

# VAT Notches, Voluntary Registration, and Bunching: Theory and UK Evidence\*

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## Abstract

We develop a conceptual framework that allows simultaneously for (i) bunching at the VAT registration threshold, and (ii) voluntary registration by some firms below the threshold. The framework predicts that higher intermediate input shares, lower product-market competition and a lower share of business to consumer sales (B2C) lead to voluntary registration. The predictions are exactly the opposite for bunching. We test the theory using linked administrative VAT and corporation tax records in the UK from 2004-2009, finding empirical support for the model's predictions. We also find suggestive evidence that bunching is due to sales underreporting, rather than real output responses.

**Keywords:** Value-Added Tax (VAT), Voluntary Registration, Bunching

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# 1 Introduction

Most countries around the world use the value-added tax (VAT) as their primary indirect tax. It is standard to set a minimum registration threshold, usually based on turnover, below which businesses do not need to register for VAT. In the EU, all but two countries (Spain and Sweden) currently have positive thresholds, with the UK threshold being the highest at £81,000 (\$105,000).<sup>1</sup> As VAT rates are often quite high (in excess of 20% in many EU countries), this may create a large and salient tax notch for businesses whose turnover is around the threshold, depending on firm characteristics as we explain below.<sup>2</sup> The effects of these VAT notches on firm behavior have received little attention in the existing literature.

In this paper, we study the behavior of firms around the VAT registration threshold theoretically and also empirically, using administrative data on UK corporations. We begin by documenting two stylized facts. First, we find strong evidence that some firms bunch below the registration threshold by restricting their reported turnover to avoid having to register for the VAT.<sup>3</sup> Second, we observe that 44% of the firms with turnover below the threshold were registered for VAT in the period that we study, 2004-2009. This is noteworthy because voluntary payment of any tax by businesses, when it is explicitly optional, is uncommon.<sup>4</sup>

How can we explain the coexistence of voluntary VAT registration and bunching at the threshold? Our first observation is that for both behaviors to occur simultaneously within a given sector, firms in that sector must make *both* sales to final consumers (B2C sales) and sales to other VAT-registered businesses (B2B sales). Moreover, these firms must themselves use intermediate inputs in production. To see this, suppose that firms make only B2C sales. Then, it is easily shown that irrespective of the degree of competition between firms, the cost of voluntarily registering exceeds the benefit, because the burden of VAT paid on output when registered exceeds the burden of VAT paid on inputs when not registered.<sup>5</sup> Conversely, with

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<sup>1</sup>The thresholds in the EU are generally low compared with those in countries that have more recently introduced a VAT, such as Singapore, which currently has a threshold of about 540,000 Euro (<http://www.vatlive.com>).

<sup>2</sup>A notch arises when the tax liability changes discontinuously.

<sup>3</sup>Bunching is generally inefficient for two reasons. First, it might artificially reduce some firms' size and growth. Moreover, unregistered firms face so-called embedded VAT on inputs they acquire from VAT-registered firms, which distorts their input choices and may cascade through the production chain (Ebrill et al., 2001).

<sup>4</sup>Of course, this behavior may be due to the fact that, in a VAT system, firms play the role of fiscal intermediaries. As such, they do not necessarily bear the burden of the tax which they must legally remit to the government.

<sup>5</sup>This is proved very generally in Appendix A below.

only B2B sales, voluntary registration is always weakly optimal, absent compliance costs, because the burden of output VAT can be passed on to the buyer. However, it is only strictly optimal if the firm uses inputs on which it can then claim back input VAT.

It follows that the most parsimonious model that can explain both voluntary registration and bunching must have three stages of production, because the small firms must sell some of their output to other VAT-registered firms and buy inputs that bear VAT. This implies that the two best-known models of VAT thresholds, [Keen and Mintz \(2004\)](#) and [de Paula and Scheinkman \(2010\)](#), are not suitable for our purposes because both these models only have two stages of production. Indeed, as explained in more detail in [Section 4](#), neither of these models can explain the coexistence of voluntary registration and bunching.

Therefore, the first contribution of this paper is to develop a simple general equilibrium model with three stages of production, where we can explain both these phenomena in a unified way. In this setting, we show the following. First, under some assumptions, the effect of the VAT system on the registration decision can be captured by a *VAT sufficient statistic*, which combines the effects of both input and output VAT. We then show that voluntary registration by a firm is more likely when either (i) the cost of inputs relative to sales is high, or (ii) when the proportion of B2C sales by the firm is low.<sup>6</sup> The intuition for (ii) is simply that if most customers are VAT-registered, the burden of an increase in VAT can easily be passed on in the form of a higher price, because the customer itself can claim back the increase. The intuition for (i) is that when input costs are important, registration allows the firm to claim back a considerable amount of input VAT.

Second, we show that the determinants of bunching at the registration threshold are the same as for voluntary registration, with the signs of the effects reversed. Specifically, bunching is more likely when (i) the cost of inputs relative to sales is low, or (ii) when the proportion of B2C sales is high.

Third, we study the effect of product market competition on voluntary registration and bunching. A mix of analytical and numerical results show that as markets become more competitive, voluntary registration becomes less attractive, and bunching increases. The

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<sup>6</sup>Both these characteristics clearly differ widely across small firms that are close to the registration threshold. For example, a small tradesperson such as a plumber or electrician may typically have mostly B2C sales of his services to householders, and make relatively light use of intermediate inputs. So, they would face a low effective VAT rate when not registered, but a high rate when registered. Conversely, a small specialist engineering firm, such as a car component firm, may make mostly B2B sales with heavy use of intermediate inputs, and so will be in the reverse position.

intuition is simple; in a more competitive market, it is more difficult to pass on the burden of output VAT.

Finally, note that extending the model to allow for evasion responses does not affect any of our qualitative predictions. We discuss this extended model in the online appendix.

We test the main predictions of our model using an administrative data-set created by linking the population of VAT and corporation tax records in the UK for the period 2004-2009. One advantage of studying the UK's VAT system is that businesses below the registration threshold are not subject to any other tax to replace the VAT, as is the case in other countries.<sup>7</sup> We first show that the pattern of voluntary registration in the data is consistent with the theory. In particular, voluntary registration is more likely with a low share of B2C sales, a high share of input costs, or when the industry is less competitive. Quantitatively, the probability that a firm voluntarily registers for VAT is increased by 1.1 percentage points for a one-standard deviation (s.d.) decrease in the share of B2C sales, by 0.7 percentage points for a one-s.d. increase in the input-cost ratio, and by 1.6 percentage points for a one-s.d. decrease in the Lerner index of competition. The results are robust to use of either a linear probability model or fixed-effects logit model, and to the inclusion of additional firm-level control variables such as the distance to the VAT threshold.

