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# Are SMEs Avoiding Compliance Costs? Evidence from VAT Reforms in Japan*

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Abstract

This study disentangles the motives behind enterprises' responses to size-dependent tax regulations by exploiting value-added tax (VAT) reforms in Japan. Tax threshold and tax rate in Japan have changed over the past three decades since the introduction of VAT. We build on the model of Harju et al. (2019) to incorporate various tax reforms and conducted bunching estimation. By using a novel panel of the Japanese Census of Manufacture covering the periods of VAT introduction and reforms, we find from the local estimates that the observed output response of enterprises is mainly caused by compliance costs rather than tax rates for small enterprises in Japan. The results suggest that the authorities would be better served by easing compliance costs while enhancing tax revenue to improve the efficiency of tax design.

Keywords: tax compliance costs; value-added tax; sole proprietor; firm behavior; SMEs

JEL classification: D22; H25; H32; L11



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# 1 Introduction

Size-dependent regulations are common for tax systems all over the world, and it is known that these regulations create undesirable incentives for enterprises to avoid exceeding the threshold. Kleven and Waseem (2013) and Best et al. (2015) exploit Pakistani tax administrative data to show that its tax systems provide enterprises with incentives to avoid taxes. Garicano et al. (2016) discuss how French regulation dependent on the number of employees distorts firm size distribution and eventually productivity distribution. More recently, Aghion et al. (2021) shows how this distortion created by the size-dependent regulation hampers innovation while the impacts are only for incremental innovations but not for radical ones.

The value-added tax (VAT) exemption for small enterprises is one example of this size-dependent regulation. In most countries, the VAT system has a certain threshold and businesses whose taxable sales fall below the threshold are exempted from paying VAT. Also, in some countries, businesses are granted to use a simplified tax scheme where enterprises can substitute the amount of taxable purchase for deemed taxable purchase, which is calculated by taxable sales multiplied with pre-specified rate of purchase. Similar to other taxes or regulations, previous studies have pointed out that size-dependent regulations create incentives to avoid exceeding the threshold by reducing sales or changing the organizational structure of enterprises. However, to the best of our knowledge, there is only limited evidence to uncover the underlying mechanisms. One exception is Harju et al. (2019), which tries to distinguish between the tax compliance costs and the tax rate responses through the bunching estimation. Harju et al. (2019) obtained a larger estimate of compliance costs than tax rate, using Finnish institutional reform that reduced the compliance costs of VAT.

We build on the theoretical model of Harju et al. (2019) and extend it to incorporate Japanese tax reforms. In Japan, the Consumption Tax (equivalent to the VAT) was introduced in 1989[1]. The government has had several tax reforms, which affects especially small enterprises with sales near the exemption threshold. We quantitatively estimate the size of compliance costs in a comparable manner with tax rate by analyzing the changes in the estimated bunching size in the sales distribution around the threshold before and after the reforms[2].

[1]Consumption tax in Japan is a form of VAT. One distinction from the VAT system in other countries is that enterprises are not required to issue an invoice. After the introduction of the multiple tax rates in October 2019, the government announced to introduce an invoice system from October 2023. We discuss the impacts of the VAT on enterprises in cases with and without invoicing in the next section.

[2]In this paper, we refer to tax compliance costs as the sum of monetary, time, operational and psychological expenses incurred through tax payments. For instance, compliance costs include remittance and accounting costs for tax imposed on sales or profits and collection fees for information of legal obligations and penalties. The concept is broader in scope than the expenses incurred when enterprises outsource tax

We have obtained four findings. First, we found clear bunching below the tax threshold. Using the Japanese firm-level data covering over two decades, we observed that the excess bunching is substantially large during the entire sample period. Second, we analyzed how the excess bunching varies over time. It increased when the VAT was introduced, then sharply declined when the VAT exemption threshold was reduced, which is consistent with our theoretical model. Interestingly, the VAT hike during the period did not trigger larger excess bunching. This suggests that the tax rate changes did not significantly impact the enterprises' incentives to adjust their taxable sales. Third, we found that the bunching estimates are persistently larger for sole proprietors than for firms, as found in Harju et al. (2019). Forth, exploiting our theoretical implications, we estimated tax elasticity and compliance costs and found that the compliance costs are dominant in determining responses by enterprises to taxes. While the VAT rates were three or five percent during the analysis period, the estimated compliance costs were approximately thirteen percent of enterprises' value added. Though this estimate is considered relatively large, it is reasonable if we assume that it includes the fixed costs required for businesses that have never faced VAT compliance. This is in line with Harju et al. (2019).

This paper contributes to three strands of the literature. The first is the literature on tax compliance costs. Although extensive studies have documented tax filing costs, a relatively small number of papers have quantitatively estimated the costs by analyzing the behavioral responses (e.g., Aghion et al. 2017; Harju et al. 2019; Benzarti 2020). Aghion et al. (2017) estimated compliance costs with French tax return data, exploiting the fact that the simplicity of tax filing systems for the self-employed varies with the size of revenues. Benzarti (2020) estimated the costs of filing taxes using U.S. income tax return data. Harju et al. (2019) use the Finnish administrative data and find that the VAT compliance costs are higher than the tax rate elasticities. Our findings add to this literature by providing the size of VAT compliance costs for small enterprises in Japan where the tax system does not incentivize enterprises to select trading partners based on tax status.

Japanese VAT does not have the invoicing system. Under the invoicing system, which is a common system of VAT in other countries, only the tax-paying businesses can issue an invoice. Tax-exempt businesses tend to be excluded from business-to-business transactions from the tax-payers perspective. However, this is not the case in the Japanese setting. Regardless of whether the supplier is taxable or exempt, buyers can treat the VAT included in all their purchases as an input tax credit. Thus, it suffices to use a relatively parsimonious model that does not take into account enterprises' choices of trading partners.

When it comes to the taxation of businesses, tax compliance costs are particularly crucial

accountants.

for small and medium-sized enterprises (SMEs) since the burden of complying with taxes for SMEs is higher than that for large enterprises (e.g., EC-KPMG, 2018). In particular, the VAT requires SMEs to take a substantial amount of time and effort to comply with the tax compared to other types of taxes (Hansford and Hasseldine, 2012). It demonstrates that the VAT presumably hinders business activities more severely than other tax systems due to large compliance costs. Our estimates show that the share of compliance costs out of value added is much larger than the VAT rate, providing important evidence for policy discussions of the VAT system.

The second strand is the literature on enterprise responses to tax notches and tax kinks (e.g., Chetty et al. 2011; Kleven and Waseem 2013; Best et al. 2015; Harju et al. 2019). Our paper provides evidence on enterprise responses to a tax kink and notch at a tax exemption threshold in Japanese VAT. In Harju et al. (2019), the Finnish VAT reform changes a tax notch to a kink. However, in Japanese VAT system, the reforms abolished a kink and introduced a notch.

It is also related to the studies on size-dependent regulations of VAT in Japan. Onji (2009) finds that the threshold of the simplified tax system of VAT gives firms an incentive to split into smaller firms to remain below the threshold. Ichikawa et al. (2020) estimate the size of the excess bunching of firms around the exemption threshold before and after the tax hike in 2014. They argue that tax compliance costs are a major factor causing bunching. Although Ichikawa et al. (2020) show that compliance costs are an important factor in explaining the adjustment of firms' taxable sales, they do not quantitatively estimate the size of compliance costs as we do in this paper[3].

The rest of the paper is structured as follows. In the next section, we explain the institutional background of Japanese VAT system and its reforms over the past three decades. We also describe our plant-level panel data set. In section 3, we construct the theoretical model and its implications, which we use for empirical exercises. Section 4 documents the estimation procedures, and section 5 discusses the findings about tax elasticity and compliance costs. Section 6 concludes with policy discussions.

# 2 Institutional Background and Data

## 2.1 Value Added Tax in Japan

In Japan, VAT is imposed on domestic transactions of goods, services, and imports by enterprises. Enterprises are in charge of VAT payment to the tax authority, but they are

[3]Hosono et al. (2019) take a different approach from ours and look at the relationship between the bunching size and the costs of employing accountants for tax purposes at the prefectural-level.

entitled to deduct the remitted VAT from their payment to avoid double taxation. This means that in the supply chain, enterprises' tax liability is calculated by output VAT minus input VAT. It also can be described that their tax base is equal to the taxable sales minus taxable purchase.

The VAT was first introduced in April 1989 with three percent tax rate. It was raised to five percent in April 1997, eight percent in April 2014, and ten percent in October 2019, respectively. Before October 2019, the tax rate was uniform for all taxed transactions. After October 2019, ten percent tax rate is applied for most goods and eight percent tax rate is imposed on necessities, such as food and newspaper. As of 2016, VAT comprises 34.3% of the total tax revenue and 6.3% of the total GDP, which is lower than the OECD members' average of 45.4% and 11.0%, respectively. Although these ratios in Japan remain low, the relative magnitude of VAT is steadily increasing from the level of 1989 (17.2% of tax revenue and 3.6% of GDP), which implies that the analyses of Japan's VAT is increasingly insightful for other countries, especially for advanced economies. Also, the repeated reforms in Japan enable us to bring rich policy implications about the VAT system. When the VAT was introduced in April 1989, the government eased the tax burden and compliance costs for small and medium-sized enterprises with three special measures. In our context, we refer to the cost associated with filing/reporting required information for VAT payment as compliance costs. So far, the following two types of measures have been implemented to lower compliance costs of small and medium-sized enterprises in Japan. First, the Tax Exemption System is applied for small enterprises. Specifically, if taxable sales of a firm are less than or equal to the threshold amount during the base period, enterprises are exempt from remitting VAT and filing/reporting required information. The base period is defined as two fiscal years before the taxation occurs. The exemption threshold was lowered in 2004. It was initially set at 30 million JPY, but then was lowered to 10 million JPY in April 2004. Enterprises which earned more than 10 million JPY in the first half of the previous fiscal year also became subject to VAT since April 2012. Meanwhile, new enterprises were originally exempt from VAT as they did not have sales records two fiscal years before the year of establishment, but they became no longer exempted if their registered capital amount was 10 million JPY or more since April 1997. New enterprises whose parental firm has sales more than 500 million JPY and holds more than 50 percent of their stock also became subject to VAT even if their capital is less than 10 million JPY.

