Limits to VAT Self-Enforcement*

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Abstract

The Value-Added Tax (VAT) has become a powerful tool for raising tax revenue in contexts with low state capacity. Many countries rely on technology and automation to further strengthen self-enforcement and reduce the burden on tax officers. In this paper we show that such increased reliance on self-enforcement can perversely reduce compliance. Strategic complementarity increases non-compliance among firms that remain connected to non-compliant suppliers. We experimentally increase perceived enforcement of tax filing among Goods and Services Tax (GST) taxpayers in New Delhi, India, which increases compliance by 10 percent on average. However, only taxpayers with above median levels of compliance in their supplier network respond to enforcement at all. Buyers in networks with more non-compliant suppliers are also less likely to shift away from these suppliers.

Keywords

Value-added tax; Tax Filing; Firm Networks; Tax Enforcement

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1 Introduction

The Value-Added Tax (VAT) is one of the largest revenue-raising tax instruments across the world. It is particularly popular in countries with limited state capacity, due to its "self enforcement property" - that transacting firms have opposing incentives to truthfully report the value of their transaction to the tax authority, thereby deterring evasion. In practice, many countries lean more heavily on these opposing incentives. Rather than simply requiring the buyer and seller to independently report the transaction, they require the two pieces of information to match before allowing the buyers to receive a tax credit on their purchase. This matching effectively links the buyer's tax liability to their seller's compliance behavior, creating strategic complementarity in compliance. If the seller does not file their return, the buyer's tax liability automatically increases. In this paper, we show how the interaction of such linkages with structural limitations of the economy, such as the competitiveness of upstream industries, imposes a ceiling on tax enforcement. Enforcement by the tax authority can only "jump-start" compliance through self-enforcement along the production network to the extent that firms can switch to compliant suppliers.

The effectiveness of self-enforcement, even among business-to-business (B2B) transactions, depends on the administrative context. Without credible enforcement, transactions between VAT-registered firms continue to be under-reported (Carrillo et al., 2022; Waseem, 2023; Mascagni et al., 2023)). Proposed solutions to both problems of B2B and final stage evasion often involve the use of technology such as e-filing (Okunogbe and Pouliquen, 2022), e-invoicing (Bellon et al., 2022; Fan et al., 2018), and electronic billing machines (Eissa et al., 2014). To realize the full revenue-efficiency potential of a VAT seems to require the tax authority to be able to fully utilize the information it collects and to do so in an automated manner. A natural use of technology in the VAT is to electronically ensure that a buyer and seller report the same transactions *before* any tax credits are issued, i.e. through invoice-matching. This is simply automating the verification of an already-existing requirement and saving tax officer resources in terms of manual verification and enforcement.

However, in examining taxpayer behavior among registered firms in the Goods and Services Tax (GST) in New Delhi, India – a setting with invoice matching in place – we find that it can limit enforcement spillovers. The existence of strategic complementarities means that taxpayers are incentivized to sort into compliant supply chains and change their own compliance behavior. Pomeranz (2015) shows how tax authorities can "jump-start" this sorting and increase in compliance through enforcement along the supply-chain. But we find that in some industries, the cost to switch to compliant supply chains is too high, which means downstream firms remain non-compliant and the increased enforcement adds to their tax burden.

A key challenge to empirically examining strategic complementarities and enforcement spillovers among non-compliant production chains is the difficulty of observing non-compliance.

There is a literature showing strategic complementarities in VAT registration because non-registration is an observable outcome. However, among registered firms, enforcement spillovers are revealed only by observing an increase in reported liability. This means we cannot distinguish between cases where firms do not increase reported liability because they are already truthful and cases where they remain non-compliant. To overcome this challenge, we focus on late-filing of mandatory tax returns as the margin of compliance. Administrative data on the taxpayer register and GST filings in Delhi from 2020-2022 enable us to perfectly measure filing compliance among all taxpayers. In the GST, tax filing and tax payment are linked – a taxpayer cannot make a payment without filing their return and vice versa – meaning that non-filing is also non-payment. All GST returns are filed electronically and since 2019, a buyer can only claim input tax credits on transactions that a seller has reported on their tax return.

Despite being observable and penalized, about 30 percent of returns are filed late and about 10 percent are never filed. To understand how non-compliance in the seller network contributes to late-filing, we introduce random variation in perceived enforcement of late-filing by the tax authority. Taxpayers with a history of late-filing are randomly assigned to receive voice-recorded messages reminding them of penalties for non-compliance (deterrence messages), simple reminders of the filing deadline (reminder), or no message at all (control). As in many other contexts, we find that these messages are effective in increasing filing compliance. Taxpayers are about 10 percent more likely to file their returns on time after receiving one of these messages.

Crucially, the strength of their response depends on the level of non-compliance among their sellers. Taxpayers who have only non-compliant sellers in their network respond very little to the messages. The average treatment effect is driven by taxpayers who have an above-median level of compliance in their seller network. This heterogeneity in response to enforcement by the network's compliance seems to be due to the increased tax liability from seller non-compliance. Taxpayers in supply chains with low level of compliance can only become compliant by increasing their tax payments or persuading their suppliers to comply. We see that such taxpayers choose neither and remain non-compliant.

One can argue that a buyer who is a part of non-compliant network might be fundamentally different from a buyer who is part of a more compliant network, and that these differences result in non-compliant firms sorting together into supply chains. However, we find that network compliance only matters in taxpayers' filing of a payment-linked return, suggesting that the link operates through its impact on a buyer's tax liability. The voice-recorded messages increase taxpayers' filing of credit-linked returns regardless of the compliance behavior of their sellers.

The impact of sellers' compliance on the buyer's behavior is consistent with a model where the buyer faces a trade-off between the benefits of non-compliance (saving on excess tax liability) with the costs of non-compliance (penalties and interest payments). We find that taxpayers file on time by reducing their reported sales or by switching to more compliant

sellers. Among those with less-compliant networks, taxpayers do not change their supplier network and do not change their own compliance behavior.

Our paper speaks to multiple strands of literature. Tax enforcement has been shown to be influenced by a taxpayer's network in other contexts, but this tends to work through an information channel, whereby taxpayers learn about enforcement through their network or adopt new norms of compliance (Boning et al., 2020; Paetzold and Winner, 2016). In the VAT, compliance in the network affects a taxpayers' own compliance by affecting their tax liability. The network is an integral part of the design of the VAT.

Despite its centrality to the mechanism of the VAT, there are few papers that have empirically investigated its network dynamics. One of the seminal papers in this literature, Pomeranz (2015), showed that the self-enforcement mechanism does work. Among a subset of highly non-compliant firms, increasing enforcement made the targeted firms more compliant which also led to their suppliers becoming more compliant. This result showed that the VAT does indeed create complementarity in buyer-supplier compliance. We show that the same mechanism can limit the response to enforcement by the tax authority. Recent work by Almunia et al. (2023) randomizes enforcement nudges across trading partners with sales discrepancies and show that the compliance effect is highest on sellers regardless of which partner received the treatment. Our work adds to this small but important literature by showing how characteristics of the network moderate the effect of enforcement.

A related literature has show the existence of strategic compliance complementarities in the VAT registration decision. De Paula and Scheinkman (2010) and Gadenne et al. (2023) find that firms tend to sort into chains of registration and non-registration. Having more unregistered suppliers means that a client firm is more likely to be unregistered themselves, both because an unregistered firm tends to purchase more inputs from unregistered suppliers and because having their suppliers register causes a firm to register. Our findings show that strengthening the VAT self-enforcement incentives results in the same strategic complementarities in compliance among *registered* VAT firms.

With access to new sources of data and renewed interest in the VAT, our understanding of the complexities of the practical administration of the tax is growing. Brockmeyer et al. (2024) and Slemrod and Velayudhan (2022) emphasize the importance of studying the VAT as it is implemented in practice. Given the VAT's close relationship with production networks, a real-world understanding of its workings must contend with frictions in the formation of trading relationships. It is well-established that matching frictions among buyers and suppliers are prevalent and quantitatively important (Eaton et al., 2022; Fontaine et al., 2023). Using VAT data, Boken et al. (2022) shows that caste influences trading partnerships in India, providing evidence of one source of frictions. More generally, matching with new suppliers is a gradual process and depends on local availability of suppliers (Miyauchi, Forthcoming). Our findings suggest that these frictions can limit the effectiveness of self-enforcement and external enforcement in the VAT.

This has several implications. First, when targeting enforcement, tax authorities may wish to consider a firm's position in the supply chain, and in fact target enforcement upstream. Pomeranz (2015)'s model suggests that collusive evasion has to begin at the final stage and that the VAT self-enforcement mechanism can be jump-started by targeting downstream firms. Our findings suggest that downstream enforcement could fail to deter all evasion upstream and could come at the cost of firms downstream from the evading firm. For any given level of enforcement, some firms may find it optimal not to comply, which then raises the cost of compliance for downstream firms.

A second implication is that a general increase in enforcement by the tax authority might actually be desirable from the firm's perspective as it shifts the cost of enforcement from the taxpayer to the tax administration. Finally, the difference in cost to enforce upstream results in horizontal inequity across firms. The implicit cost of enforcement is higher among firms with smaller value added at their production stage, and among industries where the supplier market is less competitive.

The rest of this paper is organized as follows. We describe the relevant aspects of the Indian GST in Section 2. We present a simple conceptual framework underlying firms' decisions and its dependence on their network's behavior in Section 3. We describe our data in Section 4. Our experimental intervention is presented in Section 5. Section 6 discusses our empirical strategy and Section 7 presents our results. Finally, Section 9 concludes.

