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# Digitalization and Tax Compliance Spillovers

## Evidence from a VAT e-Invoicing Reform in Peru

Matthieu Bellon, Jillie Chang, Era Dabla-Norris, Salma Khalid,  
Juan Carlos Paliza, and Pilar Villena

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**Digitalization and Tax Compliance Spillovers: Evidence from a VAT e-Invoicing Reform in Peru**  
Prepared by **Matthieu Bellon, Jillie Chang, Era Dabla-Norris, Salma Khalid, Juan Carlos Paliza, and Pilar Villena\***

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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 are mandated to adopt e-invoicing, implying positive technology adoption spillovers. Spillovers are stronger from downstream partners and from export-oriented firms. Firms are less likely to continue transacting with a partner who has been mandated into e-invoicing, with the effect only partially reversed if both firms adopt e-invoicing, suggesting that network segmentation may occur. Smaller firms who transact with partners mandated into e-invoicing report 11 percent more sales and pay 17 more VAT in the year that their partner is mandated to adopt e-invoicing, suggesting positive spillovers in tax compliance behavior for this subset of firms.

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# I. Introduction

The digitalization of tax records and widespread adoption of 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 and Zambrano, 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.<sup>1</sup>

This study investigates spillovers in the adoption of e-invoicing and examines whether they create tax compliance spillovers within firm networks using administrative- and transactions-level data from Peru. We examine if such mandates result in adoption spillovers for non-mandated trading partners, and if these spillovers impact inter-firm transactions and translate into higher tax compliance. The presence of these spillovers indicates if the overall impact of e-invoicing adoption is larger than that implied by the direct effects 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 increases the value of the product/service for others (Katz and Shapiro, 1985). E-invoicing has the potential for generating network externalities if the cost of reporting transactions between firms falls when partner firms use a similar technology for reporting purposes---in this case, switching from paper to digital invoices. These network externalities may be asymmetric in a VAT setting whereby VAT refund credits are increasing in reported taxable purchases but declining in reported taxable sales. This, in turn, can create stronger incentives for firms to fully account for their purchase invoices from their upstream sellers to lower their VAT liabilities, but no commensurate incentives for downstream partners whose sales invoices raise VAT liabilities. If transactions costs are lowered by trading partner using the same systems to file VAT liabilities (paper vs. electronic), downstream firms mandated to switch to electronic invoicing would experience large spillover benefits from their upstream trading partners adopting e-invoicing as well. Therefore, these firms are more likely to encourage their upstream partners to voluntarily adopt the technology, resulting in larger upstream spillovers.<sup>2</sup>

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 directly mandated to adopt e-invoicing was influenced by their trading

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<sup>1</sup> Fan et al. (2020), Bellon et al. (2019). Our previous study, covering the same period in Peru, finds that the direct effects are statistically significant only among small firms (sales below 1700 UIT where UIT is a monetary unit set every year by the tax authority to calculate tax and regulatory thresholds) and in some economic sectors characterized by traditionally higher tax non-compliance (services, transportation).

<sup>2</sup> Technology 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.

relationships with firms not 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 when a firm trades with a partner firm 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) mandated to adopt e-invoicing is 26 percent more likely to voluntarily adopt e-invoicing the year in which the downstream partner is mandated than a firm with no such partnership. The adoption spillover is 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 not surprising 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 strong incentive to lower 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 document changes in network structure that arise from the e-invoicing reform by examining separately whether the reform affects the probability of partnership survival (extensive margin) and the volume of transactions among surviving partnerships (intensive margin). We find a large and statistically significant probability of partnership termination when a partner firm is mandated to adopt e-invoicing, which is only partially ameliorated by the firm voluntarily adopting e-invoicing in the same year. Specifically, there is a 14 percent reduction in the likelihood of partnership survival in the year that a firm's upstream partner is mandated to adopt e-invoicing, and an 11 percent reduction when a downstream partner is mandated. This suggests that there could be significant costs of transitioning to the new system of invoicing for firms. We also find increases in transactions on the intensive margin between firms who voluntarily adopt e-invoicing when their partners are mandated to adopt, suggesting that there are network externalities in the use of the same VAT filing system, such that belonging to the same system enhances the level of intra-network transactions.

Finally, we evaluate whether mandating e-invoicing adoption among trading partners impact a firm's sales, purchase and VAT reporting behavior. We find a reduction in reported sales and purchases in firms who have partners who have been mandated to adopt e-invoicing, consistent with firms experiencing a higher rate of termination of trading partnerships following the reform. However, we find no evidence of an aggregate decline in VAT payments. Moreover, when examining heterogeneity by firm size, we find that smaller firms report higher sales, purchase, VAT liabilities and make higher VAT payment following the reform relative to larger firms and firms without partners mandated to adopt e-invoicing.<sup>3</sup> We argue that this is indicative of spillovers in

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<sup>3</sup> Our identification strategy evaluates spillovers among a sub sample of firms who have not been mandated to adopt e-invoicing as of 2017. This subsample predominantly comprises firms that are small and medium sized (medium firms have sales below 2300 UIT and small firms have 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. When evaluating heterogeneity by firm size within this sub sample, 'smaller' firms comprise firms with sales below roughly 200 UIT and 'larger' firms comprise firms with sales above 200 UIT, where 200 UIT is the sub sample median. Care must be taken to not conflate 'larger' firms in the sub sample used for analysis with 'large' firms in the SUNAT administrative classification (sales above 2300 UIT). See section IV for greater details on the sub sample characteristics. Care should also be taken in generalizing results from the estimation sample to the universe of firms in the Peruvian economy.

compliance behavior since small firms are more likely to respond to increased monitoring from their partner's adoption of e-invoicing. Prior literature on tax compliance has shown that smaller firms are more likely to improve compliance when faced with an increase in audit probability (Kleven, 2016; Slemrod, 2019). Moreover, our earlier research (Bellon et al., 2019) showed that the direct impact of the e-invoicing reform in Peru was strongest for small firms.<sup>4</sup> Hence, our results are consistent with the presence of indirect positive tax compliance spillovers for smaller firms in Peru.

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. Lopez-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' 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. (2018) 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, BenYishay, Magruder and Mobarak (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. (2021) and how production networks influence firm size, Carvahlo 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; Bellon et al., 2019, and references therein), and the electronic submission of tax returns or e-filing (Okunogbe and Poulighen, 2018; Yilmaz and Coolidge, 2013), 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.

