are illustrated in Figure (4). Firm-clustered standard errors are shown in brackets. * 0.10, ** 0.05, *** 0.01.

TABLE A.14: Impact of Having a Mandated Partner on Firm-Partner Transactions: Heterogeneity by e-Invoicing Adoption

	Extensive margin		Intensive margin	
	(active partnership)		(log transaction values)	
	(A) supplier links	(B) buyer links	(C) supplier links	(D) buyer links
treatment year when partner is mandated	-0.142*** (0.0147)	-0.113*** (0.00733)	0.00591 (0.0172)	-0.0278 (0.0193)
first year after	-0.308*** (0.0404)	-0.138*** (0.00537)	0.00634 (0.0280)	0.0243 (0.0236)
second year after	-0.197*** (0.0323)	-0.173*** (0.00736)	0.0281 (0.0360)	-0.0437 (0.0331)
third year after	-0.0790*** (0.0210)	-0.191*** (0.0126)	0.0750 (0.0539)	-0.0243 (0.0560)
treatment year × adoption dummy	0.0707*** (0.00969)	0.0374*** (0.00871)	0.0305 (0.0580)	0.119** (0.0548)
first year after × adoption dummy	0.116*** (0.0197)	0.0239*** (0.00752)	0.165*** (0.0611)	0.0480 (0.0647)
second year after × adoption dummy	0.0545*** (0.00938)	0.0149* (0.00793)	0.136* (0.0702)	0.104 (0.0751)
third year after × adoption dummy	0.123*** (0.0114)	0.0213** (0.0107)	0.124 (0.0910)	0.194** (0.0917)
Constant	0.639*** (0.00634)	0.589*** (0.00110)	10.45*** (0.00795)	10.71*** (0.0107)
Observations	3,008,216	1,722,928	291,900	194,120

Note: Results are estimated based on equation (3). The dependent variable in columns (A) and (B) is a dummy variable indicating whether we observe a positive transaction value between a firm and its partner. The dependent variable in columns (C) and (D) is the log of the transaction value between a firm and its partner. For (C) and (D), we restrict the sample to links with positive transaction values throughout sample period. Only the top-5 suppliers and top-5 buyers of every firms in 2014 are considered. The first set of explanatory variables indicate whether the partner was mandated into e-invoicing in the current year or in any of the past 3 years. These variables are then interacted with a variable indicating whether the firm adopted e-invoicing. All specifications include firm-year and firm-partner fixed effects. Standard errors that are clustered at the partner level are shown in brackets. * 0.10, ** 0.05, *** 0.01.