2 Tax Filing in the GST

The Goods and Services Tax (GST) is a value-added tax that was introduced in India in 2017. GST taxpayers have to file two forms, the GSTR-3B and GSTR-1, on either a monthly or quarterly basis based on their revenue. The GSTR-3B form is a self-reported summary of their sales, purchases, and tax liability, and is filed simultaneously with tax payment – we will refer to this as the *payment-linked* form as non-filing also means non-payment. The GSTR-1 form contains invoice-level details of a firm's transactions with other GST-registered firms over the return period and must be filed before the buyer can claim input tax credits for these transactions. We will refer to this form as the *credit-linked* form, as sellers must file this form in order to provide their buyers with tax credits. We will examine how a buyer's response to enforcement in filing their payment-linked form depends on their sellers' compliance with the credit-linked form, which materially affects the buyer's tax liability.

There are several monetary and non-monetary enforcement measures in place to encourage filing, some of which were imperfectly implemented in practice. On-time filing rate of both forms are about 70 percent in New Delhi. For comparison, on-time VAT filing rate is on average 77 percent across 117 countries, with even some lower middle-income countries reporting

100 percent on-time filing (eg. Kenya).[1] The persistence of filing non-compliance despite enforcement is not well-understood. As our results will show, strategic complementarities in filing compliance is a contributing factor.

Because our identification strategy will rely on experimental variation in enforcement, none of the existing enforcement measures described below affect the internal validity of our estimates. However, it is important to keep in mind that the structural limitations we observe to VAT enforcement are occurring in a context of relatively sophisticated enforcement and likely to understate what we might find in weaker environments.

Penalties for Filing Non-Compliance Firms are charged Rs. 200 per day for each day's delay in filing the GSTR-1, capped at a maximum between Rs. 500 and Rs. 10,000 depending on the firm's annual revenue in the previous year. Failure to file the GSTR-3B also carries penalties and additionally interest on the unpaid tax liability at the rate of 18 percent per annum. In addition to penalties, several automated enforcement measures operated through the online portal. First, the return for a subsequent month could not be filed on the online portal unless all pending returns are filed. Second, no e-way bills [2] could be generated if a GSTR-3B (payment-linked) return was pending. Third, starting in August 2021, no GSTR-1 (credit-linked) return could be filed if a GSTR-3B return was pending, which meant any taxpayer wishing to provide credits to their buyer must also make a payment, though the payment could be lower than the credits they provide.

Additional enforcement requires the intervention of a tax officer. For instance, as per law, firms that haven't filed their returns for over 6 months can be deregistered. However, this can only be done after a notice is issued by the tax officer which can sometimes take longer than 6 months. We also observe that even though late fees and interest payments are mandated under law, their payment is not enforced and requires intervention from the tax officer. Figures 3 and 4 show the probability that a taxpayer who has filed a late return pays the associated penalties in the subsequent return period. Less than 60 percent of late-filers actually pay a penalty. At the start of 2021, only about 30 percent of late-filers were paying a penalty. The probability of making any interest payments after making a late payment was even lower. Almost no taxpayers were making interest payments until the start of 2022.[3] This lax enforcement means that taxpayers may reasonably believe that they can fail to file their returns without incurring a penalty. We raise this perceived probability of enforcement through a communication intervention, allowing us to experimentally alter taxpayer incentives without increasing actual enforcement.

[1] Source: IMF RA-FIT statistics https://data.imf.org/?sk=4B1DFA79-F9A6-4FFD-8ED0-C41DDA7252F6

[2] GST E-way bill is a document used to track goods in transit. A registered taxpayer transporting goods of value greater than INR 50,000 must possess an E-way bill generated on the GST Portal

[3] Discussions with tax officers revealed that starting in 2022, the filing portal automatically calculated and filled in the interest payment due. This change could account for the sharp increase in interest payments start in January 2022. Still, no more than 40 percent of late-filers make the payment.

Linking Buyer and Seller Compliance The GST automates invoice-matching. Buyers can only claim credits on invoices filed by the supplier. When a supplier files their credit-linked form (the GSTR-1), it auto-populates the buyer's "GSTR-2" form. Buyers can download this data and cross-reference the invoices filed with their own purchase record to identify missing invoices. Because their credits are limited to what the seller has filed, late or non-filing by the seller directly impacts the buyer's tax liability. In this way, the GST more heavily relies on taxpayers for enforcement as the buyer is expected to nudge their sellers to file. In fact, accounting software specifically advertises the automation of these nudges as a selling point to taxpayers [4]. While such a policy may seem unique to the Indian context, it is trying to address a widespread issue of discrepancies in VAT payments and credits (see eg. Almunia et al. (2024)). Addressing these discrepancies after filing is costly to tax authorities and policies in several countries are attempting to do so in real-time, including through the use of such invoice-matching technology (Shah (2023); Fan et al. (2018)). The increased digitization of return filing makes such enforcement appealing, especially in contexts with low-state capacity. Our paper illustrates dynamics that can arise as a result.

First, our analysis is focused on taxpayers who are registered in the state of New Delhi. All taxpayers with a physical presence in the state (i.e, an office or branch) have to register in that state. Our results pertain most directly to the types of taxpayers who operate in Delhi. Administration of all taxpayers is shared by the central and state tax authorities, which are separate. Even if a taxpayer is registered in the state, they may be administered by either the central or state tax authority. They are subject to the same GST rules but may experience different tax administrations in terms of the quality and culture of the personnel and perhaps even stringency of enforcement. Our experiment only targets state-administered taxpayers and we focus on their outcomes.

Second, although we observe the use of tax credits from out-of-state purchases, we only know the characteristics of suppliers who are also registered in Delhi. We therefore restrict our analysis to taxpayers who mainly source their supplies within the state.

Finally, the federal structure raises the importance of increasing tax filing beyond its impact on tax revenue. As a destination-based VAT, revenue is apportioned to states based on where final consumption occurs, which is information that is only provided in tax filings. Filing non-compliance is contributing to the difficulty in distributing revenue collected by the central government on inter-state transactions (IGST) to the correct destination state – a contentious issue in India's federal structure.[5]

[4] https://cleartax.in/s/max-itc

[5] https://www.business-standard.com/article/current-affairs/cag-pulls-up-govt-for-erroneous-process-of-igst-devolution-to-sta
1.html

3 Conceptual Framework

Consider a firm's decision to file their return (and remit their liability), once they have made their production decisions.

If they choose to file on time, they must use input tax credits available to them by the deadline (i.e. from suppliers who file on time) and they may have to incur costs to increase such credits available to them. In this case, their profit is given by:

$$\pi_o = \max_c \pi_a - \tau(R - \mu(c)M) - c \tag{1}$$

where π_a is profit before tax and filing costs. Firms remit tax on the difference between their output liability (τR) and input tax credits available to them, $\tau\mu(c)M$, where $\mu(c)$ is the share of their suppliers who file on time which is an increasing function of the cost to getting them to file on time c. This cost captures factors such as how difficult it may be to switch suppliers, or to nudge their existing suppliers to file on time. Firms choose c^* optimally to maximize profits conditional on filing on time.

Alternatively, firms could file late once all their suppliers have filed their returns without incurring any filing costs. In this case, they may incur a penalty for late-filing:

$$\pi_n = \pi_a - \tau(R - M) - P(\theta, R - M) \tag{2}$$

Now they only remit tax on their true taxable value add $\tau(R - M)$ and incur penalties $P(.)$ as a function of the probability of enforcement θ and the value of tax liability remitted late which depends on $R - M$.

Firms choose to file on time if the profit from doing so, $\pi_o(c^*)$, exceeds that from filing late, π_n:

$$\pi = \max\{\pi_o(c^*), \pi_n\} \tag{3}$$

Proposition 1: Increasing the likelihood of penalties will only affect firms' compliance if it raises perceived penalties above a tipping point that is (1) increasing in the share of their supplier network that is compliant and (2) increasing in the cost of increasing compliance in the supplier network.

Proof: Firms choose to file on time if it maximizes their profits as described in equation (3).

$$\pi_a - \tau(R - \mu(c^*)M) - c^* > \pi_a - \tau(R - M) - P(\theta, R - M) \tag{4}$$

Simplifying yields the following expression:

$$\tau\Big(\frac{M}{R-M}\Big)(1 - \mu(c^*)) < \frac{P(\theta, R - M) - c^*}{R - M} \tag{5}$$

We can simplify further by specifying the penalty function: $P(\theta, R - M) \equiv \theta i \tau(R - M)$, i.e., the probability of enforcement (θ) multiplied by the interest, i, on the unpaid tax liability $\tau(R - M)$. Substituting this into the above equation means that firms should file on time if and only if:

$$\tau\Big(\frac{M}{R-M}\Big)(1 - \mu(c^*)) < \theta\tau i - \frac{c^*}{R - M} \tag{6}$$

The left hand side is the decrease in tax liability if the firms choose to delay, which is increasing in the share of their network that is non-compliant $(1 - \mu(c^*))$. The right hand side is the difference in costs if they choose to delay, which is the difference in expected penalty ($\theta\tau i$) and the cost to increase on-time filing by suppliers. The value of θ that shifts firms to comply is given by:

$$\bar{\theta} = \frac{1}{i}\Big(\frac{M}{R-M}\Big)(1 - \mu(c^*)) + \frac{c^*}{\tau i(R - M)} \tag{7}$$

Therefore, increasing θ to θ' will increase compliance if and only if $\theta' > \bar{\theta} > \theta$.

Note that $\frac{M}{R-M}$ is the firm's credits as a share of their taxable value added. The higher this share, the greater the importance of network compliance in own compliance. However, higher taxable value added also increases the potential penalties for non-compliance.

