VAT, Sales Tax, and Informality:

Does VAT Adoption Reduce Informality?

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Abstract: Informality can be staggeringly large and persistent in developing countries. While informality creates a fiscal problem, there is also growing evidence that excessive tax compliance burden weighs on the formal sector and thus makes formalization less attractive. This paper studies the impact of VAT adoption on eliminating informality using Indian firm-level surveys that contain a representative sample of formal and informal firms in the manufacturing sector. The paper features a structural framework that overcomes the limitation of natural experiments in identifying the effect of a single policy measure. I show that only 0.3% of informal firms register after VAT adoption, which corresponds to 3.5% increase in the number of formal firms. However, the expansion of the formal sector output (the intensive margin) is at a non-trivial magnitude of 8.8%. Large firms expand more than small ones after VAT adoption due to higher exposure to formal transactions. As for the concern on tax revenue loss from intermediate inputs, I show that VAT adoption leads to higher labor income and higher formal sector profits, which generate higher corporate tax and income tax to offset the VAT revenue loss. The results support the idea that economic growth comes from the expansion of the formal sector rather than the informal sector.

Introduction

In developing countries such as India and Latin American countries, the informal sector can be staggeringly large and persistent. A large part of the informal sector operates in crude environment and fails to comply with tax regulations. To the extent that informality is closely linked with development and state capacity, tackling informality has thus draw attention from both researchers and policy makers. While informality creates a fiscal problem, there is also growing evidence that tax compliance burden weighs on the formal sector and thus makes formalization less attractive (Bachi, 1994; Levy, 2008; Briand and Hoseini, 2020).

India has one of the most complex tax systems in the world according to the World Bank[1]. Since 2002, Indian states have gradually introduced VAT to replace the existing sales tax. After a decade-long journey, VAT was implemented in all states in 2014 before transferring into a more broad-based Goods and Services Tax (GST) in 2017. The "largest overhaul of the country's tax system"[2] was aimed to encourage compliance of the informal sector, reduce double taxation caused by overlapping taxes, and boost the manufacturing sector.

However, studying the linkage between VAT adoption and informality is inherently daunting. On the one hand, the informal sector often does not exist in the eyes of authorities because they do not register and do not have a track of transactions. Thus, data on the informal sector is rare in most countries. On the other hand, VAT is often simultaneously adopted with other policy measures, such as simplifying registration procedure and lowering registration costs. Empirical works face a challenge of identifying the effect of VAT adoption from other factors.

This paper study the impacts of VAT adoption in India from a structural perspective. To tackle the data challenge, I take advantage of the Indian UME (unorganized manufacturing enterprises) survey. The survey is based on the economic census, which is a complete count of all economic units, including establishments and individual firms that are not registered in tax authorities. The rich information on firms' operation and tax status provides valuable insights into the share of informal firms and outputs in the economy, which are the key concerns in the paper.

To tackle the identification challenge, I identify the effect of VAT adoption from a structural model based on De Paula and Scheinkman (2010). Different from the previous literature, this model allows the size of formal and informal sectors to change in the same or the opposite direction. This is a more realistic assumption to study the size of the informal sector relative to the formal sector. In the model, firms' tax status and output are linked to entry costs, VAT rate, VAT regime, etc. By controlling other factors, I can separate the impact of tax regime adoption on informality. My findings show that while VAT does not bring many unproductive informal firms to register or expand, it leads to a significant increase in formal sector outputs. The results support the idea that economic growth comes from the formal sector rather than the informal sector.

Specifically, I assume two stages of production, the upstream and the downstream. Firms are characterized by observed productivity. Upstream firms use labor to produce intermediate goods for downstream firms. Downstream firms produce final goods and sell to consumers. Formal firms are

[1] https://www.worldbank.org/en/news/feature/2018/03/14/india-development-update
[2] https://www.scribd.com/document/400347926/WSJ-30-March-2017

subject to tax liabilities and extra cost on labor; informal firms face penalty if detected by authorities. I adopted VAT in the model as an ad valorem tax. The tax rate applies to each sale, and downstream firm receive credits for the amount of tax paid by upstream formal suppliers on their sale of intermediate goods. Such tax credits do not exist in a cascading sales tax regime. Different from previous literature, I add entry and exit to the model so that the size of both sectors can change. To enter either the formal or informal sector, firms have to pay a one-time fixed cost and the cost is higher for the formal sector. I assume there is a fixed number of potential entrants with heterogeneous productivity waiting to join both sectors in each period. For exit, I assume an ad-hoc productivity shock in each period and a portion of incumbent firms will randomly quit the market. In the stationary equilibrium, the number of successful entrants into each sector equals the number of "dead" firms in each period.

In the counterfactual analysis, I compare VAT and cascading sales tax at the same tax rate. The results show that only 0.3% of informal firms registered after VAT adoption, which corresponds to 3.5% increase in the number of formal firms. However, the expansion of the formal sector output is at a non-trivial magnitude of 8.8% while the informal sector outputs shrink by 1%. I then study the incidence of growth among formal firms. Compared to cascading sales tax, large firms expand twice more than small ones after VAT adoption.[3] This is because large firms have a higher share of inputs from formal suppliers. The elimination of tax cascading, thus, offers a stronger tax relief for large firms than small ones.

One concern of replacing cascading sales tax is the loss of tax revenue from intermediate goods. I show that VAT adoption leads to higher labor income and higher formal sector profits, which generate higher corporate tax and income tax to offset the VAT revenue loss. The total tax revenue loss is less than 3% after adopting VAT at the same tax rate. If the VAT rate rises to keep the number of formal firms unchanged, total tax revenue will increase by 2%.

This paper is closely related to the literature on VAT adoption and informality. While there is consensus that a pure increase in tax rate increases revenue and informality, the results are mixed if there is a simultaneous change in the existing tax and VAT (Ulyssea, 2020; Emran and Stiglitz, 2005; Pomeranz, 2015; Keen, 2008). The paper that is closest to mine is Briand and Hoseini (2020) who find the increase of tax registration after VAT adoption in India. They rightly point out that removing tax cascading is the main reason of formalization after VAT reforms. Their results, however, is based on a reduced form regression that neglects the simultaneous change of other factors such as tax rate and registration costs.

This paper contributes to the study of VAT in developing countries' context from a structural point of view. The advantage of a model-based analysis is that we can go beyond the limits of natural experiment such as simultaneous policy changes. While VAT reforms with the same tax rate or the same registration procedures are rare, the model can simulate such counterfactual scenarios by controlling relevant parameters. Controlling for the tax rate, entry costs, and law enforcement, VAT adoption still leads to a significant expansion of formal sector outputs at limited cost of tax revenue. Hence, the paper identifies the pure impact of VAT in reducing informality, which supports the VAT-centric tax reforms in developing countries.

[3] I adjust the VAT rate so that the number of formal firms does not change after VAT reform. This eliminates the change of firm size due to new entrants. For example, the registration of small informal firms can drag down the average size of formal firms despite a size increase of the incumbents.

The paper also links to literature on the cause of informality. De Soto (1989) and Tokman (2007) portray informal firms as capitalists-in-waiting, reflecting the high tax burden and entry costs that prevent the entry of other small firms. Formalizing informal firms by reducing those costs will unleash the energy of the informal sector. Levy (2008) and Maloney (2004) argue that increasing formalization (by inducement or enforcement) will not have major impacts because the firms that have high returns from formalization have already registered. La Porta and Schleifer (2014) and Ulyssea (2018) document that informal firms usually operate in small scale and are far from competing with formal firms. They will not formalize even if tax burdens are removed or stronger enforcement is implemented.

This paper supports the last view by identifying that most informal firms are too unproductive to react to tax policy changes. Informality is not beauty; it is a mirror of the failure of the formal sector. Economic development comes from a booming formal sector rather than unleashing the energy of the informal sector. Policy makers should focus on expanding the formal sector through removing distortion and excessive tax burden imposed upon it. A VAT-centric tax reform is a feasible measure for developing countries to tackle informality and fosters economic growth.

Stylized facts on informality

Data

This paper uses tax registration to define informality. The firm-level annual survey of industries (ASI) and the unorganized manufacturing enterprises survey (UME) provide a representative sample of firms with registration information and operational information. Specifically, the ASI consists of manufacturing establishments registered under the factories Act, which covers all the manufacturing firms employing at least 20 workers or more than 10 workers while using industrial power. Each year, all establishments with more than 100 employees and at least 12% of the rest are surveyed with a representative sample at the state and 4-digit industry code level. The UME surveys are conducted every five years. The sample design of UME is based on the latest Economic Census: a complete count of all economic units in India synchronized with the house listing operations of the Population Census. In other words, UME covers all the manufacturing firms that are not covered by ASI.

Table 1 provides a summary of the number of observation and total number of firms in both surveys. Combining the two datasets, I construct a representative sample of all the manufacturing firms in India representative at the state level.

Another dataset used in the paper is transaction level data in West Bengal state. VAT-paying firms in West Bengal must report their purchases from and sales to other VAT-paying firms as required by the regulation. The transaction data contains information for 4.8 million transactions among formal firms between 2010 and 2016. Each supplier-client pair observation contains the tax code of both parties conducting the transactions.

[Table 1 is here]

Stylized facts

I use the combined ASI-UME dataset in 2015 and restrict the sample to manufacturing firms in West Bengal with more than two employees. This is to eliminate the household establishments that operates occasionally, which is usually not included in the tax base. For a description of the whole sample, see Appendix C.

I documented the stylized facts of informality that supports the dualism view: (i) informal firms are pervasive in number but only account for a small portion of total outputs; (ii) most informal firms are very small relative to an average formal firm; and (iii) formal (informal) firms mainly trade with other formal (informal) firms.

The size of the informal sector—Informal firms are prevalent in the Indian manufacturing sector, particularly in the downstream industries. Following Antras and Chore (2013), I calculate the downstream index for each 4-digit NIC industry using Indian I-O table (2015). For a more detailed description of the construction of the downstream index, see Appendix A. Industries whose downstream index is above the median value into the downstream and the rest to the upstream[4]. Figure 1 shows that overall, 95% of the firms in the manufacturing sector are informal. The share of informal firms is

[4] Appendix A presents the share of informality at 4-digit industry level.

particularly high in the downstream with 98% of the downstream firms being informal compared to 92% in the upstream. Despite the massive prevalence in number, informal firms only produce 21% of the total revenue in the manufacturing sector. The difference between the upstream and the downstream is also significant. The informal sector outputs account for 31% of total outputs in the downstream and 16% in the upstream. The result is consistent with the findings in Schneider and Melina (2018) that the informal sector produces 18% of GDP.

[Figure 1 is here]

Distribution of informal firms—As for the size of informal firm, I rank all the informal firms by their turnovers and select the firms at the 5^{th}, 25^{th}, 50^{th}, 75^{th}, and 95^{th} percentiles to calculate their relative size as of an average formal firm.

On average, an informal firm produces only 1.5% and 2.4% of output of a formal firm in the downstream and the upstream respectively. But even such small average size still overestimates the majority of informal firms. The median informal firm only produce 0.46% and 0.64% as much as an average downstream and upstream formal firm respectively. The 75^{th} percentile informal firm produces less than 1.5% of an average formal firm. The turnover of a large informal firm at the 95% percentile is 3.4% and 6% of an average formal firm in the downstream and the upstream respectively.

[Figure 2 is here]

Figure 3 draws dual world that highlights the separated distribution of formal and informal firms. Informal firms are clustered to the small size cohort with very limited overlap with the distribution of formal firms. Farrell (2004) documents a bunching problem that a productive informal firm might restrict its revenue below certain threshold to avoid being detected. In West Bengal, the official requirement for VAT registration is 5 million Rs. Appendix X graphs the histogram of the size of informal firms and does not find a bunching near the threshold.

[Figure 3 is here]

Trade structure of formal and informal sectors—A less documented feature of the informal sector is their trade pattern. A key constraint of analyzing domestic trade is the lack of inter-firm transaction data. Combining the transaction-level data with firm-level data, I calculate the share of inputs from formal suppliers over total inputs for both the formal sector. I also calculate the share of outputs to formal clients over total revenue. For a detailed calculation procedure, see Appendix B.

Figure 4 reveals a segmented trade structure in line with the dualism view. As for the share of formal inputs, formal firms mainly purchase from formal suppliers and informal firms mainly from informal suppliers. 80% of total inputs of the formal sector come from formal suppliers while only 29% of the informal sector's inputs is from formal suppliers. As for the share of formal outputs, formal firms sell 49% of total outputs to formal buyers while informal firms only sell 16% of their total output to the formal buyers.

[Figure 4 is here]

Theory and model

In this section, I extend the workhorse model in De Paula and Scheinkman (2010) to jointly decide the size of formal and informal sectors under VAT.

There are two stages of production, the upstream and the downstream. Upstream firms are characterized by observed productivity θ^u. They use labor to produce intermediate goods for downstream firms. I assume the labor market is competitive and the intermediate goods market is monopolistic competition. Formal firms are subject to VAT and extra cost on labor; informal firms face penalty if detected by authorities. To enter formal and informal sectors, firms have to pay a one-time fixed cost and the cost is higher for the formal sector. I assume there is a fixed number of potential entrants with heterogeneous productivity waiting to join both sectors in each period. Successful entrants will replace "dead" firms who exit the market after been hit by a random shock. The size of both formal and informal sectors is determined by profits and entry costs. For example, if profits for all potential entrants are higher, then more entrants will be able to cover the entry cost to become formal.

Downstream firms use intermediate goods from upstream firms and produce homogeneous final goods to consumers. I assume the final goods market is competitive so downstream firms are price takers. As in the upstream, downstream firms have heterogeneous productivity and face the same tradeoff except extra labor costs. I also assume entry costs to both formal and informal sectors in the downstream. Note that downstream firms have positive profits because the number of firms is limited in the equilibrium. While high productivity entrants enter the economy in every period, the model assumes that a part of incumbent high-productivity firms will exit the market. In the equilibrium, the number of productive entrants equals the number of productive quitters.

I adopted VAT in the model as an ad valorem tax. VAT is levied by the credit method. The tax rate applies to each sale and each establishment receives a credit for the amount of tax paid in the previous stages of production. The difference between VAT and cascading sales tax is the tax on intermediate goods. VAT removes the tax on intermediate goods used by downstream firms while cascading sales tax puts a tax wedge between downstream and upstream firms. The tax incidence is shared by upstream and downstream firms depending on the elasticity of supply and demand. In cascading sales tax, upstream formal firms will lower tax-exclusive prices to partly compensate for higher tax-inclusive prices; downstream formal firms will reduce the amount of intermediate goods from formal suppliers to avoid cascading tax.

1. Downstream firms.

Downstream formal and informal firms use the same technology to produce final goods. The production function is increasing, concave, and twice continuously differentiable. I assume a CES production function of downstream firms who uses inputs from a mass of upstream formal and informal firms.

1.1 Formal firms' cost minimization problem is given by:

$$min \int_0^N x(i)p^f(i)[1-\tau(i)]di \quad (1)$$

$$s.t.\ y_0 = \theta^d \left[\int_0^N x(i)^\rho \beta(i) di\right]^{\frac{\alpha}{\rho}} \quad (2)$$

Where θ^d is the observed productivity of downstream firms, $x(i)$ is the quantity of inputs from upstream firm i, $p^f(i)$ is the price paid by a formal downstream firm to an upstream firm i, y_0 is total output that maximize the profit. I use $\beta(i)$ to capture the quality difference between formal input and informal input. If the informal input is of poor quality, then $\beta(i)$ is smaller for informal input than its formal counterpart.[5] I set $\beta(i)$ equals β for all formal inputs and 1 for all informal firms. $\frac{1}{1-\rho}$ is the elasticity of substitution parameter between 0 and 1, α is a production coefficient between 0 and 1. Besides VAT, formal firms pay corporate tax on their profits at the rate of τ^{corp}.

1.2 Downstream informal firm

Informal firms face punishment and lose all its profits. I add an additional cost b_i on informal firms' total input. The punishment on the informal sector is often related to the size of informal firms. While a more general form for punishment can be adopted here as a function of firm size, for simplicity, I assume b_i is infinite if the expected discounted value of an informal firm exceeds the smallest formal firm as in De Paula and Scheinkman (2010).

The cost minimization problem of an informal firm is:

$$min \int_0^N b_i x^i(i) p(i) di \quad (3)$$

$$s.t.\ y_0^i = \theta^d [\int_0^N x^i(i)^\rho \beta(i) di]^{\frac{\alpha}{\rho}} \quad (4)$$

2. Upstream firms.

Upstream market is characterized by monopolistic competition where upstream firms have the market power to set prices of their products to different downstream buyers. I assume a simple linear function of labor input and output so that upstream firms' optimal prices to different buyers are separable. I also assume formal firms pay an extra cost on labor, including benefits, pensions, and social securities.