Second, the Marginal Deduction System (MDS) was introduced in April 1989 to mitigate the discrete change in tax burden at the exemption threshold. Enterprises are allowed to deduct the amount calculated by the following formula from the original VAT due:

$$\text{VAT deduction} = \frac{(\text{The original Amount of VAT}) \times (\text{Upper Bound} - \text{Taxable Sales})}{\text{Upper Bound} - \text{Lower Bound}}$$

The lower bound was 30 million until the abolition of this system in April 1997 while the upper bound was originally 60 million JPY but lowered to 50 million JPY in October 1991. Figure 1 summarizes the changes mentioned above, while Figure 2 graphs the VAT schedule reflecting the changes depending on the period.

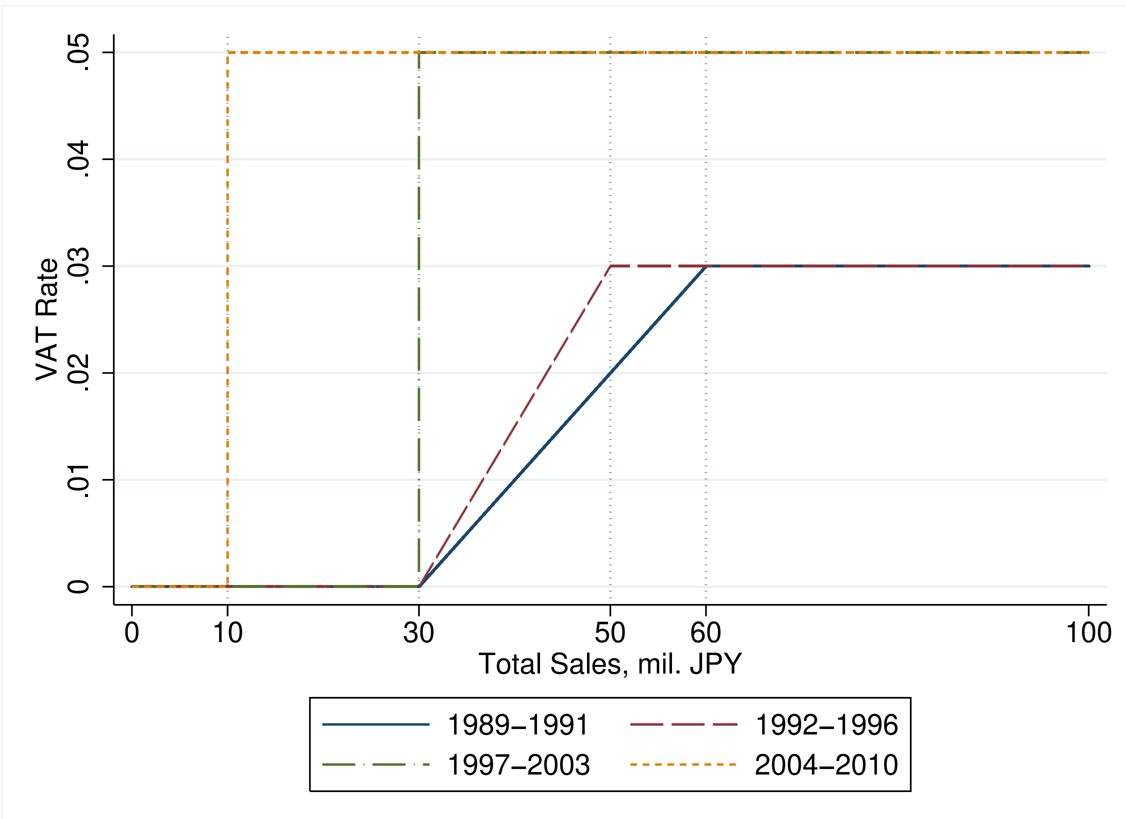
From this figure, we can expect that the introduction of VAT in 1989 generated strong incentives for enterprises to stay within the threshold at 30 million JPY to avoid compliance costs and tax burdens. In 1992, the MDS was amended to make the slope (i.e., higher tax rate) steeper. This did not affect compliance costs but did increase tax burdens for enterprises above the threshold. The abolition of the MDS in 1997 changed the threshold from a kink to a notch. While compliance costs remain the same, this made a significant change in terms of tax burdens. When a notch exists, enterprises can earn more profit if they are marginally below the threshold than marginally over the threshold, as shown in Kleven and Waseem (2013). Therefore, the 1997 policy change is an important incident as it enables us to disentangle the effect of tax burdens and compliance costs. This policy change also enables us to make an interesting comparison with Harju et al. (2019) who analyze a change from notch to kink in Finnish VAT schedules, while we analyze a change from kink to notch. In 2004, The threshold was lowered to 10 million JPY. Enterprises around the old threshold are no longer affected by the new threshold, but those who are around the new threshold are instead affected.

***Figure 1.*** *VAT Reforms Over Time*

| | 1989 | 1992 | 1997 | 2004 | 2010 |
|---|---|---|---|---|---|
| Statutory VAT rate | 3% | → | 5% | → | → |
| Exemption threshold (JPY million) | 30 | → | → | 10 | → |
| MDS upper bound (JPY million) | 60 → | 50 → | (abolition) | | |

The tax accounting system is another important factor that affects enterprises' incentives from financial perspective. In Japan, there was generally no requirement for enterprises to state the VAT rate or amount on their tax invoices during 1989-2019. In 2019, the tax

***Figure 2.*** *Changes in VAT Schedule*



authority changed the rule to mandate enterprises to state the tax amount, in response to the implementation of multiple VAT rates. It also led to the authority's decision of implementing the tax invoicing system from 2023. Under the invoicing system, enterprises will be obliged to use official tax invoices to calculate the amount of their taxable inputs. It is considered that Japan have not implemented tax invoice for long time because the single VAT rate is applied for the entire goods since the VAT was implemented.

There is no invoicing system in Japanese VAT while it is common in other countries. This provides us two advantages by enabling the simple analytical framework in the bunching literature. First, the Japanese VAT system does not brought about selection of trading partners in terms of tax payment. Under the tax invoicing system, tax-paying enterprises are incentivized to trade with other tax-paying enterprises to obtain more tax invoices and consequently pay less taxes. This selection behavior has been observed in existing studies (e.g., de Paula and Scheinkman 2010; Gadenne et al. 2019; and Liu et al. 2021), using data from countries with the invoicing system in VAT. However, this is not the case in the Japanese setting. It suffices to use a relatively parsimonious model that does not take into account enterprises' choices of trading partners. Second, it is unlikely that the price set by enterprises systematically varies depending on whether an enterprise is exempt from VAT or not. It is not required to issue invoices for business-to-business transactions in Japan, which allows enterprises to sell their products at tax-inclusive prices even if they are tax-exempt, at least for those with sale around the exemption threshold. Therefore, we can be abstract from the difference in pricing behaviors depending on whether they are VAT exempt or not. These two points imply a clear advantage of using the Japanese VAT system to study bunching behavior by enterprises and estimate compliance costs.

### 2.2 Data

The main dataset we use is the Census of Manufacture, which is conducted by the Japanese Ministry of Economy, Trade, and Industry. The survey has been conducted since 1909, sampling from all establishments that have more than three employees.[4] The survey collects various ranges of information related to production such as shipment value, input value, number of employees[5], capital stock, investment, etc. As the data does not include taxable sales, we use shipment value as a proxy for taxable sales. This substitution is justified for two reasons. First, the difference between the sales of a enterprise and the shipment value

[4] There used to be no restriction related to employee number before 2010 if a year ends with 0, 3, 5, or 8. Conversely, we can use the data of establishments with more than three employees for all the survey years.

[5] Here, employees includes regular employees, self-employed and family workers. Since 2001, regular employees are differentiated from part-time workers, temporary workers and permanent workers.

of an establishment occurs mostly in the case where an establishment sells goods to another establishment within the same enterprise, but this situation is excluded from the data as we only focus on those with a single establishment. Even if we restrict the data to a single establishment with a turnover of 30 million JPY, which is the VAT exemption threshold, we argue that the sample adequately captures the distribution of firms: it approximately covers 90% of the establishments around the threshold. Second, the difference also occurs when enterprises book sales and shipments at different timings, but it is generally thought that manufacturing enterprises book shipments and sales simultaneously in Japan. Thus, we believe that the shipment value is a valid proxy for the sales. We use the data from 1987 to 2010, covering the start of VAT in April 1989, the hike in VAT rate from 3 percent to 5 percent and the abolition of the marginal deduction system in 1997, and the reduction of the exemption threshold from 30 million JPY to 10 million JPY since 2004.