In the absence of invoice-matching and the restriction of tax credits to those filed by a firm's suppliers, $\mu = 1$, regardless of the supplier's compliance behavior. In this case, the decision to file on time will only depend on $P(.)$, and the impact of increasing enforcement (θ) will not depend on compliance in the supplier network.

4 Data

We use administrative data from registrations and tax filings of GST taxpayers registered in New Delhi between December 2020 - May 2022. The registration data tells us which taxpayers

must file GSTR-1 and GSTR-3B returns in each month/quarter. Combining this with the filing data, we can observe filing compliance. Of 735,283 who were GST-registered in Delhi at any point before June 2021, all but about 1500 taxpayers had some instance of filing non-compliance in the past.[6] That is, taxpayers either had an unfiled return pending or had filed a return late in 2021. After excluding taxpayers administered by the center and taxpayers who share a phone number with another registered taxpayer, we are left with 284,240 unique taxpayers in our data.

The remaining data allows us to construct a taxpayer-by-month dataset of all registered firms who were required to file a GSTR-1 or GSTR-3 form during this time, their filing outcomes, and tax payments. In addition, invoice-level information reported on GSTR-1 forms by taxpayers enables us to link buyers and suppliers, and the importance of the relationship as measured by the value of transactions between the two. We use baseline characteristics of the taxpayer (filing compliance behavior, type of business, turnover, etc.) as measured in July 2021 to select our target population and assign them to treatment groups as described in Section 5 below. Our outcomes are measured from August 2021 onwards.

In our main analysis, we limit attention to taxpayers whose network pre-treatment is composed of only sellers registered in Delhi. We do so because we can only characterize the compliance behavior of taxpayers registered in Delhi and so we can only get an accurate picture of compliance in a taxpayer's network if that network is in Delhi. Characteristics of the full sample and main sample of taxpayers are described in Table 1. Our main analysis sample is similar to the full sample along several characteristics like average age of registered firms, sector of operation, number of sellers in the network, and sales.

[6] We also exclude very large taxpayers who sell to a large number of taxpayers (over 200). This was to limit treatment spillovers.

Table 1: Summary Statistics

	Mean	Median	Std. Dev.	Min.	Max.	Obs.
Panel A: Full Sample						
Previous late-filer	0.53	1.00	0.50	0.00	1.00	341,854
Share Sellers State-Registered	0.61	0.70	0.37	0.00	1.00	233,222
Network Compliance, Jul 2021	0.75	0.98	0.36	0.00	1.00	193,970
Share ITC from Delhi Sellers	11.20	0.77	1,035.30	0.00	317,118.72	189,640
Retailer	0.34	0.00	0.47	0.00	1.00	341,854
Upstream	0.22	0.00	0.41	0.00	1.00	341,854
Services	0.18	0.00	0.38	0.00	1.00	341,854
Months Registered	38.60	49.00	15.11	6.00	50.00	341,853
Has Inter-state sales	0.60	1.00	0.49	0.00	1.00	333,802
Number of Sellers from Delhi	8.65	4.00	14.98	1.00	786.00	233,222
Log(Output Liability)	10.64	11.00	2.53	0.00	20.72	223,109
Panel B: Main Sample						
Previous late-filer	1.00	1.00	0.00	1.00	1.00	26,209
Share Sellers State-Registered	0.62	0.66	0.30	0.00	1.00	26,209
Network Compliance, Jul 2021	0.63	0.75	0.35	0.00	1.00	26,209
Share ITC from Delhi Sellers	13.06	0.98	794.24	0.70	76,667.33	26,209
GSTR-1 Filed On Time	0.77	1.00	0.42	0.00	1.00	26,209
GSTR-3B Filed On Time	0.81	1.00	0.40	0.00	1.00	26,209
Reminder	0.15	0.00	0.36	0.00	1.00	26,209
Deterrence	0.60	1.00	0.49	0.00	1.00	26,209
Retailer	0.40	0.00	0.49	0.00	1.00	26,209
Upstream	0.29	0.00	0.45	0.00	1.00	26,209
Services	0.10	0.00	0.30	0.00	1.00	26,209
Months Registered	43.95	50.00	12.82	6.00	50.00	26,209
Has Inter-state sales	0.84	1.00	0.36	0.00	1.00	26,209
Number of Sellers from Delhi	16.83	11.00	21.70	1.00	692.00	26,209
Log(Output Liability)	11.41	11.57	1.85	0.00	20.72	25,389
Any Cash Payment	0.45	0.00	0.50	0.00	1.00	26,209
Log(ITC Claimed)	11.37	11.52	1.87	-1.90	20.61	25,196
Any Delinquent Seller Repeated	0.35	0.00	0.48	0.00	1.00	24,774
Share Delinquent Seller Repeated	0.28	0.00	0.41	0.00	1.00	24,774

Notes: Panel A shows summary statistics of full sample of taxpayers registered in the state of Delhi in September 2021. Panel B shows the summary statistics for our main analysis sample defined as having some history of late-filing, having some non-compliance in the seller network in July 2021 (i.e. at least one seller filed their GSTR-1 late in that month), and receiving at least 100 percent of their input tax credits from Delhi sellers in July 2021.

5 Experimental Intervention

Study Population and Sampling We target the population of GST taxpayers who are registered in the state of New Delhi and who are administered by the state tax authority. Because our focus is on filing non-compliance, we limit our attention to taxpayers who were non-compliant in the past, which excludes few taxpayers. We define late-filers as taxpayers who filed their returns but only after the deadline in any return period from January 2021 - June 2021. These taxpayers are more likely than others to file their future returns late. Past late-filing behavior is indicative of future late-filing behavior – about 78% of taxpayers who late-file in a given month also file late in the subsequent month. In contrast, only 25% of taxpayers who file on time in a given month, fail to do so in the subsequent month.

With the introduction of GST, the taxpayers from the previous tax regime were assigned to either the central or the state government. Since our experiment was conducted in collaboration with the state government, the intervention only consists of taxpayers assigned to the state. 90 percent of all taxpayers with annual revenue below ₹15 million were randomly assigned to the state administration and the rest to the center. Taxpayers with revenue above ₹15 million and subsequent new registrants were assigned to one of the two administrations with equal probability.

Focusing on state-administered taxpayers means that the average firm is slightly smaller than the average GST-taxpayer in Delhi as we can see in Table 2, which shows a comparison of characteristics of taxpayers registered with the center and state. State-registered taxpayers are also about 7 percentage points more likely to have inter-state sales, and have on average been registered for about 6 months longer. Overall differences between the two populations are economically small though statistically significant, particularly in terms of filing non-compliance behavior. Both taxpayers are similarly likely to have a pending return (about 20 percent) and similarly likely to have filed a return – about 50 percent file their GSTR-3B late and about 80 percent file their GSTR-1 late. About 39 percent of centre-administered taxpayers and 37 percent of state-administered share a registered phone number with another taxpayer.

Because treatment assignment was on the basis of registered phone number, we excluded any firms that shared a phone number with another taxpayer in the target population. Table 3 compares taxpayers with and and without a shared phone number, among state-administered taxpayers. Again differences here are statistically significant though economically small – even smaller than differences between centre and state taxpayers. The two groups are similar in age, inter-state sales, size of network, and other characteristics. Compliance behavior among the two groups is also very similar with differences of no more than 1 percentage point in ever-filing and on-time filing rates.

Taxpayers were stratified according to four criteria: type of filing non-compliance, revenue (nil-filer, <₹15mn, >₹15 mn), and nature of business (retail, wholesale, service, or other). See

Appendix B for further details of sampling and stratification.

Table 2: State Vs. Centre-Registered Taxpayers

	Centre	State	P-value of Difference
SGST in FY 2020	586894.37	471256.39	0.000
Has Inter-state sales	0.51	0.58	0.000
No. of Delhi buyers	8.86	9.83	0.000
Months Registered	20.04	25.98	0.000
Retailer	0.34	0.35	0.000
Upstream	0.20	0.23	0.000
Services	0.20	0.18	0.000
Monthly Filer	0.59	0.54	0.000
Pending GSTR 3	0.24	0.21	0.000
Pending GSTR 1	0.23	0.17	0.000
Late Filed GSTR 3	0.50	0.49	0.000
Late Filed GSTR 1	0.75	0.81	0.000
Shared Phone Number	0.39	0.37	0.000
Observations	274861	452551	.

Notes: Comparison of State vs Centre-registered taxpayers with some history of filing non-compliance. Sample includes all taxpayers who were GST-registered in Delhi and active as on June 2021.

Table 3: Taxpayers With and Without Shared Registered Phone Numer

	Unique Number	Shared Number	P-value of Difference
SGST in FY 2020	422830.89	553044.07	0.000
Has Inter-state sales	0.60	0.54	0.000
No. of Delhi buyers	10.25	9.09	0.000
Months Registered	26.00	25.94	0.236
Retailer	0.36	0.33	0.000
Upstream	0.23	0.22	0.000
Services	0.17	0.20	0.000
Monthly Filer	0.54	0.54	0.001
Pending GSTR 3	0.21	0.22	0.000
Pending GSTR 1	0.17	0.18	0.000
Late Filed GSTR 3	0.49	0.49	0.621
Late Filed GSTR 1	0.81	0.80	0.000
Observations	284250	168301	.

Notes: Sample consists of population of State-registered taxpayers with some history of non-compliance, active and registered as on June 2021.