2.1. Upstream informal firms

When upstream formal firms sell to downstream formal firms, their profit maximization problem is:

$$max(1-\tau^{corp})[(1-\tau)p_f^f x_f^f - w(1+\tau_l) l(x_f^f)] \quad (5)$$

$$s.t. x_f^f = \theta^u l \quad (6)$$

When upstream formal firms sell to downstream informal firms, their profit maximization problem is:

[5] This resembles Antras and Chor (2013) who put an indicator function on the upstream product to emphasize its importance in the output. We can also rewrite the production function as $y_0 = \theta^d \{\int_0^N [x(i)\beta(i)^{1/\rho}]^\rho di\}^{\frac{\alpha}{\rho}}$. $\beta(i)$ can be interpreted as the share of inputs that is usable. Because informal firms produce lower quality goods, $\beta(i)$ is smaller for informal firms than formal ones.

$$max(1-\tau)p_f^i x_f^i - w(1+\tau_l)l(x_i^i) \quad (7)$$

$$s.t.\, x_f^i = \theta^u l \quad (8)$$

Where p_f^f and p_f^i is respectively the demand function of downstream formal and informal firms from equation (3), τ_l is the additional cost of labor for formal firms, θ^u is observevd productivity of upstream producers, and l is the number of workers hired by an upstream firm

2.2. Upstream informal firms

The profit maximization problem for informal firms selling to formal buyers is:

$$max\, x_i^f x_i^f - w(1+b_i)l(x_i^f) \quad (9)$$

$$s.t.\, x_i^f = \theta^u l \quad (10)$$

When upstream informal firms sell to downstream informal firms, the profit maximization problem is:

$$max\, x_i^i x_i^i - w(1+b_i)l(x_i^i) \quad (11)$$

$$s.t.\, x_i^f = \theta^u l \quad (12)$$

b_i is the punishment on informal firms with the same assumption as in the downstream.

3. Entry and exit

I assume there is endogenous entry but exogeneous exit. There are M potential entrants into the downstream market and M potential entrants into the upstream market in each period. Potential entrants observe their pre-entry productivity θ^d that follows the distribution $\theta^d \sim G^{\mathrm{d}}$. In each period, there is an ad-hoc productivity shock and a fixed proportion of firms will randomly exit the market. The exit rate is different between formal sector and informal sector, reflecting their different level of resilience to economics shocks. Hence, the value function based on pre-entry productivity θ as:

$$\widetilde{V_s} = max\left\{\frac{\pi_s(\theta)}{1-\kappa_s}, 0\right\} \quad (13)$$

κ_s is the probability of exit for sector s. The discount rate is normalized to 1.

Assume the realized productivity v follows the process: $v = \varepsilon\theta$, and remains constant in the following periods. The expected present value function is:

$$V_s = \int \widetilde{V_s} dF(v|\theta) \quad (14)$$

$F(v|\theta)$ is the CDF of realized productivity conditional on the observed productivity.

Firms will enter the formal sector if the expected value of being formal V_f is larger than the expected value of being informal V_i^d plus the difference of entry costs between the downstream formal sector E_f and the downstream informal sector E_i. Hence, a necessary condition for being formal is:

$$V_f > V_i + E_f - E_i, with\ \overline{V}_f\ as\ the\ cutoff\ present\ value \quad (15)$$

If a firm's expected present value is less than $\overline{V_f^u}$, then a firm can still choose to enter the informal sector or quit the market. The necessary condition for being informal is:

$$E_i < V_i < \overline{V_f^u} \quad (16)$$

However, if firms are surprised with a low productivity draw such that the present value based on the realized productivity is less that the corresponding entry costs, a firm will exit market immediately without producing. That is, a firm will quit the market if:

$$V_s^r < E_s$$

V_s^r is the realized present value of a firm in sector s, and E_s is the entry cost of sector s.

4. Equilibrium

To close the model, it is necessary to specify the demand of consumer. Assume a representative household with a utility function: $U = u(x)$. Total consumption x is the sum of labor income $(1 + \tau_l)wL^f + wL^i$, firm profit Π, and total tax T. Fines from informal firms are treated as sink cost or a compensation of law enforcement. Assume the total labor supply is fixed at $L = L^f + L^i$. All the components of consumption are endogenously determined by the model except the fixed total labor supply L.

$$consumption = (1 + \tau_l)wL^f + wL^i + \Pi + T$$

The equilibrium is determined by: (i) intermediate goods market clear, (ii) final goods market clear, (iii) labor market clear, and (iv) a stationary equilibrium.

4.1. Intermediate goods market clear

The demand of intermediate goods by buyer i from supplier j must equal the supply from supplier j to buyer i. This determines the optimal prices charged by upstream firms to downstream buyers.

4.2. Final goods market clear

The total supply of final goods by downstream firms equals the total demand of final consumers. Since the model does not have saving and investment, the household income is equal to the consumption of final goods.

4.3. Labor market clear

The total labor employed by upstream firm must equal the total labor supply by households. This equilibrium determines the equilibrium wage.

$$l(x_1^f) + l(x_2^f) + l(x_1^i) + l(x_2^i) = L \quad (17)$$

4.4. A stationary equilibrium

A stationary equilibrium requires that all aggregate variables remain constant. Therefore, the number of entrants in each sector equals the number of exits in the corresponding sector.

$$M_f^d = \frac{1 - F^d(\overline{v_f^d}|\overline{\theta_f^d})}{\kappa_f} M[G^d(\overline{\theta_f^d}) - G^d(\overline{\theta_i^d})] \quad (18)$$

$$M_i^d = \frac{F^d(\overline{v_f^d}|\overline{\theta_f^d})}{\kappa_i} M \cdot [G^d(\overline{\theta_i^d}) - G^d(\underline{\theta_i^d})] \quad (19)$$

$$M_f^u = \frac{1 - F^u(\overline{v_f^u}|\overline{\theta_f^u})}{\kappa_f} M[G^u(\overline{\theta_f^u}) - G^u(\overline{\theta_i^u})] \quad (20)$$

$$M_i^u = \frac{F^u(\overline{v_f^u}|\overline{\theta_f^u})}{\kappa_i} M \cdot [G^u(\overline{\theta_i^u}) - G^d(\underline{\theta_i^u})] \quad (21)$$

In equation (18), M Is the total number of potential entrants. $\overline{\theta_f^d}$ is the upper bound of downstream formal firms' observed productivity, $\overline{\theta_{\mathrm{i}}^{\mathrm{d}}}$ is the upper bound of downstream informal firms' observed productivity, $\underline{\theta_i^d}$ is the lower bound of downstream informal firms' observed productivity, $\overline{\mathrm{v_f^u}}$ is the upper bound of downstream formal firms' realized productivity. $\mathrm{M}[G^d\left(\overline{\theta_{\mathrm{f}}^{\mathrm{d}}}\right) - G^d(\overline{\theta_{\mathrm{i}}^{\mathrm{d}}})]$ is the ex-ante number of downstream firms who decide to enter the formal sector before drawing their realized productivity. $1 - \mathrm{F^d}(\overline{\mathrm{v_f^u}}|\overline{\theta_{\mathrm{f}}^{\mathrm{u}}})$ is the share of successful entrants into the formal sector over the ex-ante number of firms who decide to enter. $\mathrm{M}_f^{\mathrm{u}}$ is the total number of incumbent formal firms in the downstream. Thus, equation (18) requires that the number of successful entrants into the downstream formal sector in each period equals the total number firms that exit. The stationary equilibrium applies to the downstream informal sector, the upstream formal sector, and the upstream informal sector.

Since the model does not have an analytical solution, I run the estimation based on the numerical solution of the model. The simpler version of the model eliminates free entry and assume there is only one formal/informal firm in the upstream/downstream. The prepositions are shown in Appendix D.

Calibration and estimation

This section specifies the function form and discusses the estimation of the full model in an equilibrium setting. The equilibrium outcome should be able to capture the key stylized facts stated in the previous section. I use the simulated method of moment (SMM) to estimate the parameters in the model.

The first part will parameterize the functional forms of all the objects in the model. Then, I will discuss the SMM estimation and the selection of moments. Finally, I will report estimation results and model fitness.

1. Parameterization

Before estimating the parameters, I specify the distribution function of the observed productivity $G(\cdot)$ and the realized productivity $F(\cdot)$. The pre-entry productivity distribution $\mathrm{G}(\cdot)$ is assumed to follow the Pareto distribution. I allow the distribution of observed productivity to vary between the downstream and the upstream. Specifically, the downstream pre-entry productivity distribution $G^d(\cdot)$ and the upstream pre-entry productivity distribution $G^u(\cdot)$ have the following function forms:

$$G^d(\theta \geq x) = \begin{cases} \left(\frac{v_0}{x}\right)^{\xi^d} & for\ x \geq v_0 \\ 1 \quad for\ for\ x \leq v_0 \end{cases} \quad (22)$$

$$G^u(\theta \geq x) = \begin{cases} \left(\frac{v_0}{x}\right)^{\xi^u} & for\ x \geq v_0 \\ 1 \quad for\ for\ x \leq v_0 \end{cases} \quad (23)$$

where v_0 is the minimum possible value of X, and ξ is a positive shape parameter. The only difference of the pre-entry productivity distribution between the upstream and the downstream is the parameter ξ, which governs the right tail of the distribution. This setting requires the same minimum size of firm in both the downstream firms and the upstream, but allows the maximum size of firms (large firms) to differ. This is consistent with our data where we limit the minimum size of firm to be 3 employees while not controlling for the maximum size of firms.

Remember the realized productivity distribution follows a simple process $v = \theta\varepsilon$. I assume the misperception of productivity ε has a log-normal distribution with mean zero and variance of σ^2. Therefore, realized productivity v is the product of a log-normal and a Pareto random variable, which follows the Pareto-Lognormal distribution. The three-parameter distribution has a log-normal body and a Pareto right tail, which indicates a large share of small firms and some super-large firms. Luttmer (2007) and Ulyssea (2018) prove that the Pareto-Lognormal distribution fits many salient features of firm size distribution in developing countries.

2. Calibration and estimation of parameters

The parameters are divided into two sets. The first set includes 3 parameters which are calibrated from the real data. These parameters are:

$$\psi = \{\tau, \tau^{corp}, \kappa_f\}$$

The second set includes 12 parameters, which are estimated by SMM. These parameters are:

$$\varphi = \{\beta, \xi^d, \xi^u, E_i^d, E_f^d, E_i^u, E_f^u, \alpha, \rho, \tau_l, \kappa_i, \sigma\}$$

2.1 Calibration

The corporate tax rate is set to 30%, which equals the effective corporate tax rate for domestic companies in India in 2015[6]. I use the 2015 VAT rate in West Bengal to calibrate the VAT tax rate, which equals 5% (Briand and Hoseini, 2015). The exit rate of formal firm is calibrated from ASI annual data (2014-15). After controlling for the industry fixed effect, the exit rate of formal firm is calibrated at 8%. The Pareto distribution scale parameter (v_0) is set to 6.7 in accordance with Ulyssea (2018). This parameter only affects the scale of the key variables.

2.2 SMM estimator

Given the calibrated parameters in the first step, I use the SMM estimator to obtain the second set of parameters. The basic idea of SMM estimator is to find a set of parameters so that it generates a dataset whose moments fits the moments from the real data. For any given set of parameters, the model will generate a full set of observations that simulates firms' behavior, including tax status, outputs, and trade structure. I the use this set of observations to generate the set of moments listed in the stylized facts, which capture the key feature of the informal sector in the economy. The SMM estimator is the set of parameters that best approximates the moments calculated from the real data. Appendix G provides a detailed discussion of the SMM estimator.

First, I bootstrap the real data 500 times so that I have 500 sets of bootstrapped datasets. Using these datasets, I calculate the vector of moments for each dataset and take the mean of all vectors of moments and the standard deviation of all vectors of moments.

$$\widehat{m_N} = \frac{1}{N}\sum_{i=1}^{N} m_i \quad (24)$$

m_i is the vector of moment in the i[th] dataset and $\widehat{m_N}$ is the mean of all the vectors of moments.

Second, I choose the initial set of parameters $\varphi_0$to generate 50 simulated datasets. Then I calculate the vector of simulated moments for each dataset and take the mean of all vectors of moments.

$$\widetilde{m_N} = \frac{1}{N}\sum_{i=1}^{N} \widetilde{m_i}(\psi, \varphi_0) \quad (25)$$

$\widetilde{m_i}(\psi, \varphi_0)$ is the vector of moments from the i[th] simulated dataset and $\widetilde{m_N}$ is the mean of all the vectors of simulated moments.

Third, I define the distance between the real moments $\widehat{m_N}$ and the simulated moments $\widetilde{m_N}$ as $g(\psi, \varphi_0) = \widehat{m_N} - \widetilde{m_i}(\psi, \varphi_0)$. Then the SMM estimator is:

$$\hat{\varphi} = argmin\{g(\psi, \varphi_0)'\widehat{W_N}g(\psi, \varphi_0)\}$$

Where $\widehat{W_N}$ is a positive, semi-definite $r \times r$ matrix and r is the length of the vector of moments $\widehat{m_N}$. Under the suitable regularity conditions, the estimator is consistent and asymptotically normal and the

[6] https://tradingeconomics.com/india/corporate-tax-rate

weighting matrix $\widehat{W_N}$ is chosen optimally in order to minimize the asymptotic covariance. I use the variance of real moments as $\widehat{W_N}$. For detailed discussion, see Appendix G.

2.3 Moments and identification

I choose 24 moments to capture extensive and intensive margins of informality, including: (i) the share of informal firms in the downstream, the share informal firms in the upstream, the share of informal firm outputs in the downstream, the share of informal firm outputs in the upstream (4); (ii) the ratio of output by the 5^{th},25^{th}, 50^{th}, 75^{th}, 90^{th} percentile informal firms over the average formal firm output in the downstream, and the same ratio in the upstream (10); the ratio of output by the 5^{th}, 10^{th} percentile informal firms over the average formal firm output in the downstream, and the same ratio in the upstream (4); (iii) the share of input from formal suppliers in the formal sector, the share of input from formal suppliers in the informal sector, the share of output to the formal buyers in the formal sector, the share of output to the formal buyers in the informal sector (4); (iv) the standard deviation of outputs divided by the mean output (coefficient of variance) in the downstream and upstream (2).

I provide an intuitive analysis on how these moments determine the parameters. The distribution of informal and formal firms in the downstream/upstream determines the Pareto shape parameter in the downstream/upstream. The larger share of small informal firms indicates a more clustered distribution of productivity and a larger Pareto shape parameter. The share of the number of informal firms in the downstream/upstream determines the entry cost into the downstream/upstream sector, in which the higher entry cost leads to a larger share of informal sector.

The trade structure and the distribution of upstream formal and informal firms jointly determine the extra cost of formal worker τ_l. Higher extra cost of formal labor results in a smaller formal sector in the upstream, and less purchase from formal sellers among downstream buyers. Small formal sellers are more sensitive towards extra labor costs due to lower labor productivity by assumption. The trade structure and the distribution of downstream firms jointly determines the quality of formal input β. Higher quality of formal input induces both formal and informal buyers to purchase from formal suppliers and enlarge their outputs. However, the larger firms benefit more from higher input quality since they purchase more from formal sellers.

3. Estimates and model fit

Table 2 shows the calibration and estimation results. The entry cost into the formal sector in the is 1.1 and 1.8 times of the average annual profit of a formal firm in the downstream and the upstream respectively. This suggest that it is more difficult to enter the formal sector in the downstream than in the upstream, which is consistent with the larger share of informal sector in the downstream than the upstream. Moreover, the entry costs into the formal sector equals 90 and 37 times of the average annual profit of an informal firm in the downstream and upstream respectively. Informal firms are too unproductive to overcome the entry cost into the formal sector. But in fact, below analysis will show that even entry costs are removed, most informal firms will not survive from competition of formal firms. The Pareto shape parameters governed by the relative size of an average informal firm is 2.35 for the downstream firms and 1.4 for the upstream firms.

The parameters disciplined by the trade structure are consistent with the hypothesis. First, the quality parameter of the formal inputs β is 1.15, which indicates that the quality of formal inputs is 15% higher

than informal inputs. The difference of labor cost between the formal and informal sector is 10.7. This means that formal firms will have to pay 11 times more wage on a worker than informal firms.

[Table 2 is here]

Table 3 compares the moments generated from the real data and from the model using the above parameters. The model captures the share informal firms and outputs but overestimates relative size of large informal firms in the upstream. The model does not fit well the relative size of small formal firms, partly due to the different constraints or advantages enjoyed by small formal firms.

The model predicts that share of the number of informal firms in the downstream and the upstream is 97% and 93% respectively, with less than 1% deviation from the real data. The model predicts that 30% of the downstream output and 14% of the upstream output are produced by informal firms. This is similar to the share of output in the real data at 31% and 16% in the real data. In general, the model captures the pervasive number of informal firms in both the downstream and the upstream who contribute a small fraction of total outputs.