***Table 1.*** *Sample Distribution by Organization Types*

| Year | Firms | Sole proprietors | Others | Total |
|---|---|---|---|---|
| 1986 | 202,214 | 128,643 | 2,310 | 333,167 |
| 1989 | 203,083 | 110,732 | 2,170 | 315,985 |
| 1992 | 210,155 | 89,883 | 2,065 | 302,103 |
| 1995 | 200,496 | 78,803 | 1,912 | 281,211 |
| 1998 | 198,148 | 68,019 | 1,917 | 268,084 |
| 2001 | 174,630 | 49,298 | 1,671 | 225,599 |
| 2004 | 152,570 | 36,922 | 1,421 | 190,913 |
| 2007 | 145,415 | 29,540 | 1,330 | 176,285 |
| 2010 | 127,374 | 22,722 | 1,241 | 151,337 |
| Total | 4,512,347 | 1,710,157 | 44,460 | 6,266,964 |

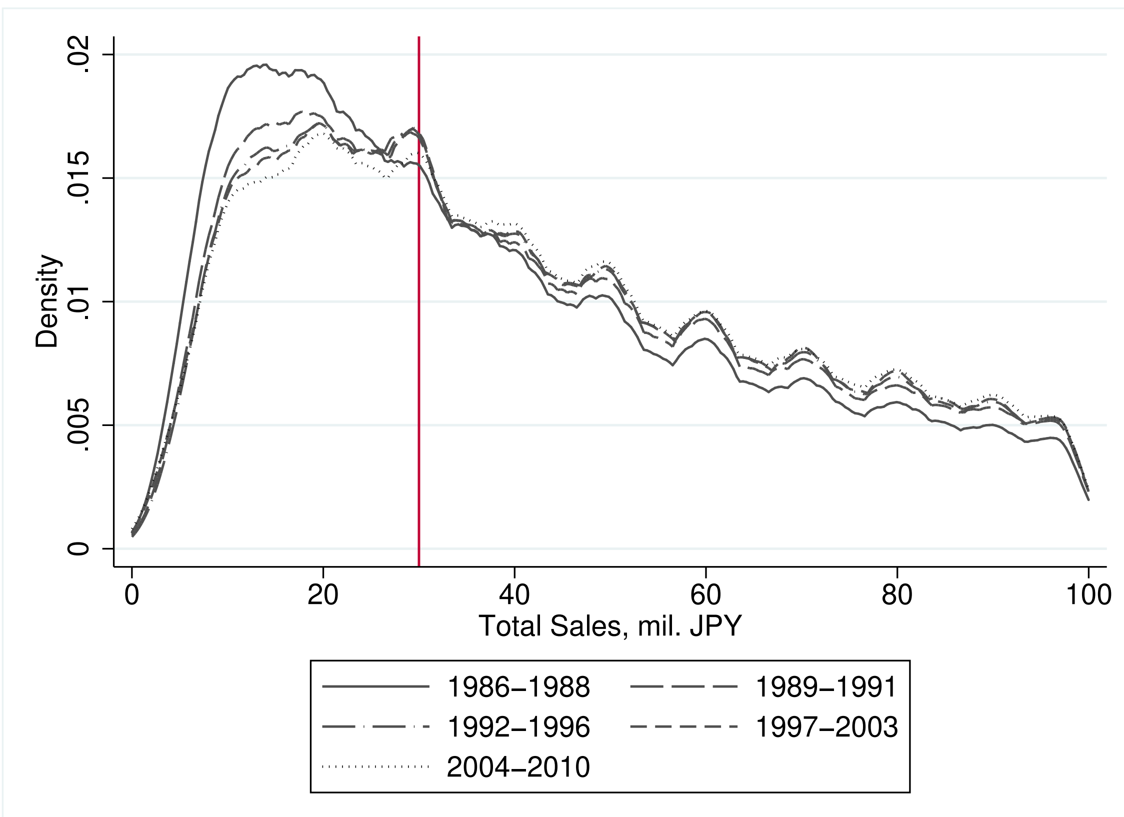
Notes: (i) The table only list the numbers every three years starting 1986, and skip listing them in years between. (ii) The sample only includes establishments which have the same address with their headquarters and no other establishments.
Source: Census of Manufacture (1986 - 2010), the Ministry of Economy, Trade and Industry (METI)

### 2.3 Summary Statistics

Table 1 shows the distribution of observations in our sample. In this table, we only list the numbers every three years starting 1986, and skip listing them in years between due to the space constraint although our data is a yearly panel. The total number of observation in each year is ranging from 151,000 to 333,000. The number is monotonically decreasing over the sample years, which is consistent with existing studies constructing the official panel converter of the Census (e.g., Shimpo et al. 2005; Abe et al. 2012). Table A1 and A2 illustrate the sample distribution by establishment types and by industry classifications, respectively. It is confirmed that firms with a single establishment in the same place are dominant in the survey data. Interestingly, textile manufacturers hold the biggest share (12.8 percent), although they occupy less than 1 percent of the total output of manufacturing industries in Japan.

The distribution of total sales in each tax regime is shown in Figure 3. We can see a bulge below the VAT exemption threshold (30 million JPY) after the introduction of VAT while the valley which we expect to see above the threshold is not that clear. Over the sample years, we observe the decrease in the number of enterprises whose total sales are below the threshold and the increase in the number of those above the threshold. Also, it is noteworthy that we observe a mass at round numbers (e.g., 40 million JPY and 60 million JPY). We explicitly take care of the round number bunching in our estimation procedures.

***Figure 3.*** *Kernel Density in Each Tax Regime*




Note: The red vertical line shows the size of VAT exemption threshold, 30 million JPY.

Then, the summary statistics of other enterprise characteristics are summarized in Table 2. The unit is 1 million JPY. Total sales ranges from 1.80 million JPY to over 18,000 million JPY, which shows the large coverage of the Japanese Census of manufacture. Firm size is defined as the number of employees and ranges from 4 to 499[6]. The reason why the minimum number of the employees is 4 is that the survey targets firms with 4 or more employees. Also, the why the maximum number of the employees is 499 is that we currently only focus on firms with a single establishment. Without this restriction, the number is much larger.

***Table 2.*** *Summary Statistics for Years 1986 - 2010*

| Variables | Mean | Median | SD | Min | Max |
|---|---|---|---|---|---|
| Total Sales | 256.40 | 64.72 | 9.67 | 1.80 | 18,525.06 |
| Firm Size | 15.76 | 8.00 | 31.15 | 4.00 | 499.00 |
| Total Wage | 53.08 | 21.70 | 1.39 | 0.00 | 2,465.91 |
| Capital | 10.71 | 3.00 | 0.49 | 0.00 | 1,135.46 |
| Value Added | 60.72 | 14.12 | 2.38 | -214.44 | 4,548.21 |
| VAT Paid | 1.51 | 0.00 | 0.08 | -0.56 | 153.65 |
| Input Cost | 138.66 | 22.00 | 6.20 | 0.05 | 12,032.06 |
| Input-Cost Ratio | 0.39 | 0.38 | 0.22 | 0.00 | 1.00 |

Notes: (i) The number of observations is 6,266,964. The sample only includes establishments which have the same address with their headquarters and no other establishments. (ii) The unit of price is in one million JPY. We pooled all the sample years, and winsorized the variables at level 0.1% and 99.9% levels. (iii) Firm size is defined as the number of employees. Value added is defined as Total Sales minus the sum of Input Cost and Amount of VAT Paid. Input-cost ratio is defined as dividing Input cost by Total sales, and we are excluding observations which exceed one.
Source: Census of Manufacture (1986 - 2010), the Ministry of Economy, Trade and Industry (METI)

# 3 Theoretical Model

We basically build on the theoretical model in Harju et al. (2019) and extend it to incorporate various tax reforms in Japan over the last two decades[7]. Consider a large number of owners

[6]Since we winsorized variables at level 0.1% and 99.9% levels, maximum size becomes smaller than the actual size.

[7]Our model has two limitations. Firstly, we are considering the case where enterprises cannot pass on any tax at all to their selling price. However, some enterprises may be able to pass VAT. Secondly, we do not take into account taxable enterprises near the tax exemption threshold can use the simplified tax system.

of a small enterprise[8] that produce a single homogeneous good and sell all their products to customers. Assume that demand for the good is perfectly elastic, and producer price of the good is normalized to be 1. An enterprise's productivity, $a$, follows CDF $F(a)$ and PDF $f(a)$. We assume that the value added can be described as $v = (1-\alpha)y$ where $y$ denotes revenue and $\alpha$ denotes the share of input costs out of revenue[9]. Enterprises are assumed to have iso-elastic cost of generating output

$$\phi(y;\alpha) = \frac{a}{1+1/e}\left(\frac{(1-\alpha)y}{a}\right)^{1+1/e}$$

where $e$ denotes the elasticity of value added with respect to the net-of-VAT rate.

Then, the firm owner's maximization problem of its profit $\pi(y;\alpha)$ becomes

$$\max_{y} \quad \pi(y;\alpha) = (1-\alpha)y - T(y;\alpha) - \Theta(y;\alpha) - \phi(y;\alpha)$$

where $T(y;\alpha)$ denotes tax payments, and $\Theta(y;\alpha)$ denotes compliance costs. Here, we assume compliance costs are proportional to value added $v$ such that $\Theta(y;\alpha) = \theta(1-\alpha)y$ with $\theta \in [0,1]$. Note that enterprises incur three type of costs other than tax payment costs: cost of buying raw materials, cost of producing goods, and compliance costs for their tax payment.

## 3.1 Marginal Deduction System

### 3.1.1 Derivation of the formula

As we explain in section 2.1, there used to be the Marginal Deduction System when the VAT was introduced in Japan. Under the Marginal Deduction System, the effective tax rate increases gradually above the threshold. In other words, it creates a kink in the tax system as we can see in Figure 2. For those below the threshold (i.e., $y \leq y^*$), the objective function of the enterprise can be rewritten as:

$$\begin{aligned} \pi(y;\alpha) &= (1-\alpha)y - t\alpha y - \phi(y) \\ &= (1-\alpha)y(1-t^A) - \phi(y) \end{aligned}$$

where $t$ is VAT rate, and $t^A = \frac{t\alpha}{1-\alpha}$ is effective tax rates below the threshold.

For those above the threshold (i.e., $y > y^*$), the objective function of the enterprise can

[8] Since we focus on small firms and sole proprietors, we assume that enterprise owners make enterprise-level decisions and respond to tax systems identically with enterprises, as Bonzaanier et al. (2019).

[9] Here we are thinking about input cost in VAT so it does not include cost of hiring labor.

be approximated[10] as:

$$\begin{aligned}\pi(y;\alpha) &= (1-\alpha)y - \left(1-\frac{\bar{y}-y}{\bar{y}-y^*}\right)\left(\frac{t}{1+t}y - t\alpha y\right) - t\alpha y - \theta(1-\alpha)y - \phi(y) \\ &\approx (1-\alpha)y\left(1-t^B-\theta\right) - \frac{(y^*)^2}{\bar{y}-y^*}\left(-\frac{t}{1+t}+t\alpha\right) - \phi(y)\end{aligned}$$

where $\bar{y}$ denotes as the upper bound, $t^B = \frac{1}{1-\alpha}\left(\frac{y^*}{\bar{y}-y^*}\frac{t}{1+t} + \frac{\bar{y}-2y^*}{\bar{y}-y^*}t\alpha\right)$ as effective tax rates above the threshold. We have $t^A < t^B$ as far as $\alpha \in [0, \frac{1}{1+t})$.