Intervention Within sampling strata, 25% of taxpayers were assigned to the control group. The remainder were assigned to one of three treatment arms:

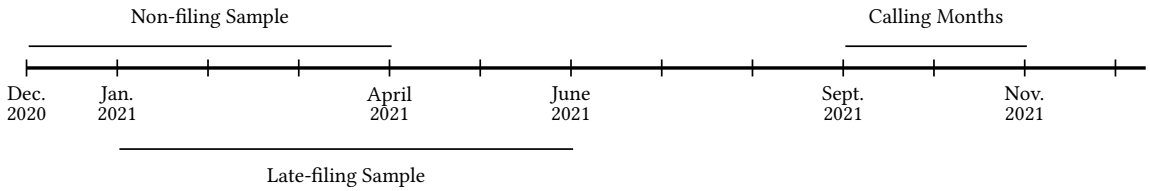
1. Reminder: In this category of message, the taxpayers were informed about the deadlines for filing. They were also directed to the GST portal that is used to filing.

2. Deterrence: In addition to the content of the reminder message, this message also reminded about the fees and penalties associated with non-filing and late filing.

3. Customized Deterrence: The taxpayers in the third treatment arm are sent customized messages. We informed these taxpayers that tax departments has analyzed their returns and found the some of their returns are pending or late-filed in the previous months or quarters.

We sent these messages four times to each taxpayer every month. The first and second messages were sent on the 9th and the 11th of the month, which is just before the filing deadline of GSTR1 form. The third and fourth messages were sent on the 18th and 20th of the month, before the filing deadline of the GSTR3B. The first set of calls were made in September with the first calls going out on September 9th. We called firms for 3 months, making the last round of calls on the 20th November.

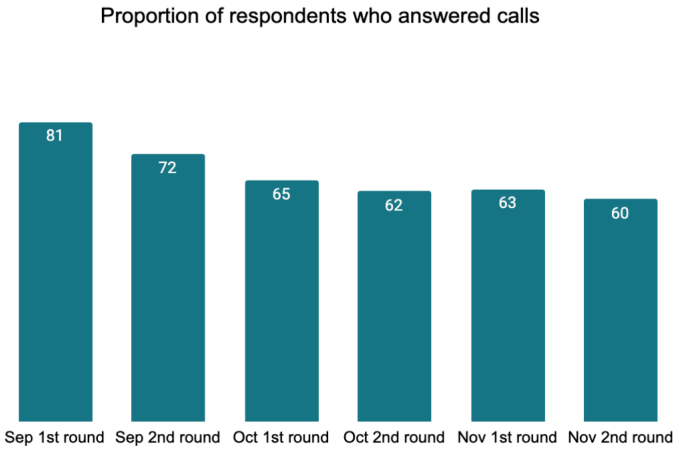
Figure 1: Intervention Timeline



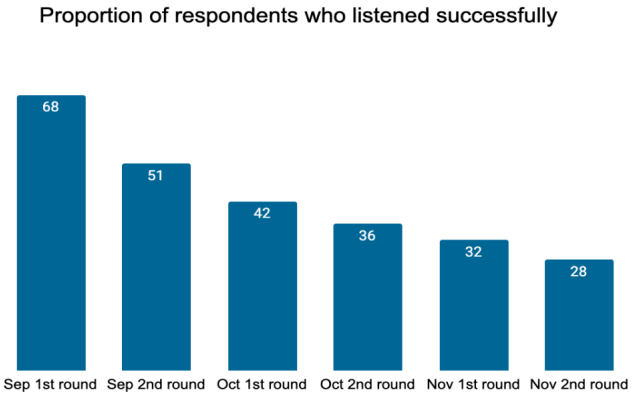
The automated voice-calls allow us to track whether the calls were picked up and how long the receiver listened to the message. Around 80 percent of all firms listened to the voice messages in the first round across all the treatment arms. The response rate declines to around 60 percent in the subsequent rounds (see Figure 2a). We define a call as successful if the taxpayer listens to the primary content of the message. The primary content of the message that reminds or deters a taxpayer against non-compliance comes at different points of time from the start of the call across different treatment arms. Figure 2b shows that in the initial rounds of calling the taxpayers are more inclined to listen to the whole message. The success rate is above 50 percent. However, the success rate declines sharply over the subsequent rounds. In the last month of calling the success rate is around 30 percent.

Figure 2: Round-wise summary of calls

(a) Response rate of the firms for each round of calling



(b) Success rate of calls for each round of calling



6 Empirical Strategy

We are interested in the causal effect of nudges on on-time filing by non-compliant firms. Formally, we define this as:

$$\phi \equiv E[Y_{1i} - Y_{0i} | Y_{0i} = 0] = \frac{P(Y_{1i} = 1 \cap Y_{0i} = 0)}{P(Y_{0i} = 0)} \tag{8}$$

where Y_{1i} and Y_{0i} are firm i's potential outcome under treatment (1) or control (0). The equality follows by the application of Bayes' rule, random assignment of treatment and control, and the fact that $P(Y_{0i} = 0 | Y_{1i} = 1 \cap Y_{0i} = 0) = 1$.

We estimate this treatment effect using the following empirical specification:

$$P(Y_i = 1 | D, X) = \beta_0 + \beta_D D_i + \beta_X X_i + \beta_{DX} D_i X_i + \beta_1 \text{Share Sellers Treated}_i + \varepsilon_i \tag{9}$$

where D_i denotes treatment assignment and X denotes dimensions of treatment effect

heterogeneity in which we are interested such as the compliance level of the buyer's network. Because we randomized treatment across taxpayers and not the taxpayer network, suppliers of a taxpayer could also be treated. We therefore control for the share of a taxpayer's credits coming from treated sellers.

The treatment effect for a given level of X is then given by[7]:

$$\phi(X) = \frac{\beta_D + \beta_{DX}X}{1 - \beta_0 - \beta_X X} \tag{10}$$

We also separately estimate treament effects for each treatment arm analogously:

$$P(Y_i = 1|D, X) = \beta_0 + \sum_{k=1}^{N} \beta_{Dk} D_{ki} + \beta_X X_i + \sum_{k=1}^{N} \beta_{DkX} D_{ki} X_i \tag{11}$$

$$+\beta_1 \text{Share Sellers Treated}_i + \varepsilon_i \tag{12}$$

where D_k denotes each treatment arm.

The conditional average treatment effect for each treatment arm k is then given by:

$$\phi_k(X) = \frac{\beta_{Dk} + \beta_{DkX}X}{1 - \beta_0 - \beta_X X} \tag{13}$$

We examine how the compliance behavior of a taxpayer's supplier network affects their response to the nudge among buyers in our sample. We only observe the compliance behavior and sales of Delhi-registered firms. Therefore, we limit the sample to buyers who use 100 percent or more of the tax credits from Delhi-registered sellers. These restrictions determine our main analysis sample as described in Section 4.

We categorize the seller network of this sample of buyers by their on-time filing of GSTR-1 in March 2021, defined as the share of sellers who file their GSTR-1 on time, weighted by their respective shares of sales to the buyer in the first quarter of 2021.

7 Results

Nudges Increase On-Time Tax Filing We find that the voice-recorded messages make taxpayers more likely to file both the payment-linked and credit-linked forms on time. Table 4 reports results of specification (9) without any interactions with other firm characteristics (i.e. omitting X_i terms). The outcome is a dummy for whether a firm filed their September 2021 return on time, the first return that would have been impacted by the voice-recorded messages. We find that both reminder and deterrence message have statistically significant and

[7] Evaluate equation 9 for the values given in 8

positive impacts on GSTR-3B filing rates of about 2 percentage points, and on GSTR-1 filing rates of about 2.5 percentage points. These translate to a 9 percent and 8.6 percent approximate decrease in non-filing rates, respectively, among the target population of previous late-filers.

Non-compliance in the seller network is not the only reason why firms may fail to file their returns on time. About half the population of previous late-filers have at least one delinquent seller in their network. This non-compliance seems to limit compliance downstream. We restrict the sample further to buyers with some non-compliance in their seller network and find similar treatment effects on average among this sub-group of 9.5 and 7.5 percent respectively on GSTR-3B and GSTR-1 filing (columns 5 and 6).

The rest of our analysis is focused on this second group of buyers where at least one seller failed to file a GSTR-1 return on time in the first quarter of 2021. We restrict attention to this sample because we are interested in the impact of non-compliance in the seller network on buyer's compliance.

Only Buyers With Sufficiently Compliant Sellers Respond We examine heterogeneity in treatment effects on GSTR-3B filing (payment-linked form) according to the pre-treatment level of compliance on GSTR-1 filing (credit-linked form) in the seller network. We estimate specification (9). Our quantity of interest - treatment effects at different levels of network compliance (defined in equation (10)) are shown in Figure 5. We evaluate the treatment effect at 5 values of network compliance starting with 0, which means that none of the sellers filed their GSTR-1 returns on time. At this level, the treatment effect is about 2 percent and not statistically significant at the 5 percent level. The effect size increases at the 25th percentile level of network compliance and then even more at the median level of network compliance to about 8 percent and is statistically significant at the 5 percent level. The median level of network compliance is 0.79, meaning for the median buyer, credits on 79 percent of their input purchases are available on time.

Figure 6 shows the heterogeneity in effects separately for the reminder and deterrence treatment groups. Interestingly, the deterrence treatment has a larger impact among taxpayers with the least network compliance. This difference is consistent with taxpayers perceiving a larger increase in the probability of enforcement from the deterrence rather than reminder messages. Still, deterrence messages increase in effectiveness at higher levels of network compliance as we would expect.