In the model, the relative size of an informal firm in each quantile is 0.22%, 0.31%, and 0.66% as an average formal firm in the downstream. This is similar to the moments from the real data, except the model predicts a smaller relative size of the third quantile informal firm. As for the upstream informal firms, the model predicts relative size of an informal firm in each quantile at 0.09%, 0.19, 0.72% of an average formal firm, which is about of half the value in the real data. For small formal firms, the model overestimates the size of downstream small firms relative to an average formal firm. One reason is that the model does not have size-dependent constraints that apply to small formal firms, such as access to finance. These factors lead to a smaller size of small formal firms than the model predicts.

The model predicts a segmented trade structure where formal firms purchase 80% of their inputs from formal sellers while informal firms only purchase 43% of their inputs from formal sellers. The share of sale to formal buyers is 48% and 28% for formal and informal firms respectively in the model, compared to 48% and 16% in the real data. In general, the model captures the segmented trade structure where formal (informal) firms are more likely buy or sell to other formal (informal) firms.

[Table 3 is here]

Figure 5 illustrates the framework by plotting the relationship between firm productivity and the *counterfactual* values of entering the formal and informal sector (net of entry costs). The blue line shows the value of entering the informal sector for each level of productivity, and the orange line similarly shows the value of entering the formal sector. There is a positive relationship between productivity and value of entry in either the formal or informal sector, but the shape of this relationship differs across the two. The vertical distance between the two lines represents, for each level of productivity, the difference in the value of the firm between the two choices/statuses of either being formal or informal.

Firms with the lowest levels of productivity have a negative value of entry into the formal sector. This is because their net profits are either negative, or not large enough to cover the fixed costs of formality. In contrast, they have a positive value of entering the informal sector because if they do so, they will not be

paying taxes or the entry costs. Hence, these low-productivity firms will choose to enter the informal sector.

As productivity rises, profit net of taxes starts to outweigh the fixed costs of formalization, while the expected penalty of informality shoots up. Hence, as productivity rises, the value of entering the formal sector rises faster than that of entering the informal sector. Thus, there is cutoff level of productivity θ^1 such that firms with productivity below the cutoff choose to enter the informal sector and those above it choose to enter the formal sector.

[Figure 5 is here]

4. Identifying different type of informal firms: Reservoir or parasite or unproductive?

In the introduction, I have listed three views of informality. Now I categorize the informal firms into the corresponding groups, namely reservoir, parasite, and unproductive groups. According to the model setup, I define the reservoir-type firms as those who will become formal after all tax burdens (VAT and corporate tax) are removed. This means that when the tax rates lower to zero, these firms will have a present value of being formal that is higher than that of being formal plus the difference of entry costs between formal and informal sectors. I define parasite-type firms as those who will remain informal but can actually survive as formal ones when all tax burdens are removed. When tax rates lower to zero, these firms will have a present value of being formal burden that is higher than the entry cost of the formal sector but lower than the present value of being informal plus the difference of entry costs between formal and informal sectors. I define unproductive-type firms as those who will remain informal and will quit the market as formal ones when all tax burdens are removed. When tax rte lower to zero, these firms will have a negative present value of being formal but a positive present value of being informal.

My results echo the “dualism” view that most informal firms are too unproductive to formalize. Figure 6 shows more than 99.6% of informal firms cannot survive as formal ones even if tax rates lower to zero.

A small fraction of informal firms as capitalists in the “reservoir” or “parasites” in the market. 0.12% and 0.3% of informal firms belongs to the “parasite”-type of firms in the downstream and the upstream respectively; 0.04% of downstream and 0.15% upstream informal firms are “reservoir”-type. When tax rates are lower, some of the reservoir-type firms will rationally choose to formalize. On the contrary, the parasite-type firms will opt to remain informal even if tax burdens are completely removed. But these firms can actually survive as formal ones. The unproductive-type firms, unfortunately, are the majority of informal firms who are too unproductive to survive as formal ones even after tax burdens are removed.

[Figure 6 is here]

It is worth noting that different views of informality imply sometimes contradictory policy recommendations on informality. The “reservoir” view of informality implies “carrot” policy which reduces the cost of the formal sector. When tax burdens are lowered, productive firms in the reservoirs will formalize and contribute to the tax revenue. De Paula and Scheinkman (2010) argue that creating

incentives for formalization is an important step to increase aggregate productivity, include reducing the costs of doing business, tackling corruption, and improving access to finance and services. The “parasite” view of informality suggests “stick” policy by enhancing the law enforcement on the informal sector. In practice, a sizeable minority of informal firms report having received some type of inspection visit (most often from municipality), but very few firms report being fined (Bruhn and McKenzie, 2014). Echoed by Andrade et al. (2013), they show that more enforcement by inspectors can induce informal firms to become formal. The “dualism” view of informality suggests “development” policy should aim at expanding the formal sector. Without a significant productivity increase in the formal sector, these firms will never be able to compete with formal firms and survive as formal ones even without tax burdens.

Counter-factual analysis: VAT vs. cascading sales tax

In the counterfactual analysis, I consider three scenarios of VAT reform that replace a cascading sales tax at the rate of 7.5%. The first VAT scenario has the same tax rate of 7.5% as the cascading sales tax. The second VAT scenario has the tax rate at 8.2% that generates the same amount of formal and informal firms after reform (informality-neutral). The third VAT scenario has the tax rate at 13.4% that generates the same level of VAT tax as the cascading sales tax (revenue-neutral).

Informality: number and outputs

[Table 4 is here]

shows share of informality after VAT reforms. In the first scenario with the same tax rate, the share of formal firms slightly rises from 3.87% to 4.01% and the share of formal outputs rises from 81.6% to 82.97%. When the tax rate rises to 10.4%, the share of formal firm is informality-neutral which means the number of formal firms remain the same as before the reform. The share of formal firms in the economy remains similar at 3.85% which accounts for 81.7% of total outputs. When the VAT rate is 10%, it collects the same amount of VAT as cascading sales tax (revenue-neutral). The share of formal firms is 3.87% and the share of formal output is 82%.

[Table 4 is here]

However, the share of informality neglects the change in the absolute number of informal firms and the total volume of informal outputs. Table 5 shows the change of absolute number of firms and total volume of output when replacing sales tax with VAT. The number of formal firms increases by 3.5% under VAT with the same tax rate than sales tax regime. These formal firms produce 9% more outputs than before the reform, suggesting. On the other hand, the number of informal firms drops by 0.3% and its outputs drop by 0.9%. In the second informality-neutral scenario, the number of formal firms remains unchanged but its output increases by 2%. The informal sector slightly expands by 0.5% in number and 1.5% in outputs. In the third revenue-neutral scenario, the number of formal and informal firms increases by 0.3% and 3% respectively, accounting for 3% and 0.4% increase in their outputs respectively.

The number of formal firms does not change significantly, or the change on the extensive margin of formality is small. This is consistent with the previous finding that most informal firms are too unproductive to formalize. However, the intensive margin of formality or the share of formal output increases at a non-trivial magnitude, suggesting an increase in the size of formal firms.

[Table 5 is here]

However, the growth of the formal sector is not equal. Large firms grow more than small ones when informality-neutral VAT replaces the cascading sales tax[7]. In the downstream, small firms below the median size grow less than 3% while firms at the 90th percentile grow by 4.3%. In the upstream, small firms at the 10th percentile, 50th percentile, and 90th percentile grow by 1.5%, 2.8%, and 3.4% respectively (Figure 7).

The size-dependent growth in size arises from size-dependent exposure to formal transactions. VAT removes the tax cascading on formal inputs and reduce the cost on intermediate inputs, which improves production efficiency of downstream formal firms. VAT also sharpens the competitiveness of upstream formal firms whose intermediate products becomes relatively cheaper for formal firms than before. Formal sellers raise their selling prices to the formal buyers because they envisage that formal buyers can get tax credit by purchasing from them. Informal sellers, on the other hand, are not able to increase their prices to formal buyers because their products do not give tax credits. Therefore, formal sellers find it more profitable to sell to formal buyers than informal sellers do.

Therefore, firms with larger exposure to formal transaction benefit more from the removal of tax cascading. Downstream firms with a higher share of formal inputs experience a larger decrease in input costs, while upstream firms with a higher share of outputs to formal buyers gain a higher profit from selling to formal buyers. Figure 7 shows that large firms often have larger exposure to formal transactions. Small downstream formal firms at the 10th percentile purchase 50% of inputs from formal suppliers while large firms at the 90th percentile purchase two thirds of inputs from formal suppliers. Therefore, tax deduction is higher for large firms than small ones, which leads to an uneven growth in the downstream. Similarly, small upstream formal firms at the 10th percentile sell 41% of their outputs to the formal sector while large firms at the 90th percentile sell 46% of outputs to the formal sector. The latter gains more from selling to formal buyers than the former.

[Figure 7 is here]

Now that we find a segmented trade structure between formal and informal sectors, a subsequent question is: to what extend the segmented trade can be attributed to VAT. Table 6 compares the share of inputs from and outputs to the formal partners. In the baseline scenario, the formal sector purchase 67% of inputs from formal suppliers and sells 41% of outputs to formal buyers. After VAT reform at the same tax rate, the share of formal purchase rises to 72% and the share of outputs to formal buyers rises to 46%. Different VAT tax rate does not change the magnitude of change much.

It is true that VAT leads to a slightly more segmented trade structure, but the main reason of segmentation is the quality difference between formal and informal inputs. In fact, if we lower the quality of formal inputs by 50%, the trade structure becomes less segmented even under VAT. This is consistent with the "dualism" view that informal firms are too unproductive to trade with (large) formal firms.

[Table 6 is here]

[7] Since the extensive margin of formality does not change in the informality-neutral scenario, it is easier to interpret the results on firm growth at different percentiles.

Taxation, corporate profits, and household income

Then what about the tax revenue? One concern of the existence of a large informal sector is the potential loss of tax revenue which could have been used to finance public goods. Besley and Persson (2013) emphasize the difference in tax revenues to GDP ratios across developing and industrialized countries and argue that the main question in taxation and development is: "how does a government go from raising around 10% of GDP in taxes to raising around 40%?"

First, VAT reform generates less VAT revenue than cascading sales tax revenue if the tax rate remains the same or informality neutral. VAT revenue decreases by 45% and 39% in the same-rate scenario and the informality-neutral scenario. However, when considering corporate tax, these two scenario does not reduce total tax revenue despite a loss of VAT revenue. VAT reduces the tax burden and improve the production efficiency of formal firms. This leads to an increase in formal firms' profits which leads to higher corporate tax. The increase of corporate tax offsets the loss of VAT revenue so that the overall tax loss is zero. On the other hand, if the VAT rate is revenue neutral, it squeezes the profits of formal firms and leads to an overall tax loss by 3% when considering corporate tax.

In fact, the correlation between VAT rate and total tax revenue is negative. While higher VAT rate leads to higher VAT, it also decreases the formal firms' profit and corporate tax revenue. The reduction in corporate tax is more than offset the increase in VAT, which leads to a negative correlation between tax rate and total tax revenue (Figure 8).

[Figure 8 is here]

Second, VAT increases labor demand of the formal sector and increases equilibrium wage of both formal and informal workers. Table 7 shows that the VAT reform not only increases the wage of formal workers, but also maintains the income of informal workers. When replacing sales tax with the informality-neutral VAT, total wage income of formal workers will increase 4% while informal workers' wage will remain unchanged. Since the model assume a fixed amount of labor in the economy, this implies the wage rate increases for workers in the formal sector. In the tax-neutral scenario, the positive impacts of VAT on household income disappear. Formal workers lose 9% of income while informal workers remain unchanged.

For informal firms, a distinctive feature is the blurred boarder between firm profit and individual wage. A loss of corporate profit could also make informal workers worse off despite an unchanged wage income. I show that the corporate profit also remains the same level after informality-neutral VAT reform.

[Table 7 is here]

Conclusion

In the past thirty years, more than 50 countries adopted VAT. Yet its impact on informality is not well understood. This paper presents a structural framework to study the relationship between VAT adoption and informality. My findings show that while VAT does not bring many unproductive informal firms to register or expand, it leads to a significant increase in formal sector outputs. The results suggest a viable policy to tackle informality should aim at removing distortions and excessive tax burdens imposed upon the formal sector.

Specifically, I assume two stages of production, the upstream and the downstream. Firms are characterized by observed productivity. Upstream firms use labor to produce intermediate goods for downstream firms. Downstream firms produce final goods and sell to consumers. Formal firms are subject to tax liabilities and extra cost on labor; informal firms face penalty if detected by authorities. I adopted VAT in the model as an ad valorem tax. The tax rate applies to each sale, and downstream firm receive credits for the amount of tax paid by upstream formal suppliers on their sale of intermediate goods. Such tax credits do not exist in a cascading sales tax regime. Different from previous literature, I add entry and exit to the model so that the size of both sectors can change. To enter either the formal or informal sector, firms have to pay a one-time fixed cost and the cost is higher for the formal sector. I assume there is a fixed number of potential entrants with heterogeneous productivity waiting to join both sectors in each period. For exit, I assume an ad-hoc productivity shock in each period and a portion of incumbent firms will randomly quit the market. In the stationary equilibrium, the number of successful entrants into each sector equals the number of "dead" firms in each period.

In the counterfactual analysis, I compare VAT and cascading sales tax at the same tax rate. The results show that only 0.3% of informal firms registered after VAT adoption, which corresponds to 3.5% increase in the number of formal firms. However, the expansion of the formal sector output is at a non-trivial magnitude of 8.8% while the informal sector outputs shrink by 1%. I then study the incidence of growth among formal firms. Compared to cascading sales tax, large firms expand twice more than small ones after VAT adoption. This is because large firms have a higher share of inputs from formal suppliers. The elimination of tax cascading, thus, offers a stronger tax relief for large firms than small ones.

One concern of replacing cascading sales tax is the loss of tax revenue from intermediate goods. I show that VAT adoption leads to higher labor income and higher formal sector profits, which generate higher corporate tax and income tax to offset the VAT revenue loss. The total tax revenue loss is less than 3% after adopting VAT at the same tax rate. If the VAT rate rises to keep the number of formal firms unchanged, total tax revenue will increase by 2%.

Developing countries often face an urgent need to reform the chaotic and complex systems of domestic trade tax. A levy of tax on inputs and factors, lack of harmony in states' sales tax system, and exclusion of service sector from the tax base results in a cascading effect of tax upon tax. This paper shows the cascading of tax impedes production efficiency and exerts excessive tax burden on the narrow tax base (usually the formal sector). Removing such distortion and streamlining the tax system would foster growth of the formal sector.

For policy makers trying to tackle informality, this paper suggests that the reduction of informality is driven by the expansion of formal firms. As economies grow, the informal sector remains stagnant and unproductive. Labor and capital will gradually shift from the informal sector to the formal one provided a free mobility of resources. The process could be slow, particularly in countries with tax cascading that

slows down the absorption of labor and capital in the formal sector. But the process will take place. Tax reforms can speed up the expansion of the formal sector and eventually kill the informal sector.

Reference

Antràs, Pol, and Davin Chor. "Organizing the global value chain." *Econometrica* 81.6 (2013): 2127-2204.

Bagchi, Amaresh, et al. "Reform of domestic trade taxes in india: issues and options." *National Institute of Public Finance and Policy, New Delhi* (1994).

Banerji, Arup, and Sanjay Jain. "Quality dualism." *Journal of Development Economics* 84.1 (2007): 234-250.

Benjamin, Nancy C., and Ahmadou Aly Mbaye. "The Informal Sector, Productivity, and Enforcement in West Africa: A Firm-level Analysis." *Review of Development Economics* 16.4 (2012): 664-680.

Besley, Timothy, and Torsten Persson. "Taxation and development." *Handbook of public economics*. Vol. 5. Elsevier, 2013. 51-110.

Besley, Timothy, Ethan Ilzetzki, and Torsten Persson. "Weak states and steady states: The dynamics of fiscal capacity." *American Economic Journal: Macroeconomics* 5.4 (2013): 205-35.

Briand, Oceane, and Mohammad Hoseini. *VAT reform, distortions, and informality: evidence from Indian states*. Working Paper, 2015.

Bruhn, Miriam, and David McKenzie. "Entry regulation and the formalization of microenterprises in developing countries." *The World Bank Research Observer* 29.2 (2014): 186-201.

Bruhn, Miriam. "A tale of two species: Revisiting the effect of registration reform on informal business owners in Mexico." *Journal of Development Economics* 103 (2013): 275-283.

Chelliah, Raja J. "Agenda for Comprehensive Tax Reform." *Indian Economic Journal* 41.3 (1994): 38.

Dabla-Norris, Era, Mark Gradstein, and Gabriela Inchauste. "What causes firms to hide output? The determinants of informality." *Journal of development economics* 85.1-2 (2008): 1-27.

De Andrade, Gustavo Henrique, Miriam Bruhn, and David McKenzie. *A helping hand or the long arm of the law? Experimental evidence on what governments can do to formalize firms*. The World Bank, 2013.

De Giorgi, Giacomo, and Aminur Rahman. "SME's Registration: Evidence from an RCT in Bangladesh." *Economics Letters* 120.3 (2013): 573-578.

