Misallocation or Misreporting? Evidence from a Value Added Tax Notch in India *

Tejaswi Velayudhan †

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Abstract

This paper analyzes the effect of an Indian value added tax (VAT) on production. The VAT system features a revenue-based exemption threshold intended to exempt small firms, which also incentivizes firms to either appear or remain small. Analysis using a novel dataset created by linking detailed establishment and commodity-level survey data to time-varying and commodity-specific VAT rates indicates that firms' reported revenues are on average 10 percent lower in the neighborhood of the exemption threshold. This neighborhood represents about 1 percent of total manufacturing output. This output response is largely due to compliance costs and additional enforcement associated with VAT registration rather than increased tax liability. Based on the revenue-to-input cost ratio of firms just below the exemption threshold, the observed production distortions appears to correspond to production changes rather than tax noncompliance. These findings indicate that the VAT would distort production even with perfect enforcement and that efforts to reduce firms' compliance burden could be welfare enhancing. Because the exemption threshold for a VAT is a ubiquitous and salient size-based regulatory threshold for most firms in developing countries, the insights and challenges illustrated in the context of the Indian VAT on manufacturing are widely applicable.

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†Department of Economics, The Ohio State University. Email: tvelayud@umich.edu.

1 Introduction

An important measure of the welfare consequence of taxation is how it distorts economic activity. Recent literature has demonstrated large responses by firms to tax "notches" and "kinks" at size-based thresholds, which are ubiquitous features of tax systems where tax liability changes discontinuously. Yet evidence of real production distortions, as opposed to strategic misreporting of true production, is elusive. This paper finds evidence in survey data of a substantial real reduction in production. I estimate a 10-20 percent production decrease among firms in the neighborhood of the exemption threshold, a tax kink and compliance notch created by a value added tax (VAT) in India. The use of survey data instead of more commonly-used administrative tax return data is important for two reasons. First, we might expect to be able to better measure real effects of taxation in data that does not directly affect a firm's tax liability, unlike tax returns. Second, if survey data is nonetheless influenced by strategic misreporting in response to tax incentives, that has consequences for research on productivity estimation and comparisons, which relies on the veracity of such establishment data in India and other countries.

The empirical approach of this paper is in the tradition of papers like Hurst et al. (2014), which is described as the "traces of evasion" approach by Slemrod and Weber (2012). Because evasion is difficult to observe directly, they use information on associated activities to reveal evidence of evasion. To arrive at their conclusion that the self employed underreport income even in survey data, Hurst et al. (2014) compare the income of self-reported individuals to the income of employees with the same reported consumption under the assumption that the consumption of both types of people and the income of the employees are truthfully reported. Analogously, this paper assumes that production inputs that have no bearing on tax liability are truthfully reported and uses this information to infer whether the observed output response is due to real production changes. Modeling heterogenous firms' responses to the CenVAT incentives shows that we would expect average revenue-to-input-cost ratios to be distorted upwards just below the exemption threshold if firms limit real production to remain below the threshold. On the other hand, if firms strategically underreport revenue, we would expect revenue to input cost ratios to be distorted downwards.

Existing research on firms' responses to tax incentives in developing countries uses administrative data from tax returns and shows that reported output is highly responsive to kinks and notches in the tax schedule (Best et al. (2015); Alejos (2018), etc.). In fact, some authors argue the estimated output elasticity with respect to the tax rate is too high to be a real production response. Given reasonable output elasticities, Best et al. (2015) estimate that evasion accounts for 15 to 70 percent of the change in the corporate tax base in Pakistan in response to the profit tax rate. This substantial misreporting might

carry over to establishment survey data if firms believe this information may be accessible to tax officials or even if firms find it simpler to report the same figures in all reports and documents. We cannot take as given that establishment survey data is not plagued by the same mismeasurement.

The anatomy of the behavioral response to the VAT notch also matters for the appropriate policy response. As Slemrod and Kopczuk (2002) argue, the elasticity of taxable income (ETI) is sensitive to the regulatory and enforcement environment. If a larger portion of the ETI is due to evasion response than to real response, as previous research has suggested, it may be affected by enforcement policy. Furthermore, to the extent that firms' evasion costs reflect transfers to others agents in the economy (e.g., revenue from penalties in tax audits), it is the elasticity of the real tax base with respect to the tax rather than reported base that is a sufficient statistic for excess burden (Chetty (2009)). Although under some assumptions the distinction between evasion and real response does not affect the welfare consequences of a tax (Saez, Slemrod and Giertz (2012); Feldstein (1999)), the *enforcement elasticity of the tax base* (as described in Keen and Slemrod (2017)) is in general an important parameter for optimal tax systems. Finally, we may have specific welfare objectives such as "fairness" for which we directly care about the level of evasion.

What is a VAT notch? Firms are responsible for remitting the VAT to the tax authority. Recognizing that the costs associated with this responsibility (such as tax filing and record keeping) may be burdensome for small firms, and the administrative costs to the tax authority for dealing with small firms may not be worth the additional revenue, most tax authorities give firms with revenue below a certain threshold the option to be exempt from the tax. For firms that would take this exemption, there is a discontinuous change in their tax liability around this revenue threshold. If their revenue is below the threshold, they do not remit any tax on their output. Above the threshold, their tax liability increases by their value-add, creating a "notch" in their tax schedule. In the context considered in this paper, which is a VAT on manufacturing called the "CenVAT", the rules create only a "kink" in the tax liability instead of a notch because firms have the option to only remit tax on their output above the exemption threshold. However, the compliance costs associated with registering for the CenVAT create a notch in firms' total costs.

The VAT is a major source of revenue in most countries, making the revenue-based exemption threshold for a VAT a widespread and salient size-based regulatory threshold for firms nearly everywhere. Moreover, the VAT is generally broad-based and covers most goods and services in an economy, which means the VAT notch is relevant for most firms within countries as well. A thorough understanding of firms' response to a VAT notch is therefore applicable in many contexts.

To document and analyze the response to the VAT threshold, I use data from the the Annual Survey of Industries (ASI), which is both an annual census of manufacturing establishments with over a 100 workers and a 20 percent random sample of the "organized" manufacturing sector with fewer than 100 workers. This data has been used in recent years to study various aspects of manufacturing productivity in India (Hsieh and Klenow (2009); Martin et al. (2017); Rotemberg (2017) etc.). I link this production data to information on CenVAT rates by 8-digit product code. As a survey intended to generate detailed production statistics about the manufacturing sector, the ASI contains balance sheet information on establishments that are never reported to the tax authority, such as fixed capital, working capital, loans, investment in plant and machinery, number of workers and man-hours worked. The data may also cover firms that are not registered with any tax authority. Hence information on firms' inputs potentially provide a second source of information about firms' true revenue.

Firms' response to the VAT is apparent in the excess mass of firms with revenue just below the exemption threshold, suggesting that the VAT lowers reported output (see Figure 4). The exemption threshold was raised by 50 percent in 2008, causing the excess mass in the firm revenue distribution to shift to the new threshold. This shift confirms that the shape of the distribution around the threshold was due to tax incentives. The revenue distribution of firms producing goods that are exempt from the CenVAT shows no such excess mass, providing further evidence that the excess mass in the revenue distribution of taxable goods producers is caused by the tax incentives at the threshold.

The analysis proceeds as follows: First, I use standard bunching estimation techniques as described in Kleven and Waseem (2013) to estimate the excess mass of firms due to the notch as well as the upper bound of the "manipulation region". Firms whose potential revenue is in the manipulation region are the firms who may reduce output to remain below the threshold. Next, I examine the revenue to input cost ratio of firms in the estimated bunching region. As I show in the conceptual framework, the pattern we would expect to see if the bunching were caused by real production changes is the opposite of what we would expect under misreporting. This production response seems to be due to the compliance costs and increase in enforcement at the exemption threshold. Finally, I show that at least some of the change in revenue to input costs around the threshold is likely explained by the selection of firms into bunching based on factor-specific productivity.

Results show that reported output would have been higher by about 8 to 20 percent on average among taxable goods producers with reported revenue in the neighborhood of the exemption threshold, in absence of the CenVAT. The total reported output of these firms represent about 1 percent of total output of all taxable goods manufacturers. These figures are an average across firms that do and do not value the VAT exemption, which

means the response of firms who value the exemption is even larger. Public and private limited companies are more responsive than sole proprietorships and partnerships. The magnitude of the response is similar even when the threshold increases by 50 percent in nominal terms from ₹10 million (approx $150,000) to ₹15 million (approx $230,000).

Comparing firms producing goods taxed at the standard CenVAT rate to those producing goods at the reduced rate, I find similar output reduction in both groups, suggesting that it is the compliance costs and additional enforcement associated with CenVAT registration that drives output reduction - not the change in tax liability. Finally, I address the concern that the observed difference in revenue to input cost ratio around the exemption threshold is driven by selection into bunching and voluntary registration. Even controlling for the determinants of voluntary registration, I find that revenue to input cost ratio is higher just below the exemption threshold, suggesting that the observed output response reflects real economic activity.

In Section 2, I describe how this paper relates to various strands of literature, Section 3 provides details of the empirical context and firms' incentives in the CenVAT, Section 4 illustrates the theoretical framework linking firm's incentives, observed outcomes, and the assumptions required to identify evasion. Section 5 presents the empirical strategy to first estimate the extent of bunching at the threshold and then to separately estimate the extent of real response at the notch. Sections 6 and 7 describe the data and provides relevant descriptive statistics, Section 8.1 presents evidence on bunching at the tax notch, Section 8.2 shows the extent of evasion, and Section 8.3 argues that the output reduction is due to compliance costs. Section 9 addresses selection and voluntary registration. Finally, Section 10 concludes.

2 Related Literature

This paper builds on the "traces of evasion" literature starting with Pissarides and Weber (1989) and summarized in Slemrod and Weber (2012). Evasion is difficult to measure directly except through audits. Instead, evasion is inferred from observed activity with the help of assumptions about the link between this activity and true income. For example, in their seminal work, Pissarides and Weber (1989) infer the extent of income underreporting among the self-employed by comparing the reported consumption to income ratio of the self-employed to employees with similar consumption profiles. Assuming that the self-employed and employees truthfully report their consumption, and that employees also truthfully report their income, the difference in the consumption to income ratio of self-employed individuals from that of employees tells us the extent of income underreporting.

Johnson et al. (1997) take a similar approach in aggregate data to estimate the extent of the informal sector that is not captured in official GDP estimates by using the total electricity consumption in various countries. Assuming the elasticity of GDP to electricity is approximately 1, deviation from this elasticity is an estimate of the underreported GDP because electricity consumption can be measured accurately and truthfully. In this paper, I apply the same intuition to compare the electricity use among firms just below the VAT exemption threshold to firms far away from the threshold.

Although I use data from a statutory survey of manufacturing establishments, which is never shared with the tax authority, the data may still reflect evasion. First, the data is presumably based on firms' records, which may be maintained with possibility of audits in mind. If firm owners and accountants believe there is even a small chance of detection based on discrepancies between what is reported to the tax authority and their records or survey responses, they may not report truthfully to the survey. For example, Amirapu and Gechter (2018) find that firms underreport the number of employees in the Economic Census, which is used to construct the sampling frame for the survey of manufacturers. Labor regulations set in at various worker thresholds, which incentivizes firms to underreport their workers even in the census data. An important difference here is that the worker information reported in the economic census is shared with regulatory bodies.

The paper also contributes to the literature on behavioral responses of firms at tax kinks and notches. Size-based regulation are a common feature of tax systems. These regulations introduce kinks or notches where either compliance costs, enforcement or tax liability change discontinuously across a revenue threshold. Firms' responses to these kinks inform us of the elasticity of their output with respect to these various cost margins. For example, Asatryan and Peichl (2017) estimate the elasticity of firms output with respect to a compliance cost notch. Harju, Matikka and Rauhanen (2018) study firms' responses to both a compliance cost notch and a tax liability notch and find that firms' output is much more responsive to compliance costs than tax liability. Finally, Almunia and Lopez-Rodriguez (2018) examine the response of Spanish firms to a revenue-based enforcement notch created by the "Large Taxpayers Unit". They find that firms reduce their output by 2 percent on average in response to the increase in enforcement at the threshold.

There are differences across contexts in the extent to which firms' response reflect strategic misreporting or real production response. The estimated extent of evasion in Pakistan (Best et al. (2015) stands in stark contrast to Harju et al. (2018), who suggest that in an advanced economy like Sweden, firms bunch below the VAT registration threshold by reducing real rather than reported output. One contribution of this paper is to examine

firm behavior in survey data, which captures firms outside of the tax net and information not reported to the tax authority.

While this paper separates the real and reporting response, it does not estimate an elasticity of the tax base with respect to the tax rate. Lockwood (2018) stresses that under a notch, the elasticity of the tax base with respect to the tax rate is no longer a sufficient statistic for the marginal excess burden due to the tax. This is because a change in the tax rate under a notch can have a first order effect on tax revenue. Under a notch, firms who bunch reduce their tax liability on all their income and not just by the amount they reduced their income above the threshold. This results in a discontinuous change in their tax liability unlike in the case of a tax kink, and therefore a first-order effect on tax revenue. However, the share of the real output response is still informative about how much of the true elasticity of the tax base can be influenced by enforcement.

Productivity differences across firms, both within and across countries, are a focus of much research in economics. Measures of productivity differences rely on establishment censuses, including in India, where the Annual Survey of Industries (ASI) is the only source for such information. Productivity differences are estimated using differences in measured input use relative to revenue. Strategic misreporting because of tax incentives can lead to incorrect estimates of productivity. For example, the "cost-shares" approach to production function estimation (Ackerberg et al. (2015)) estimates Cobb-Douglas coefficients using the ratio of reported input costs to revenue. If revenue is underreported in response to taxes, these ratios are incorrectly measured.