The interdependence of seller and buyer compliance is driven by the impact on the buyer's tax liability rather than sorting on any tendencies toward compliance. This is apparent from the finding that whether a buyer files their credit-linked form on time in response to treatment is uncorrelated with compliance among their sellers. The credit-linked form is unrelated to tax payment and the seller's filing of their own credit-linked form has no material impact on the buyer's cost to file their credit-linked form. In fact, buyers file their credit-linked form before they observe their sellers' filing behavior. Therefore, any correlation between the two would

indicate that buyers and sellers have similar propensities toward compliance. Figure 7 shows the treatment effect on GSTR-1 (credit-linked form) filing for the same quantiles of the seller network compliance. In this case, we do not see the same gradient in the treatment impact and the compliance in the seller network.

Treatment raises perceived enforcement, and therefore the perceived costs of non-compliance. Our findings suggest that this is sufficient to outweigh the benefits among those with more compliant sellers whose tax liability is closer to actual tax liability on value added.

Firms File On-time by Reducing Reported Output Taxpayers with delinquent sellers in their network will not have access to input tax credits from these sellers by the deadline to file the payment-linked form. To make their payment on time, they can do one of the following: (1) Accept a larger net liability, (2) lower their reported output, or (3) nudge their sellers to file returns on time. We find that firms do not increase their cash payments and instead lower their reported output. Table 7 shows the impact on reported sales, cash payments (i.e. net tax liability), and input tax credits claimed among those with above-median compliance in the seller network, that is, the taxpayers who respond to treatment. These taxpayers are 2 percentage points more likely to report a net zero tax liability in response to a deterrence message, an approximately 4.5 percent increase relative to the mean (Column 1). They are 7 percent likely to report a larger net tax liability (Column 2). This decrease in net liability at the time of filing is coming from a decrease in reported output liability – taxpayers are 13 percent more likely to report zero output tax liability and 5 percent less likely to report an increase in output tax liability (Columns 3 and 4), counteracting a decrease in input tax credits claimed at the time of filing of about 3 percent (Column 5).

Table 8 shows the same outcomes for taxpayers with below-median compliance in the seller network, i.e. those who do not increase filing compliance in response to treatment. Notably, we do not see any changes in their reported tax liability or sales, though we do see a small decline in credits claimed. This is consistent with their lack of response to the treatment.

This margin of behavioral response shows that taxpayers are becoming more compliant along the filing dimension by possibly becoming *less* compliant along the payment dimension or by decreasing the size of their operations, both of which are undesirable outcomes from the perspective of raising tax revenue and production efficiency.

Buyers do not change their sellers' behavior Another way in which firms file on time is by changing their supplier network. Table 9 shows how various characteristics of the seller network change as a result of treatment for taxpayers with above-median compliance in the seller network before treatment. This margin of response is more muted. Taxpayers are about 2 percent less likely to have make any purchases from a delinquent seller who was previously in their network (Column 1). As a result, the share of repeated delinquent sellers in their network falls by about 2 percent (Column 3). Average compliance in the seller network does not change

(Column 4).

Again, there is very little change in the seller network of taxpayers who had below-median levels of seller compliance before treatment (Table 10). These results are consistent with firms having more compliant seller networks to begin with because they are able to switch suppliers more easily.

8 Discussion

9 Conclusion

Tax authorities increasingly rely on technology-aided and taxpayer-led tax enforcement, particularly in low-capacity contexts. We analyze the limits of such an approach in the Goods and Services Tax in India. We find that despite strong incentives to file tax returns on time, many GST taxpayers are late in filing their returns and making payments. Automated voice-recorded messages from the tax authority containing either simple reminders or reminders of the penalties associated with late-filing can increase compliance – but only to an extent. The response to such a perceived increase in enforcement is mediated by the level of non-compliance among a firm's input sellers.

Because we can directly observe non-compliance, unlike in other types of non-compliance like under-reporting of sales, we can show that non-response by taxpayers does not necessarily imply full compliance. In fact, buying firms continue to file and make late payments despite an increase in perceived enforcement if they have many late sellers in their network. This association arises because non-compliance by the sellers directly affects the tax liability of a buyer, as is intended by the invoice-matching policy. However, instead of encouraging buyers to switch to more compliant sellers and inducing positive spillovers up the supply chain, this liability link results in negative spillovers down the supply chain.

We find suggestive evidence that the lack of competitiveness among input markets limits the ability of taxpayers to switch suppliers or put pressure on suppliers to comply. Our results suggest that structural features of the economy such as the competitiveness of intermediate product markets can limit enforcement spillovers in a VAT.

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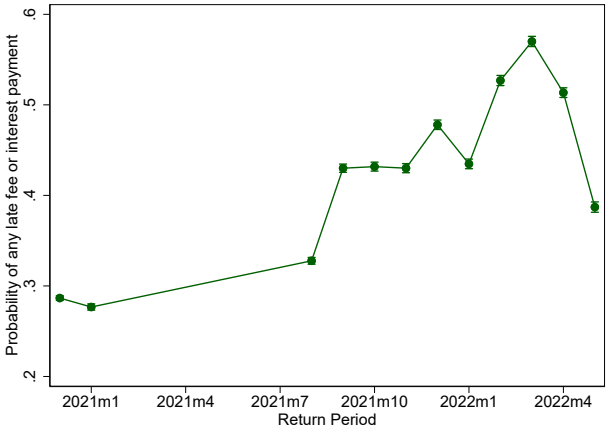
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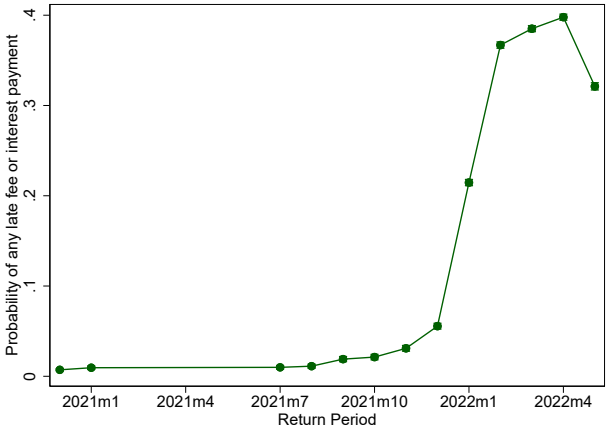
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Figure 3: Late Fee or Interest Payment by Late Filers



Notes: Figure shows the probability that a taxpayer pays any late fee or interest after filing their previous GSTR-1 or GSTR-3B return late. Sample is restricted to firms that are supposed to file on a monthly basis. We omit Feb - June 2021 return periods because of incomplete data.

Figure 4: Interest Payment by GSTR-3B late filers



Notes: Figure shows the probability that a taxpayer pays any interest after filing their previous GSTR-3B return late. Sample is restricted to firms that are supposed to file on a monthly basis. We omit Feb - June 2021 return periods because of incomplete data.

Table 4: On-time Filing Response to Nudges

	Previous Late-Filers		With Seller Non-Compliance	
	(1) GSTR-3B	(2) GSTR-1	(3) GSTR-3B	(4) GSTR-1
Reminder	0.014***	0.020***	0.004	0.006
	(0.004)	(0.004)	(0.008)	(0.008)
Deterrence	0.020***	0.025***	0.020***	0.018***
	(0.003)	(0.003)	(0.006)	(0.006)
Constant	0.783***	0.712***	0.793***	0.762***
	(0.002)	(0.003)	(0.005)	(0.005)
Observations	114,050	114,050	26,210	26,210

Notes: Table presents results of specification (11) without allowing for treatment effect heterogeneity (i.e. omitting all X_i terms). The sample in the first two columns is restricted to taxpayers who had filed their return late in any month between April - June 2021. Columns (3) and (4) further restrict the sample to buyers with only sellers administered by the central government in their network. We further restrict the sample to those with at least one non-compliant seller in columns (5) and (6). Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Monthly On-time Filing of GSTR-3B: Above-Median Network Compliance

	GSTR-3B Return Month:				
	(1) August	(2) September	(3) October	(4) November	(5) December
Reminder	0.009	0.009	0.027**	0.008	0.009
	(0.013)	(0.011)	(0.012)	(0.013)	(0.011)
Deterrence	0.024**	0.025***	0.024***	0.007	0.005
	(0.010)	(0.008)	(0.009)	(0.009)	(0.008)
Share Sellers Treated	0.019	0.021	0.009	0.014	0.033**
	(0.016)	(0.014)	(0.016)	(0.016)	(0.014)
Constant	0.791***	0.796***	0.823***	0.829***	0.823***
	(0.009)	(0.007)	(0.008)	(0.008)	(0.007)
Sample Mean	0.80	0.81	0.83	0.83	0.83
Observations	9,494	13,223	9,016	9,014	12,572

Notes: Table presents results of specification (11). The dependent variable is a dummy for whether a taxpayer filed the GSTR-3B return (payment-linked) by the deadline in the month listed on top of the column. The sample is restricted to our main analysis sample of firms with at least 80 percent center-administered sellers, with some history of non-compliance, and at least 100 percent of tax credits from Delhi-registered sellers prior to treatment. The sample in this table is additionally restricted to those with above-median (i.e. greater than 87%) credits filed by their suppliers in July. All specifications include strata by month fixed effects. Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Monthly On-time Filing of GSTR-3B: Below-Median Network Compliance

	GSTR-3B Return Month:				
	(1) August	(2) September	(3) October	(4) November	(5) December
Reminder	−0.015	−0.002	−0.007	−0.003	0.003
	(0.014)	(0.012)	(0.014)	(0.014)	(0.011)
Deterrence	0.006	0.014	0.001	0.013	0.014*
	(0.011)	(0.008)	(0.010)	(0.010)	(0.008)
Share Sellers Treated	0.046***	0.039***	0.037**	0.033**	0.048***
	(0.016)	(0.013)	(0.016)	(0.016)	(0.013)
Constant	0.766***	0.777***	0.812***	0.796***	0.796***
	(0.010)	(0.008)	(0.009)	(0.009)	(0.008)
Sample Mean	0.77	0.78	0.81	0.80	0.80
Observations	8,617	12,987	8,130	8,126	12,374