De Mel, Suresh, David McKenzie, and Christopher Woodruff. "The demand for, and consequences of, formalization among informal firms in Sri Lanka." *American Economic Journal: Applied Economics* 5.2 (2013): 122-50.

De Paula, Aureo, and Jose A. Scheinkman. "Value-added taxes, chain effects, and informality." *American Economic Journal: Macroeconomics* 2.4 (2010): 195-221.

De Soto, Hernando. "The other path." (1989).

Fajgelbaum, Pablo D., et al. "State taxes and spatial misallocation." *The Review of Economic Studies* 86.1 (2019): 333-376.

Farrell, Diana. "hidden dangers." *The McKinsey Quarterly* 3 (2004): 26.

Fotoniata, Eugenia, and Thomas Moutos. "Product Quality, Informality, and Child Labor." *Review of Development Economics* 17.2 (2013): 268-283.

Fullerton, Don. "On the possibility of an inverse relationship between tax rates and government revenues." *Journal of Public Economics* 19.1 (1982): 3-22.

Gadenne, Lucie, Tushar K. Nandi, and Roland Rathelot. "Taxation and Supplier Networks: Evidence from India." (2019).

Gelb, Alan, et al. "To formalize or not to formalize? Comparisons of microenterprise data from Southern and East Africa." *Comparisons of Microenterprise Data from Southern and East Africa (July 20, 2009)* (2009).

Gérard, François, and Joana Naritomi. "Value Added Tax in developing countries: Lessons from recent research." *IGC Growth Brief Series* 15 (2018).

Gerard, François, Joana Naritomi, and Arthur Seibold. *Tax systems and inter-firm trade: evidence from the VAT in Brazil*. Tech. rep., Mimeo London School of Economics, 2018.

Gordon, Roger, and Wei Li. "Tax structures in developing countries: Many puzzles and a possible explanation." *Journal of public Economics* 93.7-8 (2009): 855-866.

Hsieh, Chang-Tai, and Peter J. Klenow. "Misallocation and manufacturing TFP in China and India." *The Quarterly journal of economics* 124.4 (2009): 1403-1448.

Ihrig, Jane, and Karine S. Moe. "Lurking in the shadows: the informal sector and government policy." *Journal of Development Economics* 73.2 (2004): 541-557.

Kaplan, David S., Eduardo Piedra, and Enrique Seira. *Entry regulation and business start-ups: Evidence from Mexico*. The World Bank, 2007.

Keen, Michael, and Ben Lockwood. "The value added tax: Its causes and consequences." *Journal of Development Economics* 92.2 (2010): 138-151.

Keen, Michael. "Targeting, cascading and indirect tax design." *Indian Growth and Development Review* (2014).

La Porta, Rafael, and Andrei Shleifer. "Informality and development." *Journal of Economic Perspectives* 28.3 (2014): 109-26.

Levy, Santiago. *Good intentions, bad outcomes: Social policy, informality, and economic growth in Mexico*. Brookings Institution Press, 2010.

Loayza, Norman V., and Jamele Rigolini. *Informality trends and cycles*. The World Bank, 2006.

Luttmer, Erzo GJ. "Selection, growth, and the size distribution of firms." *The Quarterly Journal of Economics* 122.3 (2007): 1103-1144.

Maloney, William F. "Informality revisited." *World development* 32.7 (2004): 1159-1178.

McFadden, Daniel. "A method of simulated moments for estimation of discrete response models without numerical integration." *Econometrica: Journal of the Econometric Society* (1989): 995-1026.

Medina, Leandro, and Friedrich Schneider. "Shadow economies around the world: what did we learn over the last 20 years?." (2018).

Medvedev, Denis, and Ana María Oviedo. *Informality and profitability: Evidence from a new firm survey in Ecuador*. The World Bank, 2013.

Papp, Tamás K., and Elöd Takáts. *Tax Rate Cuts and Tax Compliance--The Laffer Curve Revisited (EPub)*. International Monetary Fund, 2008.

Pomeranz, Dina. "No taxation without information: Deterrence and self-enforcement in the value added tax." *American Economic Review* 105.8 (2015): 2539-69.

Porta, Rafael La, and Andrei Shleifer. *The unofficial economy and economic development*. No. w14520. National Bureau of Economic Research, 2008.

Prado, Mauricio. "Government policy in the formal and informal sectors." *European Economic Review* 55.8 (2011): 1120-1136.

Steel, W., and Donald Snodgrass. "Raising productivity and reducing risks of household enterprises: diagnostic methodology framework." *World Bank Africa Region Analysis on the Informal Economy with the support of the WIEGO network* (2008).

Trabandt, Mathias, and Harald Uhlig. "The Laffer curve revisited." *Journal of Monetary Economics* 58.4 (2011): 305-327.

Ulyssea, Gabriel. "Firms, informality, and development: Theory and evidence from Brazil." *American Economic Review* 108.8 (2018): 2015-47.

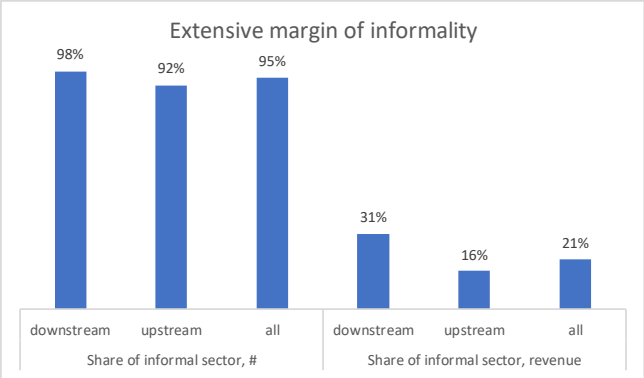


Figure 1: Share of informal sector

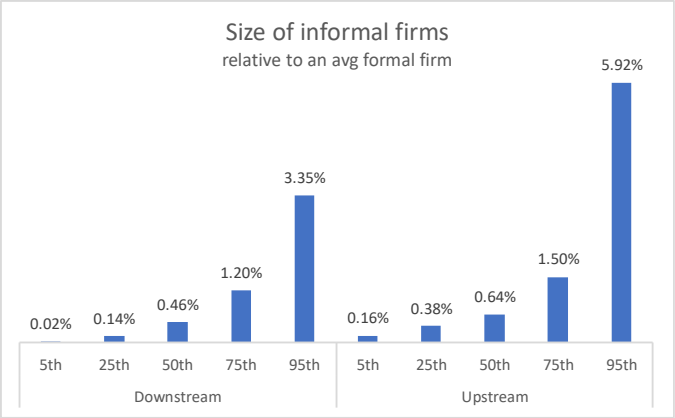


Figure 2: average size of an informal firm relative to a formal one

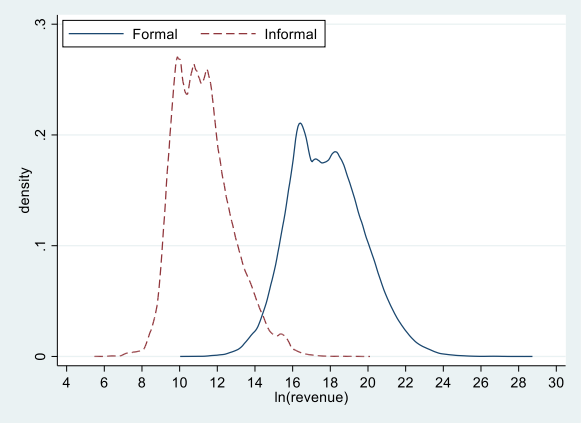


Figure 3: distribution of size of manufacturing firms

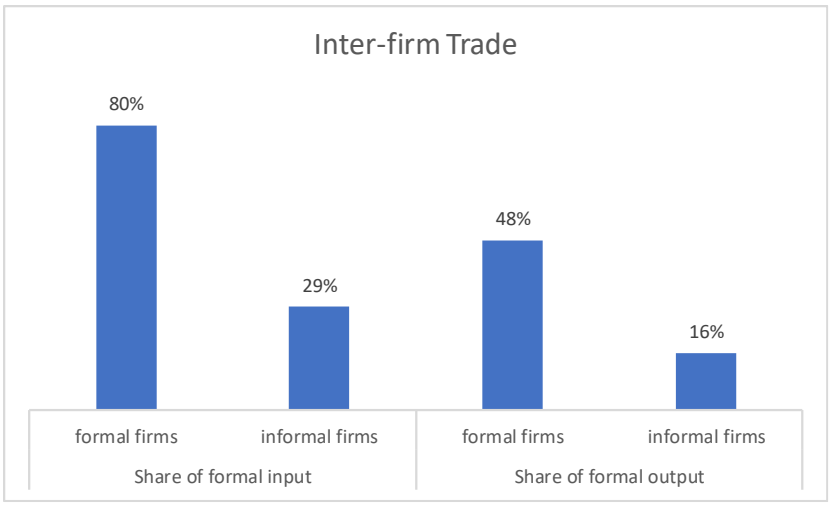


Figure 4: trade pattern

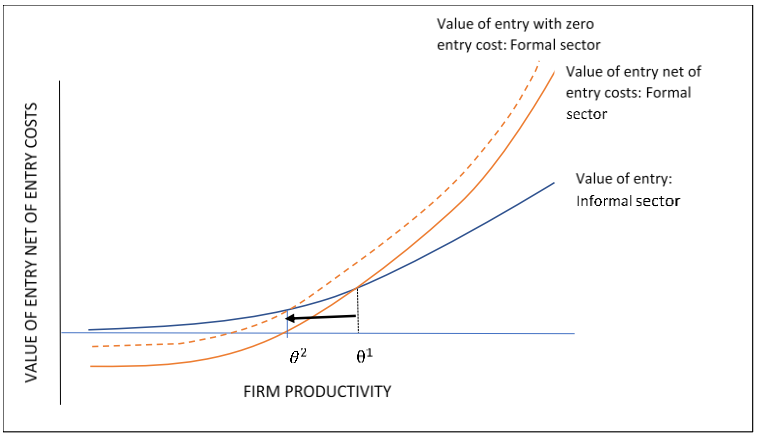


Figure 5: illustrative analysis of formalization choice

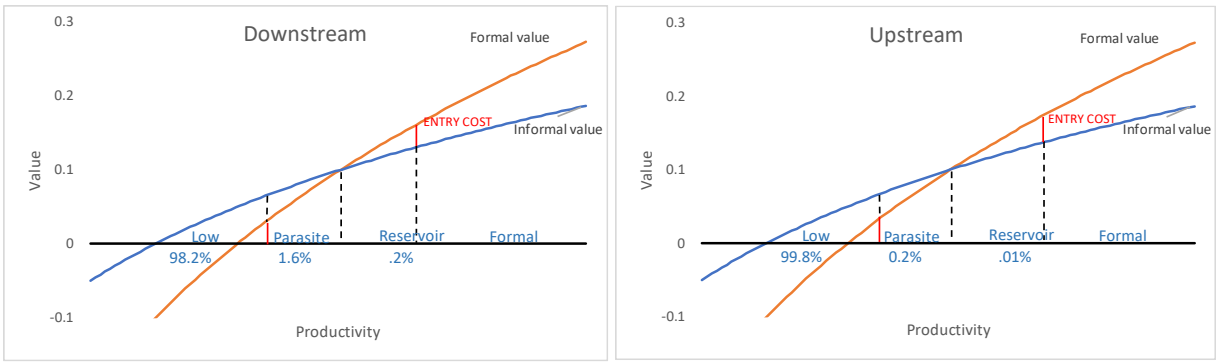


Figure 6: type of informal firms in the upstream and the downstream

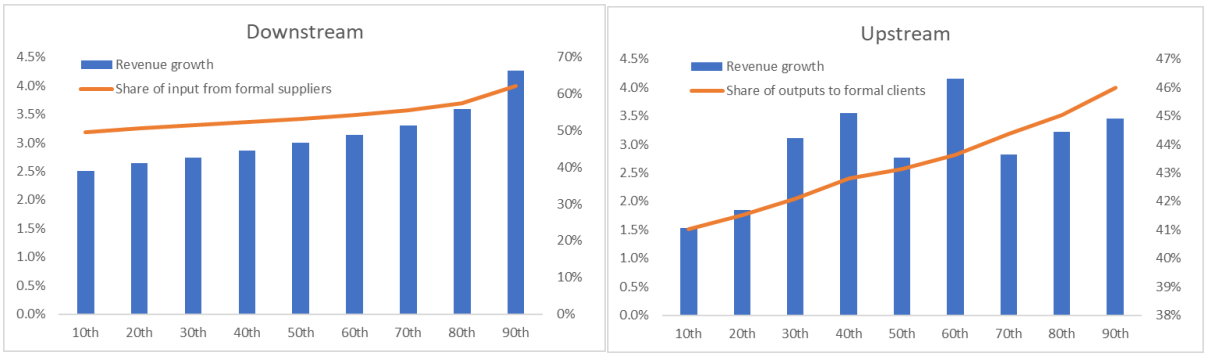


Figure 7: revenue growth by size percentile

Figure 8: total tax revenue and tax rate

Table 1: ASI and UME surveys (2015)

	obs	# of firms
ASI	57,005	211,931
UME	40,932	40,545,867

Source: Pooled ASI and NSS Unincorporated Survey (2015)

Table 2: calibration and estimation

Parameter	Description	Value	SE
Calibrate			
τ	VAT rate	0.05	-
τ^{corp}	Corporate tax rate	0.3	-
κ_f	Formal exit probability	0.08	-
SMM Estimate			
β	Formal input quality	1.15	0.09
ξ^d	Pareto shape parameter (downstream)	2.35	0.03
ξ^u	Pareto shape parameter (upstream)	1.40	0.03
E_i^d	Downstream informal entry cost scaled by avg downstream informal profit	0.51	0.01
E_f^d	Downstream formal entry cost scaled by avg downstream formal profit	1.08	0.04
E_i^u	Upstream formal entry cost scaled by avg upstream informal profit	1.22	0.06
E_f^u	Upstream informal entry cost scaled by avg upstream formal profit	1.80	0.16
α	production function coefficient	0.62	0.01
ρ	Substitution parameter	0.64	0.00
τ_l	wage gap	10.7	1.10
κ_i	Informal exit probability	0.15	0.01
σ	Post-entry shock variance	0.10	0.01

Table 3: model fit

Moments		Data	Model
Share of informal sector, #	downstream	98%	98%
	upstream	92%	93%
Share of informal sector, revenue	downstream	31%	30%
	upstream	16%	14%
Share of input from formal suppliers	formal firms	80%	80%
	informal firms	29%	43%
Share of output to formal buyers	formal firms	48%	48%
	informal firms	16%	28%
Distribution of downstream informal firm: relative size towards avg formal firm	5th percentile	0.02%	0.06%
	25th percentile	0.14%	0.22%
	50th percentile	0.46%	0.31%
	75th percentile	1.20%	0.66%
	95th percentile	3.35%	3.33%
Distribution of upstream informal firm: relative size towards avg formal firm	5th percentile	0.16%	0.05%
	25th percentile	0.38%	0.09%
	50th percentile	0.64%	0.19%
	75th percentile	1.50%	0.72%
	95th percentile	5.92%	7.92%
Distribution of downstream formal firm: relative size over avg formal firm	5th percentile	7.91%	15.15%
	10th percentile	9.70%	16.12%
Distribution of upstream formal firm: relative size over avg formal firm	5th percentile	1.42%	0.65%
	10th percentile	2.07%	0.72%
Standard deviation divided by mean	downstream	24.5	27.8
	upstream	24.4	37.8

Table 4: Share of informality under different tax regimes and rates

	Number Share		Revenue Share	
	F	I	F	I
ST, 7.5%	3.87%	96.13%	81.61%	18.39%
VAT, 7.5%	4.01%	95.99%	82.97%	17.03%
VAT, 17.5%	3.40%	96.60%	76.27%	23.73%
VAT, informality neutral	3.85%	96.15%	81.69%	18.31%
VAT, revenue neutral	3.87%	96.13%	81.98%	18.02%

Table 5: change of the informal size under different tax regimes and rates

	Number		**Revenue**	
	F	I	F	I
ST, 7.5%	0%	0%	0%	0%
VAT, 7.5%	3.5%	-0.3%	8.8%	-0.9%
VAT, 17.5%	-12.2%	0.5%	-21.3%	8.7%
VAT, informality neutral	0.1%	0.5%	2.0%	1.5%
VAT, revenue neutral	0.3%	0.2%	3.0%	0.4%

Table 6: share of formal and informal inputs by downstream producers

	Inputs		**Outputs**		**Avg Revenue**	
	F from F	I from F	F to F	I to F	F	I
ST, 7.5%	67.1%	39.5%	40.5%	27.0%	0%	0%
VAT, 7.5%	71.7%	39.5%	45.8%	27.0%	5%	-1%
VAT, 17.5%	72.4%	33.4%	44.1%	20.3%	-9%	8%
VAT, informality neutral	72.3%	37.7%	45.9%	25.5%	2%	1%
VAT, revenue neutral	72.2%	38.3%	45.9%	25.7%	3%	0%

Table 7: change in tax, HH income, and corporate profits under different tax regimes (F=Formal, I=Informal)

	VAT/ST	**VAT+Corp tax**	**HH income**		**Corporate profit**	
	F	F	F	I	F	I
ST, 7.5%	0%	0%	0%	0%	0%	0%
VAT, 7.5%	-25%	-3%	10%	0%	9%	-1%
VAT, 17.5%	57%	6%	-22%	4%	-22%	9%
VAT, informality neutral	4%	2%	1%	-1%	2%	2%
VAT, revenue neutral	0%	2%	2%	-1%	3%	0%

Appendix A: downstream index

Using the input-output table (IO table), Atras and Chor (2013) propose a measure to capture the "downstreamness" of an industry in the value chain. I provide a sketch of their measurement and document the application to the Indian IO table. The basic input-output identity is:

$$Y_i = F_i + Z_i$$

Where Y_i is the total output in industry i, F_i is the output of i that goes towards final use, Z_i is the use of i's output as inputs to other industries. In a world with N industries, this identity can be expanded as:

$$Y_i = F_i + \sum_{j=1}^{N} d_{ij}F_j + \sum_{j=1}^{N}\sum_{k=1}^{N} d_{ik}d_{kj}F_j + \sum_{j=1}^{N}\sum_{k=1}^{N}\sum_{l=1}^{N} d_{il}d_{lk}d_{kj}F_j + \cdots$$

Where d_{ij} for a pair of industries is the amount of i used as an imput in producing one-dollar worth of industry j's output. $\sum_{j=1}^{N} d_{ij}F_j$ captures the value of i's "direct use" as an input by industry j to produce output that immediately goes to final use. The remaining terms $\sum_{j=1}^{N}\sum_{k=1}^{N} d_{ik}d_{kj}F_j + \sum_{j=1}^{N}\sum_{k=1}^{N}\sum_{l=1}^{N} d_{il}d_{lk}d_{kj}F_j + \cdots$ that involve higher-order summations reflect the "indirect use" of i as an input. These indirect inputs enter the value chain for future production, at least two production stages away from final use.