More popular "proxy-based" methods of estimating production functions are neither appropriate nor necessary in the presence of misreporting. One of the key assumptions in the proxy-based approach – scalar unobservables - is that intermediate inputs depend only on observables like labor and capital input and a single unobservable, which is productivity. It is likely that this assumption fails in the VAT context as VAT-registered firms are incentivized to misreport intermediate inputs.

3 Empirical Context

3.1 Small Scale Industry (SSI) Exemption under the CenVAT

Until July 2017[1], the central government of India imposed a value added tax on manufactured goods called the "CenVAT"[2] . The CenVAT was nominally a tax "on" manufacturing, which for the purpose of this tax was defined as any activity that resulted in the creation of a new and marketable product. This definition included repackaging, relabeling and branding of products but exempted wholesalers and retailers.

The CenVAT operated like a standard VAT up to the manufacturing stage in most respects except for two key differences. Like other VAT systems, firms remitted tax on their output and could receive input tax credits on any taxable inputs purchased from CenVAT-registered firms, creating the classic self-enforcing chain mechanism of a VAT and preventing cascading taxes. It offered an exemption for firms whose annual revenue was below an exemption threshold, which was ₹10 million (approx. $150,000) until 2007 or below ₹15 million (approx. $230,000) thereafter. Firms whose revenue was below the exemption threshold, and therefore were eligible for the exemption, could choose to voluntarily register for and remit the CenVAT, another standard feature of VAT systems. The differences from a standard VAT arise because of two particular rules regarding the revenue-based exemption for the CenVAT, which was called the "Small Scale Industry" (SSI) exemption[3].

Unlike other VAT systems, firms had two options once they crossed the exemption and registration threshold. They could either remit tax on their entire revenue and claim input tax credits (i.e. remit tax on their value added) or they could remit tax only on the revenue above the exemption threshold without claiming any input tax credits. In a standard VAT, firms would have to remit tax on their entire value added once they register. A second difference from the standard VAT is that firms could only opt for this SSI exemption if their revenue in the previous fiscal year was below ₹40 million (approx. $600,000). This second condition turns out to have little effect on firm behavior for reasons discussed in Appendix A. However, the option to remit tax on your turnover in

[1] In July 2017, India introduced the comprehensive "Goods and Services Tax" (GST), which subsumed this CenVAT along with many other taxes including the State Value Added Tax, Service Tax and others.

[2] This tax is also referred to as the "Central Excise Tax". The use of the term "excise" tax in its description is due to its origins as an excise tax on salt under British rule. Over time the tax base was expanded to cover nearly all manufacturing. A major reform in 1999 introduced the value added tax structure to the Central Excise Tax, when it was named the "CenVAT". Starting in 2001, firms could claim input tax credits on all taxed intermediate inputs and capital goods.

[3] Establishments designated as "SSI" received other preferential treatment such as the license to produce certain commodities or lower interest loans. But the criteria to qualify as an SSI firm for all other benefits was in terms of the original value of investment in plant and machinery, not their revenue. The revenue-based SSI classification only applied to the CenVAT exemption.

excess of the exemption threshold instead of the entire value-add creates a kink in the tax liability instead of a notch. Taxpayers still face a compliance cost notch at the exemption threshold because firms must register once they cross the threshold regardless of whether they choose to remit tax on turnover or on value-add.

Registration for the CenVAT is separate from any other registrations of the business. To register, firms have to fill out paperwork and obtain a taxpayer ID number specifically for the CenVAT, which they will then use to file either monthly or quarterly returns. Once a firm is registered and filing returns, they have to keep certain records and could be subject to audit according to the selection criteria of the tax authority such as risk of evasion and potential tax revenue. These additional requirements introduce a fixed compliance cost once a firm registers. It is possible to de-register if a firm's output remains below the exemption eligibility threshold.

3.2 Tax Liability Under the CenVAT

Consider a firm with pre-tax revenue of R_{it} and pre-tax cost of taxable intermediate inputs of $p^M M_{it}$, where p^M is the pre-tax unit price of intermediate inputs M_{it}. If the firm always registers for the CenVAT, regardless of whether they may be eligible for the SSI exemption, their tax liability is:

$$T(\tau, R_{it}, p^M M_{it}) = \tau R_{it}$$

where τ is the CenVAT rate. They remit tax on their revenue, R_{it} and receive input tax credits on their taxable inputs[4].

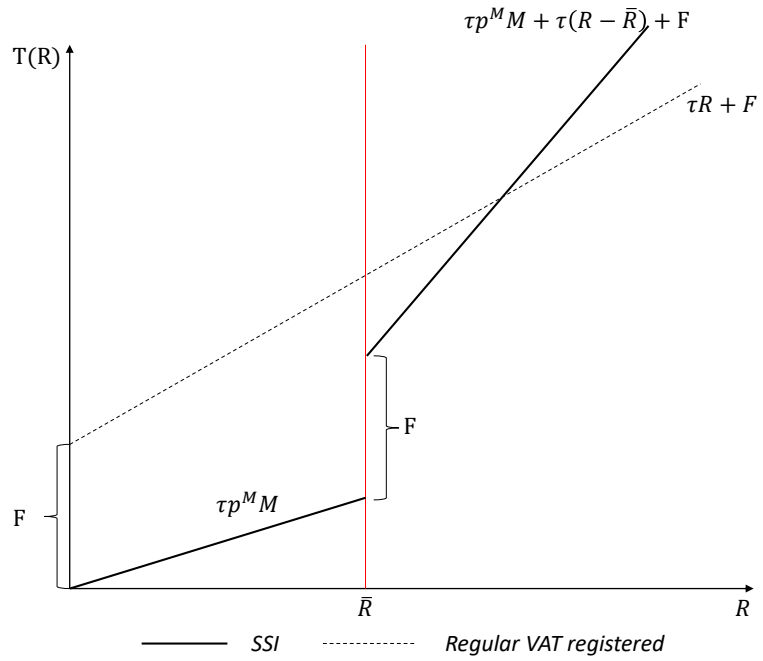
In addition, they incur compliance costs associated with CenVAT registration, which I treat as a fixed cost of compliance, F. The sum of their tax liability and compliance cost is:

$$T(\tau, R_{it}, p^M M_{it}) + F = \tau R_{it} + F \tag{1}$$

On the other hand, if a firm takes the SSI exemption when eligible, their tax liability and compliance costs are as follows:

[4]One might be expecting tax liability under a VAT to be written as the tax rate multiplied by the value added of firm, $\tau(R_{it} - p^M M_{it})$. However, here I have represented it as the tax on a registered firm's total revenue, so that it is clear to the reader that an unregistered firm still contributes to VAT revenue through their foregone input tax credits. Under this notation, the *difference* in tax liability for a registered and unregistered firm, is the tax on their value added, $\tau(R_{it} - p^M M_{it})$

Figure 1: Tax Liability and Compliance Cost under the CenVAT



$$T(\tau, R_{it}, p^M M_{it}, \bar{R}) = \begin{cases} \tau p^M M_{it} & \text{if } R_{it} < \bar{R} \\ \tau p^M M_{it} + \tau(R_{it} - \bar{R}) + F & \text{if } R_{it} > \bar{R} \end{cases} \tag{2}$$

They do not remit any tax on their output if their revenue is below the exemption threshold, $\bar{R}$ but must forgo their input tax credits. Once their revenue crosses the exemption threshold, they must remit tax on any revenue above the exemption threshold but still do not receive input tax credits and face a compliance cost notch equal to F at this threshold, which represents the costs associated with monthly filing, record keeping and higher probability of audit once a firm is registered. Tax officials need permission from a senior official to enter the premises of SSI firms but not of registered firms, which creates an additional enforcement notch at this threshold.

Figure 1 shows how the CenVAT rules create a kink in the tax liability and a notch in compliance costs at the exemption threshold, $\bar{R}$. The dashed line shows the sum of their tax liability $T(R_{it})$ and fixed compliance cost, F if they are always registered under the CenVAT. It is a linear function of their revenue with a slope of τ and an intercept of F. On the other hand, if they take the SSI exemption, their tax liability is described by the solid line. Until their revenue reaches $\bar{R}$, they do not have to register for the CenVAT

and therefore do not incur the fixed compliance cost. Their tax liability is the forgone input tax credits, $\tau p^M M_{it}$, which increases with revenue as they require more inputs to generate greater revenue. Once they cross the exemption threshold, they incur the fixed compliance cost F and they must remit tax on revenue above threshold in addition to the forgone input tax credits. Their tax liability now increases more quickly with revenue, creating a tax kink and the fixed compliance cost creates the notch.

To summarize, firms faced a kink in tax liability at ₹15 million, a notch in tax liability at ₹. 40 million, and a notch in compliance costs at ₹15 million. This paper focuses on firm behavior at the ₹15 million exemption threshold, and treats it as a combination of a compliance cost notch and a tax kink[5].

Unlike the VAT threshold in many advanced economies, the exemption threshold for the CenVAT was relatively high. In 2004, nearly 50 percent of "organized" manufacturing firms were below the exemption threshold. Because the threshold is in nominal terms and not indexed to inflation, this share declined over time and in 2012 about 30 percent of organized manufacturing firms were below the exemption threshold. As we might expect, exempt firms have smaller output and therefore only represent between 1 to 3 percent of organized manufacturing output. They also represent a sizable proportion of total employment in organized manufacturing ranging from between 5 to 15 percent of total employment in the decade between 2005 and 2015. The substantial discrepancy between the output share and employment share is because these small firms are much less productive.

Although tax liability is higher for a registered firm, their output may also be more attractive to other registered businesses because they can provide input tax credits. Under the CenVAT, a registered downstream firm can only claim input tax credits on purchased from a registered upstream firm. As a result, in the CenVAT as with other VAT systems, upstream firms may have an incentive to voluntarily register. The voluntary registration decision depends primarily on the whether their potential buyers are registered CenVAT businesses, or if they are unregistered entities such as unregistered firms or final consumers, who cannot avail of input tax credits. A second determinant, conditional on firms being able to sell to both registered and unregistered firms, is their taxable input costs as a share of revenue. A more detailed explanation of the voluntary registration decision along with an example is provided in Appendix A. In the conceptual framework that follows, I derive the conditions under which a firm would voluntarily register based on parameters of the production function and the price of the firms' output if they are or are not registered.

[5]This SSI exemption threshold of ₹15 mn is still salient under the new tax regime that replaced the CenVAT - the Goods and Service Tax or GST. Firms whose revenue is below this threshold can opt for the "composition scheme" under the GST which means they are subject to a turnover tax instead of a VAT.

3.3 Other features of the CenVAT

After 2001, the CenVAT had 3 to 4 applicable rate categories – the standard rate, reduced rate, exempt and special rate categories. The applicable VAT rate within these categories changed over time. Some manufactured commodities (largely food items, medicines and publishing) were exempt from the CenVAT, but only exports were zero-rated, which means exporters faced a zero rate on their revenue but could claim input tax credits. On the other hand, firms that produced exempt commodities faced a zero rate on their revenue but could not claim input tax credits.

4 Conceptual Framework

This section presents a model that demonstrates how evasion and true production changes manifest themselves in the observed average revenue-to-labor cost ratio of firms that bunch at a size-based exemption threshold. The key intuition here is that the observed revenue-to-labor cost ratio in the bunching region is an average across firms in a range of productivity from whom it is optimal to report revenue at the threshold. When their true revenue is equal to or close to this reported revenue, higher productivity firms require less input to produce at that level. On the other hand, when firms' true revenue is unrelated to their report (i.e. when evasion costs are low), more productive firms use more inputs to produce more but nevertheless report output equal to the threshold, thereby driving down the average revenue-to-labor cost ratio.

4.1 Distribution of Revenue and Input Use

Ignoring voluntary registration for the moment, consider firms' optimization with and without evasion. In both cases, in a model with firms of varying productivity levels, the CenVAT notch incentivizes some firms to bunch below the threshold. Without evasion, this bunching represents firms optimally producing output at or below the threshold. Allowing for evasion, some firms who produce output greater than the exemption threshold under-report revenue to exactly the exemption threshold. As this model will show, as the mix of output response shifts from under-reporting to a real production response, the average revenue-to-labor cost ratio of bunching firms rises above the non-tax average.

No misreporting Consider firms that use only labor inputs, denoted by E_i which are exempt from VAT. Without taxable inputs in production, voluntary registration is

never optimal so we can characterize the revenue and revenue-to-labor cost distribution ignoring this factor. In a later section I will show that allowing voluntary registration does not affect these characterizations under certain conditions. Firms are heterogenous in an exogenously given productivity parameter, ω_i, which gives rise to the firm size distribution, as firms' productivity determines their unique size given production with decreasing returns to scale.[6] Returns to scale is denoted by $\psi \in [0, 1)$ and firms' profit is given as:[7]

$$\pi_i = \omega_i E_i^{\psi} - p^E E_i - \bar{\tau}(R_i - \bar{R}) - \mu F \tag{3}$$

where

$$(\bar{\tau}, \mu) = \begin{cases} (0, 0) \text{ if } R_i \leq \bar{R} \\ (\tau, 1) \text{ if } R_i > \bar{R} \end{cases}$$

Price of labor p^E is exogenously given. Tax liability is modified from equations (1) and (2) to ignore voluntary registration and μ is a dummy for whether the firms' revenue is above the exemption threshold. Note that in this benchmark model, I am not allowing for misreporting.