These can be summarized as follows:

$$\pi(y;\alpha) = \begin{cases}(1-t^A)(1-\alpha)y - \phi(y) & \text{if } y \leq y^* \\ (1-t^B-\theta)(1-\alpha)y - \frac{(y^*)^2}{\bar{y}-y^*}\left(-\frac{t}{1+t}+t\alpha\right) - \phi(y) & \text{if } y > y^*,\end{cases}$$

The maximization problem brings

$$(1-\alpha)y = \begin{cases}a(1-t^A)^e & \text{if } y \leq y^* \\ a(1-t^B-\theta)^e & \text{if } y > y^*\end{cases}$$

Next, we consider the behaviors of the marginal bunchers whose revenues are equivalent. Marginal bunchers would be indifferent between bunching and not bunching. By the former, they obtain

$$\pi_{bunch} = (1-t^A)(1-\alpha)y^* - \frac{a^*+\Delta a^*}{1+1/e}\left(\frac{y^*(1-\alpha)}{a^*+\Delta a^*}\right)^{1+1/e}$$

By the latter, they obtain

$$\pi_{not} = (a^*+\Delta a^*)(1-t^B-\theta)^{e+1}\left(\frac{1}{e+1}\right) - \frac{(y^*)^2}{\bar{y}-y^*}\left(-\frac{t}{1+t}+t\alpha\right)$$

Marginal bunchers would satisfy the following first-order condition when they choose not to bunch: $(1-\alpha)y^* = (a^*+\Delta a^*)(1-t^B-\theta)^e$. Also, they would satisfy the first-order condition when there were no threshold: $(1-\alpha)(y^*+\Delta y^*) = (a^*+\Delta a^*)(1-t^A)^e$.

Then, the indifference between bunching and not bunching, i.e., $\pi_{bunch} = \pi_{not}$, brings the

[10] The details of the derivation are shown in Appendix B.

following formula:

$$1-\frac{e}{e+1}\left(1+\frac{\Delta y^*}{y^*}\right)\left(\frac{1}{1+\frac{\Delta y^*}{y^*}}\right)^{1+1/e}=\frac{1}{e+1}\left(\frac{1-t^B-\theta}{1-t^A}\right)^{e+1}\left(1+\frac{\Delta y^*}{y^*}\right)-\frac{y^*}{\bar{y}-y^*}\frac{-\frac{t}{1+t}+t\alpha}{(1-\alpha)(1-t^A)}$$

Arranging terms, we obtain

$$\begin{aligned}
&\frac{1}{1+\frac{\Delta y^*}{y^*}}\left[1-\frac{y^*}{\bar{y}-y^*}\frac{-t\alpha+\frac{t}{1+t}}{(1-\alpha)(1-t^A)}\right]-\frac{e}{e+1}\left(\frac{1}{1+\frac{\Delta y^*}{y^*}}\right)^{1+1/e}-\frac{1}{e+1}\left(\frac{1-t^B-\theta}{1-t^A}\right)^{1+e}\\
=\;&\frac{1}{1+\frac{\Delta y^*}{y^*}}\left(1-t^C\right)-\frac{e}{e+1}\left(\frac{1}{1+\frac{\Delta y^*}{y^*}}\right)^{1+1/e}-\frac{1}{e+1}\left(\frac{1-t^B-\theta}{1-t^A}\right)^{1+e}\\
=\;&0 \qquad (1)
\end{aligned}$$

where we denote $t^C=\frac{y^*}{\bar{y}-y^*}\frac{-t\alpha+\frac{t}{1+t}}{(1-\alpha)(1-t^A)}$.

### 3.1.2 1992 VAT Reform

In October 1991, the upper bound of VAT deduction of the Marginal Deduction System was lowered from 60 million to 50 million JPY [11]. This led to the change in the effective tax rate above the threshold, i.e., $t^B=\frac{1}{1-\alpha}\left(\frac{y^*}{\bar{y}-y^*}\frac{t}{1+t}+\frac{\bar{y}-2y^*}{\bar{y}-y^*}t\alpha\right)$ while it does not affect the effect tax rate below the threshold, i.e., $t^A=\frac{t\alpha}{(1-\alpha)}$. As we confirm that $\partial t^B/\partial\bar{y}<0$[12], the VAT reform in 1992 resulted in the rise in effective tax rate $t^B$. In other words, the last term in equation (1), i.e., $(1-t^B-\theta)/(1-t^A)$, gets larger after the reform. Given the decline in $\bar{y}$, the first term in equation (1), i.e., $1-t^C$, gets larger as well as is seen from $\partial t^C/\partial\bar{y}<0$[13]. Based on the observation, we newly denote these rates as $t^B_{1992}$ and $t^C_{1992}$.

The formula can be written as

$$\frac{1}{1+\frac{\Delta y^*_{1992}}{y^*}}\left(1-t^C_{1992}\right)-\frac{e}{e+1}\left(\frac{1}{1+\frac{\Delta y^*_{1992}}{y^*}}\right)^{1+1/e}-\frac{1}{e+1}\left(\frac{1-t^B_{1992}-\theta}{1-t^A}\right)^{1+e}=0 \qquad (2)$$

The positive changes in tax rate terms ($t^B_{1992}$ and $t^C_{1992}$) leads to the change in the magnitude of bunching, i.e., $\Delta y^*_{1992}/y^*$.

[11] This amendment was applied to firms' base period that started after October 1991. In most Japanese firms, the base period starts in April and ends in March. For sole proprietors, the base period starts in January and ends in December. That means that this reform was applied from April 1992. Thus, we refer to this reform as 1992 reform.

[12] This holds as far as $\alpha\in[0,\frac{1}{1+t})$. Although the statutory tax rate did not change under the regime of marginal deduction system, we can check that $\frac{\partial t^B}{\partial t}>0$.

[13] The result comes from the relationship between $t^B$ and $t^C$, i.e., $(1-t^C)=\frac{1-t^B}{1-t^A}$.

### 3.2 1997 VAT Reform

We observe two shifts in the VAT system in 1997. First, the Marginal Deduction System was abolished and there exists no deduction since then. Second, the tax rate was increased from 3 percent to 5 percent. Denoting the new tax rate as $t_{1997}$, we obtain the profit functions as

$$\pi(y;\alpha) = \begin{cases} y - \alpha y - \alpha y t_{1997} - \phi(y) & \text{if } y \leq y^* \\ y\left(\frac{1}{1+t_{1997}} - \alpha\right) - \theta(1-\alpha)y - \phi(y) & \text{if } y > y^* \end{cases}$$
$$= \begin{cases} (1-\alpha)y(1-t^D) - \phi(y) & \text{if } y \leq y^* \\ (1-\alpha)y(1-t^E-\theta) - \phi(y) & \text{if } y > y^*, \end{cases}$$

where

$$t^D = \frac{\alpha t_{1997}}{1-\alpha} \text{ and } t^E = \frac{t_{1997}}{(1-\alpha)(1+t_{1997})}$$

are the new effective tax rates.

Then, the formula becomes

$$\frac{1}{1+\frac{\Delta y^*_{1997}}{y^*}} - \frac{e}{e+1}\left(\frac{1}{1+\frac{\Delta y^*_{1997}}{y^*}}\right)^{1+1/e} - \frac{1}{e+1}\left(\frac{1-t^E-\theta}{1-t^D}\right)^{1+e} = 0 \qquad (3)$$

Due to the fact that there are two changes in the tax system, we expect that the volume of the bunching should be also changed and we are again using a different subscript in the equation above.

In the next section, we estimate the size of the excess bunching, and derive the tax elasticity and the compliance costs.

## 4 Empirical Specifications

In those equations (1) to (3), we can observe values of $\alpha$, $t^A$, $t^B$, $t^C$, $t^B_{1992}$, $t^C_{1992}$, $t^D$, $t^E$. Also, we can obtain the estimates $\Delta y^*/y^*$ from bunching estimation. Below, we explain the estimation procedures.

The existence of the tax threshold gives enterprises an incentive to bunch just below the threshold in order to avoid taxation. This is the behavioral response which we focus on. We observe the excess mass below the threshold and the hole above it in empirical turnover distribution. By comparing the empirical distribution to the counterfactual distribution that would exist in the absence of the threshold at $y^*$, we obtain the estimates of the behavioral responses. We follow the existing literature on bunching estimation (see, e.g., Chetty et al. 2011; Kleven and Waseem 2013) and estimate the counterfactual density by fitting a flexible polynomial function to the empirical distribution with eliminating an area around (below and above) the threshold $y^*$.