The idea of downstream index is measuring the "distance" of an industry to the final products consumed by final consumers. The higher share of its input used by the final products, the closer an industry is to the downstream. Hence, the downstream index is measured by the ratio of aggregate direct sue to the aggregate total use of i as an input. In practice, the index is calculated by dividing the direct use of industry i's product as an input for final-use production by the total use of i's product as inputs for other industries. The higher the ratio for a given industry i, the more intensive is its use as a direct input for final-use production, so that the industry is closer to the downstream stage of the value chain. Conversely, a lower ratio indicates that most of the contribution of input i to production processes occurs indirectly, and the industry is located more in the upstream stage of the value chain.

Based on their methodology, I use the Indian Input-Output Table to calculate the relative position of each industry. The IO table has been constructed for the year 2013-14 consistent with the national accounts estimates given the national accounts statistics (NSA) 2015. The IO table contains 140 rows (products) and 67 columns (sector), which have been collapsed and expanded to make the 130*130 input-output table by Singh and Saluja (2016)[8].

First, I calculate the N*N direct requirement matrix D, the N*1 final-use vector F by summing over the value of each industry i's output purchased for consumption and investment by private or government entities, and the N*1 output vector Y as the summation of all entries in row i in the IO table. Then I calculate the direct use of each industry as DF, and the total input use for each industry as $Y - F$, I divide the ith element of the direct use vector DF by the corresponding ith element of the input vector Y-F, which generates the downstream index of industry i.

[8] For detailed construction of the symmetric IO table, see Singh and Saluja (2016).

Table A1 shows the results of the estimation. I categorize industries whose downstream index is above the medium as downstream industries and others as upstream industries.

Informal firms are prevalent among the miscellaneous food producers, textile producers, and leather producers, whose share of informal output are 89%, 94%, and 93% respectively. At the same time, these industries are also closer to the final consumers with their downstream indices are higher than average. On the other side, there are less informal firms among petroleum producers, metallic mineral producers, and drug and medicine producers. The share of informal firms is 48%, 27%, and 55% for these three industries respectively. Contrary to the other three industries in the downstream with the highest informality rate, these three industries with the lowest informality rate are placed in the upstream with below than average downstream index.

Table 8: share of informal firms across the largest 10 manufacturing industries

Industry	**Downstream Index**	**Share informal N**	**Share informal Revenue**
Petroleum products	0.85	48%	0%
Miscellaneous food products	1.20	89%	17%
Iron, steel and ferro alloys	0.65	27%	0%
Motor vehicles	0.37	63%	1%
Miscellaneous manufacturing	0.76	89%	11%
Miscellaneous metal products	0.44	80%	21%
Drugs and medicines	1.69	55%	0%
Cotton textiles	1.12	94%	8%
Plastic products	1.00	64%	4%
Leather and leather products	1.20	93%	31%

The correlation between downstream index and informality might not be a coincident. Briand and Hoseini (2015) find that the informality is more salient at the downstream of the value chain. They calculate the backward linkage as a proxy for the position of an industry in the production chain. The larger the backward linkage, the longer chain of input that a firm faces, which is similar to the downstream index in my paper. They argue that a cascading sales tax distorts the product prices, which tends to accumulate as the value chain moves towards the downstream. Since downstream industries typically have strong backward linkages and purchase high added value inputs resulting from a large number of production steps, their product prices will deviate more from its production price as a result of cumulative tax liabilities. Higher prices of formal products leave bigger space for cheaper informal products whose prices are not distorted by tax wedges. Hence, informal firms are more prevalent in the downstream than the upstream. However, the linkage of downstream index and informality is beyond the scope of this paper. I will treat the difference of informality between the upstream and the downstream as stylized facts without causal analysis.

Table A1

Industry	Downstream Index	Share informal N	Share informal Revenue
Petroleum products	0.85	48%	0%
Miscellaneous food products	1.20	89%	17%
Iron, steel and ferro alloys	0.65	27%	0%
Motor vehicles	0.37	63%	1%
Miscellaneous manufacturing	0.76	89%	11%
Miscellaneous metal products	0.44	80%	21%
Drugs and medicines	1.69	55%	0%
Cotton textiles	1.12	94%	8%
Plastic products	1.00	64%	4%
Leather and leather products	1.20	93%	31%
Non-ferrous basic metals	0.25	38%	1%
Other non-metallic mineral prods.	0.90	87%	23%
Cement	1.22	24%	0%
Other non-electrical machinery	0.84	65%	4%
Organic heavy chemicals	0.36	82%	0%
Motor cycles and scooters	0.86	3%	0%
Edible oils other than vanaspati	1.26	54%	1%
Beverages	1.28	82%	2%
Industrial machinery(others)	0.68	94%	51%
Electrical industrial Machinery	0.64	62%	2%
Paper, paper prods. & newsprint	0.59	71%	4%
Sugar	1.11	98%	13%
Soaps, cosmetics & glycerin	0.91	75%	3%
Fertilizers	1.37	55%	0%
Synthetic fibers, resin	0.92	43%	1%
Iron and steel casting & forging	0.25	69%	1%
Rubber products	1.12	58%	2%
Miscellaneous textile products	1.39	94%	48%
Art silk, synthetic fiber textiles	1.10	86%	1%
Electrical wires & cables	0.63	77%	2%
Tractors and agri. implements	2.38	62%	4%
Printing and publishing	0.26	74%	21%
Tobacco products	1.97	98%	14%
Wood and wood products	1.19	93%	46%
Structural clay products	0.90	79%	43%
Other chemicals	0.68	35%	1%
Electrical appliances	0.39	58%	2%
Paints, varnishes and lacquers	0.90	9%	0%
Silk textiles	0.93	99%	21%
Pesticides	1.36	31%	0%

Leather footwear	0.97	96%	17%
Furniture and fixtures-wooden	0.76	92%	77%
Readymade garments	0.19	91%	13%
Communication equipments	0.61	18%	1%
Batteries	0.59	57%	13%
Electronic equipments(incl.TV)	0.46	53%	0%
Hand tools, hardware	0.86	77%	16%
Hydrogenated oil(vanaspati)	1.74	56%	0%
Other electrical Machinery	0.72	76%	7%
Industrial machinery(F & T)	0.53	60%	9%
Machine tools	0.35	68%	1%
Carpet weaving	1.03	91%	13%
Jute, hemp, mesta textiles	1.39	48%	2%
Bicycles, cycle-rickshaw	0.49	58%	8%
Woolen textiles	1.05	41%	4%
Other transport equipments	2.55	86%	4%
Ships and boats	4.52	75%	3%
Khandsari, boora	1.14	93%	4%
Rail equipments	0.89	0%	0%

Appendix B: calculating the share of formal input and the share of formal output

According to my model setup, there are four agents in the trade structure. In the upstream stage, there are upstream formal firms and upstream informal firms. These firms produce intermediate inputs for the downstream firms and HH consumers. In the upstream, there are downstream formal firms and downstream informal firms who purchase inputs from upstream sellers and sell to final consumers.

First, I restrict the firm-level data to the manufacturing sector in West Bengal province whose transaction data is available from the local tax authority. Then I divide firms into the above four categories and aggregate the total revenue and total expense of the formal and the informal sector using the sample weights of each firm. Revenue F denotes total revenue of formal firms, Revenue I denotes total revenue of informal firms, Expense F denotes total expense of formal firms, Expense I denotes total expense of informal firms.

Share of sales from formal sellers to formal buyers. Among the total revenue of formal firms (Revenue F), I need to calculate the share of revenue from formal firms to formal buyers. I use Revenue FF to denote the revenue from formal sellers to formal buyers. Here, I use the transaction level data from the tax authority that covers all the transactions of formal firms in the province. Formal firms report all their sales to other formal firms as required by the regulation. I aggregate the total sales from formal sellers to formal buyers (Revenue FF) and divide it by the total revenue of formal firms (Revenue F). This yields the share of sales from formal sellers to the formal buyers.

Share of inputs of formal firms from formal sellers. Among the total inputs of formal firms (Expense F), I need to calculate the share of inputs of formal firms from formal sellers. Expense FF denotes the total inputs of formal firms from formal sellers. Formal firms have to report all their purchases from other formal firms to the tax authority. I aggregate the total inputs of formal buyers from other formal sellers (Expense FF) and divide it by the total inputs of formal firms (Expense F). This yields the share of inputs of formal firms from formal sellers.

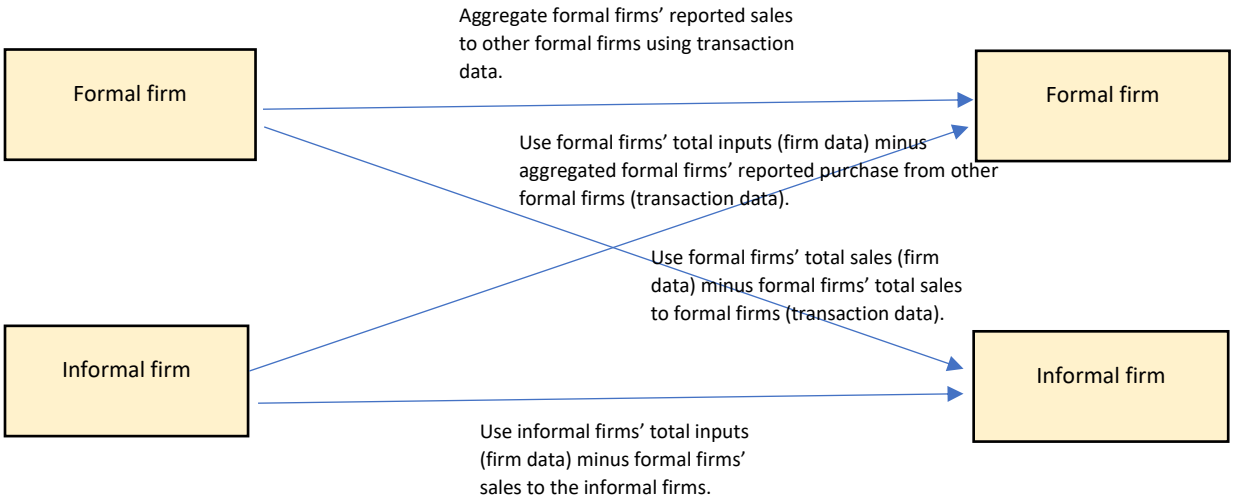
Share of sales from informal firms to formal buyers. Among the total revenue of informal firms (Revenue I), I need to calculate the share of revenue from informal firms to formal buyers. I use Revenue IF to denote the total revenue from informal sellers to formal buyers. Since I do not have the transaction level data for informal firms, I cannot use the same aggregation to get the total revenue from informal firms to formal buyers. However, I have calculated the total revenue from formal firms to formal buyers (Revenue FF) and the total inputs of formal firms (Expense F). Note that formal firms purchase inputs from either formal sellers or informal sellers, which means Expense F=Revenue FF + Revenue IF. I use the identity and distract the inputs of formal buyers (Expense F) by the total sales from formal sellers to formal buyers (Revenue FF). This yields the total sales from informal sellers to the formal buyers (Revenue IF). Divided sales from informal sellers to the formal buyers (Revenue IF) by total sales of informal firms (Revenue I) yields to share of sales from informal sellers to the formal buyers.

Share of inputs of informal firms from formal sellers. Among the total inputs of informal firms (Expense I), I need to calculate the share of inputs of informal firms from formal sellers. Since there is no transaction level data from the informal firms, aggregation is not possible for the informal firms. But I have calculated the total inputs of informal firms (Expense I), total sales of formal sellers (Revenue F) and the total sales from formal sellers to the formal buyers (Revenue FF). I calculate the total sales of formal sellers to the informal buyers (Revenue FI) using the identity (Revenue FI + Revenue FF =

Revenue F). Dividing the revenue from formal sellers to the informal buyers (Revenue FI) by the total inputs of informal buyers (Expense I), I calculate the share of inputs of informal buyers from formal sellers.

It is worth noting that I treat household who purchase products from the upstream as informal firms. The difference between formal buyers and informal buyers is whether they require exempt certificate. Since both informal firms and final consumers do not require such certificate, they are categorized into the informal sector despite consumers might not use the products as inputs. However, treating the final consumer leads to an overestimation of informal firms' purchase from formal sellers. This is because I use the revenue from formal firms to informal buyers and final consumers as a proxy for the input of informal firms' purchase from formal sellers.

Figure B1. Measuring transaction between the formal and the informal sector



Appendix C: Indian tax reform background

India adopted VAT between 2003 and 2008 with variation across states. Both direct tax and indirect tax are levied in India. Direct taxes are mainly collected by the central government with the exception of profession and property taxes; indirect taxes are levied by both the central and the state governments. The service tax, custom duties and union excise duties which include all manufacturing products are the prerogative of the federal government. The only indirect tax at state level is state sales tax which comprises more than half of total states' own tax revenue and has been replaced by a VAT between 2003 and 2008.

The main source of tax revenue among the states is the sales tax which explains the reluctance of states to reform it despite its flaws being regularly underlined. The sales tax in Indian states were generally cascading even under the two general rules that intend to differentiate between final and intermediate consumption. According to the "physical ingredient" rule, an "input" is a material or component that is physically incorporated in the goods destined to be sold. According to the "direct use" rule, items directly used in the production of goods are exempted from sales taxes. However, these rules are neither easy to apply nor guaranteeing the non-taxation of business inputs. there exists heterogeneity in tax treatment of inputs among the different Indian states: raw materials are exempted in only a few states (Delhi and Gujarat) but due to the widespread adoption of the "physical ingredient" rule, fuels, tools, machinery and equipment are also not considered as inputs in these states. For a detailed discussion of the tax system in India, see Briand and Hoseini (2015).

In the context of West Bengal, it is a large state in east part of India with 90 million residents. The total GDP in West Bengal is $210 billion in 2019-2020, which accounts for 7% of the national GDP. West Bengal implemented VAT in 2003 with **tax regime border**. West Bengal implemented VAT since June 1st 2003.[9] All firms with a turnover of more than 500,000 INR (**threshold**)are required to remit tax to the state. Firms with a turnover of less than 5 million INR (**border**) can opt to remit tax under a simplified tax scheme under which they only pay a 0.025% tax on their total sales. However, firms in the simplified scheme cannot deduct tax paid by their suppliers from their tax liabilities.

Firms face different VAT rates depending on the goods they sell: 75% of them sell goods belonging to the "reduced" tax schedule and taxed at 4%, 21% sell goods in the "main" tax schedule taxed at 12.5%, and the remainder of firms are taxed at super-reduced rates of 0%-1%. In 2014, the VAT rates of the main and reduced schedules increased by 1 percentage points. For simplicity, this paper does not distinguish different tax schedule and assume that all firms pay a flat VAT rate at 12.5%.

Before the analysis, I characterize VAT, cascading sales tax, and non-cascading sales tax.