We then look at bunching. In the aggregate, there is clear evidence of bunching at the VAT threshold. Investigating further, we find that firms are more likely to bunch when (i) the proportion of B2C sales is low, (ii) the cost of inputs relative to sales is high, or (iii) when the Lerner index of their industry is low. So, there is a clear pattern of heterogeneity in bunching that is consistent with the theoretical predictions.

We further investigate some of the mechanisms underlying the registration decision.<sup>8</sup> There is some suggestive evidence that part of the bunching response is driven by evasion, in the form of under-reporting of sales. Specifically, we find that the average input cost ratio moves in parallel between the registered and non-registered firms outside the bunching region but starts to increase substantially for the non-registered companies just below the threshold.<sup>9</sup> We also analyze changes in registration status in a dynamic regression setting. Specifically, we address the possibility that voluntary registration may not be an optimizing

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<sup>7</sup>These businesses may still be liable for corporation tax (if they are incorporated) or income tax (if they are self-proprietorships or other kinds of businesses).

<sup>8</sup>The empirical results discussed in this paragraph are reported in online appendices C and D.

<sup>9</sup>The details of this exercise are reported on online appendix B.

choice of firms, but simply a failure to deregister due to inertia (or high deregistration costs) when sales fall below the threshold. Our empirical findings suggest that, while there is a considerable amount of persistence in firm behavior, the decision is not entirely driven by inertia. Indeed, firms change their registration decisions in a way that is consistent with profit-maximizing behavior.

The rest of the paper proceeds as follows. The next section reviews related literature. Section 3 develops the conceptual framework to analyze VAT bunching and voluntary registration. Section 4 derives the main empirical predictions. Section 5 provides an overview of the VAT system in the UK and describes the data. Sections 6.1 and 6.2 present the empirical analysis for voluntary registration and bunching, respectively. Finally, Section 7 concludes.

## 2 Related Literature

This paper contributes to several strands of literature. First, our work relates to the literature on the effect of tax and regulatory thresholds, and in particular, the effect of VAT thresholds on small business behavior. In an important paper, [Keen and Mintz \(2004\)](#) were the first to set up a model of VAT including a threshold, and they show that there will be bunching below the threshold. However, there are a number of differences between their approach and ours. First, their model only allows for final consumer sales (B2C sales), which cannot by itself explain voluntary registration, as argued above. Second, their main focus is on the optimal registration threshold, whereas our focus is on the coexistence and determinants of voluntary registration and bunching. [Kanbur and Keen \(2014\)](#) extend the [Keen and Mintz \(2004\)](#) framework to allow for VAT evasion and avoidance. A simplified version of our model without B2B is closely-related to the framework in [Keen and Mintz \(2004\)](#), as explained in more detail in Section 3.1 below. In a related paper, [Brashares et al. \(2014\)](#) use a calibrated formula from [Keen and Mintz \(2004\)](#) to infer that for a 10 percent VAT rate, the optimal level for the threshold in the United States is \$200,000.

Second, there is a related literature on the relationship between the VAT and business informality in developing countries ([Emran and Stiglitz, 2005](#); [de Paula and Scheinkman, 2010](#)). In particular, [de Paula and Scheinkman \(2010\)](#) present a model where firms can choose between formal and informal production, where the distinction is whether they must register for VAT. Firms can also choose to buy inputs from formal or informal suppliers. In

their model, informality can be interpreted as producing below a VAT threshold. Moreover, because they model two stages in the chain of production (upstream and downstream firms), they allow for both B2C and B2B sales. Nevertheless, their model is not really suited to our task because voluntary registration cannot occur in equilibrium, as there are only two stages of production. The formal argument for this is further discussed in Section 3.1 and in the online appendix.

Third, there is a small empirical literature on the effects of VAT registration thresholds in different countries. Onji (2009) documents the effects of the introduction of a VAT threshold in Japan, focusing on the incentives for a large firm to split in order to stay below the threshold. More recent papers, appearing after the first version of this paper was completed, document bunching of small firms at the VAT registration threshold in Finland (Harju et al., 2016), as well as lack of bunching in response to the VAT threshold in Armenia (Asatryan and Peichl, 2016).<sup>10</sup> In particular, Harju et al. (2016) provide strong evidence of bunching below the VAT threshold in Finland, and argue that compliance costs are the main driver.<sup>11</sup> However, neither of these papers studies the determinants of voluntary registration in detail, nor do they develop a theoretical framework specific to the VAT.<sup>12</sup>

More broadly, there are a few recent papers on the effects of other kinds of thresholds. Almunia and Lopez-Rodriguez (2017) find strong bunching at a large taxpayers unit (LTU) threshold in Spain, where firms with turnover above €6 million (\$ 6.9 million) face increased tax enforcement. They show that bunching is more pronounced in sectors with a *lower* fraction of B2C sales, which is the opposite of what we find. Their explanation is that, since B2C sales generate less paper trail than B2B sales, firms trying to evade taxes by misreporting B2B sales are more likely to be detected when they are above the LTU threshold. Notice

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<sup>10</sup>The first version of the current study was first published as a working paper form in 2015 (Liu and Lockwood, 2015).

<sup>11</sup>There are several reasons that compliance costs may be more important in Finland than for our study. First, the VAT threshold in Finland is very low, at €8,500 (\$ 9,800), compared to well over \$ 100,000 in the UK over our study period. Other things equal, larger firms find compliance less costly. Second, in the UK, all active companies are required to file company accounts and corporation tax returns, so they already have the information required for the VAT return, and the VAT return itself is short and simple.

<sup>12</sup>Harju et al. (2016) present formulae for the reduced-form elasticity implied by observed bunching which are taken directly from Kleven and Waseem (2013). However, these formulae are originally developed for a labour supply model, and are not directly applicable to the VAT due to the influence of input costs on the incentives for registration. In an earlier version of our paper, (Liu and Lockwood, 2015), we show that to apply the Kleven-Waseem formulae directly, one has to assume that all sales are B2C, firms are price-takers, and the production function is fixed-coefficients. Moreover, the elasticity estimated is an output supply elasticity, taking the price of output as given, not the elasticity of the tax base, because the latter will also be determined by the elasticity of demand.

that, in the Spanish setting, firms on either side of the threshold are equally liable for VAT, so the incentives we focus on are not relevant. The contrast between our results and those of [Almunia and Lopez-Rodriguez \(2017\)](#) indicates that the purpose of the turnover threshold, i.e. whether it relates to a change in tax liability (as in our case) or in enforcement intensity (as in theirs) is key to understand firms' behavioral responses.<sup>13</sup>

Our work also relates to the broader literature on tax notches ([Slemrod, 2010](#); [Kleven and Waseem, 2013](#); [Best and Kleven, 2013](#); [Kopczuk and Munroe, 2015](#); [Kleven, 2016](#)). As shown below, the “bunching equation” in this paper, which relates the amount of bunching to the elasticity of the tax base and parameters of the tax system, is mathematically very similar to the equation of ([Kleven and Waseem, 2013](#)). However, for reasons discussed below, it is much more difficult to back out credible elasticity estimates in the VAT case, and so we do not attempt this in the paper.