There are three steps in the bunching estimation: constructing the counterfactual density, estimating the size of the bunching, and calculating the standard errors with bootstrapping. First, we construct the counterfactual density with the following regression. We treat the enterprises in a group of bins with 0.5 million JPY and exclude the region around the threshold, i.e. $y \in [y_L,\ y_U]$, where $y_L$ denotes the lower bound of the excluded region and $y_U$ denotes the upper bound.

$$c_j = \sum_{i=0}^{p} \beta_i (y_j)^i + \sum_{i=y_L}^{y_U} \gamma_i \cdot 1\{y_j = i\} + \sum_{r \in \mathbb{R}} \eta_r \cdot 1\left\{\frac{y_j}{r} \in \mathbb{N}\right\} + \epsilon_j \tag{4}$$

where $c_j$ is the count of establishments in bin $j$, and $y_j$ denotes the sales in bin $j$. We include the polynomials up to the seventh order in the baseline estimation as Chetty et al. (2011) did. Also, we take care of round number bunching because establishments often report round numbers such as 10 million and 50 million JPY. The third term in the equation (4) is a set of round number dummies to control for bunching at integers, $\sum_{r \in \mathbb{R}} \eta_r \cdot 1\left\{\frac{y_j}{r} \in \mathbb{N}\right\}$, where $\mathbb{R}$ is a vector of the sales in 1, 5 and 10 million JPY, and $\mathbb{N}$ is the set of natural numbers. The counterfactual density can be constructed by the fitted values

$$\hat{c}_j = \sum_{i=0}^{p} \hat{\beta}_i (y_j)^i + \sum_{r \in \mathbb{R}} \hat{\eta}_r \cdot 1\left\{\frac{y_j}{r} \in \mathbb{N}\right\} \tag{5}$$

Second, we estimate the relative bunching mass as follows. $\hat{b}(y^*)$ refers to the excess mass relative to the average density of the counterfactual turnover distribution.

$$\hat{b}(y^*) = \frac{\sum_{i=y_L}^{y^*} (c_j - \hat{c}_j)}{\sum_{i=y_L}^{y^*} \hat{c}_j / N_j} \tag{6}$$

where $N_j$ is the number of bins within $[y_L,\ y^*]$. There are two things to be noted about estimating the relative bunching mass. One is about how to determine $y_L$, which is the lower bound of the excluded region. As is done in Harju et al. (2019), we conduct this exercise based on visual observations of the sales distribution. We run several robustness checks depending on the values of the lower bound and find the similar results. The other thing is about how to determine $y_U$, which is the upper bound.

Following Kleven and Waseem (2013) and Harju et al. (2019), we determine $y_U$ so that the estimated excess mass below the threshold, $\hat{b}_E(y^*)$, equals the estimated missing mass above the threshold, $\hat{b}_M(y^*)$, where

$$\hat{b}_E(y^*) \quad = \quad \sum_{i=y_L}^{y^*}(c_j - \hat{c}_j) \tag{7}$$

$$\hat{b}_M(y^*) \quad = \quad \sum_{i=y>y^*}^{y_U}(\hat{c}_j - c_j) \tag{8}$$

When we set $y_U$, we start from a small value and increase it to have $\hat{b}_E(y^*) = \hat{b}_M(y^*)$. This defines the sales response by the marginal buncher. We denote the value as $\hat{y}_U$.

Lastly, we calculate the standard errors by bootstrapping, which is a common practice in the existing literature. We generate the distributions by randomly resampling the residuals from equation (4) with replacement and obtain new estimates with the bootstrap procedure.

In the next section, we will exploit estimates of excess bunching size to derive the elasticity and compliance costs. However, one problem is that equation (6) is the relative bunching size which reflects the behavioral response of enterprises and not the structural one which is applicable to equation (1), (2), and (3). Therefore, we exploit the estimates of upper bound of excess bunching to derive the elasticity and compliance costs, which is provided as the "convergence method" in Kleven and Waseem (2013). The upper bound of excess bunching is defined as follows:

$$\hat{b}_U(y^*) = \hat{y}_U - y^* \tag{9}$$

Kleven and Waseem also provides the estimator of lower bound of excess bunching. However, it is difficult to construct the estimator for us because it contains the parameter of compliance costs, that is what we want to estimate. Thus, we stick to only using the upper bound of excess bunching size.

# 5 Results

## 5.1 Sales Distribution

First, we show the changes in sales distributions over time in Figures 4. Each panel corresponds to a different tax regime. We observe clear excess bunching of enterprises around 30 million JPY in panel (b), (c), and (d), which correspond to the time when the VAT exemption threshold was introduced at 30 million JPY. One notable feature in these figures is round number bunching. There are many points in these distributions for which we observe mass. This is partly because we are using Census of Manufacture and not tax administrative data. The information in the census surveys comes from the answers of firms in the questionnaire and can be more prone to rounding bias while the tax administrative data tell us the exact levels of total taxable sales, total input costs and the amount of VAT paid. We also show the case when splitting the sample to firms and sole proprietor in Appendix Figure A1 and A2. Although the shape of distribution is different from each other, we observe clear bunching around 30 million JPY in both figures after the introduction of the VAT exemption threshold, and decreasing the size of bunching after the reduction of the threshold.

### 5.2 Bunching Estimation

Second, we show the bunching estimates, $\hat{b}(y^*)$ in equation (6) and $\hat{b}_U(y^*)$ in equation (9). The second and third column in Table 3 describe the estimates of excess bunching $\hat{b}(y^*)$ and their standard errors. The fourth column exhibits the lower bound used for the estimations. The fifth and sixth column shows the estimates of the upper bound of excess bunching $\hat{b}_U(y^*)$ and their standard errors following the "convergence method" provided in Kleven and Waseem (2013). We have five rows, each of which corresponds to a different tax scheme.

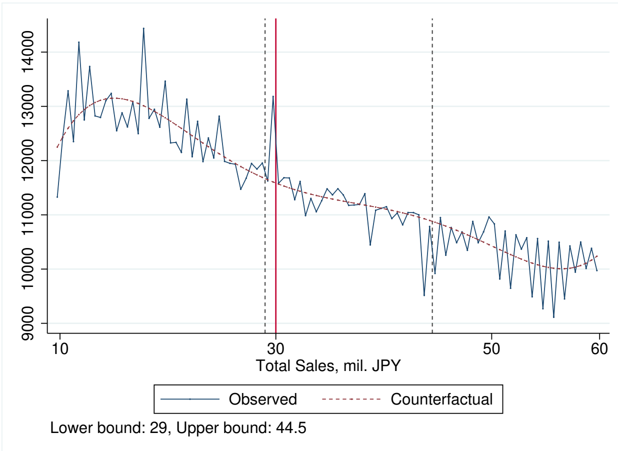
Since the introduction of VAT, we see that the bunching estimate has got larger after the change in the tax system, as we have expected. However, it turned to decrease since the period of 2004-2006. We suppose that it is triggered by the substantial reduction of the exemption threshold from 30 million to 10 million JPY starting from April 2004, of which base period starts from April 2002, as explained in Section 2.2. We can confirm this effect from Figure 5, which describes the estimates of excess bunching $\hat{b}(y^*)$ for each sample year. The size of excess bunching jumped in around 1989, the period of the VAT introduction.

Interestingly, the VAT hike in 1997 did not trigger larger excess bunching. The bunching size sharply decreased after 2004, the period of the threshold reduction. The size of excess bunching further decreased gradually after 2004, which arguably reflects the more extended period for production adjustment in some industries.

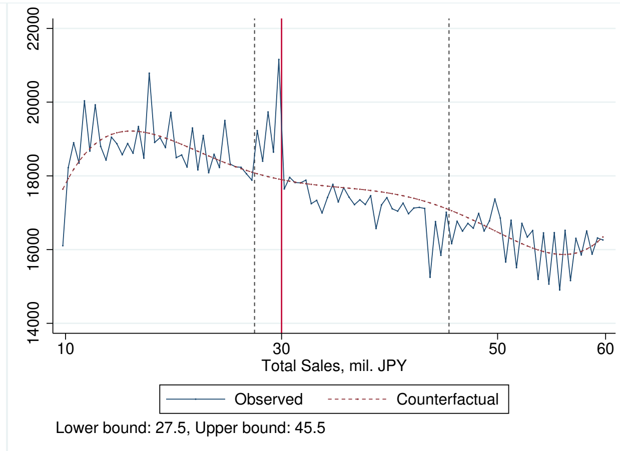
Table 4 gives the estimates separately for firms and sole proprietors. We see that the estimates are larger for sole proprietors than for firms. The yearly trend of bunching size is qualitatively the same in both cases, and the nonlinear change in bunching estimates is apparent in this case as well.

In sum, the observation of these estimates with several VAT reforms in Japan implies that firms respond more to the increase of both the tax burden and compliance costs (i.e., VAT introduction in 1989 and reduction of the VAT exemption threshold in 2004) rather

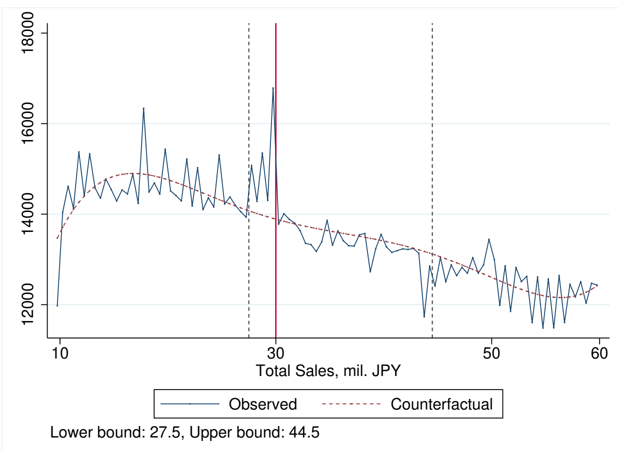
***Figure 4.*** *Size of the Bunching for Each VAT Regime*



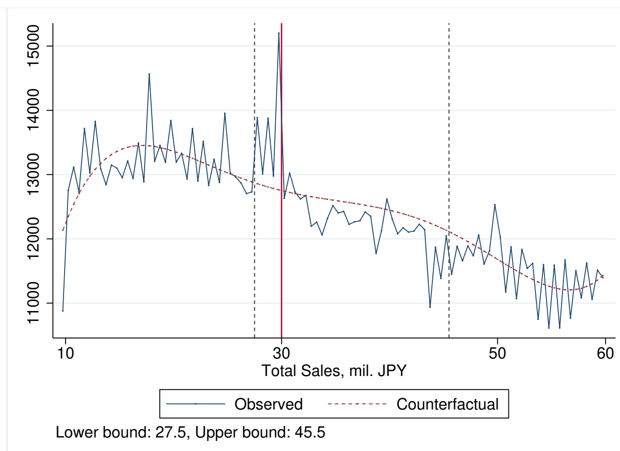

(a) Year: 1986 - 1987



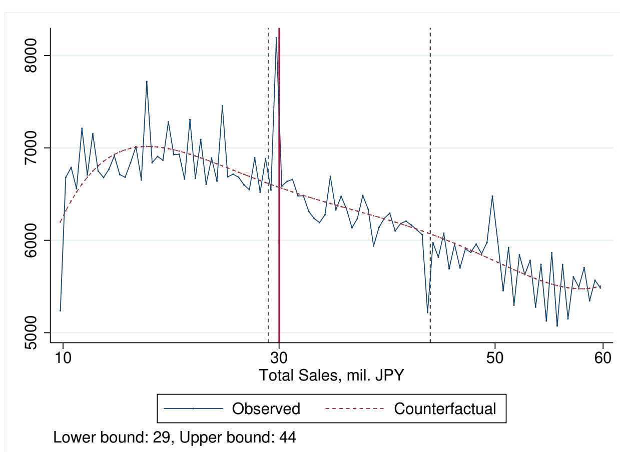

(b) Year: 1989 - 1991




(c) Year: 1992 - 1994




(d) Year: 1997 - 1999




(e) Year: 2004 - 2006

Note: We dealt with round number bunching in our estimation procedure but it is not presented here.

than just raising their tax burden (i.e., 1992 and 1997 reforms of VAT rate and marginal deduction system), suggesting that firms are more sensitive to tax compliance costs than tax burden.