VAT is a consumption tax placed the value-added at each stage of the value chain. A firm's VAT tax base is the value of output less any of the costs of inputs that have already been taxed. Contrary to the sales tax that suffers from enforcement problem, VAT introduces the third-party reporting, verifiable paper trails, and whistle-blowers that play an important role in facilitating tax enforcement.

[9] https://www.rediff.com/money/2003/apr/08vat2.htm

Non-cascading sales tax only applies to the final consumers rather than the business owners who purchase the goods as their inputs. In principle, only final consumers pay the sales tax on their purchases. Business owners who purchase inputs for resales should issue resale certificates or exemption certificate to their sellers so that they do not pay tax on the purchases.

Cascading sales tax. However, sales tax often suffers from enforcement problems. Sellers cannot always distinguish final consumers from business owners when sell to these customers—and they have little incentive to find out. In addition, tax authorities prefer collecting tax at the earlier stage of production from large-scale manufacturers or wholesalers rather than the later stage from a mass of retailers. If a seller does not impose a sales tax on consumer purchases, it incurs the tax evasion; if a seller imposes a tax on business purchases, the tax "cascades", which means that the sales tax is paid twice by both the seller and the buyer.

Theoretically, VAT is equivalent to non-cascading sales tax. In practice, however, sales tax often becomes cascading and distortive in firms' input decisions. The major difference in the model setup between VAT and ST is that under the VAT, downstream formal buyers can deduct tax on its intermediate input purchase from upstream formal sellers; and upstream formal sellers can issue invoices to downstream formal buyers. On the contrary, cascading ST applies to all upstream formal firms and downstream firms cannot collect tax credit from formal inputs. In the case of India, Bagchi (1994) estimates that at least 30% of sales tax revenues are collected on business inputs. Briand and Hoseini (2015) show that tax cascading is more severe in the downstream sector with more "backward linkage".

To illustrate the price distortion between formal inputs and informal inputs, consider a 3-stage production chain as in Table 9. The output price of upstream product 1 is $p_1$in VAT, cascading ST, and non-cascading ST system. For the midstream firms, let γ_1 denotes the units of upstream product 1 used to produce 1 unit of midstream product 2. Assume the markup is α_2 and tax rate is τ. Hence, the output price of midstream product 2 is markup plus intermediate input and tax. Since non-cascading tax imposes zero tax on intermediate input, the output price of midstream product 2 is $\alpha_2 + \alpha_1\gamma_1$. VAT applies to the upstream product and the original purchase price of product 1 is $\alpha_2 + (1+\tau)\alpha_1\gamma_1$. However, midstream firms can get tax credit of $\tau\alpha_1\gamma_1$ if they purchase from formal sellers. Hence, the net-of-tax output price of midstream firms is also $\alpha_2 + \alpha_1\gamma_1$. For the cascading sales tax, the input price is $\alpha_1\gamma_1$. Since there is no tax deduction, their net-of-tax output price is $\alpha_2 + (1+\tau)\alpha_1\gamma_1$. Hence, the output price of midstream product is distorted under cascading ST, which will be carried to the downstream who uses product 2 as its input.

Table 9: illustration of exclusive price of output under VAT, cascading ST, and non-cascading ST

	Price (net of tax)	VAT	Cascading ST	Zero tax
Upstream	p_1	α_1	α_1	α_1
Midstream	p_2	$\alpha_2 + \alpha_1\gamma_1$	$\alpha_2 + (1+\tau)\alpha_1\gamma_1$	$\alpha_2 + \alpha_1\gamma_1$
Downstream	p_3	$\alpha_3 + \alpha_2 + \alpha_1\gamma_1$	$\alpha_3 + (1+\tau)[\alpha_2 + (1+\tau)\alpha_1\gamma_1]$	$\alpha_3 + \alpha_2 + \alpha_1\gamma_1$

Source: Briand and Hoseini, 2015

Since the input prices are distorted under cascading sales tax, firms will also change their input combination to maximize their profits. Assume downstream producers can select input materials from both formal and informal upstream sellers, cascading sales tax raises the price of input materials by formal sellers compared to the informal ones. Hence, downstream firms will increase their purchase of cheaper input materials from the informal sellers despite a better quality of the formal products, leading to a productivity loss and social welfare loss.

Cascading sales tax has a more significant on the input choice between formal and informal goods. Higher cascading tax significantly reduces the share of formal goods used in the formal firms' production, implying an uneven advantage of informal goods due to tax evasion. The true distortion of cascading sales tax takes the form of excessive use of informal goods in the production that might reduce the overall production efficiency rather than the larger share of informal firms. Under cascading sales tax, firms either favor purchase cheaper inputs from informal sellers or pay a higher expense on formal inputs that squeezes the employment or the investment. The tax builds up over each successive stage of production, incurring market distortions and deadweight loss (Keen, 2014).

Appendix D: model solution

Downstream formal firm

Formal buyers receive tax credit from formal input at the rate of τ but not from informal input. The formal inputs give tax credit at the rate of τ. Here I impose both VAT and corporate tax into the model.[10] Corporate tax is imposed on the net profit of formal firms in both the downstream and the upstream. VAT is levied on the gross margin at the downstream with tax deduction if a formal buyer purchases from a formal supplier. Informal buyers and final consumers cannot deduct tax of intermediate input. Compared to corporate tax, VAT is levied on sales of formal firms but can be deducted by purchasing from other formal sellers. This creates an incentive for formal buyers to purchase from formal sellers than informal sellers if the price difference between formal input and informal input is less than the tax deduction, which might lead to the market segmentation between formal and informal sector as depicted in the stylized facts.

Solving equation (1) and (2), the demand function of $x(i)$ for upstream firm i is:

$$x^f(i) = [1-\tau(i)]^{\frac{1}{\rho-1}}\beta(i)^{-\frac{1}{\rho-1}}[\frac{y_0^f}{\theta^d}]^{\frac{1}{\alpha}} \cdot \left[\frac{p^f(i)}{P^f}\right]^{\frac{1}{\rho-1}} \quad (26)$$

With price index for downstream formal firms P^f:

$$P^f = [\int_0^N [(1-\tau(i))p^f(i)]^{\frac{\rho}{\rho-1}}\beta(i)^{-\frac{1}{\rho-1}}di]^{\frac{\rho-1}{\rho}} \quad (27)$$

$$P^f = [\int_{\underline{\theta^u}}^{\overline{\theta^u}} N[p_i^f]^{\frac{\rho}{\rho-1}}dF(\delta) + \int_{\overline{\theta^u}}^{\infty} N[(1-\tau)p_f^f]^{\frac{\rho}{\rho-1}}\beta^{-\frac{1}{\rho-1}}dF(\theta^u)]^{\frac{\rho-1}{\rho}} \quad (28)$$

Here, θ^u denotes the productivity of an upstream firm that sells to the buyer. I assume that downstream firms can observe the pre-entry productivity of upstream firms and form an initial expectation of the tax status of upstream suppliers, which coincides with the pre-entry productivity in the equilibrium. Specifically, downstream firms expect an upstream firm being formal if its pre-entry productivity exceeds the upper bar of $\overline{\theta^u}$, and an upstream firm being informal if its productivity exceeds the lower bar of $\underline{\theta^u}$, but is below the higher bar of $\overline{\theta^u}$. In the equilibrium, $\underline{\theta^u}$ is the realized lower bar of pre-entry productivity of informal firms, and $\overline{\theta^u}$ is the realized lower bar of pre-entry productivity of formal firms.

Then firms choose the optimal output to maximize their profits:

$$max(1-\tau^{corp})\{y_0 - \int_0^N x(i)p^f(i)[1-\tau(i)]di\} \quad (29)$$

Which yields the optimal output as:

$$y_0^f = \theta^d[\frac{(1-\tau)\theta^d\alpha}{P^f}]^{\frac{\alpha}{1-\alpha}} \quad (30)$$

[10] https://www.business-standard.com/article/pf/10-taxes-you-should-know-about-114041100175_1.html

Hence, the net profit of formal downstream firm is:

$$\pi_f^d = (1-\tau^{corp})\{y_0^f - \int_0^N x(i)p^f(i)[1-\tau(i)]di\} \quad (31)$$

Downstream informal firms

Solving the cost minimization problem from equation (9) and (10) yields the demand function of $x(i)$ for an upstream informal firm i:

$$x^i(i) = \beta(i)^{-\frac{1}{\rho-1}} \cdot \frac{y_0^{i\frac{1}{\alpha}}}{\theta^d} \cdot \left[\frac{p^i(i)}{P^i}\right]^{\frac{1}{\rho-1}} \quad (32)$$

With price index P^ias:

$$P^i = [\int_0^N [p^i(i)]^{\frac{\rho}{\rho-1}}\beta(i)^{-\frac{1}{\rho-1}}di]^{\frac{\rho-1}{\rho}} \quad (33)$$

$$P^i = \{\int_{\underline{\theta^u}}^{\overline{\theta^u}} N[p_i^i]^{\frac{\rho}{\rho-1}}dF(\theta^u) + \int_{\overline{\theta^u}}^{\infty} N[p_f^i]^{\frac{\rho}{\rho-1}}\beta^{-\frac{1}{\rho-1}}dF(\theta^u)\}^{\frac{\rho-1}{\rho}} \quad (34)$$

Then, downstream firm choose the optimal output to maximize its profit:

$$max\{y_0 - b_i\int_0^N x(i)p^f(i)[1-\tau(i)]di\} \quad (35)$$

And the optimal output is:

$$y_0^i = \frac{\theta^d}{b_i}[\frac{\theta^d\alpha}{P^i}]^{\frac{\alpha}{1-\alpha}} \quad (36)$$

Hence, the maximized profit of a downstream informal firm is:

$$\pi_i^d = y_0^i - \int_0^N b_i x^i(i)p^i(i)di \quad (37)$$

Upstream formal firms

Solving the maximization problem in equation (17) and (18), the optimal output for formal firm i to a formal buyer is given by:

$$x_f^f = [\frac{w(1+\tau_l)}{\theta^u\rho\beta p^f}]^{\frac{1}{\rho-1}}\left[\frac{y_0^f}{\theta^d}\right]^{\frac{1}{\alpha}} \quad (38)$$

Solving equation (16) and (19), the optimal output for a formal seller to an informal buyer is:

$$x_f^i = [\frac{w(1+\tau_l)}{(1-\tau)\theta^u\rho\beta P^i}]^{\frac{1}{\rho-1}}\left[\frac{y_0^i}{\theta^d}\right]^{\frac{1}{\alpha}} \quad (39)$$

Equation (19) and (21) show the optimal sale of a formal supplier to a single formal firm and a single informal firm. We assume upstream firms can observe the pre-entry productivity of downstream firms, based on which upstream firms form an initial expectation of the tax status of downstream buyers. The realized tax status in the equilibrium coincides with the initial guess. Specifically, upstream firms expect a downstream firm being formal if its productivity exceeds the upper bar of $\overline{\theta^d}$; and an downstream firm being informal if its productivity exceeds the lower bar of $\underline{\theta^d}$, but is below the higher bar of $\overline{\theta^d}$. In the equilibrium, $\underline{\theta^d}$ is the realized lower bar of pre-entry productivity of informal firms, and $\overline{\theta^d}$ is the realized lower bar of pre-entry productivity of formal firms. With the initial guess of the tax status of downstream firms, the profit of an upstream formal firm is:

$$\pi_f^u = \int_{\underline{\theta^d}}^{\overline{\theta^d}} x_f^i p_f^i - w(1+\tau_l)(\frac{x_f^i}{\theta^u})dF(\theta^d) + \int_{\overline{\theta^d}}^{\infty}(1-\tau)x_f^f p_f^f - w(1+\tau_l)(\frac{x_f^f}{\theta^u})dF(\theta^d) \quad (40)$$

Upstream informal

Solving equation (16) and (23), the optimal sales to a formal buyer is:

$$x_i^f = [\frac{w(1+b_i)}{\theta^u \rho \beta P^f}]^{\frac{1}{\rho-1}}\left[\frac{y_0^f}{\theta^d}\right]^{\frac{1}{\alpha}} \quad (41)$$

The optimal sale to an informal buyer is:

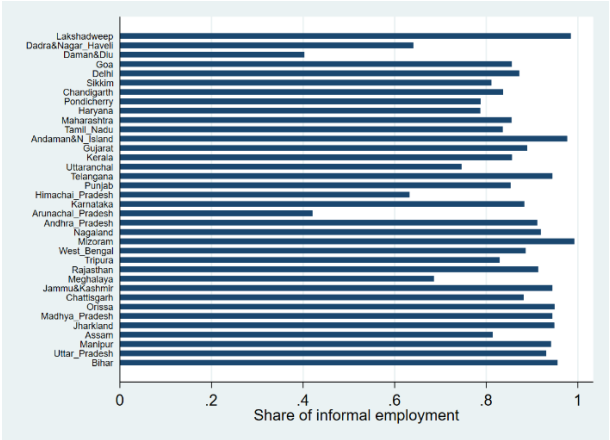
$$x_i^i = [\frac{w(1+b_i)}{\theta^u \rho P^i}]^{\frac{1}{\rho-1}}\left[\frac{y_0^i}{\theta^d}\right]^{\frac{1}{\alpha}} \quad (42)$$

Equation (23) and (24) show the optimal sale of an informal supplier to a single formal buyer and a single informal buyer. Upstream informal firms can also observe the pre-entry productivity of downstream firms, based on which they form an initial expectation of the tax status of downstream buyers. The realized tax status in the equilibrium coincides with the initial guess. With the initial guess of the tax status of downstream firms, the profit of an upstream informal firm is:

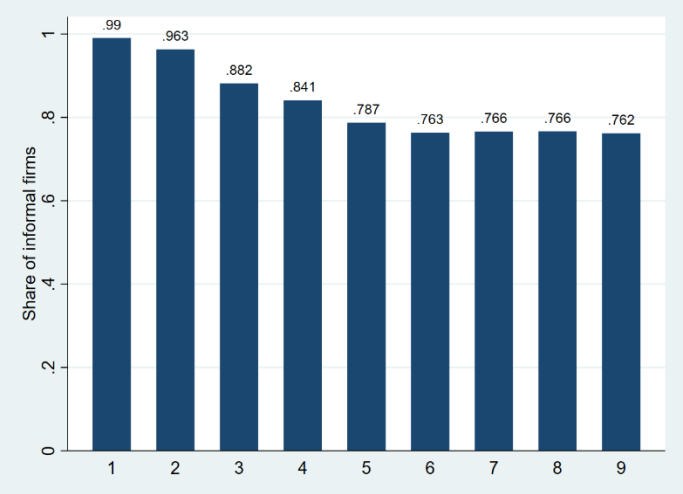
$$\pi_i^u = \int_{\underline{\theta^d}}^{\overline{\theta^d}} x_f^i p_f^i - w(\frac{x_i^i}{\theta^u})dF(\theta^d) + \int_{\overline{\theta^d}}^{\infty} x_i^f p_i^f - w(\frac{x_i^f}{\theta^u})dF(\theta^d) \quad (43)$$

Appendix E: distribution of informality

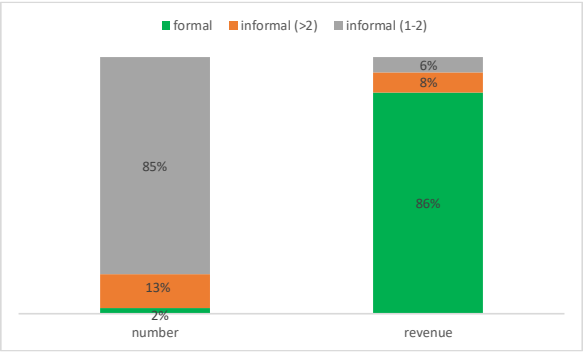
I plot the share of informal employment and the share of informal firms by states, sorted by their GDP per capita from high to low. As Ulyssea (2018) suggests, the informal employment and the informal firms do not necessarily move in the same direction. I show similar result using Indian data. The share of informal employment surpasses 95% among Mizoram, Lakshadweep, and Andaman, but barely reached 40% in Daman&Diu and Arunachal. The share of informal firm, on the other hand, is the highest among Manipur, Andaman, and Meghalaya, but the lowest among Daman&Diu, Dadra, and Goa. The distribution of informal workers and informal firms varies largely across states, but firm informality and employment informality do not necessarily move in the same direction. An example is Dehli, who ranks the 4th lowest share of informal firms, but only the 18th lowest share of informal employment.