Solving the firm's optimization problem, their optimal revenue can be described as a function of ω_i as follows:

$$R_i^* = \begin{cases} \omega_i^{\frac{1}{1-\psi}} \left[\frac{p^E}{\psi} \right]^{\frac{\psi}{\psi-1}} & \text{if } \omega_i < \omega^1 \\ \bar{R} & \text{if } \omega^1 < \omega_i < \omega^2 \\ \omega_i^{\frac{1}{1-\psi}} \left[\frac{p^E}{(1-\tau)\psi} \right]^{\frac{\psi}{\psi-1}} & \text{if } \omega_i > \omega^2 \end{cases} \tag{4}$$

where ω^1 and ω^2 are defined by the following conditions: ω^1 is the productivity level at which profit-maximizing revenue is equal to the threshold level of revenue, i.e. $R_i^*(\omega^1) =$

[6] Entry and exit are not explicitly modeled but this framework is consistent with models where firms must pay a fixed cost to enter the market and only realize their productivity draw upon entering. Their decision to enter or exit is based on the expected productivity draw.

[7] Because no firm would voluntarily register, the tax schedule is that of firms that would always choose the exemption.

$\bar{R}$. The upper bound, ω^2 is such that the firm is indifferent between constraining revenue at the exemption threshold and producing at a level of revenue above the exemption threshold. Firms with productivity between these two thresholds choose to bunch at the exemption threshold.

Their revenue-to-input cost ratio is given as:

$$\frac{R_i^*}{p^E E_i} = \begin{cases} \frac{1}{\psi} & \text{if } \omega_i < \omega^1 \\ \frac{\bar{R}^{\frac{\psi-1}{\psi}} \omega_i^{\frac{1}{\psi}}}{p^E} & \text{if } \omega^1 < \omega_i < \omega^2 \\ \frac{1}{\psi(1-\tau)} & \text{if } \omega_i > \omega^2 \end{cases}$$

With Misreporting Now consider firms' optimization allowing for misreporting. I modify firms' profit in equation 3 to allow firms to under-report their revenue at a cost $c(R_i - \hat{R}_i)$, where $c(.)$ is a convex function of the amount of misreporting $e = (R_i - \hat{R}_i)$ and reported revenue is $\hat{R}_i$. Firms' profit is:

$$\pi_i = \omega_i E_i^{\psi} - p^E E_i - \bar{\tau}(\hat{R}_i - \bar{R}) - \mu F - c(R_i - \hat{R}_i) \tag{5}$$

where

$$(\bar{\tau}, \mu) = \begin{cases} (0,0) \text{ if } \hat{R}_i \leq \bar{R} \\ (\tau, 1) \text{ if } \hat{R}_i > \bar{R} \end{cases}$$

Now the tax and compliance costs applicable depend on reported instead of true revenue. Again, there are threshold levels of productivity, ω^1 and $\tilde{\omega}^2$, such that firms with $\omega_i \in [\omega^1, \tilde{\omega}^2]$ will report revenue equal to the exemption threshold. Reported revenue-to-labor cost ratio is now given by:

$$\frac{\hat{R}_i^*}{p^E E_i} = \begin{cases} \frac{1}{\psi} & \text{if } \omega_i < \omega^1 \\ \bar{R}(\omega_i \psi)^{\frac{1}{\psi-1}} (p^E)^{\frac{-\psi}{\psi-1}} [1 - c_e(R_i - \bar{R})]^{\frac{1}{\psi-1}} & \text{if } \omega^1 < \omega_i < \tilde{\omega}^2 \\ \frac{1}{\psi(1-\tau)} - \frac{c_e^{-1}(\tau)}{p^E} \left[\frac{p^E}{\omega_i \psi(1-\tau)} \right]^{\frac{1}{1-\psi}} & \text{if } \omega_i > \tilde{\omega}^2 \end{cases}$$

Note that for all firms with $\omega_i \in [\omega^1, \omega^2]$, their reported revenue will be $\bar{R}$. So the average revenue-to-labor cost ratio we will observe for firms reporting revenue at the exemption threshold (i.e. the bunching region) will be an average across all firms in this range of productivity:

$$E\left[\bar{R}\left(\frac{\omega_i}{p^E}\right)^{\frac{\psi}{\psi-1}}[1-c_e(R_i-\bar{R})]^{\frac{1}{\psi-1}} \mid \omega_i \in [\omega^1, \tilde{\omega}^2]\right] \tag{6}$$

This average revenue-to-labor cost ratio is a function of the marginal cost of misreporting at the equilibrium level of under-reporting, $R_i - \bar{R}$. As the marginal cost increases, firms underreport less and so the firms that bunch (i.e. report revenue of $\bar{R}$) must produce less, which increases the average reported revenue-to-labor cost. At one extreme when there is zero cost of misreporting, all firms would bunch at the threshold and true output would be equal to the no-tax counter-factual such that average revenue-to-labor cost ratio would be given by:

$$E\left[\bar{R}(\omega_i\psi)^{\frac{1}{\psi-1}}(p^E)^{\frac{-\psi}{\psi-1}} \mid \omega_i \in [\omega^1, \tilde{\omega}^2]\right] \tag{7}$$

where we get this expression by evaluating expression 6 with $R_i = \bar{R}$.

At the other extreme, when the cost of misreporting is prohibitively high such that no one can misreport, the average revenue-to-labor cost ratio of bunching firms is given by:

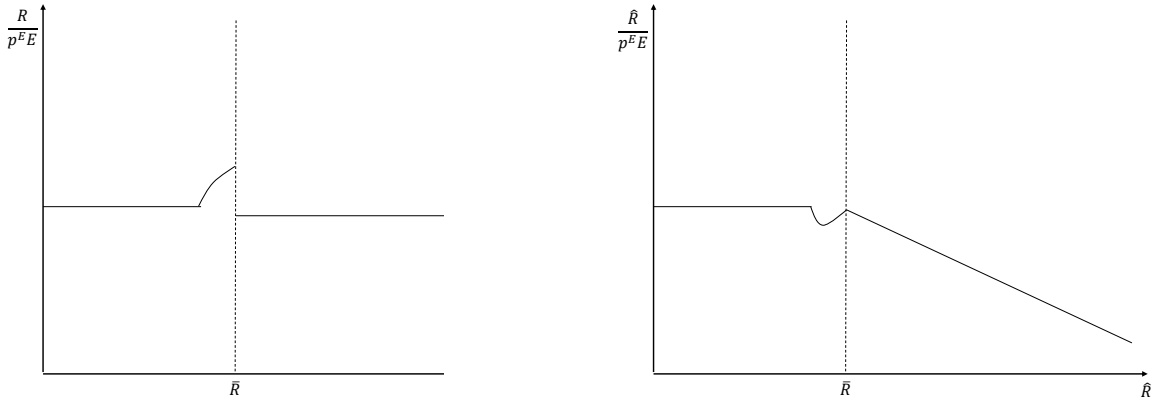
$$E\left[\frac{\bar{R}^{\frac{\psi-1}{\psi}}\omega_i^{\frac{1}{\psi}}}{p^E} \mid \omega_i \in [\omega^1, \omega^2]\right] \tag{8}$$

By definition of ω^1, it must be the case that the revenue-to-labor cost ratio of this marginal bunching firm is equal to $\frac{1}{\psi}$, its no-tax revenue-to-labor cost ratio. In Expression 7, the term inside the expectation is decreasing in productivity, which means that the average is lower than the revenue-to-labor cost ratio of the firm with ω^1 productivity. In Expression 8, the term inside the expectation is increasing in productivity, which means that the average is higher than the revenue-to-labor cost ratio of the firm with ω^1 productivity, i.e.:

$$E\left[\bar{R}(\omega_i\psi)^{\frac{1}{\psi-1}}(p^E)^{\frac{-\psi}{\psi-1}} \mid \omega_i \in [\omega^1, \tilde{\omega}^2]\right] < \frac{\hat{R}}{p^E E_i}(\omega^1) = \frac{1}{\psi} < E\left[\frac{\bar{R}^{\frac{\psi-1}{\psi}}\omega_i^{\frac{1}{\psi}}}{p^E} \mid \omega_i \in [\omega^1, \omega^2]\right]$$

As the cost of evasion for a given level of evasion increases, fewer firms under-report their revenue, and those who do, under-report by a smaller amount and reduce their true production by more. Therefore, the average observed revenue-to-labor cost ratio among bunching firms would increase as the cost of misreporting rises and true production is distorted to a greater extent.

With and without evasion, we would observe bunching in the revenue distribution. However, without evasion, we would expect a higher revenue to input cost ratio for the bunching firms, which is the opposite of what we would expect when there is no true production distortion. Whether or not firms would choose to under-report revenue depends on the marginal cost to doing so. I examine the revenue-to-labor cost observed in the data to see which of the two extremes described above better matches the data.



(a) High misreporting cost (b) No misreporting cost

Figure 2: Revenue to input cost ratio by Revenue

4.2 Voluntary Registration

Although firms with revenue less than the exemption threshold can choose to be exempt from the CenVAT, they can also voluntarily register for the CenVAT. Some firms do choose to voluntarily register, which means they have no incentive to bunch at the exemption threshold as there is no change in their tax liability. There is a concern therefore that the difference in input use efficiency of firms on either side of the exemption threshold may re-

flect selection of firms into voluntary registration. This section describes the determinants of voluntary registration and its converse - bunching - and shows how given standard production functions, selection would not result in systematic differences in revenue-to-input ratio around the exemption threshold among firms within a commodity market. Firms' propensity to voluntarily register only varies across commodity markets.

To analyze voluntary registration, firms' production must depend on taxable intermediate inputs in addition to tax exempt inputs. I modify the framework presented in the preceding section to have Cobb-Douglas production that depends on M (taxable inputs) and E: $F(E, M) = E^{\alpha}B^{\beta}$. Returns to scale is decreasing such that $\alpha + \beta = \psi$. A key assumption is that pre-tax input prices, p^M and p^E can vary across commodity markets but not based on firms' registration status. Output prices vary across commodity markets and by firms' registration status. Registered firms receive p_B^Y and unregistered firms receive p_B^Y. Under these conditions, it can be shown that a sufficient condition for firms to prefer not to register when we do not allow for evasion is that:

$$\frac{p_C^Y}{(1+\tau)^{\beta}} \geq (1-\tau)p_B^Y \tag{9}$$

This is also a necessary condition in the absence of fixed compliance costs. This condition encapsulates the results from Liu et al. (2017) that firms are more likely to select into bunching if the reduction in output tax is sufficient to compensate for the difference in price of their output as a registered and unregistered firm. They are also more likely to select into bunching if their production process is less reliant on taxable intermediate inputs for which they can only claim input tax credits if they are registered. The empirical analysis compares firms producing the same commodity, so we can abstract away from selection across commodities and focus on selection within more disaggregated categories.

The sufficient condition shows that there is no theoretical reason to expect that firms that select into voluntary registration would have systematically different revenue-to-labor cost ratios than bunching firms as the selection is independent of the unit price and intensity of use of tax-exempt intermediate inputs. If this sufficient condition fails, then there is a threshold productivity level conditional on all other parameters above which firms will voluntarily register. Therefore, more productive firms are more likely to register, which means we would expect revenue-to-input cost ratio (which is higher for more productive firms) to be lower among bunching firms. To the extent that there is selection on productivity in this manner, it would bias against finding revenue-to-labor cost ratios consistent with a true production response.

5 Empirical Strategy

5.1 Bunching Estimation

Following many previous examples in the literature (Saez (2010); Kleven and Waseem (2013); Almunia and Lopez-Rodriguez (2018)), I estimate the change in reported output of the marginal buncher and the average output response at the notch. For each of two periods (before and after 2008), I collapse the data into counts of firms within revenue bins of ₹200,000 (approx. $3000). I estimate the counterfactual density by fitting a 4th degree polynomial to these counts, with dummies for the manipulation region as follows:

$$F_k = \sum_{i=0}^{4} \beta_i R_k^i + \sum_{k=r^{lb}}^{r^{ub}} \delta_k \mathbf{I}(R_k = k) + \sum_{m \in M} \eta_m + \epsilon_k \tag{10}$$

where β_i is the coefficient on each polynomial term and the coefficients, δ_k on dummies $\mathbf{I}(R_k = k)$, identify either the excess or missing mass within each revenue bin relative to the counterfactual density. F_k is the actual density of firms in each revenue bin, k. R_k is the midpoint of revenue in each bin. I also control for potential round-number bunching by including dummies for whether the interval contains a multiple of ₹50 K, 100K, 250K, 500K, 1000K or 5000K. These dummies are represented in the specification above by η_m where $m \in M = \{50K, 100K, 250K, 500K, 1000K, 5000K\}$.

The revenue density is generally decreasing in revenue but increasing just below the exemption threshold. I set the lower bound r^{lb} at the point where the density starts to increase and iterate over different choices of the upper bound r^{ub} to find the upper bound such that the estimated excess mass to the left of the exemption threshold equals the missing mass to the right of the threshold as follows:

$$\sum_{k=r^{lb}}^{\bar{R}} \hat{\delta}_k = \sum_{k=\bar{R}}^{r^{ub}} \hat{\delta}_k$$

Average bunching response is estimated as:

$$b = \frac{\sum_{k=r^{lb}}^{\bar{R}} \hat{\delta}_k}{\frac{1}{2}(\hat{F}_{r^{lb}} + \hat{F}_{r^{ub}})}$$

which represents the average response across all firms, some of whom may not bunch. $\hat{F}_{r^{lb}}$ is the counterfactual density at the lower bound and $\hat{F}_{r^{ub}}$ is the counterfactual density at the estimated upper bound of the manipulation region.

The bunching estimates are translated into the percentage decrease in output they imply by multiplying the estimate by the bin size, which is ₹200,000 and dividing by revenue at the exemption threshold, which was ₹10 mn before 2008 and ₹15 mn afterward.