### 3 Conceptual Framework

**Key Features of the Model.** We aim to model the behavior of “small” firms selling to both final consumers and to businesses, where both voluntary registration and bunching can be equilibrium outcomes. As already explained in the introduction, the coexistence of these two behaviors requires that the “small” firms make *both* B2B and B2C sales, and that they buy produced inputs. So, as already remarked, the model must have (at least) three stages of production.<sup>14</sup>

Second, we wish to study the effect of the input cost ratio, share of B2C sales, and the level of industry competition on voluntary registration and bunching, so the model must incorporate parameters measuring these.

We construct the simplest general equilibrium model that has the required features. There is a single representative consumer that supplies labour and buys two kinds of goods; a differentiated good sold by the small firms, and a single good produced by a large downstream

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<sup>13</sup>It may be argued that being registered for VAT increases the probability of audit. However, in our setting, this effect may be attenuated by the fact that all firms, VAT-registered or not, are also companies and thus file a corporate tax return.

<sup>14</sup>Suppose that firms make only B2C sales. Then, it is easily shown that irrespective of the degree of competition between firms, the cost of voluntarily registering exceeds the benefit, because the burden of VAT paid on output when registered exceeds the burden of VAT paid on inputs when not registered. Conversely, with only B2B sales, the voluntary registration is always optimal, because the burden of output VAT can be passed on to the buyer. Both these points are made formally below.

firm. The large firm also buys inputs from the small firms, generating a B2B demand. We assume that the large firm is operating at a scale where non-registration for VAT (i.e. operating so that the value of sales are below the VAT threshold) is never profitable. Finally, a homogeneous input to the small firm is produced by a third sector of upstream competitive firms from a labour input via a constant returns technology. The behavior of this last sector is summarized by a zero-profit condition that says that the price of the small-firm input is equal to the wage. The structure of this economy is illustrated in Figure 1. Note that there are three stages of production.

**Consumers.** There is a representative household that has preferences over the homogeneous good, consumed at level  $Y$ , a set of differentiated goods  $a \in [\underline{a}, \bar{a}]$ , consumed at levels  $x(a)$ ,  $a \in [\underline{a}, \bar{a}]$ , and leisure  $l$ . These preferences are of the following form:

$$U(X) + V(Y) + l, \quad X = \left[ \int_{\underline{a}}^{\bar{a}} (x(a))^{(e_C-1)/e_C} da \right]^{e_C/(e_C-1)}, \quad e_C > 1 \quad (1)$$

where  $X$  is a CES index of differentiated products, and

$$U(X) = \lambda^{1/\phi} \frac{X^{1-1/\phi}}{1-1/\phi}, \quad V(Y) = (1-\lambda)^{1/\gamma} \frac{Y^{1-1/\gamma}}{1-1/\gamma}, \quad \phi > 0, \quad \gamma > 1$$

Here,  $\lambda$  is a measure of the final demand by households for the goods produced by the small firms relative to demand for the good produced by the large downstream firm; as such, it will be the parameter that measures B2C demand in what follows.

Each differentiated good  $a$  is produced by a single small firm  $a$ , which can be either registered for VAT or not. For reasons further discussed below, we also allow the homogeneous good  $Y$  to be subject to VAT or not. For reasons discussed below in Section 3.1, we also allow the firm to price-discriminate between final and intermediate consumers, so let  $p_C(a)$ ,  $p_B(a)$  be the prices charged to final consumers and the large firm respectively for good  $a$ , excluding VAT.

So, the household faces a budget constraint

$$P(1+t)Y + \int_{\underline{a}}^{\bar{a}} [p_C(a)(1+I(a)t)] x(a) da = w(1-l) + \Pi \quad (2)$$

where  $1-l$  is labour supply,  $w$  is the wage,  $P$  is the price of the homogeneous good produced by the large firm, and  $I(a) \in \{0, 1\}$  is an indicator recording whether the firm registers for

VAT or not, with a “1” indicating registration. So, if the firm is registered, the consumer price is grossed up by VAT i.e.  $p(a)(1+t)$ . Finally,  $\Pi$  is aggregate profit, which can be defined formally using (11) below; because utility is linear in leisure, there are no income effects in demand for  $x(a), Y$  and so this term plays no further role.

So, by standard arguments, maximization of (1) subject to (2) gives household demand for the homogeneous and differentiated goods:

$$Y = (1-\lambda)(1+t)^{-\gamma}P^{-\gamma} \quad (3)$$

$$x(a) = \lambda \left( \frac{p_C(a)(1+I(a)t)}{Q} \right)^{-e_C} Q^{-\phi} \quad (4)$$

where  $Q$  is the CES price index corresponding to the quantity index  $X$  i.e.

$$Q = \left[ \int_a^{\bar{a}} (p_C(a)(1+I(a)t))^{1-e_C} da \right]^{1/(1-e_C)} \quad (5)$$

We assume that in equilibrium, positive leisure is consumed, so that from (1), the wage is fixed at the marginal utility of leisure, unity.

**The Large Firm.** The large firm combines inputs  $y(a)$ ,  $a \in [a, \bar{a}]$  bought from the small firms via a constant returns CES production technology to produce output  $Y$ . This production technology is characterized by a CES cost function per unit of output of

$$C = \left[ \int_a^{\bar{a}} (p_B(a))^{1-e_B} da \right]^{1/(1-e_B)}, \quad e_B > 1 \quad (6)$$

where  $p_B(a)$  is the price of the input net of tax (as the large firm is VAT-registered, it can claim back any tax on inputs). So, the large firm chooses  $P$  to maximize  $(1-\lambda)P^{-\gamma}(P-C)$ . This gives the usual mark-up equation for price i.e.

$$P = \frac{\gamma}{\gamma-1}C \quad (7)$$

and thus, combining (7),(3), ultimately, output is

$$Y = (1-\lambda)(1+t)^{-\gamma} \left( \frac{\gamma}{\gamma-1}C \right)^{-\gamma} \quad (8)$$

Finally, input demand for variety  $a$  is, by Shephard's Lemma and (8):

$$y(a) = \frac{\partial C}{\partial p_B(a)} Y = (1 - \lambda)(1 + t)^{-\gamma} \left( \frac{\gamma}{\gamma - 1} \right)^{-\gamma} C^{-\gamma} \left( \frac{p_B(a)}{C} \right)^{-e_B} \quad (9)$$

**The Small Firms.** To keep things simple, we assume, following Keen and Mintz (2004), that the production technology is fixed coefficients, with one unit of output for an  $a$  type firm requiring  $\omega/a$  units of the input, and  $(1 - \omega)/a$  units of labour.<sup>15</sup> The input costs are  $w, r$ , where  $r$  is the cost of the input. By assumption,  $w = 1$ , and we have also assumed, without loss of generality that one unit of the intermediate good requires one unit of labor, so  $r = 1$  also.