Notes: Table presents results of specification (11). The dependent variable is a dummy for whether a taxpayer filed the GSTR-3B return (payment-linked) by the deadline in the month listed on top of the column. The sample is restricted to our main analysis sample of firms with at least 80 percent center-administered sellers, with some history of non-compliance, and at least 100 percent of tax credits from Delhi-registered sellers prior to treatment. The sample in this table is additionally restricted to those with below-median (i.e. less than 87%) credits filed by their suppliers in July. All specifications include strata by month fixed effects. Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Mechanisms: Tax Payment among Above-Median Network Compliance

	August-October 2021				
	(1) Zero Cash	(2) More Cash	(3) Zero Output Liab.	(4) More Output Liab.	(5) More ITC claimed
Reminder	0.018*	−0.017**	0.002	−0.026***	−0.026***
	(0.009)	(0.008)	(0.003)	(0.009)	(0.009)
Deterrence	0.021***	−0.024***	0.004*	−0.023***	−0.016**
	(0.007)	(0.006)	(0.002)	(0.007)	(0.007)
Share Sellers Treated	−0.018	0.007	0.002	0.024**	−0.006
	(0.011)	(0.011)	(0.004)	(0.011)	(0.011)
Constant	0.450***	0.331***	0.024***	0.463***	0.539***
	(0.006)	(0.006)	(0.002)	(0.006)	(0.006)
Sample Mean	0.46	0.32	0.03	0.45	0.52
Observations	31,730	31,730	31,730	31,730	31,730

Notes: Table presents results of specification (11). Each observation is a taxpayer and return period. *Zero Cash* is a dummy for whether the taxpayer reported net zero liability (i.e. zero payment in cash) in a return period. *More Cash* is a dummy for whether the taxpayer reports net liability greater than their net liability in July 2021. *Log(Output Liability* is the logged value of their reported output liability. *Log(ITC Claimed)* is the logged value of tax credits claimed in the taxpayer's GSTR-3B in a given month. The sample is restricted to our main analysis sample of firms with at least 80 percent center-administered sellers, with some history of non-compliance, and at least 100 percent of tax credits from Delhi-registered sellers prior to treatment. The sample in this table is additionally restricted to those with above-median (i.e. greater than 87%) credits filed by their suppliers in July. All specifications include strata by month fixed effects. Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Mechanisms: Tax Payment among Below-Median Network Compliance

	August-October 2021				
	(1) Zero Cash	(2) More Cash	(3) Zero Output Liab.	(4) More Output Liab.	(5) More ITC claimed
Reminder	−0.012	0.003	−0.005	0.010	0.005
	(0.009)	(0.009)	(0.004)	(0.009)	(0.009)
Deterrence	0.008	−0.007	0.003	−0.001	−0.015**
	(0.007)	(0.006)	(0.003)	(0.007)	(0.007)
Share Sellers Treated	0.013	0.004	−0.014***	−0.002	−0.011
	(0.011)	(0.010)	(0.005)	(0.011)	(0.011)
Constant	0.450***	0.323***	0.051***	0.437***	0.512***
	(0.006)	(0.006)	(0.003)	(0.006)	(0.006)
Sample Mean	0.46	0.32	0.05	0.45	0.51
Observations	29,734	29,734	29,734	29,734	29,734

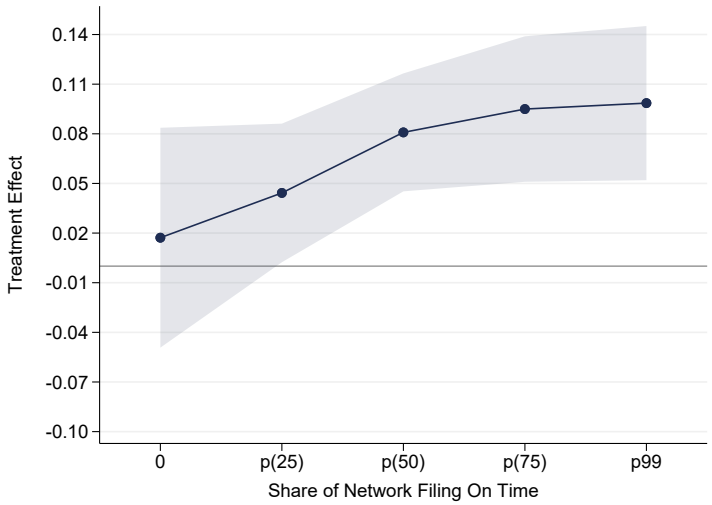
Notes: Table presents results of specification (11). Each observation is a taxpayer and return period. *Zero Cash* is a dummy for whether the taxpayer reported net zero liability (i.e. zero payment in cash) in a return period. *More Cash* is a dummy for whether the taxpayer reports net liability greater than their net liability in July 2021. *Log(Output Liability* is the logged value of their reported output liability. *Log(ITC Claimed)* is the logged value of tax credits claimed in the taxpayer's GSTR-3B in a given month. The sample is restricted to our main analysis sample of firms with at least 80 percent center-administered sellers, with some history of non-compliance, and at least 100 percent of tax credits from Delhi-registered sellers prior to treatment. The sample in this table is additionally restricted to those with below-median (i.e. less than 87%) credits filed by their suppliers in July. All specifications include strata by month fixed effects. Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Mechanisms: Seller Compliance among Above-Median Compliance

	September-October 2021			
	(1) Prob. of Repeating Any Late Seller	(2) Prop. of ITC from Repeat Late Sellers	(3) Prop. Late Seller Repeated	(4) Share Seller On Time
Reminder	−0.017*	0.005**	−0.014	−0.006*
	(0.010)	(0.003)	(0.009)	(0.004)
Deterrence	−0.010	0.002	−0.006	−0.000
	(0.008)	(0.002)	(0.006)	(0.003)
Share Sellers Treated	−0.071***	−0.001	−0.051***	−0.026***
	(0.013)	(0.003)	(0.011)	(0.004)
Constant	0.372***	0.036***	0.280***	0.861***
	(0.007)	(0.002)	(0.006)	(0.002)
Sample Mean	0.35	0.04	0.27	0.85
Observations	21,700	21,956	21,700	21,956

Notes: Table presents results of specification (11). Each observation is a taxpayer and return period. *Prob. of Repeating Any Late Seller* is a dummy for whether a seller with some history of delinquency from the taxpayer's network in July 2021 appears again in the taxpayer's network. *Prop. of ITC from Repeat Late Sellers* is the input tax credits available to the taxpayer from previously delinquent sellers in their July 2021 network, as a share of their total ITC available. *Prop. Late Seller Repeated* is the share of all delinquent sellers in their July 2021 network that appear again in their seller network. *Share Seller On Time* is the share of their sellers in the current return period that filed their GSTR-1 on time in this return period. The sample is restricted to our main analysis sample of firms with at least 80 percent center-administered sellers, with some history of non-compliance, and at least 100 percent of tax credits from Delhi-registered sellers prior to treatment. The sample in this table is additionally restricted to those with above-median (i.e. greater than 87%) credits filed by their suppliers in July. All specifications include strata by month fixed effects.
Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 5: Heterogeneity in Treatment Effect by Network Compliance



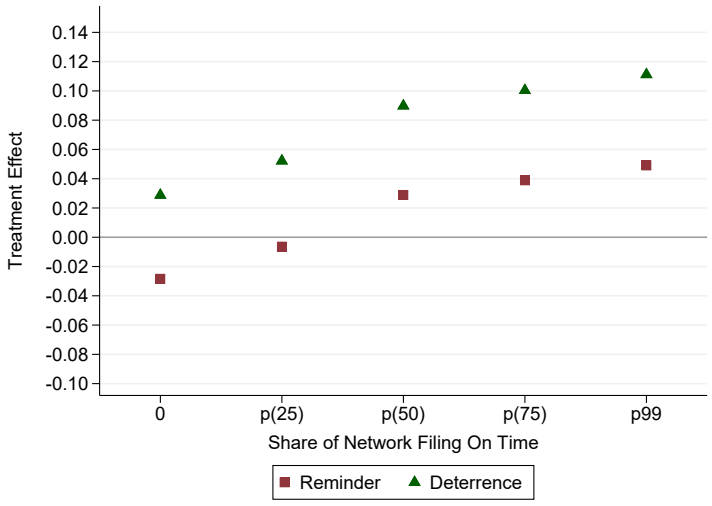
Notes: Figure plots treatment effect as defined in equation (10), evaluated at different quantiles of compliance of the taxpayer's seller network. Standard errors are calculated using the delta method. The treatment effect denotes the percent change in on-time filing among non-filers induced by the treatment.