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<sup>4</sup> Sales below 1700 UIT

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 present our conclusions.

## II. 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 that e-invoicing would 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. E-invoicing was also seen as a way to streamline the tax payment process and reduce compliance costs.

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).<sup>5</sup> 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.

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.

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

Over the main period of study from 2013 to 2017, there were 6 waves of requirements into e-invoicing targeting six different groups of firms (Figure 1). The 6 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). On average, they reported annual sales of \$15 million and employed 178 workers each. Together, the firms in waves 1, 3, 4, and 5 represented just over 77 percent of total value added in our database. 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. These firms in waves 2 and 6 were typically much smaller, with average sales of \$0.2 million and an average of 3 employees. They accounted for less than 1 percent of total value added in our database.

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.

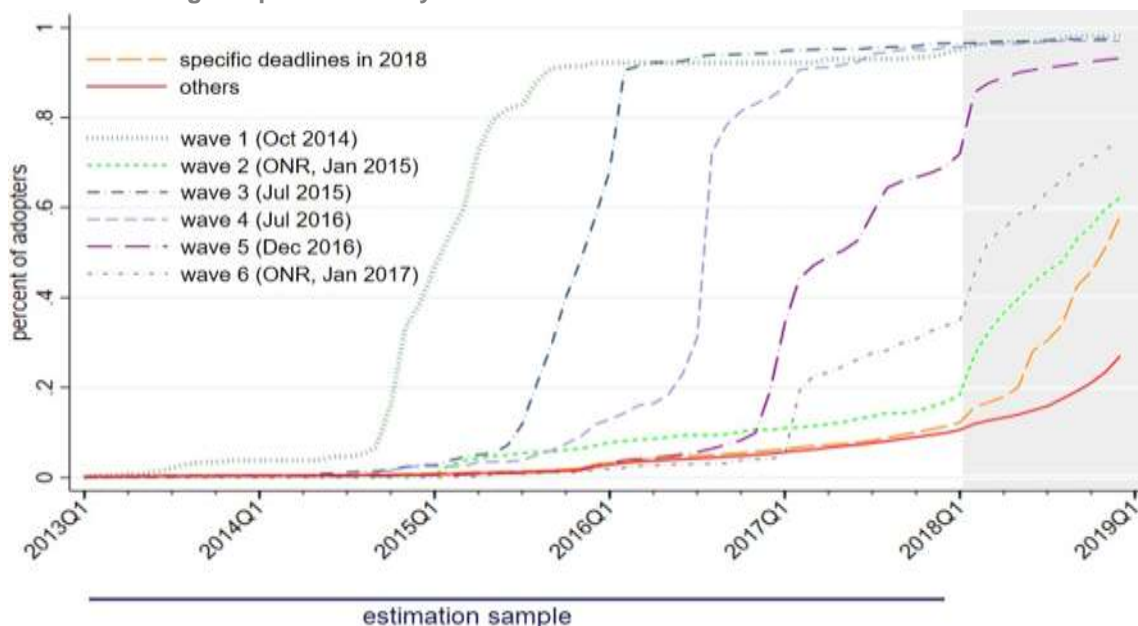
The first six reform waves mandated firms to adopt e-invoicing in October 2014, January 2015, July 2015, July 2016, December 2016 and January 2017 respectively. For many groups, the original deadlines for adopting e-invoicing were subsequently extended by a few quarters (between 2 and 5 quarters) to give taxpayers more time to comply.<sup>6</sup> A previous study (Bellon et al., 2019) 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 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.

<sup>6</sup> See 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.

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.<sup>7</sup> These firms were typically SMEs with a few exceptions (5 percent of large firms). They tended to be much smaller than the firms mandated before. On average, they reported annual sales of \$0.8 million and employed 14 workers each. 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. 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 coverage of e-invoicing by lowering this threshold.

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.

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

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.

### III. Empirical Specification

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

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 viewed as "voluntary adoption". We examine whether having a trading relationship with firms mandated to adopt e-invoicing results in a higher likelihood of voluntary 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 dynamic panel difference-in-differences linear probability model at the firm level:

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

where the dependent variable captures whether firm  $i$  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  $\beta_0^S$  and  $\beta_0^B$  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  $\beta_0^S$  or  $\beta_0^B$  should be positive. The coefficients  $\beta^S$  and  $\beta^B$  for  $s = 1, \dots, T$ , capture the effects of having a partner 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 prior. Therefore, we choose  $T = 3$ . When comparing  $\beta_0^S$  with  $\beta_s^S$  (or  $\beta_0^B$  with  $\beta_s^B$ ) 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  $\beta_0^S$  and  $\beta_0^B$ .

Equation (1) introduces a number of controls:  $\delta_i$  is a firm fixed effect capturing time-invariant firm characteristics which can influence voluntary e-invoicing adoption;  $\gamma_{gt}$  is a vector of group-year fixed effects, where a group  $g$  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.

We next explore the effect of the e-invoicing technology on a firm's transactions with its partners and firm networks. Specifically, we examine the impact of the reform following a partner being mandated into e-invoicing using detailed transactions-level data. This analysis is conducted at the partnership level between every firm  $i$  and each of its individual partners,  $p$ :

$$Y_{i,p,t} = \sum_{s=0}^T \beta_s \times I(\text{MandatedSupplier}_{p,t-s} = 1) + \delta_{i,p} + \gamma_{i,t} + \varepsilon_{i,p,t} \quad (2)$$

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  $I(\text{MandatedSupplier}_{p,t-s} = 1)$  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;  $\gamma_{i,t}$  captures firm-year fixed effects to control for time-variant features of the firm that may influence transactions in the partnership. Hence,  $\beta_0$  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 further explore whether firm-partner transactions are impacted by whether a firm voluntarily adopts e-invoicing by adding an interaction term:

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

where the dummy variable  $I(\text{Adoption}_{it} = 1)$  indicates whether firm  $i$  has adopted e-invoicing in year  $t$ .