Let the unit cost function be denoted  $c(I(a); a)$ , where  $I(a)$  is the variable recording registration status. Then, under the assumptions just stated, the unit cost function is:

$$c(1; a) = \frac{1}{a}, c(0; a) = \frac{1 + \omega t}{a} \quad (10)$$

So, cost of the input is grossed up by the tax  $t$  if the firm is not registered, as the firm cannot claim the input tax back. Note that  $a$  is a measure of productivity, and  $\omega$  is a measure of the firm's use of intermediate inputs relative to labour, independently of productivity.

Suppressing the dependence of  $p_C, p_B, I$  and etc. on  $a$  to lighten notation, the firm's profit is

$$\pi(p_C, p_B, I; a) = (p_C - c(I; a))x + (p_B - c(I; a))y \quad (11)$$

where from (4), (9):

$$x = \lambda A_C (p_C(1 + I.t))^{-e_C}, \quad y = (1 - \lambda) A_B (p_B)^{-e_B} \quad (12)$$

where

$$A_C = Q^{e_C - \phi}, \quad A_B = (1 + t)^{-\gamma} \left( \frac{\gamma}{\gamma - 1} \right)^{-\gamma} C^{e_B - \gamma} \quad (13)$$

are parameters that the small firms take as given, but are determined in equilibrium.

The small firm chooses  $p_C, p_B \in [0, \infty)$ ,  $I \in \{0, 1\}$  to maximize  $\pi(p_C, p_B, I; a)$  subject to the registration constraint, which says that if the firm chooses not to register ( $I = 0$ ),

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<sup>15</sup>All the results below generalize straightforwardly if the small firm production function is assumed a constant returns CES function of labor and the intermediate input.

the value of sales  $s \equiv p_C x + p_B y$  must be less than the VAT sales threshold  $s^*$ . This allows of course, for *voluntary registration*, which is defined by a choice  $I = 1$  when  $s < s^*$ . The costs and benefits of registration are clear from equations (11) and (12). The benefit is that registration,  $I = 1$ , lowers the unit cost of production. The cost is that at a fixed price, registration lowers B2C sales, because demand by the household is reduced by the tax.

**Equilibrium.** An *equilibrium* is (i) a price  $P$  for the homogeneous product given by (7); (ii) for each  $a \in [\underline{a}, \bar{a}]$ , prices  $p_C(a)$ ,  $p_B(a)$  and a registration decision  $I(a)$  that maximises (11) subject to (12) and  $A_C, A_B$  fixed; (iii) demand shifts  $A_C, A_B$  in (13) that are functions of  $p_C(a), p_B(a), I(a)$  via (6) and (5). It should be noted that this describes a general equilibrium for the whole economy. Note that the equilibrium is conditional on fixed values of the share of B2C sales,  $\lambda$ , and the intensity of input use,  $\omega$ , and we will vary these parameters in what follows.

### 3.1 Discussion

Here, we discuss some modelling choices. First, as already remarked, we allow the small firms to price-discriminate between B2C and B2B customers. The reason for this is the following. As long as the elasticities of demand from the household and the large firm are different, i.e.  $e_C \neq e_B$ , the small firm prefers to price discriminate if it can. Moreover, ruling out price discrimination is not very tractable, as the profit-maximising price cannot then be solved for in closed form, unless it is assumed that  $e_C = e_B$ . However, for some results (Proposition 2, parts (c) and (d), Propositions 4-b.1) we do assume  $e_C = e_B$ , so that given this, the assumption of price-discrimination is without loss of generality.

Second, in practice, there are compliance costs to VAT registration. These could be introduced to the model, at the cost of some additional complexity. However, it should be noted that these costs are relatively small for the UK: for example, a recent literature review found that at the registration threshold, these costs were around 1.5% of turnover, declining to 0.1% or less for large companies (Federation of Small Businesses, 2010), and so we do not feel it necessary to include these in our analysis<sup>16</sup>.

Third, it has been argued that the amount of output exported is a determinant of registration, because in practice, exports are exempt from VAT, and so firms exporting more

<sup>16</sup> Also, empirically, there are no major changes in compliance requirements during our sample period.

of their output are more likely to register (Brashares et al., 2014). Our model could be interpreted to cover this case. This is because in the case of exports, the exporter does not bear any of the burden of the output VAT, and so from the supplier’s point of view, domestic B2B sales and exports are equivalent in this respect. So, we could interpret good  $Y$  as being purchased by foreigners, rather than domestic consumers.<sup>17</sup> Finally, in our baseline model, we do not allow for evasion, to avoid overloading the analysis. We introduce evasion in Section B.

Note that when  $\lambda = 1$ , our model is closely related to the Keen-Mintz model. Then, both models have a set of firms of different productivity producing good from labor and an intermediate input that they sell only to final consumers. The main differences are that we have constant returns to scale and monopolistic competition, whereas in their model, firms are perfectly competitive, facing a world producer price for the good, but have decreasing returns to scale. But under both sets of assumptions, the firms bear the burden of output VAT to a point where voluntary registration is not desirable.

Note finally that our model has three stages of production; upstream, an input is produced, which is then sold to the small firms, who produce goods, some of which are then sold as inputs to the downstream large firm. This is no accident; as argued in the introduction, it is clear that *at least three stages are required* to generate voluntary registration in equilibrium. This observation explains why the model of de Paula and Scheinkman (2010), which is elegant in many ways, is not suitable for our investigation, as it only has two stages of production.<sup>18</sup>

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<sup>17</sup>In that case, technically, we would have to replace the term  $1 + t$  in (3) by  $1 + t^*$  where  $t^*$  is the foreign rate of VAT.