5.2 Strategic Misreporting and Real Response

What we would like to know is by how much the CenVAT reduces true output. If firms produce as if there was no CenVAT and simply report output at or below the exemption threshold (i.e. 100 percent of the measured output loss is due through underreporting), it has to be the case that these firms face no misreporting costs and that the revenue to labor cost ratio would be reduced by the average amount of output under-reporting. Suppose firm i reports revenue $\hat{R}_i$ and the proportion of revenue underreporting is $\theta_i = \frac{R_i - \bar{R}}{R_i}$ for true revenue R_i, which is equal to their no-tax counterfactual revenue. Note that this expression for the amount of under-reporting takes into account that all bunching firms report revenue at the exemption threshold. Let $\bar{\theta} = E(\theta_i | \omega_i \in [\omega^1, \omega^2])$, which is the average percentage decrease in output of bunchers. Then the observed average revenue-to-labor cost ratio of bunchers is given as:

$$\begin{aligned} E\left[\frac{\hat{R}_i}{p^E E_i} \mid \omega_i \in [\omega^1, \omega^2]\right] &= E\left[\frac{(1-\theta_i)R_i}{p^E E_i} \mid \omega_i \in [\omega^1, \omega^2]\right] \\ &= E\left[(1-\theta_i) \mid \omega_i \in [\omega^1, \omega^2]\right] E\left[\frac{R_i}{p^E E_i} \mid \omega_i \in [\omega^1, \omega^2]\right] \\ &\quad - Cov\left(\frac{\bar{R}}{R_i}, \frac{R_i}{p^E E_i} \mid \omega_i \in [\omega^1, \omega^2]\right) \end{aligned} \tag{11}$$

We can estimate the last three terms from the data. The conditional expectation of θ_i is directly estimated from bunching, which gives us the average percent decrease in output. I estimate the second expectation term and the covariance from the sample of non-bunchers

in the manipulation region above the exemption threshold under the assumption that the revenue-to-labor cost ratio of non-bunchers is the same as that of bunchers.

Turning to the other extreme, where all of the observed output response is due to a decrease in true production, the percent change in revenue-to-input cost ratio as a function of revenue can be given as follows:

$$\log(\frac{R}{p^E E}) = B + \frac{\alpha + \beta - 1}{\alpha + \beta} \log R \tag{12}$$

where B is some constant and $\alpha + \beta$ is returns to scale in the economy. Equation 13 is derived from the cost-minimizing choices of tax-exempt inputs with and without the CenVAT. Therefore, the expected percent change in the revenue-to-labor cost ratio as a result of the percent change in output can be given as:

$$\frac{\partial \log(\frac{R}{p^E E})}{\partial \log R} = \frac{\alpha + \beta - 1}{\alpha + \beta} \tag{13}$$

Using the expression above, we can calculate the expected revenue-to-labor cost ratio from the counterfactual revenue-to-labor cost ratio, returns-to-scale as estimated in the data, and change in output estimated from bunching.

What we observe in the data is not only a mix of potential under-reporting and true production responses, but also firms whose output is unaffected by the threshold. We also see that the revenue to labor cost ratio is increasing in revenue instead of constant. The proportion of firms in the bunching region that are "bunchers" is the definition of the bunching estimate. The average revenue-to-labor cost ratio we observe in the bunching region is an average across these bunchers and non-bunchers. To estimate the counterfactual ratio for non-bunchers in the bunching region, I estimate the relationship between revenue-to-input cost ratio and revenue and the deviation from this relationship in the bunching region as follows:

$$\frac{\hat{R}_{it}}{p^E E_{it}} = \beta_1 \hat{R}_{it} + \beta_2 \mathbf{I}(\hat{R}_{it} \in [r^{lb}, \bar{R}]) + \beta_3 \mathbf{I}(\hat{R}_{it} \in [\bar{R}, r^{ub}]) + \delta_t + \gamma_s + \eta_m + \mathbf{X}_{it} + \epsilon_{it} \tag{14}$$

where the dependent variable is the ratio of reported revenue to exempt or non-deductible input costs, the independent variables are reported revenue, a dummy for whether reported revenue is between the lower bound of the manipulation region and the exemption

threshold $\bar{R}$ ($\mathbf{I}(\hat{R}_{it} \in [r^{lb}, \bar{R}])$), and a dummy for whether reported revenue is between the exemption threshold and the upper bound of the manipulation region, as estimated using the bunching method. Other controls include time, state and industry fixed effects (δ_t,γ_s and η_m), as well as a set of time-varying characteristics such as ownership and urban or rural sector. The theoretical framework I consider is a static setting but each observation is a firm in a given year so the specification includes time subscripts.

The empirical specification allows for a trend in the revenue to input cost ratio with respect to revenue even though a strict interpretation of the Cobb-Douglas (or more generally, CES) production, cost shares do not change with size. There are theoretical and econometric reasons to nonetheless expect a trend. First, the observed revenue to input cost ratio at a given level of revenue is an average of the ratio of all firms with that level of revenue. The share of registered firms could be increasing at any given level of revenue because within some commodity markets, probability of registration is increasing with productivity. This factor would bias against finding a real effect as it would lead to lower revenue to input cost ratios just below the threshold (as less productive firms are more likely to bunch). Second, true production could involve some fixed cost which would give rise to increasing revenue to input cost ratios. Third, measurement error in reported revenue would also result in an increasing trend. The second and third explanations do not affect the interpretation of deviations from trend near the exemption threshold.

Based on estimates of $\hat{\beta}_1$ and the fixed effects, we can predict the counterfactual ratio in the bunching region under the extremes of 100 percent misreport and real response. $\hat{\beta}_2$ tells us how much the observed ratio deviates from the counterfactual because of bunching and can be compared to the predicted ratios with and without evasion to reveal the extent of misreporting or real response.

6 Data

6.1 CenVAT rate data

The Central Board of Excise and Customs (CBEC), which administers the CenVAT publishes the CenVAT rates according to an 8-digit Indian Tariff Code (ITC) each year. Changes to the rates, if any, are usually announced in March of each year when the annual budget document for the central government of India is tabled in Parliament. However, there may be additional changes to rates or reclassifications, which are announced at other times in the year and published as "Notifications" from the CBEC. Using these various sources of information, I construct a novel dataset of of tax rates at the 8-digit

ITC code from 2005 to present. Using a series of concordances, I link this tax rate information to detailed (5-digit) product information in an annual comprehensive survey of manufacturing establishments in India, the Annual Survey of Industries (ASI) [8].

6.2 Establishment-Level Production

I use annual data from the Annual Survey of Industries (ASI) between 2004 and 2015. This is a statutory survey administered by the Central Statistical Office (CSO) of the Government of India. It is a census of manufacturing establishments with at least a 100 workers and an approximately 15 percent random sample of manufacturing establishments with between 10 and 100 workers[9]. The ASI gathers balance sheet information about establishments including ownership structure, products manufactured, employees, fixed capital, and others. Some key variables from this data include annual establishment level revenue by 8-digit product code (gross and net of taxes and distribution costs), intermediate input costs, and electricity purchased and generated.

This data is not shared with the tax authority. Documents describing and evaluating the audit procedures of the Central Board of Excise and Customs (CBEC) never mention using data from the ASI as a source of third-party information (unlike other sources that are explicitly mentioned), suggesting they are unlikely to be used in an audit. However, the data are potentially entered by the establishment from their own records, which would be available to the tax authority in case of an audit. Therefore, the firm may exhibit the same pattern of underreporting in the survey as they do in their own records.

This dataset contains 442,533 unique firm-year observations, and 820,987 firm-product-year observations because there are firms that produce multiple products. Although revenue is reported separately for each product, inputs and other firm-level variables are not. I apportion employment and input costs to each product produced by the firm according to its share in the total revenue of the establishment. The data pertain to establishments and not firms, but I treat them interchangeably because most are single-establishment firms. I clean the data using the procedure described in Appendix B, and end up with a sample of approximately 215,395 establishment-years, which excludes any establishments that closed over three years before the survey, are owned wholly or partially

[8] The first five digits of the ITC code correspond to the international harmonized system codes or HS codes. There exists a correspondence between the HS codes and another international product classification system – Central Product Classification (CPC) codes, which are then linked to the National Production Classification for Manufacturing Sector (NPCMS) codes used in the ASI from 2010 onward. The ASI provide a concordance between the NPCMS and the classification they use in earlier years, the Annual Survey of Industries Commodity Classification (ASICC-2009).

[9] There are some exceptions. All establishments in State X Industry cells with fewer than four establishments are included in the sample. The sampling probability is higher in a few states.

by a government entity or cooperative, are in states with area-based CenVAT exemptions, or have ever exported commodities. I also exclude observations which are severe outliers following a process used by Allcott et al. (2016). Most of the reduction in sample size is because I exclude establishments in exempt states and exporters, which I exclude because exports are zero-rated regardless of the commodity.

7 Descriptive Statistics

Most of the analysis in the paper focuses on establishments producing goods taxable at the standard CenVAT rate, which covers the majority of output and employment in the organized manufacturing sector [10]. Because the ASI is focused on manufacturing, most commodities (about 55 percent of observations) in the ASI fall into the standard CenVAT rate category (See Table 1). A large minority of commodities are exempt (about 21 percent of observations), and others are taxed at non-standard rates[11]. Overall output of taxable manufacturing commodities was about 86 percent of organized manufacturing output in 2005 and 84 percent of organized manufacturing output in 2012, and a similar proportion of employment in each year (82 percent in 2005 and 86 percent in 2012). I exclude petroleum from the analysis because petroleum producers do not receive input tax credits (and therefore the CenVAT is not a VAT for petroleum).

Each establishment can produce multiple products, which may not all belong in the same tax rate category. Multi-product establishments report revenue, distribution costs and taxes remitted on each final product separately but do not separately report inputs. In such cases I apportion inputs to each product in proportion to its share in the total value of establishment output for analysis at the establishment-product level. I classify an establishment as a producer of standard CenVAT rate goods if at least 75 percent of its production value is taxable at the standard CenVAT rate. Results are similar if I change the definition to at least 90 percent of the production value taxable at the standard CenVAT rate. Most establishments that produce a good taxable at the standard rate, produce only goods that are taxable at the standard CenVAT rate (see Table 3)

There are area-based exemptions in the CenVAT, which in some cases exempts production

[10] The ASI data is often referred to as data on the "organized" manufacturing sector as the frame for the ASI comes from factories that are registered under the Factory Act 1948. Firms can be registered under the Factory Act but unregistered with the tax authority. Firms that are unregistered under the Factories Act may still be registered with the tax authority. The organized sector as defined by registration under the Factories Act accounts for less than 20 percent of total manufacturing employment in India. The remaining firms are in the "unorganized" sector, which is covered in a similar but separate survey only in the years 2005 and 2010. I also combine data from these surveys for some parts of the analysis.

[11] As appendix tables 2 and 3 show, exempt industries are agriculture, manufacture of food products, publishing, and some primary stage products in non-metallic, leather and apparel industries.

in entire states such Himachal Pradesh or in designated manufacturing areas in other states. I exclude establishments in the 10 states and union territories where there are such special exemptions, which forms 9 percent of the total sample. Like most VAT systems, exports are zero-rated in the CenVAT, which means that even commodities that are taxable at the standard rate can remit zero tax on exports but receive all input tax credits. Starting in 2009, the ASI reports the share of an establishment's output that is exported. I classify any establishment that has exported any of their output after 2009 as an "exporter" and exclude them from the analysis even in years prior to 2009. About 20 percent of establishment-years are "exporters" under this definition.

Although registration is not directly observable in the data, firms report CenVAT remitted on output. A suitable proxy for registration then is whether the firm reported remitting any CenVAT on output. Figure 3 plots the probability that a firm reports any CenVAT payment conditional on their gross revenue. As would be expected if there are firms that do not voluntarily register, there is a discrete jump in the probability of registration at the threshold from less than 10 percent to about 30 percent, continuing to rise with revenue. We would expect that the registration rate was a 100 percent above the threshold. However it is possible that firms are registered but do not report remitting CenVAT either because they only report amounts remitted above CenVAT credits or because their responses are incomplete. Still, the sharp increase in this proxy for registration suggests that the exemption threshold is a binding constraint.

8 Results

8.1 Bunching at the VAT Notch

The CenVAT induces bunching at the exemption threshold, confirming that at least some firms value the exemption and report output at or below the threshold. Figure 7 shows the revenue distribution of firms producing goods subject to the standard CenVAT rate between 2004 and 2007 when the exemption threshold was set at ₹10 million (approx. $150K). The y-axis shows the estimated number of firms (using survey weights) in green circles within ₹0.2 mn-wide revenue bins indicated on the x-axis. The solid black line is the counter-factual revenue distribution estimated using equation 10, where r^{lb} was set to ₹7 mn and r^{ub} was estimated as ₹13 mn. The region in between these two boundaries as indicated by the dashed vertical lines is the manipulation region. The observed revenue distribution clearly shows an excess mass relative to the counterfactual just below the exemption threshold, which is the solid red line at output of ₹10 mn.

That this excess mass is due to the CenVAT and the location of the exemption threshold is made apparent when the threshold shifts to ₹15 mn in 2008. From 2009 to 2015, there is no longer any excess mass below the original threshold of ₹10 mn and instead we see in Figure 8 that it has shifted to just below the new threshold. The manipulation region is now between ₹12 million and ₹20 mn. Finally, we see in Figure 9 that the revenue distribution is smooth around the exemption threshold for firms producing mainly goods that are exempt from CenVAT, providing further evidence that the bunching reflects a response to tax incentives.