Finally, we evaluate the impact of technology adoption on tax compliance of non-mandated firms. Specifically, we explore the indirect effect of the reform on tax compliance 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.

$$Y_{i,t} = \sum_{s=0}^T \beta_s \times I(\text{MandatedPartner}_{t-s} = 1) + \sum_{s=0}^T \beta_s^A \times I(\text{MandatedPartner}_{t-s} = 1) \times I(\text{Adoption}_{it} = 1) + \delta_i + \gamma_{g,t} + \varepsilon_{i,t} \quad (4)$$

In this specification,  $Y_{i,t}$  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 outcome<sup>8</sup>. All controls are defined in the same way as before.

## IV. Data and Preliminary Verifications

Our dataset is constructed by drawing from three separate administrative tax databases.<sup>9</sup> It contains partnership-level information on annual transactions between firms over the 2013-2017 time period. Therefore, for each year, we have data on a firm's upstream and downstream network, as well as the currency value of total transactions with each partner in this network. We also have firm-level information on sales, purchases, VAT liabilities and credits, and VAT payments.

We obtain firm-level information on total sales and purchases across all buyers and suppliers from a database of firm-level VAT declarations. This is supplemented with information from a VAT payment database and with data on e-invoicing requirements and e-invoicing adoption. While the data is restricted to formal small, medium and large firms, the coverage is comprehensive. This dataset follows nearly 200,000 firms accounting for 53 percent of GDP and 95 percent of domestic VAT collections in 2013.

However, the 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.<sup>10</sup> 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 database 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 supplier. For tractability, we limit the size of the supplier and

<sup>8</sup> Results available upon request.

<sup>9</sup> Confidentiality 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.

<sup>10</sup> The Unidad Impositiva Tributaria (UIT) is a monetary unit set every year by the tax authority to calculate tax and regulatory thresholds. For example, firms with less than 150 UIT in annual sales are defined as micro firms in the Peruvian legal system. In addition, firms with less than 96,000 soles (about \$29,000) in annual sales were automatically excluded from our analysis because they are subject to a simplified tax regime in Peru (the Nuevo RUS), instead of the VAT regime. The dataset was constructed by including all the firms that reported annual sales above 150 UIT at least once over the 2013-2017 period.

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 information from this network database 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.

We construct a specific panel of firm-partner transactions for the purpose of our analysis. Given that firm networks can be endogenously determined and therefore impacted 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 or 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 mandated into e-invoicing by 2017. Therefore, we restrict our estimation sample to these firms that were not mandated by 2017 while considering all partners regardless of reform requirements. Once we merge information from all sources and eliminate firms with inconsistent information across sources, we obtain a dataset covering about 150 thousand firms every year and 25,000 partners.<sup>11</sup>

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. 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 numbers 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.

Our small firms sub sample is characterized by the fact that compliance variables (sales, VAT liabilities, etc.) are often null. In our full sample, it 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 this sets can be affected by the effect the reform. To avoid composition bias, we construct a balanced of firms with positive sales in every year from 2013 to 2017. We also transform all nominal variables using the  $x \rightarrow \ln(x + 1)$  transformation. The balanced

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<sup>11</sup> There are less partners than firms because of specific construction of the dataset which focused on top-five partners. Large enterprises are over-represented among partners and tend to be the top-five partners of multiple firms.

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 A1 and Table A2)<sup>12</sup>.

Our empirical analysis also evaluates heterogeneity of results by firm size, where size is determined relative to the median level of sales in balanced sample of not-yet-mandated firms. We distinguish between larger firms (sales greater than 200 UITs) and smaller firms (sales below 200 UITs), where 200 UIT comprises the sub sample median. Care must be taken to not conflate larger firms so characterized in the analysis sample with larger firms as determined by SUNAT administrative classifications (sales above 2300 UIT), since the majority of the larger firms in analysis sample are in fact small firms from an administrative classification (with sales below 1700 UIT).

A key condition for our difference-in-differences approach to be valid, is that the data across treated and untreated groups only show parallel trends. When examining adoption, there are no pre-trends as adoption is almost nonexistent at the beginning of our sample (less than 0.5 percent in 2013). For compliance variables, the difference-in-differences approach is complicated by the fact that different groups of firms are treated at different times, when a partner gets mandated into e-invoicing for the first time. Nevertheless, we compare firms based on their treatment year using subsamples where we have additional data for 2010 (see Table A.3 and A.4 in the appendix for details). In the balanced sample, the growth rate of sales from 2010 to 2013 (before any treatment) is very similar when we compare the firms treated in a year T and those not yet treated by T. For the four years in our sample, the difference across treatment groups by year is insignificant at the 10 percent level except in one case. In that one case however, this could be due to time-invariant effects that are controlled for in our specifications. Thus, we test for significant pre-trends using the controls in our specifications (group 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). We regress the growth rates of sales and purchases from 2010 to 2013 on dummy variables indicating the first year of treatment if any. The results in Table A.5 for the balanced sample show that none of these dummies are significant, indicating no specific pre-trends compared to the default group of having no mandated partners by the end of the sample. We interpret this as evidence in favor of our empirical strategy.

Finally, we use the partnership-level data underlying the firm-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.3 in the appendix for details).<sup>13</sup> 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.

<sup>12</sup> The distribution of large (sales above 2300 UIT), medium (sales between 1700 UIT and 2300 UIT) and small (sales below 1700 UIT) firms is as follows: 9 percent large, 3 percent medium and 88 percent small in the full sample of firms; 7 percent large, 3 percent medium and 90 percent small in the sample of not-yet-mandated firms; 8 percent large, 3 percent medium and 89 percent small in the balanced sample used in our estimation.

<sup>13</sup> The numbers of links in other years are slightly lower as some firm exit the sample.