<sup>18</sup>It may be asked why we did not develop a theoretical framework by adding a third stage to the de Paula and Scheinkman model. We did not do this, because with this addition, it is not clear that the algebra would be less burdensome than what we have. In particular, although their model is very simple to write down, establishing comparative statics results is surprisingly difficult, as prices are endogenous. In our setting with constant returns production technologies and prices being a constant mark-up on marginal cost, comparative statics results are much more easily established.

## 4 Analysis

### 4.1 Necessary Conditions for Voluntary Registration and Bunching

As already argued above, the coexistence of both voluntary registration and bunching requires that the “small” firms make *both* B2B and B2C sales. This is relatively easy to show formally in our framework<sup>19</sup>.

**Proposition 1** *If all sales are B2C i.e.  $\lambda = 1$ , there is no voluntary registration. If all sales are B2B, i.e.  $\lambda = 0$ , all firms register voluntarily, whatever their turnover, so there can be no bunching. So, to observe both bunching and voluntary registration simultaneously, we require that there are both B2C and B2B sales i.e.  $0 < \lambda < 1$ .*

Proposition 1 is in fact completely general; as shown in the not-for-publication appendix, it does not rely on our technical assumptions such as isoelastic demand or constant marginal cost. For the remainder of the theoretical section of the paper, we thus focus on the general case where  $0 < \lambda < 1$ .

Here, we face a problem; generally,  $A_C, A_B$  depend on equilibrium prices and this considerably complicates the analysis. So, for the remainder of the theoretical Section, we assume that  $e_C = \phi$ ,  $e_B = \gamma$ . This ensures that the demand parameters are exogenous i.e. from (13),  $A_C = 1$ ,  $A_B = (1 + t)^{-e_B} \left( \frac{e_B - 1}{e_B} \right)^{e_B}$ .

### 4.2 Voluntary Registration

We now turn to the registration decision, which is a choice  $I \in \{0, 1\}$ , with the firm then maximizing profit given its registration decision. We begin by defining two crucial cost and demand changes. First, from 10, the percentage increase in the firm’s unit costs due to non-registration, because of input VAT, can be defined independently of firm productivity  $a$  as

$$\Delta_c = \frac{c(0; a)}{c(1; a)} - 1 = \omega t. \quad (14)$$

Call this the *input VAT effect* on cost.

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<sup>19</sup>All proofs are in the Appendix.

Second, if  $e_C = e_B = e$ , we can define a similar kind of *output VAT effect* on demand. Specifically, it is easy to calculate that any fixed price  $p_C = p_B = p$ , the percentage reduction in overall demand for the firm's product due to the charging of output VAT on B2C sales is:<sup>20</sup>

$$\Delta_d = \frac{\lambda(1 - (1+t)^{-e})}{\lambda + (1-\lambda)(1+t)^{-e}\left(\frac{e-1}{e}\right)^e} > 0 \quad (15)$$

This is because when output VAT is charged, at a fixed price  $p$ , all B2C sales (which count for  $\lambda$  of the total) are reduced by a factor  $(1+t)^{-e}$ ; call this the *output VAT effect*. We can then show:

**Proposition 2** (a) *A firm of type a will register voluntarily iff*

$$a^{e_B - e_C} \geq \frac{\lambda B_C}{(1-\lambda)B_B} \frac{(1 + \Delta_c)^{1 - e_C} - (1+t)^{-e_C}}{1 - (1 + \Delta_c)^{1 - e_B}} \quad (16)$$

where  $B_C, B_B$  are exogenous demand shift parameters:

$$B_C = \left(\frac{e_C - 1}{e_C}\right)^{e_C} \frac{1}{e_C - 1}, \quad B_B = (1+t)^{-e_B} \left(\frac{e_B - 1}{e_B}\right)^{2e_B} \frac{1}{e_B - 1} \quad (17)$$

(b) *If the voluntary registration condition (16) holds at  $\lambda, \omega$ , it also holds at  $\omega' \geq \omega$ ,  $\lambda' \leq \lambda$ ; that is, voluntary registration is more likely, the higher the input cost ratio,  $\omega$ , and the lower the share of B2C sales,  $\lambda$ .*

(c) *If  $e_B = e_C = e$ , (16) holds independently of a iff*

$$T = (1 - \Delta_d)(1 + \Delta_c)^{e-1} = \frac{\lambda + (1-\lambda)\left(\frac{e-1}{e}\right)^e}{\lambda(1+t)^e + (1-\lambda)\left(\frac{e-1}{e}\right)^e} (1 + \omega t)^{e-1} \geq 1 \quad (18)$$

The voluntary registration condition is most easily interpreted when it is in the form (18). There, it says that if the input VAT effect on cost due to non-registration,  $\Delta_c$ , is large relative to the output VAT effect,  $\Delta_d$ , there will be voluntary registration. Note also when  $e_C = e_B$ ,  $T$  is a sufficient statistic that captures the entire effect of the VAT system on

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<sup>20</sup>To see this, note that from (12), at any fixed price  $p$ , the ratio of total demand with VAT registration to without is

$$\frac{\lambda(p(1+t))^{-e} + (1-\lambda)A_B p^{-e}}{\lambda p^{-e} + (1-\lambda)A_B p^{-e}} = \frac{\lambda(1+t)^{-e} + (1-\lambda)A_B}{\lambda + (1-\lambda)A_B}$$

Using the fact that  $A_B = (1+t)^{-e} \left(\frac{e-1}{e}\right)^e$ , we see that this expression is equal to  $1 - \Delta_d$ .

voluntary registration. We will see later that it is also a sufficient statistic for the degree of bunching. Note that  $T$  depends on the rate of VAT,  $t$ , and our three key parameters, the share of B2C sales  $\lambda$ , the input cost ratio  $\omega$ , and the elasticity of demand  $e$ .

The intuition for these results is the following. Generally, voluntary registration occurs when output effect  $\Delta_d$  is small, and/or when the input VAT effect  $\Delta_c$  is large. The first observation is that other things equal, the larger  $\lambda$ , the bigger is the output VAT effect  $\Delta_d$ ; this explains the fact that  $T$  falls with  $\lambda$ . Second, other things equal, the larger  $\omega$ , the bigger is the input VAT effect  $\Delta_c$ ; this explains why  $T$  rises with  $\omega$ .