***Table 3.*** *Size of Excess Bunching*

| Year | Excess bunching | SE | Lower bound | Upper bound of Excess bunching | SE |
|---|---|---|---|---|---|
| 1986-1987 | 0.426 | 0.117 | 29.0 | 13.458 | 6.676 |
| 1989-1991 | 1.397 | 0.227 | 27.5 | 16.498 | 3.793 |
| 1992-1994 | 1.243 | 0.237 | 27.5 | 16.277 | 4.594 |
| 1997-1999 | 1.212 | 0.208 | 27.5 | 16.261 | 4.211 |
| 2004-2006 | 0.495 | 0.100 | 29.0 | 14.693 | 5.779 |

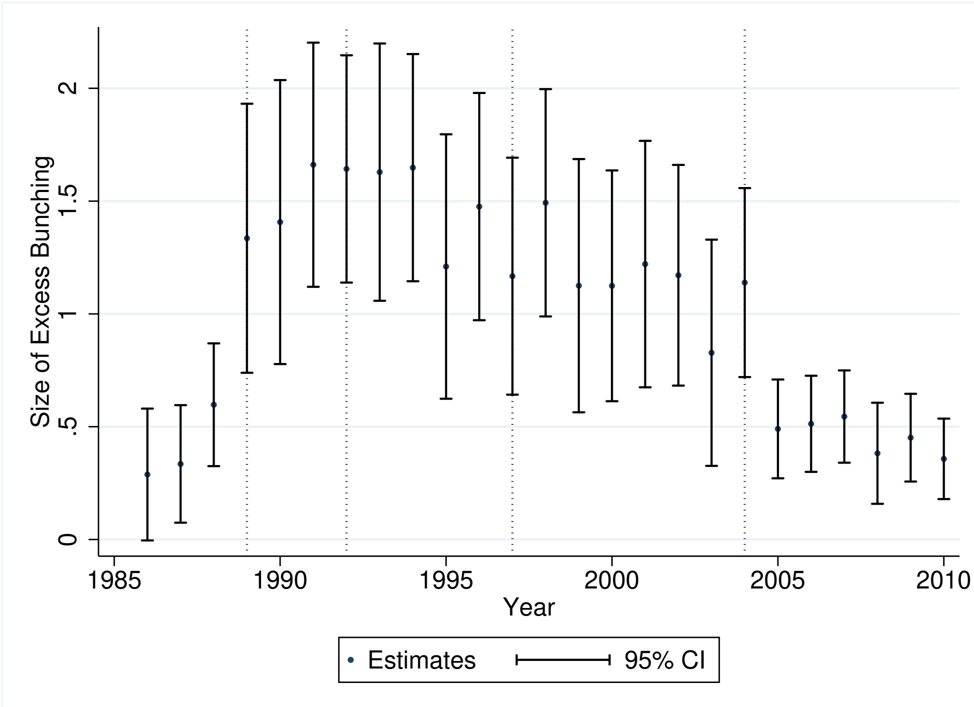
Note: (i) "SE" refers to standard error. (ii) "Upper bound" and "Lower bound" refers to upper and lower bounds of the excess bunching window, respectively. (iii) "Excess bunching" corresponds to the estimates of equation (6), and "Upper bound of Excess bunching" corresponds to the estimates of equation (9).

***Table 4.*** *Size of Excess Bunching: Firms and sole proprietors*

| Year | Excess bunching | SE | Lower bound | Upper bound of Excess bunching | SE |
|---|---|---|---|---|---|
| **Panel A: Firms** | | | | | |
| 1986-1987 | 0.238 | 0.074 | 29.0 | 9.080 | 6.411 |
| 1989-1991 | 0.942 | 0.177 | 27.5 | 14.577 | 4.140 |
| 1992-1994 | 0.857 | 0.153 | 27.5 | 14.596 | 4.202 |
| 1997-1999 | 0.880 | 0.163 | 27.5 | 14.624 | 4.615 |
| 2004-2006 | 0.449 | 0.090 | 29.0 | 11.827 | 5.762 |
| **Panel B: Sole proprietors** | | | | | |
| Year | Excess bunching | SE | Lower bound | Upper bound of Excess bunching | SE |
| 1986-1987 | 0.722 | 0.249 | 29.0 | 13.862 | 7.586 |
| 1989-1991 | 1.981 | 0.541 | 27.5 | 17.163 | 5.573 |
| 1992-1994 | 1.900 | 0.486 | 27.5 | 15.603 | 6.163 |
| 1997-1999 | 1.895 | 0.544 | 27.5 | 16.553 | 5.928 |
| 2004-2006 | 0.675 | 0.250 | 29.0 | 13.818 | 7.814 |

Note: (i) SE refers to standard error. (ii) Upper bound and Lower bound refers to upper and lower bounds of the excess bunching window, respectively. (iii) Excess bunching corresponds to the estimates of equation (6), and Upper bound of Excess bunching corresponds to the estimates of equation (9).

***Figure 5.*** *Size of Excess Bunching Over Time, Year 1986-2010*




Note: Short-dash lines refer to years of VAT reforms, and dotted lines refer to years of base period of the VAT introduction.

### 5.3 Numerical Estimation

Third, we conduct numerical estimation to obtain the tax elasticity $e$ and the parameter about compliance cost $\theta$ from the equations (1), (2) and (3). From the data, we can observe the values of $\alpha,\ t^A,\ t^B,\ t^C,\ t^B_{1992},\ t^C_{1992},\ t^D,\ t^E$. From the bunching estimation in the previous subsection, we obtain the estimates of $\Delta y^*/y^* = 55.0\%$, $\Delta y^*_{1992}/y^* = 54.3\%$ and $\Delta y^*_{1997}/y^* = 54.2\%$, with standard errors 0.13, 0.15, and 0.14 respectively[14]. With these values, we become capable of numerically estimating tax elasticity and compliance costs: $e,\ \theta$ using equations (1) and (2), and (2) and (3). The result is summarized in Table 5.

Panel A in Table 5 exhibits the estimation result when input-cost share $\alpha = 0.65$[15]. The first and second column shows the estimates of elasticity $e$ and compliance costs $\theta$ obtained from solving simultaneous equations (1) and (2), which corresponds to before and after the 1992 reform. The third and fourth column shows the estimates obtained from solving (2) and (3), which corresponds to the regime before and after the 1997 reform. In the both

[14] We have checked theoretical moving directions of the bunching size for each tax reform (table omitted), and confirmed that empirical moving directions of the bunching size is consistent with theoretical ones.

[15] According to the survey conducted by National Tax Agency of Japan in 2010, the input cost share of Japanese enterprises is approximately 65%.

1992 and 1997 reform, we observe similar estimates of elasticity and compliance costs. The obtained values of $e$ and $\theta$ fall around 0.03 and 0.13, respectively. Note that the values are rather stable against the change of input-cost share $\alpha$ (Table omitted). Since the VAT rate in Japan at this period was 0.03 to 0.05, the compliance cost estimates are more than three times larger than the tax elasticity estimates. This compliance cost size indicates that the VAT compliance cost in Japan is relatively higher than the tax burden. For example, if we suppose an enterprise produces 30 million JPY taxable sales and its input-cost share is 0.65, then its compliance costs are: Value Added $\times$ 0.13 = 30 $\times$ (1 $-$ 0.65) $\times$ 0.13 = 1.365 million JPY. Although this value is considered to be relatively excessive, it is considered to be reasonable if we include the fixed costs required for businesses that have never faced VAT compliance.

We proceed the same operation in the case which we split the sample with organization type: firms and sole proprietor. The results are provided in Panel B and C in Table 5. Panel B shows the estimates of elasticity $e$ and compliance costs $\theta$ for firms, and Panel C shows those for sole proprietor. On average, we observe that compliance costs are higher for sole proprietor than firms in both 1992 and 1997 reform. In contrast, the estimates of elasticity are higher for firms than sole proprietor, though they are statistically insignificant. The larger size of compliance costs (relative to value added) of entrepreneurs than firms would be explained by the fact that they have a smaller number of workers than firms on average. Likewise in Panel A, we confirm that the values are rather stable against the change of input-cost share $\alpha$ (Table omitted).

When we set $\theta = 0$ and estimate the model, we obtained the estimates of tax elasticity as 7.524, 4.880, and 1.408 for each tax regime as shown in Table A3, which is substantially larger than the estimates with compliance costs parameter. This finding supports our earlier argument that the enterprise's responses are coming mainly from compliance costs. These are novel findings for estimating tax elasticity and compliance costs with Japanese data.