## V. Results

### A. Spillovers in Technology Adoption

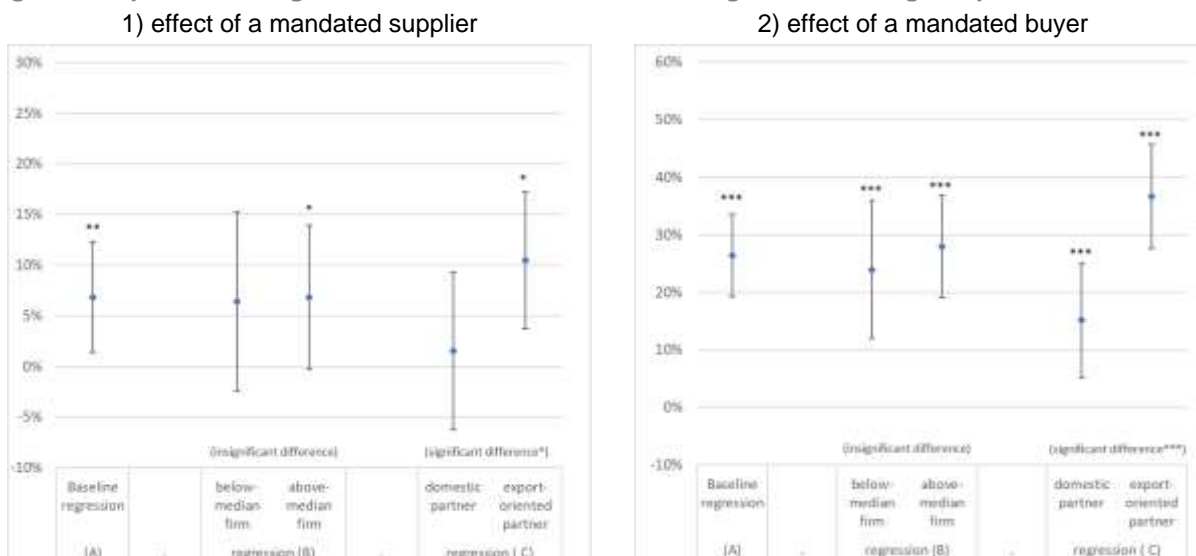
Figure 3 shows the spillover effect of e-invoicing between a treated firm and its mandated partners for the balanced sample of firms (detailed results in Table 8). We find that in the first year after a firm's supplier or buyer is mandated to adopt e-invoicing, there is a highly statistically significant 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. Voluntary adoption among treated firms with mandated suppliers increases by 7 percent in the first year in which the partner has been mandated to adopt, relative to untreated firms that do not have suppliers mandated to adopt e-invoicing.<sup>14</sup> 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 first year. 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) is 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 collect and file from the treated firm. If transactions costs are lowered for 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).

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.8 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 selection bias. Given that partner firms can 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 post-treatment outcomes for all partners, but the spillover coefficient for longer lags is determined by the subset of firms have partners who are drawn from earlier treatment waves.

<sup>14</sup> To 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 A8, column A, the treatment effect from suppliers is  $= 0.00166/0.0242 \times 100 = 6.86\%$  and from buyers is  $= 0.00639/0.0242 \times 100 = 26.41\%$ .

**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.8 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.

Additionally, we find that partners who are exporters create significantly larger spillovers, 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. This may again relate to the partner's incentives for filing VAT obligations. 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 appears to have spillover effects on their partners who are more likely to adopt e-invoicing when the exporting firm is mandated to shift to the electronic medium, likely deriving from the exporting firms' interest in lowering reporting costs.

## B. Market Segmentation: Transactions Between Firms

We have argued so far that belonging to the same VAT filing system lowers the cost of filing for firms, providing an inducement for technology adoption spillovers between firms and their trading partners. To investigate the existence of these transaction costs, we evaluate changes in transactions between partner firms on the intensive and extensive margins when a partner is mandated to adopt e-invoicing. The presence of transaction costs from operating in disparate filing systems (paper vs. electronic) would imply a reduction in transactions when a partner is mandated into the electronic system and the other partner does not voluntarily switch, and an increase in transactions between partner firms who belong in the same filing system. Hence, we evaluate separately whether the reform affects the probability of partnership survival (extensive margin) and the volume of transactions among surviving partnerships (intensive margin).

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 fictitious partner firms in the VAT system. One form of tax evasion observed in Peru involves the creation of fictitious upstream firms which generate false purchase invoices for their downstream partners, allowing downstream firms to lower their VAT burden. Mandated adoption of e-invoicing could lead to a decline in false reporting 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. However, we are unable to distinguish this effect from the transactions costs channel.

Similarly, changes in intra-network transactions can be driven by changes in tax compliance behavior that arise as a result of one or both trading partners being inducted into e-invoicing. In our earlier paper (Bellon et al., 2019), we found that the direct effect on firms of mandated adoption of e-invoicing was an increase in reported taxable sales and taxable purchases. The treatment effect was driven primarily by small firms less likely to be subject to general audit and firms in sectors historically characterized by low tax compliance, implying that the effect of the policy operates through improved monitoring and associated tax compliance behavior.<sup>15</sup> Since VAT is increasing in taxable sales and decreasing in taxable purchases, misreporting typically takes the form of under-reported sales and over-reported taxable purchases. In our results, we found increases in both taxable sales and purchases and a resulting increase in taxable value added, suggesting that e-invoicing resulted in a more comprehensive accounting of transactions through simple cross-checking of digital transaction registers of partner firms. Hence, following the introduction of e-invoicing, more transactions were brought onto the tax books resulting in commensurate increases in taxable purchases and sales.

Consequently, when we witness an increase in reported transactions between treated firms who voluntarily adopt e-invoicing and their mandated partners, this may equally be the result of lowered transactions costs or improved tax compliance, and we are unable to conclusively distinguish between the two channels.

Table 1 captures the probability of partnership links surviving when a firm's partners are mandated to adopt e-invoicing. In column A, we find that when an upstream partner (seller) is mandated to adopt e-invoicing, there is a 14 percent reduction in the probability of the partnership surviving in the year of the reform. We find a similar reduction in the likelihood of partnership survival when the partner is downstream (buyer) though the magnitude of the coefficient is smaller at 11 percent.<sup>16</sup> However, if the firm voluntarily adopts e-invoicing when its partner is mandated to adopt the negative impact on partnership survival is reduced. In this case, the net reduction in partnerships with suppliers and buyers is approximately 7 percent. Hence the positive impact of voluntary adoption is 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. 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 implying sizeable adjustment costs from switching to the new system.

Table A.9 reports dynamics of partnership survival, showing that the likelihood of partnership termination increases between year 1 and year 2 of the partner being mandated to switch to e-invoicing. By the same

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<sup>15</sup> Small firms are firms with sales below 1700 UIT

<sup>16</sup> Our difference-in-differences specification ensures that the treatment effect we are capturing is the difference in probability of partnership survival that results from the reform, since it is coincident with the year in which the partner is mandated and controls for the average rate of partnership dissolution among firms who have no partners who have been mandated (control group).

token, the longer the partner firm has voluntarily adopted e-invoicing, the greater the improvement in odds of partnership survival relative to partners who do not adopt voluntarily. This implies a trend towards segmentation of firm relationships, with mandated firms increasingly favoring relationships with other firms who voluntarily adopt e-invoicing.