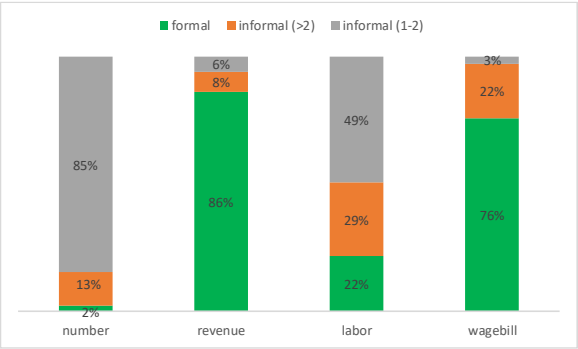


I use the subsample of firms less than 10 employees in UME survey to plot the distribution of informal firms across its number of employees. The share of informal firms decrease as their size grows. The share of informal firms is 99% in the one-person establishments, and the number drops to 96%, 88%, 84% for firms with employees of 2, 3, 4 respectively. For firms larger than 5 employees, informal firms only comprise less than 80% of the number of firms.

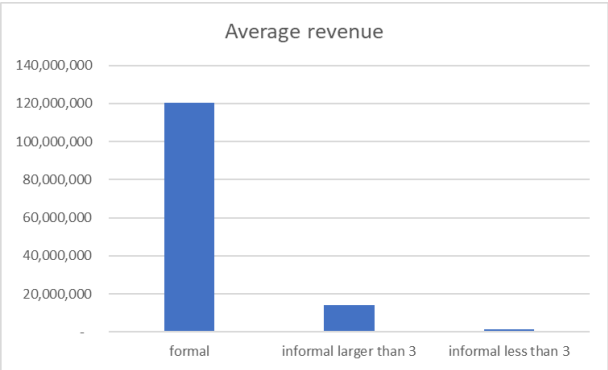


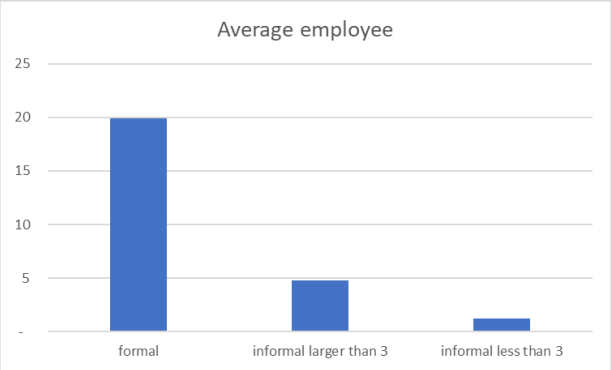
In the combined dataset of ASI and UME, the average size of an informal firm is much smaller than a formal one despite the large number of informal firms. Firms less than three workers account for more than 85% of the total number of firms, but only generate 6% of total output.



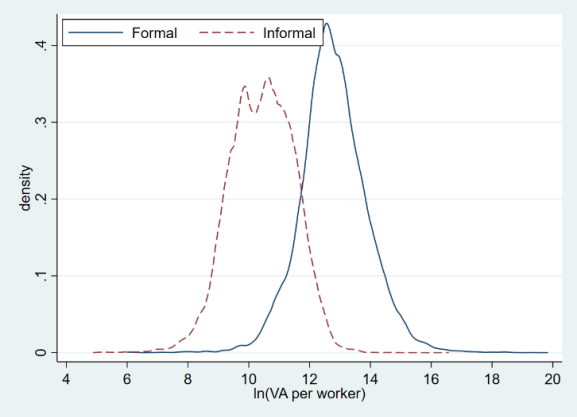


The average revenue of an informal firm larger than 3 employees is 14 million Rs, which is 11% of a formal one. For informal firms with less than 3 employees, the average revenue is only 1.3% of a formal firm. The average number of employees is 29.9, 4.8, and 1.3 for formal firms, informal firms larger than 3 employees, and informal firms smaller than 3 employees respectively.





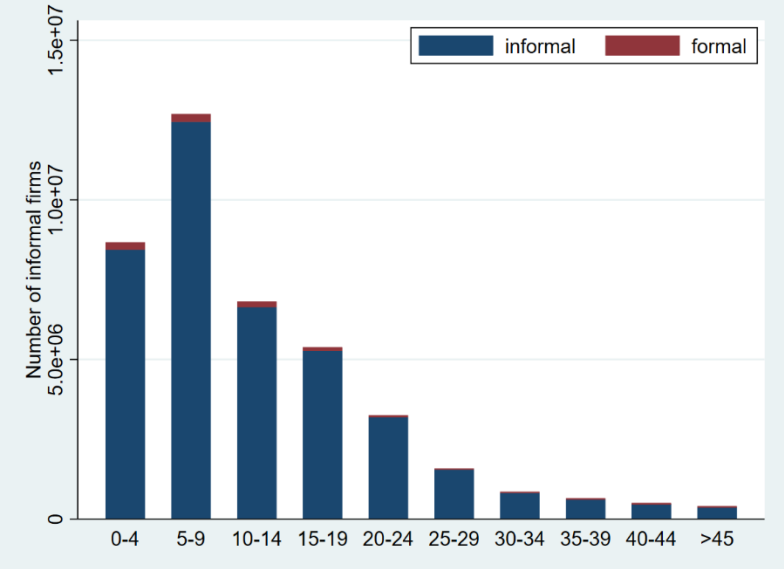
Below graph compares the distribution of value added per worker (in logs) in India's formal and informal sectors. Formal firms have on average higher value added per worker than informal firms, which is captured by the rightward crest of the distribution of formal firms. Table below **Error! Reference source not found.**shows that the difference of value added per worker between formal and informal sectors is driven by size. Value added per worker and capital per worker grow as a firm hires more employees.



	Value		
Employees	**ln(VA per worker)**	**ln(K per worker)**	**ln(wage)**
Informal firms			
1	10.62	11.52	9.27
	(0.99)	(0.99)	(1.25)
5	11.19	11.77	10.52
	(0.89)	(0.89)	(0.88)
10	11.89	13.04	11.22
	(1.31)	(1.31)	(0.54)
Formal firms			
20	12.74	13.76	11.64
	(0.89)	(0.89)	(0.66)

50	12.87	13.30	11.88
	(1.24)	(1.24)	(0.69)
100	13.02	13.32	12.07
	(1.18)	(1.18)	(0.76)
>100	13.14	13.93	12.03
	(1.11)	(1.11)	(0.83)

Informality in India is persistent. For firms over 10 years old, more than 97% are informal, suggesting a persistent informality of firms who evade tax obligations. The high share of informality in old firms coincides with the observation in Hsieh and Klenow (2014) that that the average 40-year old plant in the US employs more than seven times as many workers as a corresponding 5 years or younger plant, while in India and Mexico, surviving firms are just twice as large over the same age range. However, this does not mean that the exit rate is low for informal firms. Literature has shown that informal firms often operate discontinuously, which means that these informal firms would quit the market when facing negative shocks, but would return to the market when the shock is over.



The practice of informal firms also differs significantly from their formal counterparts. I use only the UME data and restrict the sample to firms with 3-10 employees in all sectors. The informal firms are less likely to keep a bank account than formal ones. 55% of informal firms maintain bank accounts compared to 93% for formal firms. As for the regular (book) account, only 10% of informal firms maintain a regular account while more than 70% of formal firms do so. Besides, informal firms are less likely to use computer and internet compared to formal ones. On the other hand, both types of firms have limited access to finance with 10% of informal firms and 8% of formal firms listing access to finance as stheir major challenge. At the same time, only 2% of both type of firms receives government assistance. Surprisingly, 11% of informal firms report that they took some work on contract base while only 4% of formal firms report so.

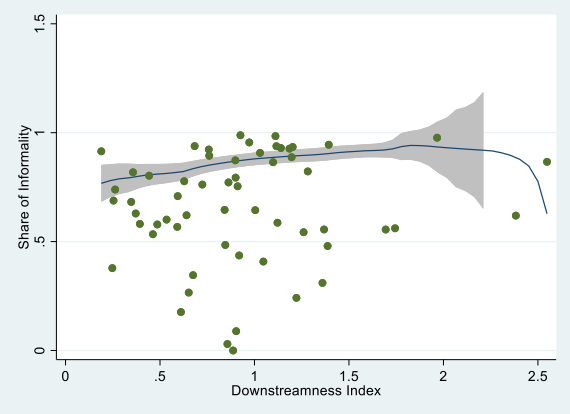
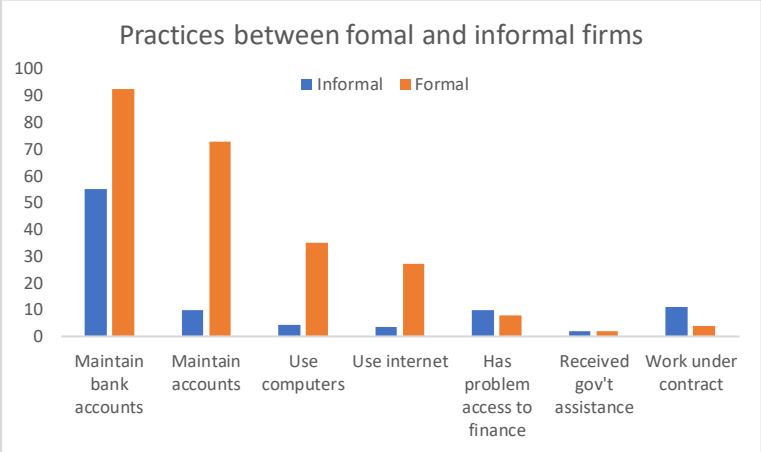


Table: operational characteristics of informal firms

	Informal	Formal
Maintain bank accounts,%	55	93
Maintain accounts,%	10	73
Use computers,%	4	35
Use internet,%	3	27
Has problem access to finance,%	10	8
Received gov't assistance,%	2	2
Work under contract,%	11	4



Source: NSSO Unorganized Manufacturing Enterprises survey (2015)

To illustrate the difference between formal firms and informal firms, I estimate the following reduced form model using the combined ASI and UME firm-level datasets.

$$y_{isj} = formal_{isj} + \alpha_s + \gamma_j + \varepsilon_{isj}$$

Where y_{isj} is the characteristics of firm i in sector s and state j, including log revenue, log number of employees, log value added, and log wage rate. $formal_{isj}$ is the dummy variable that equals 1 if firm i is registered in the tax authorities. I also control the ownership dummy, sector fixed effect and the state fixed effect.

Table 10 shows that on average, a formal firm is larger than an informal firm in terms of revenue, number of employees, wage rate, and value-added. The difference between the formal and the informal firms are more salient in the downstream than the upstream. Table 11 augments an interaction term between the formal dummy with the downstream index. It shows that the difference of revenue, labor, value-added, and wage rate between the formal and the informal sector are more salient in the downstream sectors. This implies stronger distortion in the downstream which raises the entry threshold of the formal sector. The results are robust when I use the unweighted sample that is representative of the manufacturing sector in India or when I restrict the sample to West Bengal province.

Table 10: difference between formal and informal firms

VARIABLES	(1) ln(revenue)	(2) ln(labor)	(3) ln(VA)	(4) ln(wage rate)
Formal	1.468***	0.535***	0.947***	0.490***
	(0.018)	(0.006)	(0.016)	(0.010)
Industry FE	Y	Y	Y	Y
State FE	Y	Y	Y	Y
Ownership FE	Y	Y	Y	Y
Observations	51,529	60,696	49,705	59,661
R-squared	0.486	0.447	0.460	0.307

Table 11: difference between formal and informal firms in the upstream and the downstream

VARIABLES	(1) ln(revenue)	(2) ln(labor)	(3) ln(VA)	(4) ln(wage rate)
Formal	0.914***	0.347***	0.445***	0.400***
	(0.043)	(0.015)	(0.038)	(0.023)
Formal*downstream index	0.631***	0.214***	0.572***	0.102***
	(0.044)	(0.016)	(0.039)	(0.024)
Downstream index	0.043	0.073	0.099	-0.074
	(0.138)	(0.051)	(0.123)	(0.089)
Industry FE	Y	Y	Y	Y
State FE	Y	Y	Y	Y
Ownership FE	Y	Y	Y	Y

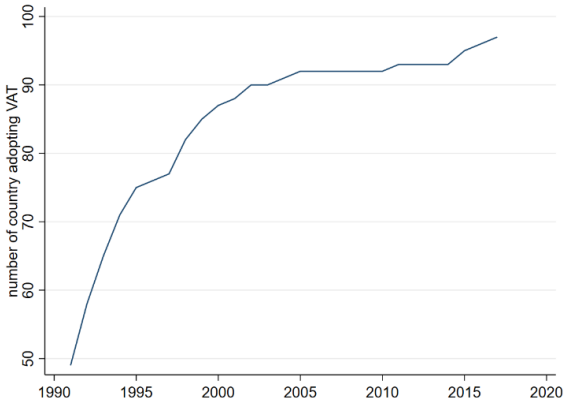
Observations	51,529	60,696	49,705	59,661
R-squared	0.531	0.561	0.473	0.542

Hsieh and Klenow (2009) show that the size of registered Indian industrial firms grows slowly even after long time of operation. The relative employment of a formal firm is less than 20% of a US firm. I find that this is particularly true in the informal sector where the firm size grows even slower than the formal sector. Table 12 shows the correlation between the firm age and the firm size. An informal firm produces 9% less and employs similar employees compared to a new informal firm after 10 years of operation. The interaction term between the formal dummy and age is significantly positive, suggesting that formal firms grow faster but still slow at an absolute sense than informal ones. For a 10-year old formal firm, it employs only 4% more workers and does not increase its output than a new formal firm.

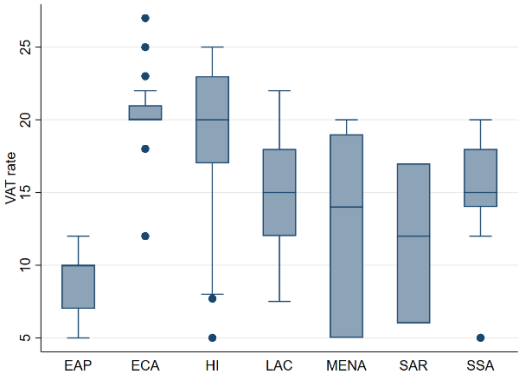
Table 12: difference between formal and informal firms in the upstream and age

VARIABLES	(1) ln(revenue)	(2) ln(labor)	(3) ln(VA)	(4) ln(wage rate)
Formal	1.386***	0.491***	0.940***	0.437***
	(0.024)	(0.009)	(0.021)	(0.013)
Formal*age	0.008***	0.004***	0.002	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Age	-0.009***	-0.001***	-0.007***	-0.003***
	(0.001)	(0.000)	(0.001)	(0.000)
Industry FE	Y	Y	Y	Y
State FE	Y	Y	Y	Y
Ownership FE	Y	Y	Y	Y
Observations	51,529	60,696	49,705	59,661
R-squared	0.529	0.562	0.472	0.544

Appendix F: VAT for a sketch



VAT rates varies significantly across regions and countries, which confounds the adoption of VAT regime and adjustment of VAT rate. VAT rates are highest among high-income countries with the median tax rate at 20%, while the lowest VAT rate is only 5% in some countries. The simple diff-in-diff method is not able to answer whether it is the VAT regime adoption or simply the tax rate adjustment that affects informality.



Appendix G: SMM estimator

TBD

Appendix G: weight matrix

TBD

Appendix H: traditional policies on informality

Table 13: comparison between traditional policies towards informality

		Carrot	Stick	TFP
Number	Downstrem	0.954	0.937	0.970
	Upstream	0.892	0.894	0.902
	All	0.922	0.915	0.935
Output	Downstrem	0.243	0.106	0.268
	Upstream	0.198	0.124	0.226
	All	0.207	0.121	0.232
Avg size	Downstrem	0.015	0.008	0.011
	Upstream	0.030	0.017	0.032
	All	0.027	0.015	0.029
Trade	F from F	0.761	0.828	0.719
	I from F	0.290	0.416	0.265
	F to F	0.534	0.574	0.488
	I to F	0.269	0.333	0.253

The impacts of "carrot" policy

Lowering the entry cost into the formal sector will encourage the ready-to-formalize firms to register which reduce the extensive margin of informality. In this part, I modify the entry cost parameters in the upstream and the downstream and produce the counterfactual behavior of firms and its implications on the macro variables. Specifically, I set the baseline scenario where the entry costs are at the original value. Then I set the entry cost parameters at 50% of their original value and run the model to get a new set of simulation results. Then I increase the entry cost by 0.5% to 50.5% of their original value and get the second set of simulation results. I repeat the above procedure so that the entry cost ranged from 50% of their original value to its original value. Then I plot the variables of interest against the entry cost to visualize their relationship.

Table 13 summarizes the impacts of "carrot policy" on informality. Lowering entry costs by 50% leads to a moderate reduction of informality in the downstream where the share of the number of informal firms decreases from 97% to 95% and the share of informal output drops from 28% to 24%. The informality rate in the upstream hardly change when entry costs are cut half. Most of the "reservoir" type of firms (99%) and a small fraction of "parasite" firms (33%) formalized in the downstream after entry costs lower. The change is less significant in the upstream where only 13% of "reservoir" firms and 2% "parasite" firms formalize.[11]

[11] The smaller share of informal firms can either reflect a growing number of formal firms or a shrinking number of informal firms. Hence, I calculate the status of firms before and after the change of entry cost. I compare the baseline scenario and the "carrot" scenario with 50% of entry costs, the results show that 2.5% of the downstream informal firms switched to be formal, which leads to an increase of the number of formal firms in the downstream by 423%. To a lesser extent, the number of formal firms in the upstream increased by 13% as a result of 0.1% of informal firms switch to the formal sector.