I translate the excess mass shown in these figures into estimates of the decrease in reported revenue due to the CenVAT liability and compliance costs above the exemption threshold. Table 4 shows the bunching estimates for all establishments and for companies separately before and after the threshold change in 2008. All estimates are statistically significant at the 1 percent level. The bunching estimate of 5 for all establishments prior to 2008 translates to a reduction in output of about 10 percent on average across all firms producing goods taxable at the standard CenVAT rate. Average percent reduction in output is calculated by multiplying the excess bunching estimate with the bin size of ₹0.2 million to get the total reduction in output, and then dividing by the threshold level of ₹10 mn before 2008 and ₹15 mn after 2008 to get the percent change. Output reduction among all establishments at the new threshold after 2008 is similar – about 8.8 percent on average. Bunching is more pronounced among establishments owned by private or public limited companies before and after the threshold change. Output is reduced by about 20 percent on average among companies before the threshold change, and by 13 percent on average after the threshold changes.

This reduction in output might have been achieved either by reducing real revenue or by underreporting true revenue in the survey data. What firms report to the survey may not be identical to what they report to the tax authority, and there may be more underreporting of revenue in tax data. If firms underreport revenue to the tax authority but report truthfully in the survey data, we would not observe any bunching. Therefore, the estimated output response of firms in the ASI reflects either real production changes or underreporting in administrative and survey data. In the next section, I estimate to what extent this recorded reduction in output is due to underreporting of output in survey data.

8.2 Real or Reporting Behavior at the VAT Notch

The previous section described the total reported output response to the VAT exemption threshold. In this section I use the information on firms' inputs to distinguish between

real and reporting behavior in the context of the model presented in Section 4. I examine whether the revenue to input cost ratio is above or below trend in the bunching region.

Figure 10 is a binned scatter-plot of the revenue to labor cost ratio of firms. Each dot represents a conditional mean of the revenue to labor cost within revenue bins with an equal number of observations. The sample is restricted to all taxable goods producers between 2009 and 2015, and the dashed vertical line indicates the exemption threshold during this period, of ₹15 mn. The first thing to note is that the ratio of revenue-to-labor costs is increasing in revenue unlike in the stylized model where we focused on producers within a commodity market. The graph shows the average revenue-to-labor cost ratio of all producers. Accounting for the linear trend, we see that the revenue to labor costs rise just below the exemption threshold, consistent with a real response.

Table 8 shows the results of specification 14, which tests whether the revenue to input cost ratios of firms are systematically higher just below the exemption threshold, controlling for various firm characteristics like year of production, state, commodity and others. I find that revenue to labor cost ratios are systematically higher just below the exemption threshold. but not just above the threshold. For example, in column 5 controlling for year, state and product fixed effects, I find that revenue to input cost ratio is 2 units higher than what would be predicted by a linear trend in revenue. To give a sense of magnitude, the average revenue to labor cost ratio is about 12.

As a placebo check, Table 9 estimates the same specification on a sample of exporters and exempt goods producers. Column 2 shows the results for exporters and column 3 shows the results for exempt goods producers while column 1 repeats the estimates in column 5 of table 8. Comparing estimates between the three columns shows that not only is there no statistically significant deviation in the the revenue to labor cost ratio among the two samples where we see no bunching, but there is also no difference in the sign of the deviation above and below the threshold. These results suggest that the deviation we observe among taxable goods producers just below the threshold is due to the exemption threshold.

I estimate the average revenue-to-labor cost ratio we should expect to see for the bunching firms based on this data according to equations 11 and 13. Estimates of parameters used to calculate the revenue-to-labor cost ratio of bunchers under no evasion and with 100 percent evasion are given in Table 6. Estimates of the revenue-to-labor cost ratio of bunchers under different assumptions is given in Table 7. The observed ratio is a weighted average of the ratio of bunching firms and of firms whose optimal revenue would have been in the bunching region even in the absence of the tax. The proportion of bunchers as reported in Table 6 is 0.83, so the observed ratio of just the bunchers must be:

$$\frac{17.3 - 0.17 * 13.8}{0.87} = 18.01$$

where 17.3 is the observed revenue-to-labor cost ratio and 13.8 is the counter-factual revenue-to-labor cost ratio in the bunching region. The revenue-to-labor cost ratio of the bunching firms is actually slightly higher than the estimated revenue-to-labor cost ratio of bunching firms in the case without evasion and with returns to scale of 0.9 (see Table 7, suggesting that the output response is almost fully due to a true production decrease.

Given bunching estimates, we can estimate the revenue-to-labor cost ratio of bunching firms under full misreporting using equation 11. Estimates of each of the terms of the equation are given below along with the corresponding revenue-to-labor cost ratio.

In the case of a true production response, assuming returns-to-scale is approximately 0.95,[12] a 10 percent reduction in output, which is what we estimate on average, should result in a 0.05 percent increase in the revenue-to-input cost ratio as given by equation 13.

8.3 Response to Tax Kink vs Compliance Cost/ Enforcement Notch

Firms' response at the exemption threshold is due to the compliance costs and additional enforcement at the exemption threshold. The key piece of evidence for this is that the extent of bunching is similar among firms producing goods taxed at higher and lower rates. Figure 6 compares the revenue distribution of firms producing goods taxable at the standard rate and those producing goods taxable at the reduced rate. The extent of bunching by firms is similar in both sets of firms even though the reduced rate is between 4 to 6 percentage points lower than the standard rate. This similarity is apparent in the estimates of excess mass shown in Table 5 where the output reduction for standard-rate taxable goods producers (8.2 percent) is similar to that of output reduction for reduced-rate taxable goods producers (11 percent), suggesting that the bunching is driven by compliance costs and additional enforcement at the exemption threshold rather than the tax kink.

Given an elasticity of output with respect to compliance cost of 2 (as estimated in Pakistan by Waseem (2018)) and assuming that about 50 percent of firms at the threshold voluntarily register for the VAT, the observed output response implies that compliance

[12]For example, this is returns to scale estimated by Allcott et al. (2016) in the ASI data.

costs amount to about 5 percent of revenue on average for firms at the threshold. This is equivalent to a fixed compliance cost of approximately $\$14,000$ per firm.

9 Selection

Because firms can and choose to voluntarily register for the CenVAT, there is a concern that the observed difference in revenue-to-labor cost ratio in the neighborhood of the exemption threshold is because of the differences in the types of firms that bunch or choose to register. Section 4.2 showed that under a hicks-neutral production function, conditional on intensity of taxable intermediate input use and difference in price of output if registered and unregistered, more productive firms are more likely to register. Therefore we would expect that selection would result in higher revenue-to-labor cost ratio immediately above the exemption threshold, which is not what we find.

As shown in Liu et al. (2017), voluntary registration is more likely the greater the share of taxable intermediate inputs in total input costs, the greater the sales to businesses, and the more competitive the market. In their empirical setting, however, compliance is much higher and the likelihood of unregistered VAT chains is lower. What matters for registration is not just the share of taxable input costs or sales to businesses but more precisely, the share of inputs purchased from registered businesses and the share of sales to registered businesses. These determinants can be measured in the ASI at the establishment level based on each establishments' inputs and outputs. For example, the share of sales of an upstream firm to registered firms is estimated as the proportion of downstream firms that are registered among firms that use inputs produced by the upstream firm. Similarly, the share of inputs from registered firms used by a downstream firm is measured as the proportion of firms registered among producers of inputs used by the downstream firm.

Table 10 shows that these explanatory variables have the expected signs and are statistically significant in predicting registration. The dependent variable use any positive CenVAT reported as a proxy for registration. The likelihood of registration is increasing the share of downstream and upstream firms registered. The Lerner index, which is a measure of competitiveness of the firm's industry is not predictive in the Indian context. Overall, these results are similar to what Liu et al. (2017) find in the United Kingdom.

Conditioning on these determinants of voluntary registration, I still find that the revenue to labor ratio of firms is higher among the bunching firms, suggesting that there is a real reduction in production. Column (1) of Table 11 shows the results of specification 14 including controls for determinants of voluntary registration. $\hat{\beta}_2$ is estimated to be

approximately 1.7 even controlling for selection.

There is still the possibility that some unobserved factors or peculiarity in the production process results in selection into bunching based on labor-specific productivity. To allow for this possibility, I condition on firms' revenue to labor cost ratio prior to 2008 before the threshold was newly set to ₹15 mn. The assumption I make here is that the firm's revenue to labor cost ratio prior to 2008 reflects the firms' true labor productivity and is unaffected by tax incentives beyond 2009. This is a reasonable assumption as there was uncertainty about the level of the new threshold even 6 months before it was changed.

Column (4) of Table 11 presents the results of specification 14 but uses the average revenue to labor cost between 2004 to 2007 as the dependent variable with revenue in the current year, which is between 2009 and 2015, as the independent variable. The coefficient on the dummy for the region just below the threshold is positive and statistically significant suggesting that the revenue to labor cost ratio of firms in the bunching region was higher than what would be predicted by the trend even before the exemption threshold was set. This result is consistent with some selection based on efficiency of labor use.

In column (3), the dependent variable is the current revenue to labor cost ratio, but includes a control for the previous revenue to labor cost share. We see that there is still a higher than predicted revenue to labor cost ratio just below the exemption threshold consistent with a real response.

These results suggest that there is some selection into bunching based on labor specific productivity of firms, although in the opposite direction as might be predicted by theory. It also implies that the total output response estimated from the excess mass of firms below the exemption threshold reflects a substantial real production response to the CenVAT. Even accounting for the increase in the observed revenue-to-labor cost due to selection, the revenue-to-labor cost ratio is higher than the counterfactual in the bunching region. The magnitude of this difference is consistent with 80 percent of the response being due to a real production change.

10 Conclusion

Manufacturing firms in India whose potential revenue is in the neighborhood of the CenVAT exemption threshold limit production largely to avoid the compliance costs and additional enforcement associated with CenVAT registration. For some firms, the benefits of CenVAT registration outweigh the additional tax liability and costs enough to voluntarily register. Consistent with findings in the United Kingdom, voluntary regis-

tration among Indian manufacturers is also predicted by the the share of upstream and downstream firms that are registered. Still, on average across these firms that voluntarily register and those that choose to bunch at the threshold, the CenVAT reduces output by about 10 percent on average. Firms in the neighborhood of the CenVAT threshold that are affected by the threshold represent about 1 percent of total manufacturing output.

Revenue-to-labor cost ratios among the bunching firms are significantly higher than what would be predicted by extrapolating from the relationship between revenue-to-labor cost ratio and revenue outside the neighborhood of the exemption threshold. This finding suggests that the observed output response is due to real production changes rather than strategic under-reporting of revenue for at least 68 percent of bunching firms. Using revenue-to-labor cost ratio of firms between 2004-2007 when the threshold was at ₹10 mn as a proxy for true labor productivity of firms between 2009 and 2015 when the threshold was increased to ₹15 mn, I find that some of the difference in revenue-to-labor cost ratio below the threshold might also be due to selection on labor productivity.

Finally, firms' output response seems to be due to the increase in compliance costs at the threshold rather than the increase in tax liability. Assuming an elasticity of output with respect to compliance cost of 2, I estimate that compliance cost due to the CenVAT amounts to about 5 percent of revenue for firms at the exemption threshold.

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11 Figures

Figure 3: Probability of Any Excise Payment, 2009-2015

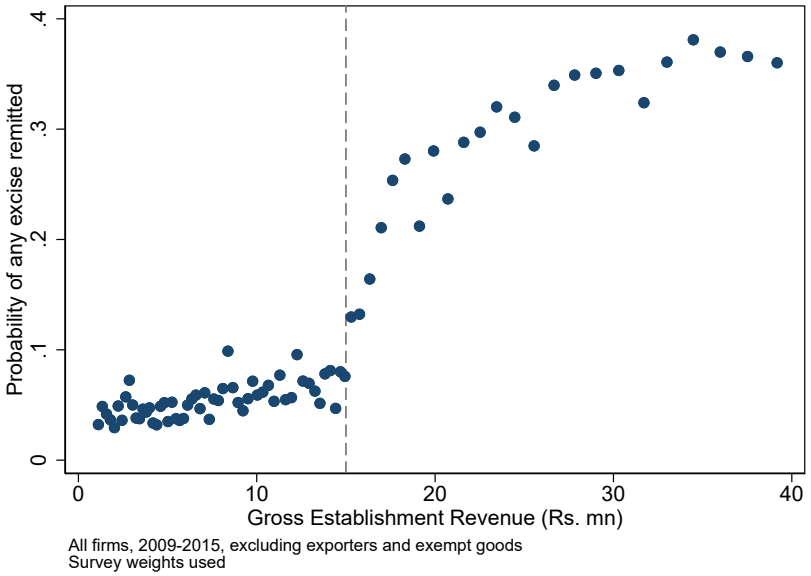


Figure 4: Revenue Distribution of Taxable vs Exempt Goods Producers, 2009 - 2015

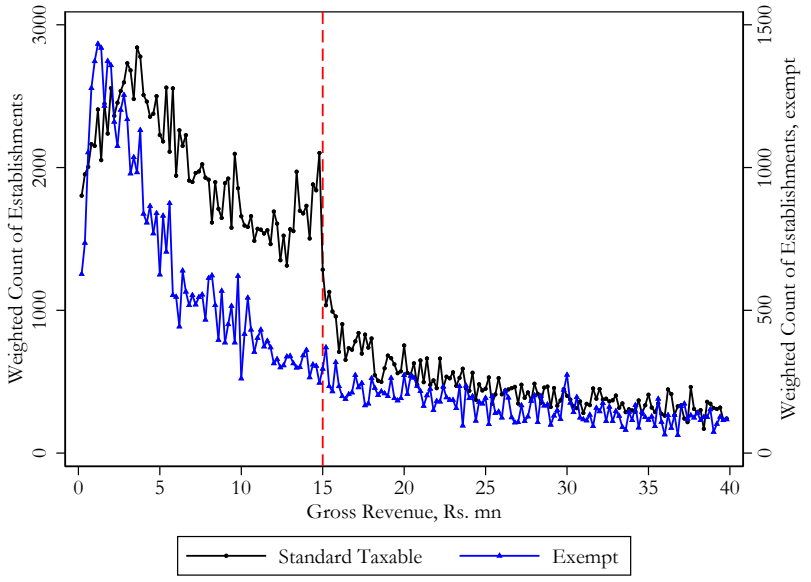


Figure 5: Revenue Distribution of Taxable Goods Producers, 2004-2007 and 2009 - 2015