Table 1: 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	-0.143*** (0.000972)	-0.112*** (0.00135)	0.00381 (0.00872)	-0.0263** (0.0115)
treatment year × adoption dummy	0.0732*** (0.00373)	0.0287*** (0.00503)	0.0934* (0.0508)	0.0875 (0.0543)
Observations	3,008,216	1,722,928	291,900	194,120

**Note:** Results are estimated based on equation (2). 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 explanatory variables indicate whether the partner was mandated into e-invoicing in the current year. It is then interacted with a variable indicating whether the firm adopted e-invoicing. 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.9 shows the control coefficient estimates. Firm-clustered standard errors are shown in brackets. \* 0.10, \*\* 0.05, \*\*\* 0.01.

Table 1 also shows the impact on transactions between firms on the intensive margin, among firm partnerships that remain stable during the time period of the policy. Here, we find that the impact of partner firms mandated to adopt e-invoicing on the level of transactions in the partnership is insignificant for sellers and weakly negative for buyers. However, if a firm voluntarily adopts e-invoicing when its partner is mandated to adopt, the level of transactions in the partnership increases symmetrically for buyers and seller partnerships, although the coefficient for sellers is imprecisely estimated. This lends further credibility to the theory that there are network externalities in the use of the same VAT filing system, such that belonging in the same system enhances the level of intra-network transactions in the portion of the network that remains stable. We should treat these results with some caution, however, because the attrition of links over time and overall instability in partnerships over multiple years in the balanced sample used for this specification is much smaller than the samples in the remainder of the analysis.

### C. Spillovers in Tax Compliance

Our final specification evaluates whether there are spillovers on a firm's sales, purchase and VAT reporting behavior as a result of their partners being mandated to adopt e-invoicing.<sup>17</sup> Table A.10 shows that the average impact of a partner being mandated into e-invoicing is statistically significant and negative. In the first

<sup>17</sup> This portion of the analysis uses information on sales, purchases and VAT declarations at the firm level, therefore encompassing the transactions of a firm with all its trading partners, and not limited to the top 5 upstream and downstream partners (See Section IV for the details of the database).

year of a partner being mandated to adopt e-invoicing, the treated firm reports 1.5 percent lower taxable sales, with the negative spillover effect increasing in subsequent years. The average effect on reported taxable purchases is also negative and large, with treated firms reporting 4 percent lower taxable purchases in the first year following their partner being mandated. This result is consistent with our results from Section 5.2 where we showed negative effects of the reform on the extensive margin. These extensive margin results of lost partnerships can translate into lower aggregate sales and purchases if it is costly to develop new transaction networks. Overall, however, there is no systematic evidence for positive spillovers into tax compliance among partners of firms who have been mandated to adopt e-invoicing, since we would expect for this to be demonstrated in an increase in reported transactions for sales and purchases. However, another possible explanation for this outcome, 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 hence false purchase invoices are a form of misreporting/evasion. Moreover, we see a large reduction in new VAT credits, which would also suggest that avenues for misreporting which allow firms to accumulate more VAT credits to offset their liabilities have been reduced. We explore heterogeneity in behavior between upstream and downstream mandated partners but find no meaningful distinction in impact on aggregate sales and purchases (results available on request).

We also evaluate heterogeneity between firms who voluntarily adopt e-invoicing when their partners are mandated to adopt e-invoicing relative to firms that do not. In Table 2 we find when a partner is mandated to adopt e-invoicing, the impact of voluntary adoption of e-invoicing on reported sales and purchases is large and positive, but only statistically significant in the case of sales. This is particularly interesting given that the un-interacted coefficient for voluntary adoption, which reflects the impact on firms who do not have mandated partners, is statistically insignificant and negative. This result suggests that there are in fact positive compliance spillovers between mandated firms and their partners if the partner voluntarily adopts e-invoicing as well. As with transactions, we cannot distinguish whether this is a 'productivity' effect, resulting from lower costs of transacting with network partners owing to a shared network technology, or a compliance effect wherein the presence of all partners in the e-invoicing system generates improved tax compliance behavior.

There are no statistically significant spillovers of being associated with a mandated firm on reported VAT obligations or VAT payments. Among firms that voluntarily adopt when their partners are mandated, VAT obligations and VAT payments rise but this result is not statistically significant due to large standard errors. Filing of VAT credits goes down among firms who have mandated partners, in line with their reduced sales and purchases, with a reversal (statistically insignificant) when the firm also voluntarily adopts.

In Table A.10, 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, once again 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.

Table 2: 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	-0.0165*** (0.00621)	-0.0410*** (0.00863)	-0.000527 (0.0109)	-0.0976*** (0.0247)	-0.00691 (0.0239)
e-invoicing adoption	-0.0144 (0.0507)	-0.0199 (0.0711)	0.0320 (0.0749)	-0.0948 (0.160)	0.244* (0.142)
adoption × mandated partner treatment year	0.107** (0.0483)	0.0788 (0.0695)	0.0984 (0.0729)	0.153 (0.160)	0.133 (0.132)
Observations	373,080	373,080	373,080	373,080	373,080

**Note:** Results are estimated based on equation (4) 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 indicates whether the firm adopted e-invoicing and the third is the interaction of the previous two variables. All specifications include control variables indicating whether the partner was already mandated in previous years 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. Control estimates are reported in Table A.11. Firm-clustered standard errors are shown in brackets. \* 0.10, \*\* 0.05, \*\*\* 0.01.

In our earlier research (Bellon et al., 2019) on the direct effects of the e-invoicing reform, we found that the positive effects of the reform on reporting and VAT payments were driven overwhelmingly by small and medium firms. In Table 3, we explore heterogeneity in the indirect effects of the reform between firms of different sizes. We distinguish between firms whose sales at the start of the sample period (2013) were above the median for the full sample, or below.<sup>18</sup> We find strong and consistent evidence of heterogeneity across our variables of interest. Firms with below median sales who have a mandated partner report 11 percent higher taxable sales in the first year of the reform, while firms with above median sales report 10 percent lower taxable sales in the same period. The same pattern is observed for taxable purchases, VAT liabilities, and VAT payments. Notably, merely by virtue of being partners with a mandated firm, smaller firms report 15 percent higher VAT liabilities and make 17 percent higher VAT payments in the year that their partner gets treated. Larger firms, on the other hand, report 9 percent lower VAT liabilities and 11 percent lower VAT payments.<sup>19</sup>

The negative spillovers for firms with larger than median sales are consistent with the results at the transactions level from Section 5.2. When partners are mandated into e-invoicing, there is a loss of partnerships on the extensive margin which may result in a loss in aggregate transactions at the firm level. However, the positive effect on reported transactions and VAT payments cannot be reconciled with the

<sup>18</sup> The sample median is approximately 750,000 soles (approximately 200 UIT).