## 6 Conclusion

Until now, there has been only limited evidence to uncover the underlying mechanisms on how enterprises react to size-dependent tax regulations. We build on the theoretical model of Harju et al. (2019) and extend it to incorporate various tax reforms that are universally applicable. Then, by using a panel of Japanese Census of Manufacture covering the period of the VAT introduction and reforms, we provide novel evidence of measuring compliance costs and the effects of tax rates in Japan. Our main findings and contributions are as follows: (1) We observed clear bunching below the tax threshold, and (2) estimated the

*Table 5.* *Tax Elasticity and Compliance Costs*

| 1992 reform | | 1997 reform | |
|---|---|---|---|
| Elasticity ($e$) | Compliance Cost ($\theta$) | Elasticity ($e$) | Compliance Cost ($\theta$) |
| **Panel A: All** | | | |
| 0.028 | 0.130 | 0.073 | 0.140 |
| (0.67) | (0.027) | (0.082) | (0.040) |
| **Panel B: Firms** | | | |
| 0.391 | 0.091 | 0.263 | 0.111 |
| (0.264) | (0.036) | (0.229) | (0.055) |
| **Panel C: Sole proprietors** | | | |
| 0.054 | 0.116 | 0.047 | 0.130 |
| (0.164) | (0.018) | (0.096) | (0.037) |

Note: (i) The column of 1992 reform shows the estimates of elasticity and compliance costs calculated from the excess mass in year 1989-1991 and in 1992-1994. (ii) The column of 1997 reform shows those results in year 1992-1994 and in 1997-1999. (iii) The numbers in the parentheses are standard errors. (iv) The input-cost share $\alpha$ is set at 0.65. (v) The values of the elasiticity and compliance costs that did not converge in the estimation were excluded from the results.

excess bunching following the existing literature. (3) We found the bunching estimates are persistently larger for sole proprietors than for firms. (4) With theoretical implications, we estimated tax elasticity and compliance costs, the latter of which is dominant in determining firm responses, in line with the finding of Harju et al. (2019). This paper is the first to estimate excess bunching and compliance costs over time using Japanese data and obtained substantially significant estimates.

The policy implication obtained from this study is that government support for small enterprises should focus on compliance costs rather than the VAT rate/burden. The authorities are encouraged to ease compliance costs while enhancing tax revenue to achieve more efficient tax design, which contributes to both pursuing firm productivity growth and maintaining fiscal sustainability in the long run.

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# A Appendix A: Tables and Figures

***Table A1.*** *Sample Distribution by Establishment Types*

| Year | Single & Same Place | Single & Different Place | Others | Total |
|---|---|---|---|---|
| 1986 | 333,167 | 42,680 | 60,162 | 436,009 |
| 1989 | 315,985 | 42,856 | 62,916 | 421,757 |
| 1992 | 302,103 | 44,255 | 68,754 | 415,112 |
| 1995 | 281,211 | 42,839 | 63,676 | 387,726 |
| 1998 | 268,084 | 44,210 | 61,419 | 373,713 |
| 2001 | 225,599 | 37,664 | 53,004 | 316,267 |
| 2004 | 190,913 | 32,379 | 47,613 | 270,905 |
| 2007 | 176,285 | 32,671 | 49,276 | 258,232 |
| 2010 | 151,337 | 28,233 | 44,833 | 224,403 |
| Total | 6,266,964 | 968,785 | 1,423,289 | 8,659,038 |

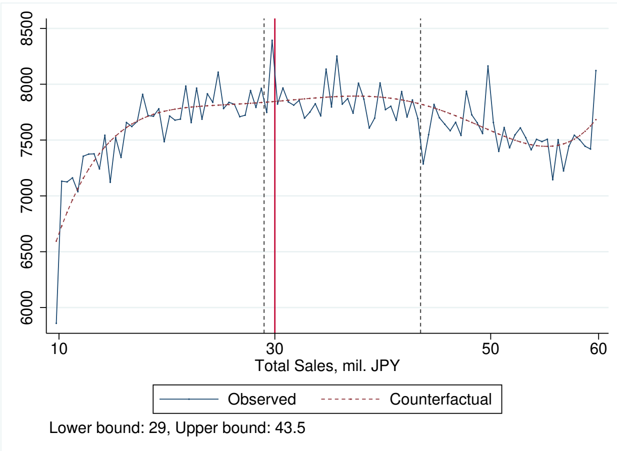
Notes: (i) Single & Same Place refers to "firms which have single manufacturing plant and their plant is locating at the same place as their headquarters." Single & Different Place refers to "firms which have single manufacturing plant and their plant is locating at different place as their headquarters." (ii) The table only list the numbers every three years starting 1986, and skip listing them in years between.
Source: Census of Manufacture (1986 - 2010), the Ministry of Economy, Trade and Industry (METI)

***Table A2.*** *Sample Distribution by Industry Classifications*

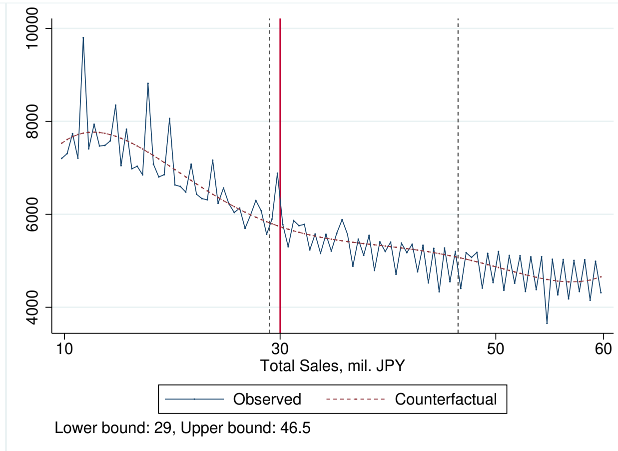
| Industry Classification Name | Total |
|---|---|
| Manufacture of Food | 735,775 |
| Manufacture of Beverages, Tobacco and Feed | 93,452 |
| Manufacture of Textile Products | 801,803 |
| Manufacture of Lumber and Wood Products, Except Furniture | 280,139 |
| Manufacture of Furniture and Fixtures | 268,705 |
| Manufacture of Pulp, Paper and Paper Products | 163,179 |
| Printing and Allied Industries | 269,842 |
| Manufacture of Chemical and Allied Products | 49,122 |
| Manufacture of Petroleum and Coal Products | 6,713 |
| Manufacture of Plastic Products, Except Otherwise Classified | 301,165 |
| Manufacture of Rubber Products | 79,599 |
| Manufacture of Leather Tanning, Leather Products and Fur Skins | 84,648 |
| Manufacture of Ceramic, Stone and Clay Products | 267,547 |
| Manufacture of Iron and Steel | 81,373 |
| Manufacture of Non-Ferrous Metals and Products | 57,077 |
| Manufacture of Fabricated Metal Products | 775,070 |
| Manufacture of General-Purpose Machinery | 391,147 |
| Manufacture of Production Machinery | 297,025 |
| Manufacture of Business Oriented Machinery | 110,923 |
| Electronic Parts, Devices and Electronic Circuits | 69,897 |
| Manufacture of Electrical Machinery, Equipment and Supplies | 330,345 |
| Manufacture of Information and Communication Electronics Equipment | 34,291 |
| Manufacture of Transportation Equipment | 222,563 |
| Miscellaneous Manufacturing Industries | 269,550 |
| Total | 6,249,981 |

Notes: Total sample size does not correspond to total sum of sample in each industry since some industries are reclassified to non-manufacturing sectors. Also, total sample is decreased from original total observations because some establishments did not respond. Source: Census of Manufacture (1986 - 2010), the Ministry of Economy, Trade and Industry (METI)

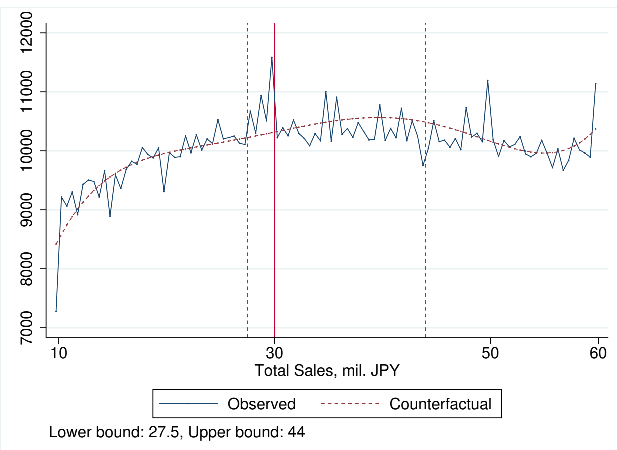
***Figure A1.*** *Size of the bunching for Firms/sole proprietors*