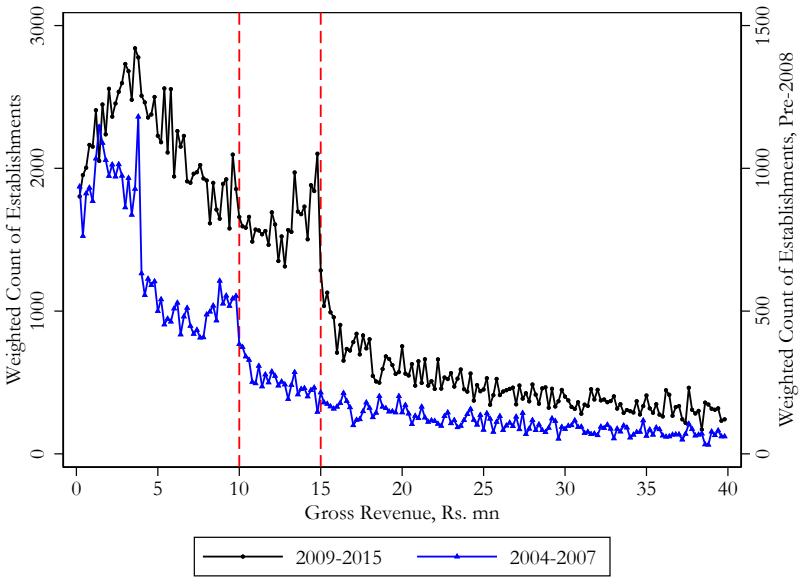


Figure 6: Revenue Distribution of Standard vs Reduced Rate Taxable Goods Producers, 2009 - 2015

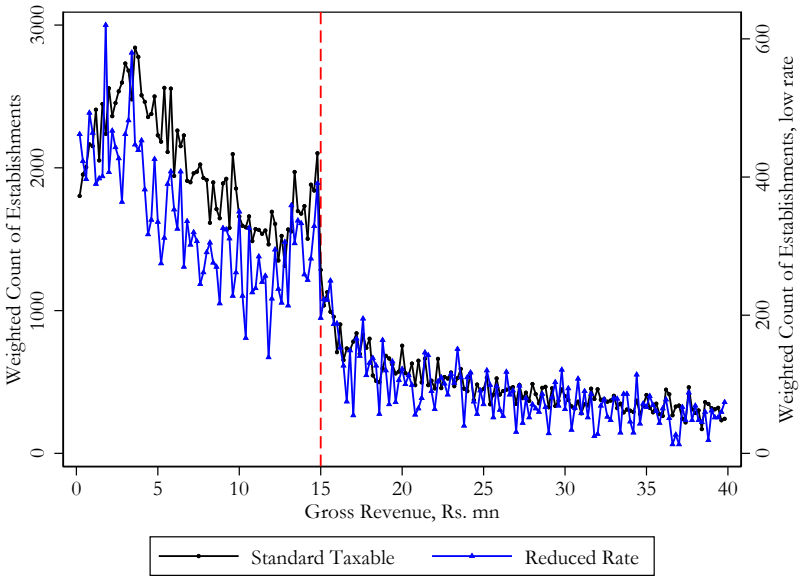
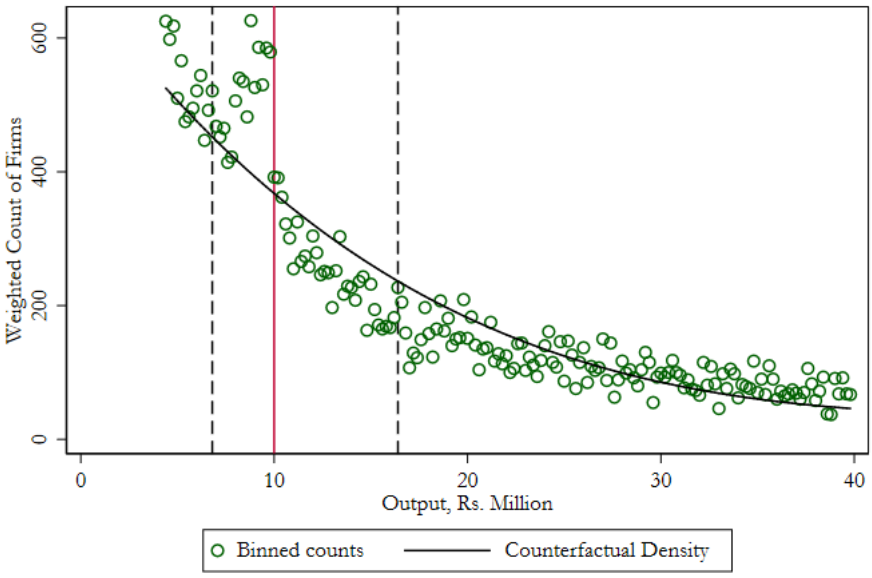
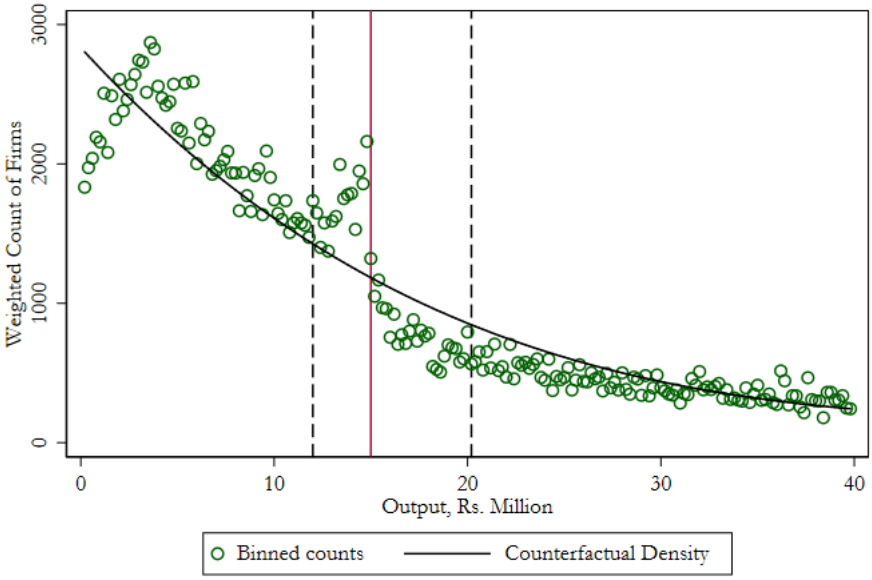


Figure 7: Bunching at the Exemption Threshold, 2004 to 2007



Note: Counts are weighted by survey weights. Pooled Sample 2004-2007.
All, taxed states, goods taxed at standard rate

Figure 8: Bunching at the Exemption Threshold, 2010 to 2015



Note: Counts are weighted by survey weights. Pooled Sample 2010-2015.
All owner types, taxed states, goods taxed at standard rate

Figure 9: Bunching at the Exemption Threshold among Exempt Goods Producers, 2010 to 2015

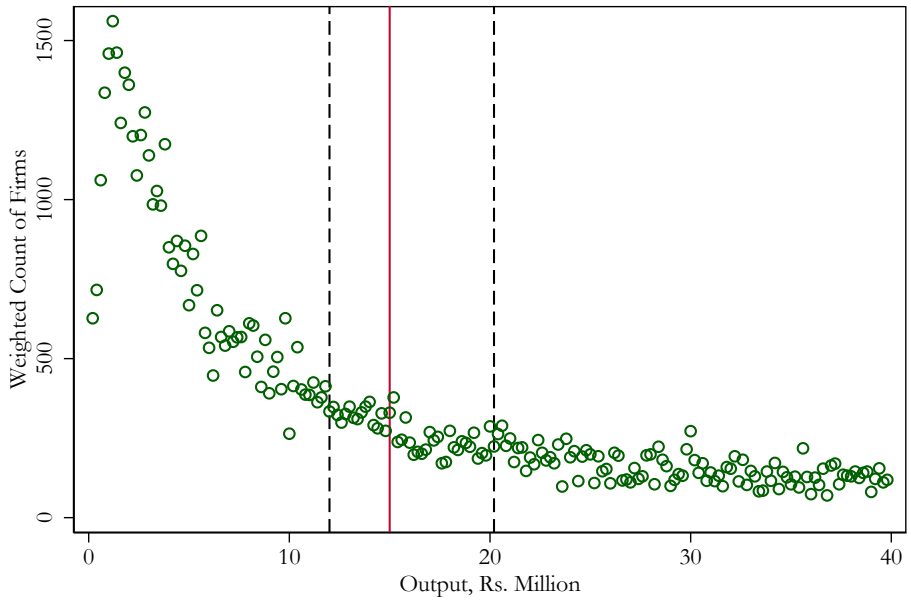
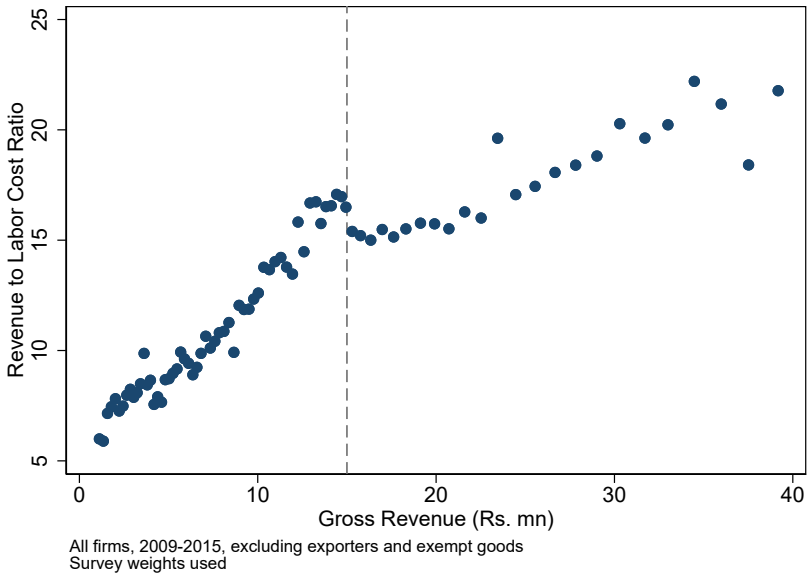


Figure 10: Revenue to Labor Cost Ratio, 2009 to 2015, All firms



Tables

Table 1: Distribution of Establishments by CenVAT rate

	Number of Observations	**Percent of Sample**
Standard	215135	54.5
Exempt	81668	20.7
Other CenVAT	61934	15.7
Other	36034	9.1
Exempt States	62168	8.9
Establishment-Years	37568	9.1
Exporter	151720	21.8
Establishment-Years	80230	19.5

Note: Unweighted counts, weighted proportion of sample. Annual data from 2004 - 2015. CenVAT rate categories are divided into "Standard", "Exempt", "Other CenVAT", and "Other". Goods falling into the "Other" category are petroleum, tobacco etc., which sometimes have specific rates and are ineligible for input tax credits. "Exempt States" are states where manufacturing in some regions or in the entire state are exempt from the CenVAT. Exports are zero-rated. Observations are Establishment X Product X Year, except for rows 6 and 8, which list Establishment X Year statistics.

Table 2: Establishment Characteristics

	Sole Proprietorship	**Partnership**	**Public or Pvt. Limited Co.**
Median Revenue (Rs. Mn), 2005	3.865	8.934	39.738
Median Revenue (Rs. Mn), 2015	9.531	19.495	89.481
Avg. Share Output Taxable (%)	68	67	78
Share of ownership category below threshold (%)	72	52	21
Share below threshold in ownership category, 2005 (%)	39	44	16
Share below threshold in ownership category, 2015 (%)	52	34	14
Establishment-Years	61328	71533	109948

Note: Unweighted counts, weighted proportion of sample. Annual data from 2004 - 2015. Exemption threshold in 2005 was Rs. 10 mn, threshold in 2015 was Rs. 15mn.

Table 3: Input Costs as Share of Revenue

	Electricity	**Labor**	**Exempt Intermediate Inputs**	**All Intermediate Inputs**
Average Cost as Share of Revenue	.03	.086	.398	.624
s.d. Across Products	.046	.054	.337	.162
Average Cost as Share of Revenue	.027	.08	.359	.655
s.d. Across Products	.051	.047	.324	.152
Number of Products with >100 obs	321	324	98	320

Note: Unweighted counts, weighted proportion of sample. Annual data from 2004 - 2015. Exemption threshold in 2005 was Rs. 10 mn, threshold in 2015 was Rs. 15mn.

Table 4: Estimates of Excess Mass

	Pre-2008	Post-2008
All Firms	18.609	5.371
	(1.493)	(.518)
Public and Private Limited Co.	9.303	10.588
	(1.55)	(1.19)

Note: Bootstrapped standard errors in parentheses. Proportion of excess mass at threshold for all types of establishments in the first row, which includes sole proprietorships, partnerships, and public and private limited companies. Second row shows bunching only among public and private limited companies. Because before 2010, sole proprietorships and partnerships faced another compliance cost notch at ₹4 million, the estimates in column 1, row 1, use only the distribution above ₹4 million to construct the counterfactual and estimate bunching.