<sup>19</sup> Larger firms in this analysis sample are defined as firms with sales above 200 UIT. The majority of these firms are still small firms from an administrative classification (sales below 1700 UIT). Care must be taken to not conflate larger firms in the analysis sample with 'large' firms from an administrative classification (sales above 2300 UIT).

extensive or intensive margin effects at the transactions level. On the other hand, these positive results are fully consistent with the direct effects of e-invoicing adoption, whereby the heightened monitoring of firms' transactions made possible by e-invoicing results in more comprehensive reporting of firms' sales, purchase and therefore results in higher VAT collections by small and medium firms. The fact that these effects are present amongst smaller firms by sales is also consistent with past literature on heterogeneity in tax compliance by size, which finds that smaller firms subject to lower probability of audit have higher tax noncompliance on average and are more responsive to an increase in likelihood of evasion detection, such as through traditional audit (Kleven, 2016; Slemrod, 2019). We argue, therefore, that the positive effects on firms' reporting of sales, purchases, and therefore VAT liabilities and VAT payments is consistent with positive compliance spillovers effect on smaller firms in the Peruvian general regime of VAT. The heightened monitoring of firms' transactions made possible by e-invoicing affects not only affects small firms mandated directly, but also small firms who are partners of firms who have been mandated to adopt. As such, the benefits of the reform for small firms are considerably larger than would be captured by analyzing direct effects alone.

## VI. Robustness Checks

Our results are robust to a number of robustness checks . We split our sample, separating the firms that belong to the large groups mandated to adopt e-invoicing in 2017 and the other firms. This allows us to check whether our results could be biased by some firms' expectations about future 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 future 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 strengthening 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.

Table 3: Heterogeneous Impact of Having a Partner Mandated into e-Invoicing on Compliance

	(A) taxable sales		(B) taxable purchases		(C) VAT liabilities		(D) new VAT credits		(E) VAT payments	
	below- median	above- median	below- median	above- median	below- median	above- median	below- median	above- median	below- median	above- median
treatment year when partner is mandated	0.113*** (0.00966)	-0.0994*** (0.00648)	0.0534*** (0.0141)	-0.103*** (0.00913)	0.146*** (0.0168)	-0.0942*** (0.0112)	-0.0701** (0.0329)	-0.115*** (0.0281)	0.165*** (0.0324)	-0.113*** (0.0268)
e-invoicing adoption	-0.00704 (0.0503)		-0.0149 (0.0709)		0.0402 (0.0745)		-0.0949 (0.160)		0.251* (0.142)	
adoption × treatment year when partner is mandated	0.135** (0.0635)	0.0685 (0.0531)	0.143 (0.0924)	0.0136 (0.0767)	0.140 (0.0920)	0.0459 (0.0812)	0.301 (0.198)	0.0184 (0.190)	0.153 (0.176)	0.0931 (0.148)
Observations	373,080		373,080		373,080		373,080		373,080	

**Note:** Results are estimated based on equation (4) where we interact all coefficients of interest with mutually exclusive dummy variables indicating if the firm had sales above or below median sales in 2013. We use 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 variable indicates whether a firm has a mandated partner for the first time in the current year. The second explanatory variable indicates whether the firm adopted e-invoicing and the third is the interaction of the previous two variables. All specifications include control variables indicating whether the partner was already mandated in previous years 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. Control estimates are reported in Table A.13. Firm-clustered standard errors are shown in brackets. \* 0.10, \*\* 0.05, \*\*\* 0.01.

## VII. Conclusion

This paper presents new evidence on the indirect effect of technological innovation and adoption in tax administrations, in a literature that so far has left this topic largely unexplored. Overall, our results point to sizeable spillovers between firms mandated by the e-invoicing reform and their trading partners. We find strong evidence for positive technology adoption spillovers with the propensity to adopt e-invoicing, particularly between firms and their downstream partners (buyers). 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 on e-invoicing adoption from Peru indicates that the pace of voluntary adoption accelerated significantly in the later years of the reform. Hence, the actual size of adoption spillovers from the reform are potentially much larger than in the estimation period considered.

Our results also suggest that e-invoicing adoption can lead to significant disruption of firm networks, with many firms losing their partnerships with mandated trading partners. This may be driven by 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. Overall, we find that firms do not exit the VAT general regime in larger numbers if they are connected to firms mandated to adopt e-invoicing. 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.

Finally, we find that the spillover effects of the reform do not reduce taxable sales, taxable purchases, VAT liabilities or VAT payments during the time period studied despite the network disruption. Moreover, this aggregate effect masks interesting heterogeneity. There are negative spillovers for larger partners of mandated firms, consistent with the presence of transactions costs and network disruption from the advent of the new technology. However, there are positive spillovers for smaller firms who actually report significantly higher sales, purchases, VAT liabilities and VAT payments when their partners get mandated to adopt e-invoicing. Our results suggest that there are strong and positive tax compliance spillovers for smaller partner firms. The positive effects of spillovers on tax compliance are even larger when the firms thereafter voluntarily adopt e-invoicing themselves.

Because our identification strategy relies on a particular firm subsample, predominately comprised of small firms, care must be taken when analyzing the results in the context of the universe of firms in the Peruvian tax system which includes several large firms that contribute a significant portion of the aggregate VAT. Nevertheless, our results indicate that the true effects of the reform in Peru cannot be captured simply by accounting for the direct effects of the reform on the firms mandated to adopt e-invoicing. To evaluate the overall reform impact, we need to also account for the indirect effects of improved voluntary adoption of e-invoicing in the networks of firms directly targeted by the reform, as well as improved tax compliance for small firms in the networks of the targeted firms. 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.

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# 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	(7,562)
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	(11,080)
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.8.