When the entry cost is high, the profit of being formal has to be large enough compared to being formal so that a firm with a given productivity has the incentive to formalize. Otherwise, the gain from being formal is not sufficient to cover the entry cost and tax liabilities. Intuitively, lower entry costs induce productive firms who opt to remain informal to formalize so that they can expand production without being worried about the punishment on the informal sector. Since the distribution of downstream productivity is more concentrated than that of the upstream as shown in Table 2, there are more downstream informal firms near the margin of formalization. Lowering the entry costs by the same magnitude would encourage more downstream informal firms to enter the formal sector than in the upstream.

Share of firms in each type that formalize after policy changes

	Downstream			Upstream		
-Carrot	98.9%	33.0%	0.0%	12.5%	1.7%	0.0%
-Stick	98.9%	70.6%	0.0%	12.5%	1.7%	0.0%
-TFP	98.9%	25.9%	0.0%	0.0%	0.0%	0.0%

However, “carrot policy” incurs higher intensive margin of informality. The newly formalized firms are less productive than the incumbent ones. These newly formalized firms maintain their trade network with their informal counterparts, which drives down the total share of inputs in the formal sector. This is also reflected in the higher share of outputs to the formal sector among informal sellers.

“Carrot policy” raises tax revenue by enlarging the size of the formal sector. Since the “carrot policy” reduces the deadweight loss of being formal, informal firms find it more profitable to formalize, enjoying the tax deduction under VAT regime and avoiding fine on the informal sector. If the entry costs are reduced to 50% of its current value, total tax revenue could be 8% higher than the current level. Hence, by removing the entry costs of the formal sector, policy makers would enjoy simultaneously a lower level of informality and a higher level of tax revenue.

Besides the benefits of taxation, lowering the entry costs can increase corporate profits at the cost of household income. Compared to the baseline scenario, lowering the entry costs by 50% would lead to 8% increase of corporate tax but a decrease in household income by 13%. The loss of household income results from a lower equilibrium wage as informal firms convert to formal ones. Because formal firms face higher labor costs, firms tend to hire less workers after formalization. Hence, part of workers who used to work informally now lose their jobs and income.

change of the components of welfare under “carrot” and “stick” policy

	Tax revenue	**HH income**	**Corporate profit**	**Welfare**
Carrot	8%	-13%	8%	8%
Stick	87%	-74%	70%	73%
TFP	23%	2063%	26%	25%

It is worth noting that reducing entry costs includes but not limited to streamlining the registration process and reduce the registration fee. Many countries have reduced the registration fee, simplified its taxation system, and implemented the "one-stop shop" to streamline the registration process for firms. However, De Mel (2013) and Bruhn and McKenzie (2014) show that waiving the registration fee is not enough to reduce the entry costs so that firms are encouraged to formalize. The ongoing costs of being registered, including but not limited to tax payment and labor market regulation, deter firms from registering even if the process of doing so is simplified. Andrade et al. (2013) and De Giorgi and Rahman (2013) reach the same conclusion using the experiment in Brazil where the government distributed a glossy brochure to informal firms and waived the registration fee. They found firms that received this brochure were not more likely to register over the following year. Gordon and Li (2009) show the significant benefit from tax evasion by not reporting cash transactions. However, when the subsidy increased to the highest level (approximately two months' profits of an informal firm's profit), almost half of them registered.

Hence it is critical to identify the entry costs into the formal sector and create a level-playing field for both formal and informal firms. For example, in India, size-dependent labor regulation that prevents large firms from laying off workers may retard the growth of high-potential firms by reducing their incentives to invest in expanding their size (Hseih and Klenow 2009). The resulting low-wage equilibrium would have too many small and informal firms (given fixed cost of registering). This section shows that identifying and removing the underlying sources of entry costs could significantly reduce informality while also increasing tax revenue and social welfare.

The impacts of "stick" policy

The "parasite" view of informality implies a stronger enforcement to punish informality. In this view, firms opt to stay informal so that they can avoid tax liabilities. In this part, I modify the punishment parameters on the informal firms and produce the counterfactual behavior of firms and of aggregated macro variables. Specifically, I set the baseline scenario where the entry costs are at the original value. Then I set the punishment parameters in the upstream and the downstream at 200% of their original value and run the model to get a new set of simulation results. Then I decrease the punishment by 0.5% to 199.5% of their original value and get the second set of simulation results. I repeat the above procedure so that the punishment ranges from 80% of their original value to 300% of its original value.

Table 13 shows that the share of informal firms decreases from 97% to 94% when enforcement on informality doubles, which corresponds to a reduction of informal output from 28% to 10%. The switch is much less significant in the upstream. In fact, 5% of informal firms quit the market and the rest reduce their production in response to the stricter enforcement. This is consistent with Andrade et al. (2013) and Bruhn and McKenzie (2014) that stronger punishment is highly efficient in reducing the extensive margin of informality.

As for the intensive margin of informality, the "stick policy" leads to a slight increase in the share of formal inputs by formal firms. When the cost of input becomes higher for informal firms, informal firms choose either to formalize or to transmit the punishment into higher product prices. Informal products become less attractive in price so downstream (formal and informal) firms will purchase less from informal sellers. In fact, informal firms will significantly increase their purchase from formal sellers.

"Stick" policy increases the cost of being informal, which increases tax revenue by a significant amount but at a severe cost of household income. When the cost of informal firms doubles, the tax base enlarges as more firms formalize, which increases the tax revenue by more than 87% (Table 13). Less informal firms reduce competition in the market and increases the profit of incumbent firms by 70%. While stricter punishment does alter the balance of formality vis-à-vis the informality, entering the formal sector would incur heavy entry costs which prohibits the informal firms from doing so. Informal firms would rather exit the market rather than entering the formal sector. Household income drops by 74%, which reflects the loss in the informal sector employment as strict punishment weighs on the small informal business owners. As many informal firms quit or reduce their production, the demand for labor shrinks which results in a lower equilibrium wage. Given the fixed labor supply in the model, household income decreases as a result of stricter punishment on the informal sector.

The impact of development policy

The "weak" view suggests improving firm productivity by employing better technology, enhancing management skills, and improving doing business environment. Some informal firms find it more beneficiary to enter the formal sector while less productive firms-in-waiting will enter the informal sector. When the TFP increases by 50%, the share of number of informal firms and the share of informal outputs hardly change (Table 13). But both the formal and the informal sector becomes larger after productivity improves. In fact, the number of formal firms increases 65% in the downstream and 92% in the upstream. The overall number of informal firms will also increase 68% and 94% in the downstream and the upstream respectively.

The intensive margin of informality increases as productivity improves. Formal firms now purchase 72% from other formal sellers compared to 81% in the baseline results. Formal firms sell slightly more to other formal firms. This reflects a larger improvement of productivity in the informal sector than the formal sector.

The most significant improvement comes from the increase of household income. Since both formal and informal sectors enlarge production, their labor demand increases and pushes up the equilibrium wage, which in turn raises household income by 20 times if productivity raises 50%. The improvement in household income is accompanied with 23% higher tax revenue and 26% increase in corporate profit.

In sum, both the "reservoir" view and the "parasite" view of informality is plausible in the model set up. The former view indicates that potentially productive informal firms are kept out of the formal sector due to high entry costs. Hence, policy makers should implement "carrot" policy by lowering the entry costs and induce the informal firms to formalize. The latter view indicates that informal firms are productive enough to enter the formal sector but intentionally stay informal to avoid regulatory liabilities. Hence, policy makers should strengthen enforcement or put "stick" on the informal sector so that the informal firms are forced to formalize.

While I show that both "carrot" and "stick" policies are effective in reducing informality and raising tax revenue, they have converse implications on the social welfare. The "carrot" policy can improve social welfare through higher level of tax revenue and higher level of firm profit. Informal firms in the "reservoir" now find it more profitable to register while less productive firms can still maintain its operation. On the contrary, the "stick" policy leads to welfare loss because it shrivels the profit of all informal firms despite the gain of tax revenue. When the loss of firm profits and household incomes is

larger than the gain of tax revenue, this would lead to a loss of social welfare despite higher level of formality.

Appendix I: more discussions on the definition of informality

Third, this paper is related to the literature on defining the informal sector. A prior question in the study of informality is its definition. Current literature includes three types of informality concept, including the size criteria, the compliance criteria, and behavior criteria. The size criteria is adopted by ILO which defines an informal firm as an unregistered firm where the owner is an individual or a household whose capital is not separable from that of the firm and for which there is not reliable accounting that could permit retracing the operations of the firm (ILO, 2002).

Dabla-Norris et al. (2008) and Benjamin and Mbaye (2012) find a strong correlation between firm size and its informality but they also argue that size might not be the only criterion of informality. Many micro firms are actually formal enterprises with tax registration and operational practices that are usually adopted only by formal firms (Gelb et al., 2009). Besides, ILO only sets up the upper bound of size of an informal firm at 10 and leaves the countries the job to clarify the actual size in their national surveys. This means that the size criterion will ignore the fact of tax compliance of many small firms.

The second criterion identifies the informality if their business activities are not registered with the appropriate authority. Gelb et al. (2009), Steel and Snodgrass (2008) use registration with tax authorities as the criterion in defining informal firms. They argue that informal sector is an entity unknown to the fiscal authorities, and hence does not comply with tax regulations.

But this criterion is also not enough to qualify a firm as formal as there is no clear cut as the definition of registration with appropriate authorities varies by country (La Porta and Shleifer, 2008). Benjamin and Mbaye (2012) demonstrate that even very small, informal firms without a known location are sometimes identified and listed by the tax department in Senegal. Even if informal firms are not always recorded at the level of central authorities, they are recorded at the local level where they also pay taxes.

The third criterion is treating informality as a continuum characteristic. There is strong heterogeneity even within the informal sector. Benjamin and Mbaye (2012) state that whatever the criteria are used, it is difficult to define the informal sector in a dichotomized manner. The criteria of size, registration, payment of taxes. do not sufficiently discriminate between formal and informal firms. So, the informal sector appears to be a continuum of situations defined by a set of factors that determine the place of each firm the formality scale. This definition often implies the most sophisticated are the best target for programs aimed at increasing registration or formal taxation (Medvedev and Oliedo, 2013)

However, this method is prone to subjective perception of “formal practices”. Identifying the practices that only apply to the formal sector is subjective, and giving weights to each of the practices is even more tricky. There is no guidance as to the selection of appropriate practices to define informality. While one might think maintaining a bank account is an important practice for the formal sector, others might regard contract-based work as the primary characteristic of the formal sector.

Appendix J: international experience on VAT adoption and the change of informality

Since more than 50 countries adopted VAT since 1990, a global experience will be a good starting point to study the impact of VAT reform on informality. Using a country-year panel data from Medina and Schneider (2018), I first implement the traditional diff-in-diff method to identify the shock after VAT adoption since 1990. I estimate the following equation:

$$Inf_{it} = \beta_0 + \alpha_i + \alpha_t + \beta_1 \cdot VAT\ adoption_{it} + \varepsilon_{it}$$

where Inf_{it} is the share of output by the informal sector in country i and year t, α_i is country fixed effect and α_t is year fixed effect, $VAT\ adoption_{it}$ is a dummy variable that equals 1 after country i adopts VAT and 0 if a country has not or does not adopt VAT. The coefficient of interest is β_1, which captures the net effect of VAT adoption on the share of informal outputs. The sample includes 109 developing countries from 1991 to 2017, out of which 55 countries adopted VAT during the period.

The adoption of VAT would lead to a drop of the share of informal outputs by 0.33 percentage points on average as shown in column 1. To capture the time lag for VAT to take effect, I augment the interaction term between the number of years before and after VAT adoption into the baseline regression[12]. On average, the drop in informality takes more than 5 years to materialize (column 2). The share of informality does not change in the first four years after VAT adoption but decreases by 0.49 percentage points after 5 years.

Column 3 and 4 replace the share of informality with log value of informal outputs as the dependent variable. This will capture the change in the total volume of informal output. The adoption of VAT has a negative impact on the informal outputs by 4.6% in developing countries. The effect is significant only in the longer term.

Table 14: net effect of VAT adoption on informality

	(1)	(2)	(3)	(4)
	Baseline	Post reform	Baseline	Post reform
VARIABLES	Share of informal output		Ln(Informal output)	
VAT adoption effect	-0.330*		-0.046**	
	(0.192)		(0.019)	
Treatment*1 year before VAT adoption		0.144		0.006
		(0.353)		(0.034)
Treatment*0 year after VAT adoption		0.024		0.020
		(0.358)		(0.034)
Treatment*2 year after VAT adoption		-0.104		-0.006
		(0.365)		(0.035)
Treatment*3 year after VAT adoption		0.090		-0.024
		(0.372)		(0.035)
Treatment*4 year after VAT adoption		-0.205		-0.046

[12] I augment seven interaction terms into the equation to compare the evolvement of informality against that prior to VAT adoption. I interact the treatment group dummy with five dummy variables corresponding to the i th year after VAT adoption. If VAT adoption generates a consecutive decrease of informality in the next five years, it would be captured by these interaction terms.

		(0.384)		(0.036)
Treatment*5 year after VAT adoption		0.290		-0.042
		(0.386)		(0.037)
Treatment*5 year after VAT adoption		-0.490**		-0.048**
		(0.241)		(0.024)
Country FE	Y	Y	Y	Y
Year FE	Y	Y	Y	y
Observations	2,916	2,916	2,825	2,825
R-squared	0.966	0.966	0.987	0.987

Appendix H

Besides the revenue gains, literature suggests an efficiency gain from VAT reform. De Paula and Scheinkman (2010) show the chain effect in which formalization can transmit through the value chain. This will improve the efficiency of tax administration because tax enforcement can only target one or several production stages that is key to transmit formalization to others. This section tests this hypothesis by showing an example of implementing strong enforcement on informal firms at one stage of the production stage. Specifically, I double the cost of inputs of either downstream informal firms or upstream informal firms and study its impact on informality. The changes in the number of each type of firms are shown in Table 15 and the changes in the output of each type of firms are shown in Table 13.

When strong enforcement is implemented to the downstream informal firms, it creates a reduction of downstream informal firms by 5%, which correspond to a stark drop of informal outputs by 53% in the downstream. The increase of formal firms is significant at 20% in the downstream, but only accounts for a 3% increase in the downstream formal outputs. But the formalization in the downstream does not transmit to the upstream. The number of both formal and informal firms shrink by 5% and 3% in the upstream respectively.

Newly formalized downstream firms have lower productivity than the incumbent formal firms. They are not productive enough to purchase heavily from formal sellers. Instead, they tend to maintain their informal network and purchase cheaply from informal sellers. For the informal sellers, they do not need to formalize to maintain their trade network even if their partners are now formal.

However, when strong enforcement is implemented to the upstream informal firms, this generate a significant chain effect and reduce informality in both production stages. The number of formal firms grows 27% and 22% in the downstream and the upstream respectively, corresponding to 14% and 86% increase in formal outputs. However, more formal buyers in the downstream also purchase more from upstream informal firms, which generates an overall positive increase in the upstream informal firms and their outputs.

When the upstream firms are forced to formalize, they can issue invoice and tax credit to their buyers. Their informal buyers, in turn, find it more profitable to formalize and take advantage of tax credit from formal sellers. This implies that tax credit from formal inputs provides a strong incentive for downstream buyers to formalize if their suppliers formalize.

In comparison to VAT, I replicate the above simulations targeting the downstream or the upstream informal firms under the cascading sales tax regime. But neither generates a chain effect in terms of formal outputs. When implementing the strong enforcement to the upstream informal firms, upstream formal firms expand outputs by 55% but downstream formal firms produce 19% less outputs. Under sales tax, the tax burden of formal inputs is bear by the downstream formal firms. In turn, downstream formal firms purchase more from informal suppliers at cheaper prices. When strict enforcement is implemented to the upstream informal firms, they will raise intermediate input prices and partially transmit the burden to the downstream sector. Hence, both formal and informal firms in the downstream suffer from higher input costs on their informal inputs.

Table 15: transmission of informality

Change from baseline	Number Downstream formal	Downstream informal	Upstream formal	Upstream informal
Imposing stricter enforcement on informal firms				
VAT, 5%: on downstream	20%	-5%	-5%	-5%
VAT, 5%: on upstream	27%	10%	22%	10%
ST, 5%: on upstream	36%	7%	23%	6%

Change from baseline	Revenue Downstream formal	Downstream informal	Upstream formal	Upstream informal
Imposing stricter enforcement on informal firms				
VAT, 5%: on downstream	3%	-53%	-5%	-3%
VAT, 5%: on upstream	14%	-10%	86%	11%
ST, 5%: on upstream	-19%	-39%	55%	6%