Table 5: Estimates of Excess Mass by Tax Category

	Standard VAT Rate	Reduced VAT Rate
Post-2008	5.445	6.717
	(.512)	(1.433)
Pre-2008	4.559	5.088
	(1.661)	(2.098)

Note: Bootstrapped standard errors in parentheses. Average reduction in output in brackets. Because before 2010, sole proprietorships and partnerships faced another compliance cost notch at ₹4 million, the estimates in column 1, row 2, use only the distribution above ₹4 million to construct the counterfactual and estimate bunching.

Table 6: Parameter Estimates to Bound Real Response

Parameter	Estimate
Pct. Output Decrease	.082
Avg. Counterfactual Ratio of Bunchers	16.97
Cov. bw. Ratio and Underreporting of Bunchers	-.026
Proportion of Bunchers to Counterfactual Density	.84

Notes: The percent change in output comes from bunching analysis - I translate the estimated excess mass to a corresponding output reduction. *Avg. Counterfactual Ratio of Bunchers* is the expectation of the revenue to labor cost ratio of bunching firms in equation 11 if there were no misreporting costs, which is identical to their ratio if there were no tax. *Cov. bw Ratio and Underreporting* is the covariance term in equation 11. Finally, *Proportion of Bunchers to Counterfactual Density* is the share of bunchers in the bunching region at the exemption threshold calculated from the estimate of excess mass at the threshold.

Table 7: Revenue-to-Labor Cost Ratio, Observed and Counterfactuals

Revenue-to-Labor Cost Ratio	Estimate
Bunchers, 100 % Evasion	15.6
Bunchers, No Evasion, $\alpha + \beta = 0.95$	17.04
Bunchers, No Evasion, $\alpha + \beta = 0.9$	17.12
Counterfactual at Bunching Region	13.8
Observed at Bunching Region	17.3

Notes: The percent change in output comes from bunching analysis - I translate the estimated excess mass to a corresponding output reduction. *Avg. Counterfactual Ratio of Bunchers* is the expectation of the revenue to labor cost ratio of bunching firms in equation 11 if there were no misreporting costs, which is identical to their ratio if there were no tax. *Cov. bw Ratio and Underreporting* is the covariance term in equation 11. Finally, *Proportion of Bunchers to Counterfactual Density* is the share of bunchers in the bunching region at the exemption threshold calculated from the estimte of excess mass at the threshold.

Table 8: Deviation From Trend in Revenue to Input Cost Ratio, 2009 to 2015

	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{I}(\hat{R}_{\text{it}} \in [\bar{R}, r^{ub}])$	0.942***	0.082	0.062	0.090	0.290	11.177**
	(0.314)	(0.297)	(0.341)	(0.342)	(0.354)	(5.384)
$\mathbf{I}(\hat{R}_{\text{it}} \in [r^{lb}, \bar{R}])$	3.187***	1.724***	1.843***	1.749***	1.936***	7.435
	(0.360)	(0.335)	(0.381)	(0.384)	(0.389)	(5.132)
Year FE	X	X	X	X	X	X
State FE	X	X	X	X	X	X
Industry FE		X	X			
Class FE				X	X	X
Class X Year FE					X	X
R^2	0.100	0.200	0.204	0.214	0.278	0.275
N	41365.000	41365.000	34749.000	34749.000	34147.000	31899.000

Note: Standard errors in parentheses, * p<0.1, ** p<0.05 *p<0.01. Columns 1 - 5 show deviations from trend in revenue to labor cost ratios. Table presents coefficients on dummy for region above threshold upto the upper bound of manipulation region and a dummy for region below threshold starting from lower bound of manipulation region. Results are from estimation of specification in 14 with controls as indicated in each column. Average revenue to labor cost ratio is 12 and average revenue to electricity cost ratio is 50. Sample in columns 3 onward restricted to single-product establishments or multiproduct establishments whose products are all in the same product group or "class".

Table 9: Deviation From Trend in Revenue to Input Cost Ratio, 2009 to 2015, Placebo

	(1)	(2)	(3)
$\mathbf{I}(\hat{R}_{\text{it}} \in [\bar{R}, r^{ub}])$	0.164	2.067	-0.682
	(0.359)	(1.387)	(1.317)
$\mathbf{I}(\hat{R}_{\text{it}} \in [r^{lb}, \bar{R}])$	1.886***	1.603	-0.569
	(0.393)	(1.433)	(1.489)
Year FE	X	X	X
State FE	X	X	X
Industry FE			
Class FE	X	X	X
Class X Year FE	X	X	X
Sample	Taxable	Exempt	Exporter
R^2	0.256	0.322	0.390
N	34539.000	5837.000	1682.000

Note: Standard errors in parentheses, * p<0.1, ** p<0.05 *p<0.01. Table presents coefficients on dummy for region above threshold upto the upper bound of manipulation region and a dummy for region below threshold starting from lower bound of manipulation region. Results are from estimation of specification in 14 with controls as indicated in each column. Average revenue to labor cost ratio is 12 and average revenue to electricity cost ratio is 50. Sample is restricted to single-product establishments or multiproduct establishments whose products are all in the same product group or "class".

Table 10: Determinants of Registration

	(1)	(2)	(3)	(4)	(5)	(6)
Share Registered Downstream	0.157***				0.069***	0.019
	(0.010)				(0.010)	(0.012)
Lerner Index		0.009			0.001	0.045
		(0.031)			(0.036)	(0.039)
Share Registered Upstream			0.208***		0.139***	0.001
			(0.008)		(0.007)	(0.011)
Share of B2C Sales				-0.123***	-0.070***	0.003
				(0.011)	(0.011)	(0.038)
Sole Proprietor				-0.199***	-0.190***	-0.026
				(0.008)	(0.008)	(0.024)
Partnership				-0.165***	-0.159***	-0.026
				(0.008)	(0.008)	(0.024)
Distance to Threshold				0.003***	0.003***	0.002***
				(0.000)	(0.000)	(0.000)
Year FE	X	X	X	X	X	X
Firm FE						X
R^2	0.008	0.001	0.024	0.178	0.190	0.892
N	89476	89738	89000	89196	88497	67629

Note: Standard errors in parentheses clustered by establishment, * p<0.1, ** p<0.05 *p<0.01. Time period restricted to 2010 to 2015. Dependent variable is whether the firm reports any positive CenVAT payment on output, which is the proxy for registration. Share registered downstream is defined as the proportion of firms who demand firm i's product that are registered. Share registered upstream is the proportion of firms producing goods demanded by firm i that are registered. Share of B2C sales is an industry-level measure of proportion of output in each industry directly consumed, as reported in Input-Output tables. Distance to threshold is the difference between reported revenue and the exemption threshold, in millions.

Table 11: Deviation From Trend in Revenue to Input Cost Ratio, 2009 to 2015, Selection

	(1)	(2)	(3)	(4)	(5)	(6)
$\mathbf{I}(\hat{R}_{\text{it}} \in [\bar{R}, r^{ub}])$	0.472	0.164	-0.697	1.036	10.949	6.042
	(0.348)	(0.359)	(0.470)	(0.638)	(7.178)	(8.272)
$\mathbf{I}(\hat{R}_{\text{it}} \in [r^{lb}, \bar{R}])$	1.771***	1.886***	1.668***	1.571**	3.221	6.336
	(0.388)	(0.393)	(0.526)	(0.665)	(6.316)	(6.854)
Rev to Lab Cost , 2004-2007			0.314***			
			(0.040)			
Rev to Elec Cost , 2004-2007					0.429***	
					(0.033)	
Year FE	X	X	X	X	X	X
State FE	X	X	X	X	X	X
Industry FE						
Class FE	X	X	X	X	X	X
Class X Year FE	X	X	X	X	X	X
Sample	Taxable	Taxable	Taxable	Taxable	Taxable	Taxable
R^2	0.293	0.256	0.397	0.321	0.396	0.309
N	34169.000	34539.000	15497.000	15510.000	13753.000	13948.000

Note: Standard errors in parentheses, * p<0.1, ** p<0.05 *p<0.01. Table presents coefficients on dummy for region above threshold upto the upper bound of manipulation region and a dummy for region below threshold starting from lower bound of manipulation region. Results are from estimation of specification in 14 with controls as indicated in each column. Column 2 includes a control for revenue to labor cost share from 2004 to 2007 and the dependent variable in column 3 is the revenue to labor cost ratio from 2004 to 2007. Average revenue to labor cost ratio is 12 and average revenue to electricity cost ratio is 50. Sample in columns 3 onward restricted to single-product establishments or multiproduct establishments whose products are all in the same product group or "class".

A Analysis of the Exemption Eligibility Threshold in the CenVAT

In the main text, I discuss firms' response to the *CenVAT exemption threshold*, which is similar to the standard VAT exemption threshold. One of the key differences from a standard VAT is that not all firms are eligible to take this exemption even if their revenue is below the exemption threshold in that year. Exemption eligibility depends on whether their revenue in the previous year was below the *exemption eligibility threshold* of ₹40 mn (or ₹35 mn before 2008).

The exemption eligibility threshold creates a notch in firms' tax liability in the following year at the threshold in revenue this year. The size of this notch is firm and time-specific, and depends on a number of factors.

Consider the one-period profit maximization problem of a firm. Let $\Pi_{it|AR}$ denote the profit a firm that is CenVAT registered and $\Pi_{it|E}$ that takes the SSI exemption at time t and may or may not be CenVAT registered depending on their revenue in t. Firm's profit in period t if they are eligible to take the SSI exemption denoted by $\Pi_{it|C}$ is:

$$\Pi_{it|C} = \max\{\Pi_{it|AR}, \Pi_{it|E}\}$$

$\Pi_{it|C} \geq \Pi_{it|AR}$ by definition, highlighting that firms' profit if they can choose the exemption will be at least as high as their profit if they are ineligible for the exemption.

Now consider the firm's problem in period $t-1$:

$$\Pi_i = \max_{M_{it-1}, E_{it-1}, \hat{R}_{it-1}} \Pi_{it-1}(M_{it-1}, E_{it-1}, \hat{R}_{it-1}) + \beta\{\mathbf{I}(\hat{R}_{it-1} > \tilde{R})\Pi_{it|AR} + \mathbf{I}(\hat{R}_{it-1} < \tilde{R})\Pi_{it|C}\}$$

where Π_i is the present value of total profit in both periods, Π_{it-1} is the one-period profit at time $t-1$, which is a function of inputs (M_{it-1}, E_{it-1}) and reported revenue $\hat{R}_{it-1}$ at time $t-1$, and β is their discount factor. The above expression makes it clear that the notch depends β and the difference in firm's profit in period t with and without the exemption eligibility, $(\Pi_{it|C} - \Pi_{it|AR})$.

I find that the distribution of output among taxable goods producers around the threshold $\tilde{R}$ is smooth and similar to the distribution of exempt goods producers. This could be due to a number of factors: (1) the size of the notch is small for firms whose potential period

$t-1$ output is close to but greater than $\tilde{R}$, i.e. firms who might be induced to bunch at the threshold, (2) optimization error is large, (3) enforcement is higher for firms at this output level and so output elasticity with respect to tax is lower – the audit manual of the tax authority specifically targets firms who have been below this exemption eligibility threshold for a few years, (4) the discount factor is very high, or (5) what firms value most about the exemption is not the reduction in tax liability but the reduction in compliance cost.

Ultimately, firms do not seem to respond to the exemption eligibility notch, and it does not affect firms' behavior at the exemption threshold.

B Data Cleaning

There are approximately 442,533 unique firm-year observations, and 820,987 firm-product-year observations because there are firms that produce multiple products. Although revenue is reported separately for each product, inputs and other firm-level variables are not. I apportion employment and input costs to each product produced by the firm according to its share in the total revenue of the establishment. Although the data pertain to establishments and not firms, I treat them interchangeably because most of them are single-establishment firms. I exclude establishment-year observations where the establishment had been closed or not operating in the last three years, which reduced the sample to 441,394 establishment-years. I also exclude government owned or cooperative establishments, which further reduces the sample to 427,938 establishment-years. Excluding establishments wholly or partially owned by public entities, I am left with 413,202 establishment-years. For most of the analysis I exclude establishments in states with area-based CenVAT exemptions either for the whole state or for large manufacturing hubs within the state. This reduces the sample to 321,635 observations. Similarly, I exclude establishments that have ever exported because exports are zero-rated regardless of the commodity produced. This leaves me with a final sample of 272,592 observations. Finally, I follow Allcott et al. (2016) to identify and exclude extreme outliers in terms of key production variables such as revenue, employment, electricity use, input use, and productivity, which leaves me with 215,395 establishment-year observations.

C Voluntary Registration

Although tax liability is higher for a registered firm under the CenVAT, some firms' profits may also be higher if they register. As a result, in the CenVAT as with other VAT systems,

some firms choose to voluntarily register. The voluntary registration decision depends primarily on the whether their potential buyers are registered CenVAT businesses, or if they are unregistered entities such as unregistered firms or final consumers, who cannot avail of input tax credits. A second determinant, conditional on firms being able to sell to both registered and unregistered firms, is their taxable input costs as a share of revenue.

From equations (1) and (2), we can see that holding all prices and quantities fixed, tax liability is higher under the CenVAT. However, in practice, firms can face a different output price depending on whether they are registered, which means the increase in their revenue from registering can outweigh the increase in tax liability. Whether this is the case depends on share of the firm's sales to registered businesses compared to their share of sales to unregistered businesses or final consumers.