**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.8.

**Table A.5: Sales and Purchases 2010-2013 Growth Rates and Treatment Dummies in 2013**

2010-2013 growth rate in:	full sample, year 2013		balanced sample, year 2013	
	(A) sales	(B) purchases	(C) sales	(D) purchases
treated in 2014	-1.145*** (0.398)	-1.334 (0.893)	-1.327 (1.543)	-1.614 (3.150)
treated in 2015	-0.160 (0.443)	0.389 (0.989)	-0.331 (1.559)	-0.633 (3.178)
treated in 2016	-0.542 (0.556)	-0.0464 (1.304)	-0.301 (1.620)	-1.027 (3.293)
treated in 2017	-0.567 (0.463)	1.893* (1.129)	-1.256 (1.580)	0.582 (3.248)
constant	5.890*** (0.375)	10.40*** (0.837)	6.253*** (1.537)	9.925*** (3.136)
observations	84,587	86,533	51,263	52,316

**Note:** Results are for year 2013, for the sample of firms that were not required to adopt e-invoicing by 2017, and specifically for the full sample in columns (A)-(B) and for the 2013-2017 balanced sample in columns (C)-(D). The growth rate of sales in columns (A), (C) and the growth rate of purchases in columns (B), (D) are regressed on dummy variables indicating when a firm has a partner mandated in e-invoicing (the treatment) for the first time. The default category is to have no partners that were mandated into e-voicing by 2018. Every regression controls for group 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.6: 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.7: Firm-Partner Links Summary Statistics over 2013-2017 (Balanced Sample)**

	<b>Firm links with suppliers</b>				
	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)
	<b>Firm links with buyers</b>				
	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.8: 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
<b>mandated supplier</b>					
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)
<b>mandated buyer</b>					
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.9: 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	-0.143*** (0.000972)	-0.112*** (0.00135)	0.00381 (0.00872)	-0.0263** (0.0115)
first year after	-0.308*** (0.00151)	-0.138*** (0.00204)	0.00678 (0.0131)	0.0212 (0.0176)
second year after	-0.202*** (0.00166)	-0.174*** (0.00259)	0.0266 (0.0178)	-0.0441* (0.0249)
third year after	-0.0782*** (0.00225)	-0.190*** (0.00368)	0.0716*** (0.0267)	-0.00894 (0.0360)
treatment year × adoption dummy	0.0732*** (0.00373)	0.0287*** (0.00503)	0.0934* (0.0508)	0.0875 (0.0543)
first year after × adoption dummy	0.143*** (0.00627)	0.0267*** (0.00868)	0.270*** (0.0837)	0.114 (0.101)
second year after × adoption dummy	0.133*** (0.00902)	0.000387 (0.0132)	0.296** (0.132)	0.130 (0.150)
third year after × adoption dummy	0.253*** (0.0185)	-0.0244 (0.0281)	0.470* (0.282)	-0.0941 (0.293)
Constant	0.639*** (0.000360)	0.589*** (0.000415)	10.45*** (0.00457)	10.71*** (0.00764)
Observations	3,008,216	1,722,928	291,900	194,120

**Note:** Results are estimated based on equation (2). 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. Firm-clustered standard errors are shown in brackets. \* 0.10, \*\* 0.05, \*\*\* 0.01.

**Table A.10: Impact of Having a Partner Mandated into e-Invoicing on Firm Compliance (1/2)**

	(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 (4). 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.11: Impact of Having a Partner Mandated into e-Invoicing on Firm Compliance (2/2)**

	(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 × 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 (4) 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: Heterogeneous Impact of Having a Partner Mandated into e-Invoicing on Compliance (1/3)

	(A) taxable sales		(B) taxable purchases		(C) VAT liabilities		(D) new VAT credits		(E) VAT payments	
	supplier	buyer	supplier	buyer	supplier	buyer	supplier	buyer	supplier	buyer
<b>mandated partner</b>										
treatment year	-0.0205*** (0.00522)	0.0105** (0.00505)	-0.0440*** (0.00710)	0.0181** (0.00716)	-0.00519 (0.00902)	0.00295 (0.00790)	-0.105*** (0.0222)	0.0142 (0.0209)	-0.0389* (0.0206)	0.0311* (0.0189)
first year after	-0.0341*** (0.00867)	0.00577 (0.00758)	-0.0693*** (0.0118)	0.0194* (0.0102)	-0.0172 (0.0138)	-0.0103 (0.0115)	-0.158*** (0.0321)	0.0169 (0.0286)	0.0369 (0.0313)	0.0467* (0.0276)
second year after	-0.0436*** (0.0123)	0.00450 (0.0105)	-0.0872*** (0.0167)	0.0157 (0.0143)	-0.0309 (0.0188)	-0.0179 (0.0153)	-0.158*** (0.0421)	0.00473 (0.0364)	0.117*** (0.0419)	0.0690* (0.0366)
third year after	-0.0687*** (0.0173)	0.0252 (0.0154)	-0.116*** (0.0238)	0.0559*** (0.0209)	-0.0638** (0.0257)	-0.00665 (0.0217)	-0.132** (0.0562)	0.0415 (0.0506)	0.105* (0.0563)	0.131*** (0.0506)
<b>e-invoicing adoption</b>	0.0453 (0.0405)		0.0122 (0.0563)		0.0903 (0.0588)		0.0234 (0.131)		0.207* (0.121)	
<b>adoption × mandated partner</b>										
treatment year	0.0353	0.0261 (0.0295)	-0.00744 (0.0549)	0.107** (0.0420)	0.0458 (0.0600)	-0.0151 (0.0432)	0.0831 (0.135)	0.0388 (0.0974)	0.172 (0.116)	-0.0632 (0.0872)
first year after	0.0484 (0.0400)	0.0178 (0.0317)	-0.00261 (0.0578)	0.0793* (0.0464)	0.0532 (0.0589)	-0.00858 (0.0460)	0.0113 (0.141)	0.117 (0.109)	0.0488 (0.128)	-0.163* (0.0942)
second year after	0.0518 (0.0417)	0.0239 (0.0327)	0.00688 (0.0594)	0.0522 (0.0490)	0.0586 (0.0604)	0.0273 (0.0469)	0.0381 (0.139)	0.00314 (0.103)	0.0963 (0.128)	-0.200** (0.0954)
third year after	0.0654 (0.0452)	0.0471 (0.0368)	0.0242 (0.0647)	0.112** (0.0539)	0.0383 (0.0650)	0.0354 (0.0529)	0.0201 (0.147)	0.0558 (0.113)	0.0376 (0.135)	-0.0928 (0.105)
Constant	13.47*** (0.00675)		13.09*** (0.00911)		10.24*** (0.0106)		6.767*** (0.0239)		7.453*** (0.0236)	
Observations	373,080		373,080		373,080		373,080		373,080	