Table 10: Mechanisms: Seller Compliance among Below-Median Compliance

	September-October 2021			
	(1) Prob. of Repeating Any Late Seller	(2) Prop. of ITC from Repeat Late Sellers	(3) Prop. Late Seller Repeated	(4) Share Seller On Time
Reminder	−0.004	0.001	−0.005	−0.005
	(0.011)	(0.005)	(0.009)	(0.005)
Deterrence	−0.010	−0.004	−0.009	0.002
	(0.008)	(0.003)	(0.007)	(0.004)
Share Sellers Treated	−0.120***	−0.030***	−0.087***	0.009
	(0.013)	(0.005)	(0.011)	(0.006)
Constant	0.391***	0.089***	0.302***	0.787***
	(0.007)	(0.003)	(0.006)	(0.004)
Sample Mean	0.36	0.08	0.28	0.78
Observations	19,589	20,265	19,589	20,266

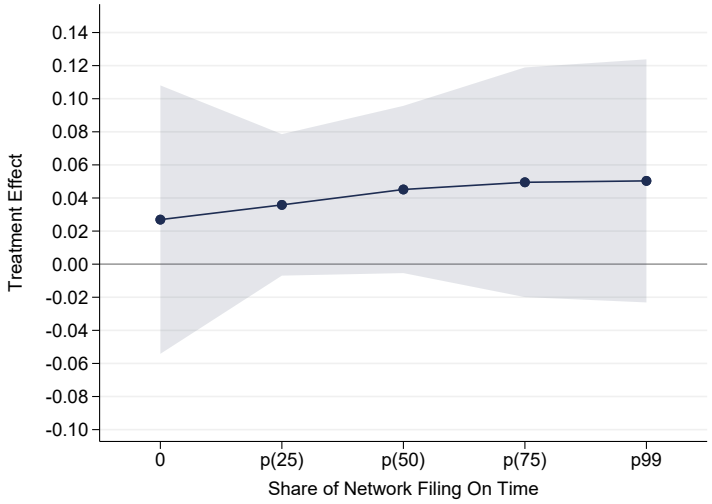
Notes: Table presents results of specification (11). Each observation is a taxpayer and return period. *Prob. of Repeating Any Late Seller* is a dummy for whether a seller with some history of delinquency from the taxpayer's network in July 2021 appears again in the taxpayer's network. *Prop. of ITC from Repeat Late Sellers* is the input tax credits available to the taxpayer from previously delinquent sellers in their July 2021 network, as a share of their total ITC available. *Prop. Late Seller Repeated* is the share of all delinquent sellers in their July 2021 network that appear again in their seller network. *Share Seller On Time* is the share of their sellers in the current return period that filed their GSTR-1 on time in this return period. The sample is restricted to our main analysis sample of firms with at least 80 percent center-administered sellers, with some history of non-compliance, and at least 100 percent of tax credits from Delhi-registered sellers prior to treatment. The sample in this table is additionally restricted to those with below-median (i.e. less than 87%) credits filed by their suppliers in July. All specifications include strata by month fixed effects. Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 6: Heterogeneity in Treatment Effect by Network Compliance, Multiple Treatment Arms



Notes: Figure plots treatment effect as defined in equation (13) for the Reminder and Deterrence messages, evaluated at different quantiles of compliance of the taxpayer's seller network. Standard errors are calculated using the delta method. The treatment effect denotes the percent change in on-time filing among non-filers induced by the treatment.

Figure 7: Heterogeneity in Treatment Effect on GSTR-1 Filing by Network Compliance



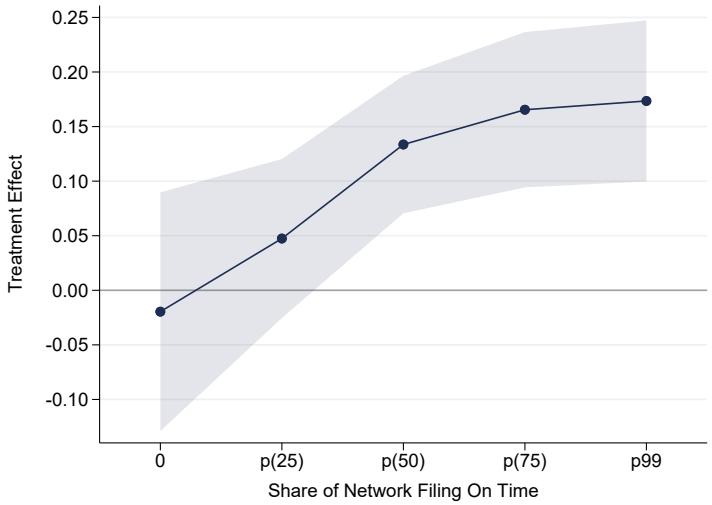
Notes: Figure plots treatment effect as defined in equation (10), evaluated at different quantiles of compliance of the taxpayer's seller network. Standard errors are calculated using the delta method. The treatment effect denotes the percent change in on-time filing among non-filers induced by the treatment.

Table 11: Difference in Treatment Effect by Compliance in the Network, with controls

	Compliance in the Network:	
	(1) Above-median	(2) Below-median
Reminder	0.015**	−0.007
	(0.007)	(0.008)
Deterrence	0.026***	0.008
	(0.005)	(0.006)
Share Sellers Treated	0.009	0.027***
	(0.008)	(0.008)
Constant	0.803***	0.789***
	(0.005)	(0.005)
Observations	31,292	28,412

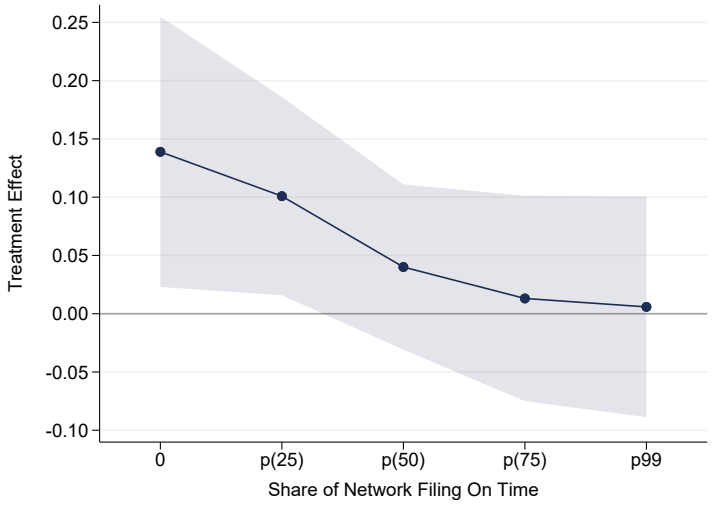
Notes: Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 8: Effect on Buyers' Payment Filing: Concentrated Supplier Networks



Notes: Figure plots treatment effect as defined in equation (10), evaluated at different quantiles of compliance of the taxpayer's seller network. Standard errors are calculated using the delta method. The treatment effect denotes the percent change in on-time filing among non-filers induced by the treatment. Sample is restricted to buyers with concentrated networks, i.e. HHI of their inputs of at least 0.3.

Figure 9: Effect on Buyers' Payment Filing: Diffuse Supplier Networks



Notes: Figure plots treatment effect as defined in equation (10), evaluated at different quantiles of compliance of the taxpayer's seller network. Standard errors are calculated using the delta method. The treatment effect denotes the percent change in on-time filing among non-filers induced by the treatment. Sample is restricted to buyers with diffuse supplier networks, i.e. HHI of their inputs of at less than 0.3.

A Variable Construction

1. **Herfindahl-Hirschman Index of the buyer's input market**: We first calculate the HHI of each supplier's output market and then calculate the HHI of a buyer's input markets as a function of the relative tax credit by each supplier.

   Each firm must list the product-codes (using standard HSN codes) that they intend to sell when they register under GST. The first two digits of the HSN describe the industry category of the product. Multi-product firms list products in order of priority. We calculate the concentration of sellers within each 2-digit industry as follows:

$$HHI_i = \sum_{s=1}^{N_2} \left(\frac{Sales_s}{\sum_{s}^{N_2} Sales_s} \right)^2$$

   where N_2 is the total number of sellers s in industry i.

   Because we do not know exactly which product is transacted between a buyer and seller, we make the assumption that a buyer is purchasing the supplier's top output and we assign the seller the HHI of the industry of their top output (HHI_s). The average concentration of a buyer's input markets (HHI_b) is then calculated as:

$$HHI_b = \sum_{s=1}^{N_1} \frac{Sales_{sb}}{\sum_{s=1}^{N_1} Sales_{sb}} \times HHI_s$$

   where the sum of HHI_s of each seller that a buyer procures from in each quarter is weighted by the sales between buyer b and seller s, $Sales_{sb}$, as a share of total sales from all N_1 suppliers to that buyer in that quarter. The HHI varies from 0 to 1 with 1 implying a perfect monopoly.

B Sample Selection

Our sample is drawn from the universe of GST taxpayers registered with the Delhi Department of Revenue. Within this firm register, we focus on a target population of taxpayers as defined by their past non-compliance behavior.

B.1 Target Population

We target two types of behavior: non-filing and late-filing. The distinction between the two behaviors is important both in terms of underlying drivers of each. Filing just a few days or even a month after the deadline is much more likely to be caused by forgetfulness, lack of salience, or disorganization than failing to file a return for 3 months or more. Another reason to distinguish between the two is that tax authorities may want to address both past and future behavior of taxpayers. Nudges could be used to get taxpayers to file pending returns (i.e. non-filers) or it could be used to ensure future on-time filing of taxpayers who filed past returns, but did so after the deadline. These two behaviors may respond differently to nudges. Moreover, identifying the population of future late-filers is not as clear as identifying the population of current non-filers.

For these reasons, we define 2 distinct target populations:

1. Non-filers: These are taxpayers who have a pending return to be filed from any time between December 2020 and March 2021, as of 31st July. We do not consider pending returns between March and July 2021 as there may be many returns filed with a delay, which would be considered late-filing instead.

2. Late-filers: These are taxpayers who filed their returns but only after the deadline in any return period from January 2021 - June 2021. These taxpayers are more likely than others to file their future returns late. Past late-filing behavior is indicative of future late-filing behavior – About 78% of taxpayers who late-file in a given month also file late in the subsequent month. In contrast, only 25% of taxpayers who file on time in a given month, fail to do so in the subsequent month.