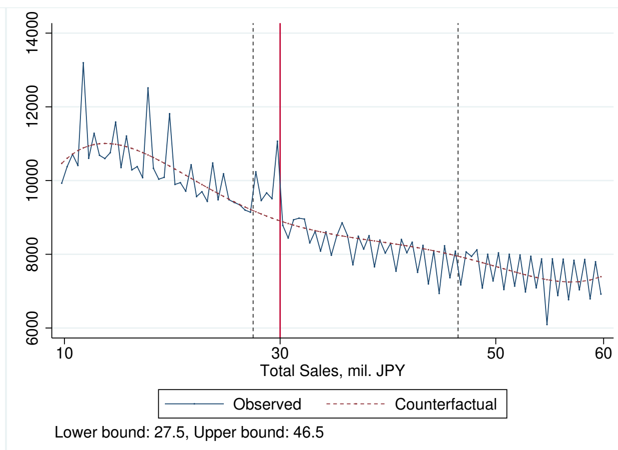

(a) Firms, Year: 1986 - 1987



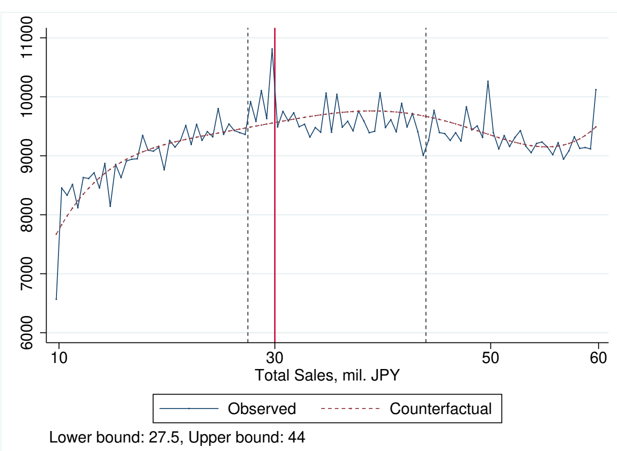

(b) sole proprietors, Year: 1986 - 1987



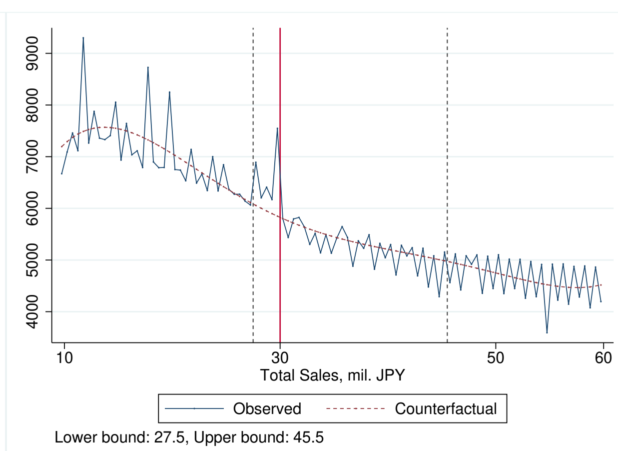

(c) Firms, Year: 1989 - 1991




(d) sole proprietors, Year: 1989 - 1991



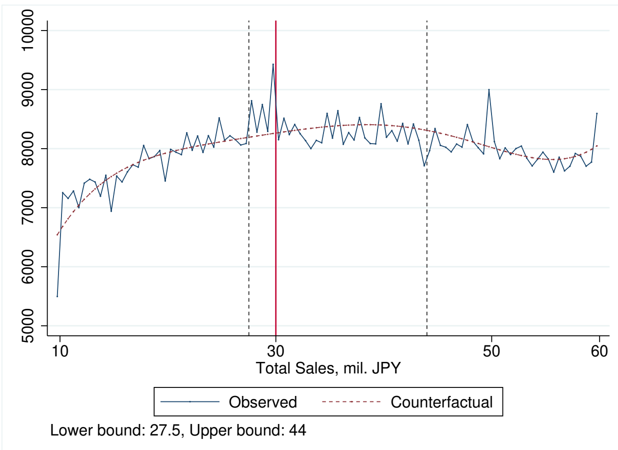

(e) Firms, Year: 1992 - 1994



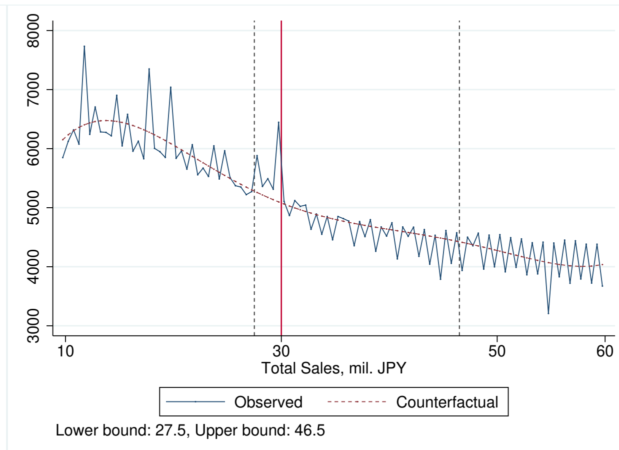

(f) sole proprietors, Year: 1992 - 1994

Note: We dealt with round number bunching in our estimation procedures but it are not presented here.

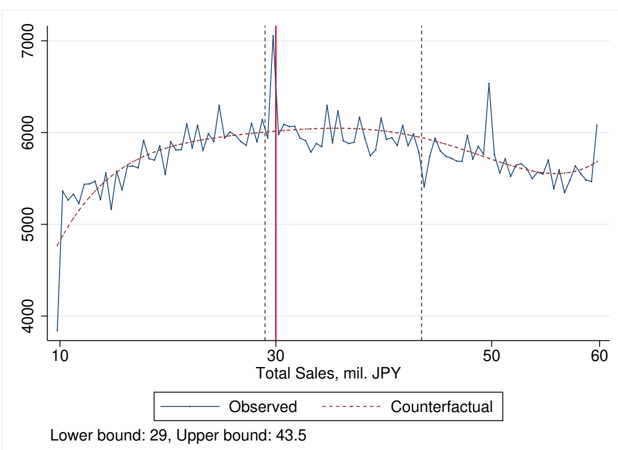
***Figure A2.*** *Size of the bunching for Firms/sole proprietors, Cont'd*



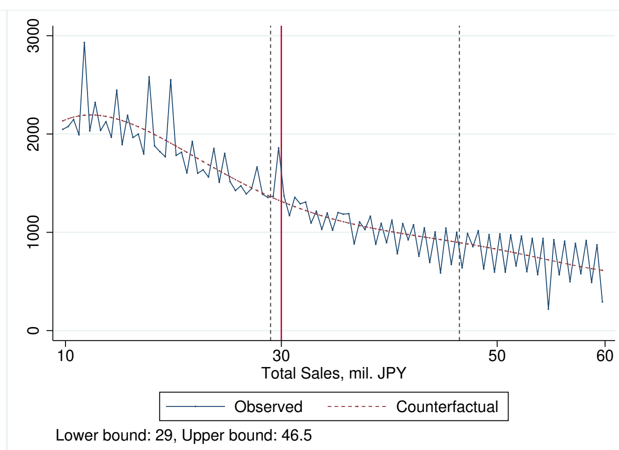

(a) Firms, Year: 1997 - 1999




(b) sole proprietors, Year: 1997 - 1999




(c) Firms, Year: 2004 - 2006




(d) sole proprietors, Year: 2004 - 2006

Note: We dealt with round number bunching in our estimation procedures but it are not presented here.

***Table A3.*** *Tax Elasticity: When Compliance Costs are Set at Zero*

| Tax Regime | Elasticity ($e$) | Standard Errors |
|---|---|---|
| Regime 1: 1989 - 1991 | 7.524 | 1.827 |
| Regime 2: 1992 - 1994 | 4.880 | 1.476 |
| Regime 3: 1997 - 1999 | 1.408 | 0.544 |

Note: The column of Elasticity shows the estimates of elasticity when we set compliance costs are equal to zero.

# B The derivation of owner's objective function under the marginal deduction system

For above the threshold (i.e., $y > y^*$), the objective function of firm owner is:

$$\pi(y) = (1-\alpha)y - \frac{y-y^*}{\bar{y}-y^*}\left(\frac{t}{1+t}y - t\alpha y\right) - t\alpha y - \theta(1-\alpha)y - \phi(y)$$

where $t$ as VAT rate, and $\bar{y}$ is upper bound of the marginal deduction formula which we discussed in section 2.1. Here, we define $T(y) \equiv \frac{y-y^*}{\bar{y}-y^*}\left(\frac{t}{1+t}y - t\alpha y\right) + t\alpha y$, and we have

$$\begin{aligned}
T(y) &= \frac{y-y^*}{\bar{y}-y^*}\left(\frac{t}{1+t}y - t\alpha y\right) + t\alpha y \\
&= \frac{1}{\bar{y}-y^*}\left[\frac{t}{1+t} - t\alpha\right]y^2 + \left[\frac{-y^*}{\bar{y}-y^*}\left(\frac{t}{1+t} - t\alpha\right) + t\alpha\right]y \\
&= \frac{1}{\bar{y}-y^*}\left(\frac{t}{1+t} - t\alpha\right)y^2 + \left(-\frac{y^*}{\bar{y}-y^*}\frac{t}{1+t} + \frac{\bar{y}}{\bar{y}-y^*}t\alpha\right)y.
\end{aligned}$$

Then, $T(y)$ gets first-order Taylor approximated around $y = y^*$

$$\begin{aligned}
T(y) &\approx T(y^*) + T'(y^*) \times (y - y^*) \\
&= T'(y^*) \times y + [-T'(y^*) \times y^* + T(y^*)] \\
&= \left(\frac{y^*}{\bar{y}-y^*}\frac{t}{1+t} + \frac{\bar{y}-2y^*}{\bar{y}-y^*}t\alpha\right) \times y + \frac{(y^*)^2}{\bar{y}-y^*}\left(-\frac{t}{1+t} + t\alpha\right).
\end{aligned}$$

Substituting $T(y,\alpha)$ into $\pi(y)$ yields, we get

$$\begin{aligned}
\pi(y) &\approx (1-\alpha)y - T(y) - \theta(1-\alpha)y - \phi(y) \\
&= (1-\alpha)y - \left(\frac{y^*}{\bar{y}-y^*}\frac{t}{1+t} + \frac{\bar{y}-2y^*}{\bar{y}-y^*}t\alpha\right) \times y - \frac{(y^*)^2}{\bar{y}-y^*}\left(-\frac{t}{1+t} + t\alpha\right) - \theta(1-\alpha)y - \phi(y) \\
&= (1-\alpha)y\left[1 - \frac{1}{1-\alpha}\left(\frac{y^*}{\bar{y}-y^*}\frac{t}{1+t} + \frac{\bar{y}-2y^*}{\bar{y}-y^*}t\alpha\right) - \theta\right] - \frac{(y^*)^2}{\bar{y}-y^*}\left(-\frac{t}{1+t} + t\alpha\right) - \phi(y) \\
&= (1-\alpha)y\left(1 - t^B - \theta\right) - \frac{(y^*)^2}{\bar{y}-y^*}\left(-\frac{t}{1+t} + t\alpha\right) - \phi(y).
\end{aligned}$$

where $t^B = \frac{1}{1-\alpha}\left(\frac{y^*}{\bar{y}-y^*}\frac{t}{1+t} + \frac{\bar{y}-2y^*}{\bar{y}-y^*}t\alpha\right)$.