**Note:** Results are estimated based on equation (4) where we interact all coefficients of interest with mutually exclusive dummy variables indicating if the firm had sales above or below median sales 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.13: Heterogeneous Impact of Having a Partner Mandated into e-Invoicing on Compliance (2/3)**

	(A) taxable sales		(B) taxable purchases		(C) VAT liabilities		(D) new VAT credits		(E) VAT payments	
	below- median	above- median	below- median	above- median	below- median	above- median	below- median	above- median	below- median	above- median
<b>mandated partner</b>										
treatment year	0.116*** (0.00967)	-0.0987*** (0.00649)	0.0562*** (0.0141)	-0.103*** (0.00916)	0.149*** (0.0168)	-0.0937*** (0.0112)	-0.0645** (0.0328)	-0.115*** (0.0281)	0.169*** (0.0324)	-0.112*** (0.0268)
first year after	0.165*** (0.0142)	-0.157*** (0.0111)	0.0951*** (0.0205)	-0.166*** (0.0157)	0.199*** (0.0234)	-0.157*** (0.0176)	-0.125*** (0.0449)	-0.187*** (0.0405)	0.331*** (0.0464)	-0.0297 (0.0404)
second year after	0.213*** (0.0188)	-0.198*** (0.0158)	0.121*** (0.0274)	-0.216*** (0.0224)	0.256*** (0.0300)	-0.215*** (0.0244)	-0.168*** (0.0570)	-0.237*** (0.0528)	0.503*** (0.0596)	0.0736 (0.0539)
third year after	0.240*** (0.0252)	-0.238*** (0.0218)	0.142*** (0.0365)	-0.242*** (0.0309)	0.278*** (0.0394)	-0.277*** (0.0327)	-0.155** (0.0745)	-0.178** (0.0694)	0.638*** (0.0773)	0.111 (0.0712)
Constant	13.49*** (0.00845)		13.11*** (0.0118)		10.26*** (0.0135)		6.800*** (0.0278)		7.423*** (0.0286)	
Observations	373,080		373,080		373,080		373,080		373,080	

**Note:** Results are estimated based on equation (4) where we interact all coefficients of interest with mutually exclusive dummy variables indicating if the firm had sales above or below median sales in 2013. We use 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. 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.14: Heterogeneous Impact of Having a Partner Mandated into e-Invoicing on Compliance (3/3)**

	(A) taxable sales		(B) taxable purchases		(C) VAT liabilities		(D) new VAT credits		(E) VAT payments	
	below- median	above- median	below- median	above- median	below- median	above- median	below- median	above- median	below- median	above- median
<b>mandated partner</b>										
treatment year	0.113*** (0.00966)	-0.0994*** (0.00648)	0.0534*** (0.0141)	-0.103*** (0.00913)	0.146*** (0.0168)	-0.0942*** (0.0112)	-0.0701** (0.0329)	-0.115*** (0.0281)	0.165*** (0.0324)	-0.113*** (0.0268)
first year after	0.158*** (0.0142)	-0.158*** (0.0111)	0.0907*** (0.0205)	-0.167*** (0.0157)	0.192*** (0.0236)	-0.158*** (0.0177)	-0.130*** (0.0451)	-0.195*** (0.0407)	0.330*** (0.0466)	-0.0265 (0.0405)
second year after	0.205*** (0.0189)	-0.201*** (0.0158)	0.116*** (0.0274)	-0.218*** (0.0225)	0.247*** (0.0302)	-0.219*** (0.0244)	-0.171*** (0.0574)	-0.243*** (0.0530)	0.504*** (0.0599)	0.0774 (0.0541)
third year after	0.224*** (0.0254)	-0.249*** (0.0219)	0.129*** (0.0367)	-0.253*** (0.0310)	0.264*** (0.0396)	-0.287*** (0.0329)	-0.162** (0.0750)	-0.189*** (0.0698)	0.631*** (0.0779)	0.107 (0.0715)
<b>e-invoicing adoption</b>										
		-0.00704 (0.0503)		-0.0149 (0.0709)		0.0402 (0.0745)		-0.0949 (0.160)		0.251* (0.142)
<b>adoption × mandated partner</b>										
treatment year	0.135** (0.0635)	0.0685 (0.0531)	0.143 (0.0924)	0.0136 (0.0767)	0.140 (0.0920)	0.0459 (0.0812)	0.301 (0.198)	0.0184 (0.190)	0.153 (0.176)	0.0931 (0.148)
first year after	0.186*** (0.0567)	0.0634 (0.0506)	0.126 (0.0835)	0.0678 (0.0712)	0.191** (0.0863)	0.0418 (0.0760)	0.206 (0.183)	0.324* (0.182)	-0.0450 (0.166)	-0.139 (0.153)
second year after	0.150*** (0.0562)	0.0879* (0.0514)	0.0909 (0.0804)	0.0588 (0.0725)	0.148* (0.0838)	0.0822 (0.0768)	0.121 (0.175)	0.188 (0.172)	-0.113 (0.158)	-0.136 (0.149)
third year after	0.167*** (0.0573)	0.143*** (0.0522)	0.137* (0.0819)	0.142* (0.0729)	0.125 (0.0849)	0.104 (0.0764)	0.150 (0.178)	0.200 (0.169)	-0.0627 (0.157)	-0.0795 (0.148)
Constant	13.48*** (0.00847)		13.11*** (0.0118)		10.26*** (0.0135)		6.800*** (0.0279)		7.416*** (0.0287)	
Observations	373,080		373,080		373,080		373,080		373,080	

**Note:** Results are estimated based on equation (4) where we interact all coefficients of interest with mutually exclusive dummy variables indicating if the firm had sales above or below median sales 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.



# PUBLICATIONS

**Digitalization and Tax Compliance Spillover**  
Working Paper No. **WP/22/57**