It is also of interest to study how the level of competition, measured by  $e$ , affects voluntary registration. Here, we assume that  $e_B = e_C = e$ . Then, we see from (18) that as  $e$  becomes large, the output VAT effect becomes very strong. Specifically, as  $e \rightarrow \infty$ ,  $1 - \Delta_d$  is proportional to  $1/(1+t)^e$ , which dominates the input effect  $(1+\omega t)^{e-1}$ . Hence, eventually  $T \rightarrow 0$ . In fact, we can prove:<sup>21</sup>

**Proposition 3** *In the competitive limit, as  $e \rightarrow \infty$ , voluntary registration is never optimal.*

The intuition for this result is the following. When the product market becomes very competitive, it becomes hard for a firm to pass on output VAT to the consumer, and so eventually, the change in the overall tax burden tax from registration becomes positive, whatever the input cost ratio  $\omega$ .

To get some further insights on the effect of  $e$  on the sufficient statistic,  $T$ , we report some numerical simulations. The table below shows the value of  $T$  for as  $e$  increases, for different combinations of  $\lambda$  and  $\omega$ .

Table: The Effect of Competition on the Sufficient Statistic  $T$

| e                             | 2     | 5     | 10    | 20    | 50    | 100   |
|-------------------------------|-------|-------|-------|-------|-------|-------|
| $\omega = 0.9, \lambda = 0.1$ | 1.039 | 1.408 | 1.967 | 2.361 | 1.564 | 0.678 |
| $\omega = 0.9, \lambda = 0.9$ | 0.826 | 0.796 | 0.739 | 0.629 | 0.381 | 0.164 |
| $\omega = 0.1, \lambda = 0.1$ | 0.898 | 0.786 | 0.530 | 0.148 | 0.001 | 0.000 |
| $\omega = 0.1, \lambda = 0.9$ | 0.714 | 0.444 | 0.199 | 0.039 | 0.000 | 0.000 |

<sup>21</sup>The proof is simple. From 18 we see that for  $e$  large,  $T$  behaves like  $(\frac{1+\omega t}{1+t})^e$ . But as  $\omega < 1$ , this term goes to zero as  $e \rightarrow \infty$ , and so  $T \rightarrow 0$  as  $e \rightarrow \infty$ .

In the first row, the input cost ratio is very high, and the share of B2C sales is very low. These are the conditions under which we expect voluntary registration ( $T > 1$ ) to occur, and indeed this is the case. Note here that  $T$  is not monotonic in  $e$ ; it first rises and then falls. This non-monotonicity is due to the fact that for low values of  $e$ , the effect of increasing competition on the input VAT component of  $T$  can dominate the effect on the output component of  $T$ . The second row is where both the input cost ratio and the share of B2C sales are very high. Here, these two opposing forces always lead to a  $T$  below 1 that is monotonically decreasing in  $T$ . The same qualitative picture as in the second row also emerges when the input cost ratio is low, for both a low and high B2C ratio.

### 4.3 Bunching

Now consider what happens if  $T < 1$ . In this case, registration leads to a drop in profit for any fixed value of sales. This implies that there must be an interval of firms,  $a \in [a^*, a^* + \Delta a^*]$ , who *bunch* by restricting the value of sales in order to stay at the VAT threshold. As demand is elastic by assumption, i.e.  $e > 1$ , they do this by cutting price to keep sales low. The firm at the bottom of this bunching interval,  $a^*$ , is the one that has a profit-maximising total value of sales of exactly  $s^*$  when not registered.

The firm at the top of the interval,  $a^* + \Delta a^*$  is indifferent between restricting the value of sales to  $s^*$  and not registering, and registering and choosing price and thus sales without any restriction. If  $\pi(I; a)$  denotes optimized profit, conditional on the registration decision  $I \in \{0, 1\}$ , this indifference condition can be written

$$\pi(1; a^* + \Delta a^*) = \pi(0; a^* + \Delta a^*) \quad (19)$$

So, the amount of bunching in the space of firms is measured by  $\Delta a^*$ .

Now, we do not observe  $a$  but we do observe firm sales. Following [Saez \(2010\)](#) and [Kleven and Waseem \(2013\)](#), we reason as follows. First, let  $s^* + \Delta s^*$  be the value of sales of the firm  $a^* + \Delta a^*$ , assuming that this firm does not have to register for VAT. So,  $\Delta s^*$  is the difference in sales between the VAT threshold and what the value of sales for the firm at the top of the bunching interval,  $a^* + \Delta a^*$ , *would have been* had it been unconstrained by the threshold.

So, following [Saez \(2010\)](#), the fraction of firms bunching,  $B$ , in the space of sales is given by

$$B = \int_{s^*}^{s^* + \Delta s^*} h(s) ds \quad (20)$$

where  $h(s)$  is the distribution of firms in the space of sales, assuming that firms do not have to register. Moreover, because each variety  $a$  is produced by a single firm, the distribution of firms on the space of varieties is uniform on  $[0, 1]$ , and so  $h(s) = 1/\bar{s}$ , where  $\bar{s}$  is the sales of the highest-productivity firm,  $a = 1$ . So, from (20), we see  $B = \frac{\Delta s^*}{\bar{s}}$ .

As  $B$  is empirically observable, this means that our empirical predictions need to be about the determinants of  $\Delta s^*$ . In the Appendix, assuming  $e_C = e_B = e$ , we can show:

**Proposition 4** *The amount of bunching at the VAT threshold  $\Delta s^*$  is given by the implicit relationship*

$$\frac{e}{(1 + \Delta s^*/s^*)} - (e - 1) \left[ \frac{1}{1 + \Delta s^*/s^*} \right]^{e/(e-1)} - T = 0 \quad (21)$$

where  $T < 1$  is the VAT sufficient statistic.

Note that the entire effect of VAT on bunching is captured by the sufficient statistic  $T$ . Note also that  $T < 1$ , because otherwise there would be voluntary registration. We can now use (21) to look at some of the determinants of bunching. We have:

**Proposition 5** *The amount of bunching  $\Delta s^*$  rises (i) as the fraction of B2C sales,  $\lambda$ , increases, and (ii) as the share of inputs in total cost,  $\omega$ , falls. Moreover, if the sufficient statistic  $T$  is decreasing in  $e$ , the amount of bunching  $\Delta s^*$  increases as  $e$  rises.*

The intuition for (i) and (ii) is very similar to the case of voluntary registration. That is, factors that make voluntary registration less attractive also provide incentives for staying under the VAT threshold by bunching. Specifically, this will be the case when most customers are not VAT-registered, so that the burden of an increase VAT can not easily be passed on to the buyer, and/or when input costs are relatively unimportant relative to labour costs. We will bring these predictions to the data below.

Finally, increased competition increases bunching as long as  $T$  is decreasing in  $e$ . While we cannot establish analytically that  $T$  is decreasing in  $e$ , the simulation results reported above

indicate this is the case for a wide range of parameter values. The intuition here is again related to the intuition with voluntary registration; increased product market competition makes it harder for a firm to pass on output market VAT and thus increases the incentive to bunch.