Consider an upstream firm A, deciding whether to register, who can sell their output to two potential downstream entities whose inputs are G (produced by firm A) and L: (1) B, a CenVAT registered business and (2) C, an unregistered business or a final consumer. Profit for B and C is given by π_B and π_C as follows:

$$\pi_B = \begin{cases} R(G,L) - p^G G - wL - \tau R(G,L) & \text{if A registered} \\ R(G,L) - \tilde{p}^G G - wL - \tau R(G,L) & \text{if A not registered} \end{cases}$$

and,

$$\pi_C = \begin{cases} R(G,L) - p^G G - wL - \tau p^G G & \text{if A registered} \\ R(G,L) - \tilde{p}^G G - wL & \text{if A not registered} \end{cases}$$

π_B only depends on the pre-tax price of input G because the registered downstream firm B can avail of input tax credits, while π_C depends on the after-tax price of G. If the market for firm A's product is mainly composed of registered businesses, like B, then A can fully "pass-through" the CenVAT to the downstream firm[13], leaving firm A's revenue, net of tax on their output, unchanged if they register. Moreover, once A registers, they can claim input tax credits, which lowers their tax liability on inputs.

On the other hand, if the market for A's output is composed of final consumers or unregistered businesses, and pass-through is less than 1, their net-of-output tax revenue falls. In the extreme case where firms sell only to registered businesses, they would always voluntarily register and at the other extreme if they only sell to unregistered businesses and final consumers, they would never register. Conditional on firms selling to both types in

[13]Because B receives input tax credits, there is no tax wedge in the price paid by B and the price received by A, and the concept of an "after-tax" price is purely theoretical.

some proportion, Liu, Lockwood and Almunia (2017) show that the registration decision depends on the share of their demand coming from final consumers or businesses, their reliance on taxable intermediate inputs in production, and competitiveness of the market matter for whether the firm values the exemption. The intuition is that the share of demand from final consumers determines the change in revenue net of output tax when firms register, while the intensity of taxable input use determines the decrease in tax liability on inputs. The higher the demand from final consumers, the lower benefit from registration and the higher the intensity of taxable input use, the higher the benefit from registration.

One concern that I address throughout the paper is that the observed difference in input cost shares of firms on either side of the exemption threshold arises because of the difference between the type of firms that value the exemption and therefore bunch below the threshold, and the type of firms that register voluntarily and do not bunch. I argue that the characteristics that determine whether firms will voluntarily register are determined by the product market in which the firm participates, but that the choice to bunch within a given product market depends on the firm's productivity.

In Liu et al. (2017)'s model, a firm's product is completely determined by their type. In this paper, there are characteristics of the commodity that a firm produces that are independent of the firm's own type. Specifically, the share of demand coming from final consumers, reliance on taxable intermediate inputs and competitiveness are independent of the firm's own type. Firms of various productivities can produce a given commodity. In the conceptual framework that I lay out in section 4, I analyze firm behavior within a commodity market taking the firm's choice of commodity and relevant characteristics of that commodity market as given.

D Theoretical Framework

Firms could be producing one of many commodities, indexed by j. Their choice of commodity determines the price received for their output if they register (p_B^Y), the price if they do not register (p_C^Y), and their reliance on taxable intermediate inputs (β). The price difference arises because of differences in demand for the product from other registered businesses and consumers. Below I describe firms' decision-making holding their commodity group (and therefore p_C^Y, p_B^Y and β) as fixed. The commodity group also determines the applicable CenVAT rate τ and the output elasticity of tax-exempt intermediate inputs α. I do not explicitly consider firms' choice of commodity market and treat this as exogenous. Within commodity markets, firms vary in their productivity ω_i, which generates the revenue distribution.

Firms have two discrete choices: whether or not to underreport output and whether to register for the standard CenVAT. We can think of the firms' profit maximization in multiple steps. First, conditional on these two discrete choices they choose inputs to maximize conditional profits. Then they maximize profits over all conditions. Inputs are exempt intermediate inputs (E_i) like electricity and labor, and taxable intermediate inputs (M_i).[14] Production is Cobb-Douglas $F(E_i, M_i) = E_i^{\alpha} M_i^{\beta}$. M_i and E_i are costlessly adjustable each period[15].

To simplify the exposition and build intuition, first consider firms that do not underreport output.

D.1 No Evasion

Firms' tax liability and output prices, and therefore their profits, depend discretely on their registration status and level of revenue. It is simplest to split their profit maximization decision into four possible cases. For a registration threshold of $\bar{R}$, firms maximize profit either: (I) Conditional on registering for CenVAT at any level of revenue (II) conditional on being unregistered with revenue below $\bar{R}$, (III) conditional on being unregistered with revenue equal to $\bar{R}$ or (IV) conditional on taking the SSI exemption with revenue above $\bar{R}$, whereby they register and remit tax only on turnover above the exemption threshold. The profit function in each of these four cases is described below where ω_i is the firm's productivity and $\rho = 0$ if the firm takes the SSI exemption:

1. Case I: Firm registers at any level of revenue

$$\Pi^*_{\rho=1}(\omega_i) = \max_{E_i, M_i} \omega_i (1-\tau) p_B^Y E_i^{\alpha} M_i^{\beta} - p^E E_i - p^M M_i$$

2. Case II: Firm is unregistered with revenue below threshold

$$\Pi^*_{R_i<\bar{R}, \rho=0}(\omega_i) = \max_{E_i, M_i} \omega_i p_C^Y E_i^{\alpha} M_i^{\beta} - p^E E_i - (1+\tau) p^M M_i$$

3. Case III: Firm is unregistered with revenue at exemption threshold

$$\Pi^*_{R_i=\bar{R}, \rho=0}(\omega_i) = \max_{E_i, M_i} \bar{R} - p^E E_i - (1+\tau) p^M M_i$$

[14] In reality, capital is an important inputs as well, but including it does not change the analysis. I therefore omit them for simplicity.

[15] Because exemption eligibility depends on revenue in the previous period, there may be a dynamic aspect to firms' decision making. However, as I describe in appendix A , this exemption eligibility threshold does not seem to influence firms' optimization and therefore I focus on the single period optimization of firms and drop the time subscript.

4. Case IV: Firm is registered with revenue above the exemption threshold, remits tax only on turnover above exemption threshold, and does not receive input tax credits

$$\Pi^*_{R_i>\bar{R},\rho=0}(\omega_i) = \max_{E_i,M_i} \omega_i p_B^Y E_i^\alpha M_i^\beta - p^E E_i - (1+\tau)p^M M_i - \tau(R_i - \bar{R}) - F$$

In Cases II and III, firms receive the price p_C^Y on their output while in case I an IV firms receive p_B^Y. In Case IV, firms who take the SSI exemption must still register because their revenue is above the exemption threshold, but they only remit tax on their output above the exemption threshold. They incur the fixed compliance cost F, and they can provide input tax credits to downstream firms and so receive the price p_B^Y. In cases II, III and IV, firms cannot claim input tax credits and so the after-tax price of their taxable inputs is $(1+\tau)p^M$.

A comparison of equilibrium profits in Cases I and II gives us a sufficient condition for firms with revenue below $\bar{R}$ not to register:

$$\frac{p_C^Y}{(1+\tau)^\beta} \geq (1-\tau)p_B^Y \tag{15}$$

In the absence of fixed compliance costs, equation (15) is also a necessary condition. The quantity on the right-hand side is the after-tax price received by a registered firm. For a firm to prefer the exemption, the price they receive if unregistered must be greater than the price received if registered, scaled by $(1+\tau)^\beta$, which captures the additional input costs to forgo input tax credits. The lower the firm's reliance on taxable inputs (β), the more likely they are to prefer the exemption. If equation (15) fails for a given commodity market, there is a threshold level of productivity above which all firms would voluntarily register.

Empirically, any differences in the revenue to exempt input cost ratio around the exemption threshold that arise because of selection into bunching based on p_C^Y, p_B^Y, τ and β should dissipate once we condition on commodity. Differences that remain depend on how the revenue to input cost ratio changes for firms that bunch based on their productivity draw within commodity markets.

Conditional on choosing the exemption, solving cases II to IV for firms' optimal input use yields the revenue distribution and corresponding revenue to input cost ratio:

$$R_i^* = \begin{cases} \left[\omega_i p_C^Y \left(\frac{\alpha}{p^E}\right)^\alpha \left(\frac{\beta}{(1+\tau)p^M}\right)^\beta\right]^{\frac{1}{1-\alpha-\beta}} & \text{if } \omega_i < \omega^1 \\ \bar{R} & \text{if } \omega^1 < \omega_i < \omega^2 \\ \left[\omega_i (1-\tau) p_B^Y \left(\frac{\alpha}{p^E}\right)^\alpha \left(\frac{\beta}{(1+\tau)p^M}\right)^\beta\right]^{\frac{1}{1-\alpha-\beta}} & \text{if } \omega_i > \omega^2 \end{cases}$$

where ω^1 and ω^2 are defined by the following conditions: ω^1 is such that optimal revenue in case I is equal to the exemption threshold. ω^2 is such that $\Pi^*_{R_i=\bar{R},\rho=0}(\omega^2) = \Pi^*_{R_i>\bar{R},\rho=0}(\omega^2)$.

Equilibrium revenue to exempt input cost ratio is

$$\frac{R_i^*}{p^E E_i} = \begin{cases} \frac{1}{\alpha} & \text{if } \omega_i < \omega^1 \\ \left(\frac{\bar{R}}{p^E}\right)\left(\frac{p_C^Y \omega_i}{\bar{R}}\right)^{\frac{1}{\alpha+\beta}} \left(\frac{\beta}{\alpha}\frac{p^E}{(1+\tau)p^M}\right)^{\frac{\beta}{\alpha+\beta}} & \text{if } \omega^1 < \omega_i < \omega^2 \\ \frac{1}{\alpha(1-\tau)} & \text{if } \omega_i > \omega^2 \end{cases}$$

Therefore, the average revenue to exempt input cost ratio of firms producing at the exemption threshold is higher than that of firms producing either above or below the exemption threshold. As we will see, this is in contrast with what we would expect when we allow for misreporting. This is because more productive firms require less inputs to produce the threshold level of output.

D.2 With Evasion

Allowing for evasion, unregistered firms' optimization can be broken down into four cases, analogous to the cases without evasion:

1. Case I: Firm registers at any level of revenue
2. Case II: True revenue is below the exemption threshold and the firm is unregistered:

$$\Pi_{R_i<\bar{R},\rho=0} = \omega_i p_C^Y E_i^\alpha M_i^\beta - p^E E_i - (1+\tau)p^M M_i$$

3. Case III: True revenue is above the threshold, but the firm is unregistered and reports revenue at the threshold:

$$\Pi_{R_i>\bar{R},\hat{R}_i=\bar{R},\rho=0} = \omega_i p_C^Y E_i^\alpha M_i^\beta - p^E E_i - (1+\tau)p^M M_i - c(R_i - \bar{R})$$

4. Case IV: True revenue is above the threshold, the firm is registered and opts for the SSI exemption:

$$\Pi_{R_i>\bar{R},\hat{R}_i<R_i,\rho=0} = \omega_i p_B^Y E_i^\alpha M_i^\beta - p^E E_i - (1+\tau)p^M M_i - c(R_i - \hat{R}_i) - \tau(\hat{R}_i - \bar{R}) - F$$

where $\hat{R}_i$ is reported revenue, $c(R_i - \hat{R}_i)$ is the cost of misreporting and I make the widely used[16] assumption that the cost of misreporting depends on the *amount* of misreporting, $e_i = R_i - \hat{R}_i$, which gives optimal evasion as a function of the known CenVAT rate (see Appendix **??**).

Let $\tilde{\omega}^1$ and $\tilde{\omega}^2$ denote productivity thresholds at which firms switch from case 1 to 2 and from 2 to 3. Reported revenue distribution and revenue to electricity ratio can then be stated as:

$$\hat{R}_i^* = \begin{cases} \left[\omega_i p_C^Y \left(\frac{\alpha}{p^E}\right)^\alpha \left(\frac{\beta}{(1+\tau)p^M}\right)^\beta\right]^{\frac{1}{1-\alpha-\beta}} & \text{if } \omega_i < \tilde{\omega}^1 \\ \bar{R} & \text{if } \tilde{\omega}^1 < \omega_i < \tilde{\omega}^2 \\ \left[\omega_i (1-\tau) p_B^Y \left(\frac{\alpha}{p^E}\right)^\alpha \left(\frac{\beta}{p^M}\right)^\beta\right]^{\frac{1}{1-\alpha-\beta}} - c_e^{-1}(\tau) & \text{if } \omega_i > \tilde{\omega}^2 \end{cases}$$

Reported revenue to electricity ratio:

$$\frac{\hat{R}_i^*}{p^E E_i} = \begin{cases} \frac{1}{\alpha} & \text{if } \omega_i < \tilde{\omega}^1 \\ \left(\frac{\bar{R}}{p^E}\right)\left[\left(\frac{\beta}{(1+\tau)p^M}\right)^\beta \left(\frac{\alpha}{p^E}\right)^{1-\beta} p_C^Y\right]^{\frac{1}{1-\alpha-\beta}} [(1 - c_e(R_i - \bar{R}))\omega_i]^{\frac{-1}{1-\alpha-\beta}} & \text{if } \tilde{\omega}^1 < \omega_i < \tilde{\omega}^2 \\ \frac{1}{\alpha(1-\tau)} - \frac{c_e^{-1}(\tau)}{p^E}\left[\left(\frac{\beta}{(1+\tau)p^M}\right)^\beta \left(\frac{\alpha}{p^E}\right)^{1-\beta} (1-\tau) p_B^Y\right]^{\frac{-1}{1-\alpha-\beta}} \omega_i^{\frac{-1}{1-\alpha-\beta}} & \text{if } \omega_i > \tilde{\omega}^2 \end{cases}$$

[16] see Amirapu and Gechter (2018); Best et al. (2015); Bachas and Soto (2018)