Any taxpayer who satisfies the criteria for both "non-filing" and "late-filing" will be classified as a non-filer for the purposes of randomization into a treatment group. Both groups will receive identical treatments. However, the distinction will matter for the analysis of our outcomes. Taxpayers who fit both criteria will be analyzed in both samples.

Because the intervention is to send automated messages to taxpayers by phone, we will randomize unique phone numbers into treatment groups, and not unique taxpayers. This matters because about 40 percent of taxpayers in our target population have registered with a non-unique phone number. We exclude any taxpayers who share a phone number from our target population. Among taxpayers who have a unique phone number, the number is classified as a "non-filer" or "late-filer" as above.

After these restrictions, we are left with a sampling frame of 283,794 taxpayers who we then stratify according to criteria described below.

B.2 Strata

B.2.1 Type of Filing Non-Compliance

We stratify unique phone numbers according to the following types of filing non-compliance:

1. Non-filer of GSTR 1 and GSTR-3
2. Non-filer of GSTR 1 but not GSTR-3
3. Non-filer of GSTR 3 but not GSTR-1
4. Late-filer of GSTR 1 and GSTR 3
5. Late-filer of GSTR 1 but not GSTR-3
6. Late-filer of GSTR 3 but not GSTR 1

We stratify by filing type because each of these filing patterns can be associated with very different reasons for non-compliance. For example, those who consistently file GSTR-1 but not GSTR-3 are likely to be invoice mills/ fake firms. GSTR-3 filing is associated with payment but GSTR-1 is not, which could mean that GSTR-3 filing is affected by liquidity issues while GSTR-1 is not, and so on.

B.2.2 Imputed Turnover

1. Zero (taxpayers have recorded zero tax payments in FY 2020 including both in cash or GST credit)
2. <1.5 crore (threshold for composition scheme [8]
3. >1.5 crore

We want to ensure that we have a sufficient sample of large firms to analyze their behavior separately, particularly when it comes to spillover effects. Turnover data is missing for about 20 percent of our target population. Therefore, we use annual total GST payments as a proxy for firms' taxable turnover, by dividing these payments by the standard rate of 18% .

B.2.3 Nature of Business

We will look at the primary nature of business and categorize taxpayers into 4 strata:

1. Wholesalers
2. Retailers

[8] Composition scheme reduces the burden of regular filing for small taxpayers. These taxpayers cannot claim input tax credit and have to pay taxes on revenue rather than profits

3. Services

4. Others

Analysis of the pilot round data suggests that nudges have a larger impact on wholesalers who are also upstream in the supply chain. We also want to separately analyze the effect on service providers as these taxpayers might behave differently because of smaller supply chains and less use on inventory.

C Appendix Tables

Table 12: Balance Table - First Stage

	(1) Control	(2) Reminder	(3) Deterrence	(4) Custom Deterrence
SGST in FY 2020	433,153.82	402,496.40	437,094.12	402,299.11
		(0.34)	(0.88)	(0.20)
Has Inter-state sales	0.60	0.60	0.60	0.60
		(0.72)	(0.77)	(0.74)
No. of Delhi buyers	10.09	10.23	10.25	10.26
		(0.35)	(0.19)	(0.17)
Months Registered	25.98	25.89	26.02	26.00
		(0.35)	(0.65)	(0.81)
Retailer	0.36	0.36	0.36	0.36
		(0.67)	(0.59)	(0.84)
Upstream	0.23	0.23	0.23	0.23
		(0.63)	(0.26)	(0.34)
Services	0.17	0.17	0.17	0.17
		(0.73)	(0.78)	(0.84)
Monthly Filer	0.53	0.54	0.53	0.54
		(0.37)	(0.57)	(0.07)
Pending GSTR 3	0.21	0.21	0.21	0.21
		(0.95)	(0.96)	(0.94)
Pending GSTR 1	0.17	0.17	0.17	0.17
		(0.92)	(0.93)	(0.95)
Late Filed GSTR 3	0.49	0.49	0.49	0.49
		(0.89)	(0.76)	(0.84)
Late Filed GSTR 1	0.81	0.81	0.81	0.81
		(0.89)	(1.00)	(0.99)

Notes: P-value of t-test of difference of mean between treatment group and control in parentheses.

Table 13: Probability of Net Zero VAT Liability: Above-Median Network Compliance

	Return Month:				
	(1) August	(2) September	(3) October	(4) November	(5) December
Reminder	−0.014	0.029	0.014	−0.013	0.044
	(0.031)	(0.033)	(0.031)	(0.031)	(0.033)
Deterrence	0.011	0.042*	0.062***	0.004	0.046*
	(0.023)	(0.024)	(0.023)	(0.023)	(0.024)
Constant	0.625***	0.442***	0.602***	0.629***	0.449***
	(0.019)	(0.020)	(0.019)	(0.019)	(0.020)
Sample Mean	0.60	0.44	0.61	0.60	0.45
Observations	2,365	2,365	2,365	2,365	2,365

Notes: Table presents results of specification. [Add Notes] Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 14: Probability of Increase in Cash Payment: Above-Median Network Compliance

	Return Month:				
	(1) August	(2) September	(3) October	(4) November	(5) December
Reminder	0.003	−0.022	−0.011	0.012	−0.019
	(0.035)	(0.043)	(0.036)	(0.037)	(0.044)
Deterrence	−0.019	−0.063**	−0.024	−0.013	−0.011
	(0.026)	(0.032)	(0.027)	(0.028)	(0.032)
Constant	0.211***	0.427***	0.234***	0.239***	0.406***
	(0.021)	(0.026)	(0.022)	(0.023)	(0.027)
Sample Mean	0.21	0.39	0.22	0.23	0.39
Observations	1,293	1,297	1,290	1,267	1,279

Notes: Table presents results of specification. [Add Notes] Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 15: Log(Output Liability): Above-Median Network Compliance

	Return Month:				
	(1) August	(2) September	(3) October	(4) November	(5) December
Reminder	−0.134	0.007	−0.009	0.067	0.033
	(0.203)	(0.175)	(0.192)	(0.193)	(0.167)
Deterrence	−0.218	−0.183	−0.199	−0.205	0.046
	(0.153)	(0.130)	(0.146)	(0.148)	(0.123)
Constant	11.386***	11.429***	11.648***	11.550***	11.479***
	(0.127)	(0.108)	(0.122)	(0.123)	(0.102)
Sample Mean	10.98	11.01	11.19	11.08	11.18
Observations	921	1,324	917	898	1,290

Notes: Table presents results of specification. [Add Notes] Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 16: Log(ITC Used): Above-Median Network Compliance

	Return Month:				
	(1) August	(2) September	(3) October	(4) November	(5) December
Reminder	−0.175	−0.167	0.219	0.302	0.048
	(0.211)	(0.179)	(0.222)	(0.229)	(0.184)
Deterrence	−0.367**	−0.215	−0.139	−0.342**	−0.141
	(0.159)	(0.132)	(0.167)	(0.172)	(0.134)
Constant	11.268***	11.386***	11.214***	11.124***	11.223***
	(0.133)	(0.110)	(0.140)	(0.144)	(0.112)
Sample Mean	10.89	10.96	10.91	10.74	10.88
Observations	962	1,358	955	933	1,329

Notes: Table presents results of specification. [Add Notes] Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 17: Log(Cash): Above-Median Network Compliance

	Return Month:				
	(1) August	(2) September	(3) October	(4) November	(5) December
Reminder	−0.257	0.582*	0.256	0.264	−0.110
	(0.357)	(0.306)	(0.395)	(0.393)	(0.310)
Deterrence	−0.013	0.397*	0.485*	0.286	0.253
	(0.272)	(0.226)	(0.289)	(0.288)	(0.229)
Constant	9.052***	8.514***	8.861***	8.964***	9.281***
	(0.225)	(0.185)	(0.236)	(0.237)	(0.191)
Sample Mean	8.52	8.46	8.83	8.87	8.99
Observations	489	735	455	463	684

Notes: Table presents results of specification. [Add Notes] Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 18: Probability of getting ITC from any of the previous month's late filing seller: Above-Median Network Compliance

	Return Month:				
	(1) August	(2) September	(3) October	(4) November	(5) December
Reminder	0.024	−0.020	−0.053	−0.023	−0.054*
	(0.038)	(0.035)	(0.037)	(0.035)	(0.032)
Deterrence	−0.000	−0.042	−0.058**	−0.028	−0.048**
	(0.028)	(0.026)	(0.027)	(0.026)	(0.023)
Constant	0.317***	0.275***	0.307***	0.240***	0.210***
	(0.023)	(0.022)	(0.023)	(0.021)	(0.019)
Sample Mean	0.46	0.28	0.29	0.23	0.19
Observations	1,519	1,520	1,512	1,476	1,496

Notes: Table presents results of specification. [Add Notes] Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 19: Probability of repeating any of the previous month's late filing seller: Above-Median Network Compliance

	Return Month:				
	(1) August	(2) September	(3) October	(4) November	(5) December
Reminder	0.024	−0.018	−0.062*	−0.028	−0.056*
	(0.038)	(0.036)	(0.037)	(0.036)	(0.033)
Deterrence	−0.000	−0.038	−0.060**	−0.032	−0.052**
	(0.028)	(0.027)	(0.028)	(0.026)	(0.024)
Constant	0.317***	0.283***	0.321***	0.250***	0.222***
	(0.023)	(0.022)	(0.023)	(0.022)	(0.020)
Sample Mean	0.47	0.30	0.30	0.24	0.20
Observations	1,519	1,459	1,459	1,434	1,424

Notes: Table presents results of specification. [Add Notes] Standard errors reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.