## 4.4 Evasion

VAT in the UK has been susceptible to fraud and avoidance, as in many other countries. According to HMRC estimates, the VAT tax gap, which is defined as the difference between theoretical VAT liabilities and total VAT receipts on a timely basis, is currently around 10% of theoretical VAT liability (HM Revenue and Customs, 2015). Some of this gap can be accounted for by VAT debt owed by firms, and by sophisticated fraud schemes, but most of the VAT gap is probably due to sales under-reporting and cost over-reporting.<sup>22</sup>

In online appendix B, we model the simplest and most common form of VAT evasion, under-reporting of sales. This has two aspects. First, as is widely recognized, a non-registered firm can hide sales, for example by using cash transactions. However, it is also the case that registered sellers can use this strategy, albeit at a higher cost of detection. We model both these evasion strategies.

With evasion, it turns out that the qualitative effects of  $\lambda$ ,  $\omega$ , and  $e$  on  $T$  do not change, and so our predictions about the determinants of voluntary registration and bunching do not change. Therefore, our key empirical predictions are robust to the presence of evasion.

However, as already mentioned in Section 1, we do not measure evasion directly. Nor do we have any obvious way of decomposing the total bunching effect into an evasion response and a real response, although this can be done plausibly for business taxes in some other countries, using special features of national tax systems.<sup>23</sup> Our empirical strategy therefore focuses primarily on identifying the effects of changes in the B2C ratio, input-cost ratio and level of competition as predicted by the theory, without taking a view on how much of this

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<sup>22</sup>For example, HM Revenue and Customs (2015) estimates that the total VAT gap in 2014-14 was 13.1 billion. Of this, at most £1.0 billion is due to Missing Trader Intra-Community fraud, £1.2 billion is VAT debt, and finally £0.2 billion due to VAT avoidance. This means that over 80% of the gap is due to other factors.

<sup>23</sup>For example, Best et al. (2015) use a minimum tax scheme for corporations in Pakistan which has a kink point where the real incentive for bunching is small, but the evasion incentive is large, and they find large bunching around the minimum tax kink. Waseem (2016), again for Pakistan, shows very large responses when reforms cut the rate of income tax to zero for the self-employed, which he interprets as being largely an evasion response.

effect works through evasion. However, in online appendix C, we do present some suggestive evidence that firms under-report turnover to stay below the threshold.

## 4.5 The Elasticity of the Tax Base

Note that (21) is closely related to the Kleven and Waseem (2013) formula relating bunching at a notch of the personal income tax schedule to the elasticity of the labor supply.<sup>24</sup> In the context of the personal income tax, Kleven and Waseem (2013) use (21) in a reverse way to us, to make inferences about the elasticity of taxable income, given an estimate of bunching from the data. The question then arises as to whether we can use (21) in the same way. It is possible to show that the value-added of a registered small firm i.e. the base of the VAT for that firm is proportional to  $(1 + t)^{-e}$ , so the elasticity of the tax base with respect to  $1 + t$  is  $e$  (see online appendix A). So, there is some interest in trying to recover  $e$  from (21). However, there are two complications here.

First, unlike the personal income tax case, VAT sufficient statistic  $T$  does not depend just on the tax code. In particular, also depends on model parameters, for example,  $e$ ,  $\lambda$  and  $\omega$  and also on the level of evasion if evasion is allowed for. This means in turn that recovery of  $e$  from (21) means making assumptions about these parameters;  $\omega$  can be calibrated from our data, but  $\lambda$  and  $\nu$  are harder to specify.

Second, as shown in Lockwood (2016), in the presence of a notch, the elasticity of the tax base (in the case of the personal income tax, taxable income), is no longer a sufficient statistic for the marginal deadweight loss of the tax, so elasticity estimates are of less interest from a normative point of view. For these reasons, we do not attempt elasticity estimates.

## 4.6 Summary of Theoretical Results

We now summarize the theoretical results in Figure 2, which shows how firms of productivity type  $a$  behave as  $T$  varies.

The figure is drawn under the simplifying assumptions that  $e_C = e_B$  and that there is no evasion. Also, we think of  $T$  varying as the statutory rate  $t$  of VAT is changed, so we

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<sup>24</sup>In particular, in their formula, the tax notch is measured by the term  $\Delta t/(1 - t)$  where  $t$  is the lower rate of income tax, and  $\Delta t$  is the increase in the tax rate at the notch. In fact, it is easily verified if we take (21) and substitute  $e_L = e - 1$ , where  $e_L$  is the elasticity of labor supply, replace  $\Delta s^*/s^*$  by  $\Delta z^*/z^*$ , and replace  $T^{1/e}$  by  $1 - \frac{\Delta t}{1-t}$ , we get equation (5) in their paper.

are holding everything else fixed. In this case, we know that all firms register for VAT if  $T > 1$ . So, all firms with  $a > a^*$  are registered with a turnover above the threshold, but all firms with  $a < a^*$  are voluntarily registered, where  $a^*$  is the firm whose sales are just at the threshold when not registered.

When  $T$  falls below 1, firms  $a \in [a^*, a^* + \Delta a^*]$  start to bunch at the registration threshold. As  $T$  falls, this bunching interval becomes larger.<sup>25</sup> So, for any fixed value of  $T$ , firms can now be in one of three regimes: when  $a$  is low, the firm will be unconstrained but below the threshold, when  $a$  is high, the firm will be unconstrained and above the threshold and thus registered, and when  $a$  is intermediate, the firm will be just at the threshold.

It is also clear from Figure 2 how voluntary registration and bunching may coexist in any given industry. Some fraction of firms may have a  $T > 1$ , so the lower-productivity ones in this group will be voluntarily registered. At the same time, some other fraction may have a  $T < 1$ , so some of this latter group will be bunching.

## 5 Context and Data

### 5.1 The Value-Added Tax System in the UK

Approximately two million registered businesses remit value-added tax (VAT) in the UK every fiscal year. The VAT is the third largest source of government revenue following income tax and national insurance contributions. In 2011/12, the VAT raised £98.2 billion, accounting for 21.1% of total tax revenue and 6.5% of GDP in the UK.<sup>26</sup>

VAT is levied on most goods and services provided by registered businesses in the UK, goods and some services imported from countries outside the European Union (EU), and brought into the UK from other EU countries. Key information about rates and thresholds for VAT in the UK is given in Table 1. As can be seen from that Table, the standard VAT rate in the UK was constant at 17.5% between April 2004 and January 2011, except for a temporary reduction to 15% during the worst months of financial crisis (between December 2008 and January 2010). The standard rate was further raised to 20% in January 2011. A small number of goods and services have VAT levied at a reduced rate of 5% and there are

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<sup>25</sup>Note that  $a^*$  falls as  $t$  falls, because the effective cost of inputs falls; similarly,  $a^* + \Delta a^*$  rises as  $t$  falls.

<sup>26</sup>See [http://www.hmrc.gov.uk/stats/tax\\_receipts/tax-receipts-and-taxpayers.pdf](http://www.hmrc.gov.uk/stats/tax_receipts/tax-receipts-and-taxpayers.pdf).

also goods and services that are zero-rated or exempt from VAT altogether.<sup>27</sup>

All businesses must register for VAT if their taxable turnover is above a given threshold.<sup>28</sup> In the case of the UK, the registration threshold is regularly updated to keep up with inflation, as shown in Table 1.<sup>29</sup> The UK has the highest registration threshold in the EU, which is perceived as a way for the government to reduce the compliance costs of small businesses not wishing to register for VAT.<sup>30</sup>

As is standard in most VAT systems, VAT-registered businesses pay VAT on their purchases (input tax), and charge VAT on the full sale price of their taxable supplies (output tax). Businesses with a turnover below the threshold may choose to register voluntarily in order to recover the VAT paid on their intermediate inputs. Businesses cannot charge output VAT on their sales of zero-rated or exempt goods. In the case of zero-rated supplies, the firm can claim back the VAT paid on inputs, whereas the same is not true for exempt supplies.

In the specific case of the UK, there are two rules governing registration: a forward-looking rule and a backward-looking one. Under the forward-looking rule, a business must register for VAT if its taxable turnover is likely to go over the threshold in the next 30 days. Under the backward-looking rule, a business must register if its taxable turnover in the previous 12 months was above the threshold. Strictly speaking, our theoretical model is static and applies only to the forward-looking decision; that is, the business must register if turnover in the current year is expected to exceed the threshold. In our sample, around 68% of first-time registers have a previous-year turnover lower than the VAT threshold. This suggests that the forward-looking decision is the most relevant in practice.

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<sup>27</sup>The 5% reduced rate is charged on a small number of supplies under schedule 7A of the *Value Added Tax Act of 1994 (VATA)*. This mainly includes the supply of domestic fuel and power, the installation of energy saving materials, women's sanitary products, children's car seats and certain types of construction work.

<sup>28</sup>Taxable turnover includes the value of any goods or services a business supplies *within* the UK, unless they are exempt from VAT. All zero-rated sales, except exports, are included as part of the taxable turnover.

<sup>29</sup>Specifically, under Article 24(2)(c) of the sixth EC VAT directive (77/388/EEC 17 May 1977). These provisions are now consolidated in the principal VAT directive (2006/112/EC); article 287 allows for States to increase the registration threshold in line with inflation. As far as we are aware, there is no interaction between the VAT registration threshold with other major taxes in the UK, not does it change the probability of being audited for firms around the threshold.

<sup>30</sup>Small firms with annual taxable turnover above the registration threshold but below £150,000 can use a simplified flat-rate VAT scheme. In 2007, only 16% of eligible firms were registered under the flat-rate scheme (Vesal, 2013).

## 5.2 Data

We construct our data by linking two administrative datasets: (i) the universe of VAT returns and (ii) the universe of corporation tax records in the UK (called CT600). The first dataset provides detailed information on VAT-registered businesses, which may take a variety of legal forms including sole proprietorships, partnerships, and companies. To obtain information on business not registered for the VAT, we link the VAT records to the population of corporation tax records based on a common anonymized taxpayer reference number. The linked dataset allows us to identify whether *companies* are registered in the VAT or not, and contains rich information on VAT and corporation tax for each business and year.<sup>31</sup>

We further merge the linked tax dataset with two additional data sources: (i) the Financial Analysis Made Easy (FAME) annual company account database for additional firm characteristics and accounting information and (ii) the annual sector-level statistics on the share of sales to final consumers based on the Office of National Statistics' (ONS) Input-Output tables. The latter gives us an empirical proxy for  $\lambda$ , the share of sales that are B2C at the 2-digit SIC industry level.

The final dataset contains 714,571 observations for 257,373 unique companies between April 1, 2004 and March 30, 2010.<sup>32</sup> For each company-year observation, we have information on the VAT-exclusive turnover taken from the corporate tax records, and whether the company is registered for VAT.<sup>33</sup> We examine several key factors that drive firms' decisions

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<sup>31</sup>Note that this linked dataset does not include sole proprietorships or partnerships that are below the VAT threshold and have chosen to not register for VAT. These types of business are taxed through the individual income tax. The data on the universe of self-assessment taxpayers is available (and it has been used in a recent paper by [Almunia et al. \(2017\)](#)), but this dataset does not have an identifier to link individual taxpayers to the VAT records.

<sup>32</sup>We take several steps to refine the sample to study the VAT registration decisions of individual companies. First, we eliminate companies which are part of a larger VAT group and focus only on standalone independent companies. This is because companies under common control—for example, subsidiaries of a parent company—can register as a VAT group and submit only one VAT return for all companies in a VAT group.

Second, we drop all observations with partial-year tax or accounting records because the registration decision can be based on turnover in the previous 12 months. We further eliminate companies that mainly engage in overseas activities based on the HMRC trade classification. This is because the taxable VAT turnover excludes exports. Finally, we drop companies with an effective rate of VAT that is less than 10%, where the effective rate is the output VAT relative to VAT-eligible sales for registered companies, to form the main sample for empirical analysis. Empirical results based on the full sample that includes all firms with an effective VAT rate below 10% are quantitatively similar to those obtained using the main sample and are available upon request.

<sup>33</sup>Our empirical analysis is based on turnover reported in the CT600 for two reasons. The first is mechanical: we only observe turnover liable for VAT for firms that are registered. The second is related to salience, given that firms that are not registered for VAT are more likely to base their registration decision on the overall amount of turnover, instead of computing a separate measure of turnover that is subject to VAT. To

about voluntary registration, including the share of input costs relative to total turnover (input-cost ratio), the share of sales to final consumers (B2C sales ratio), firm-specific history of registration, and the degree of industry-level competitiveness.

In order to have a measure as close as possible to the theory, we use the Lerner index of competition. This is defined as one minus the average ratio of trading profit to value of sales for firms in that industry. It is easily checked that if demand is iso-elastic at  $e$ , for all firms in an industry, as it is in our theoretical model, the Lerner index is simply  $(e - 1)/e$ . This means that the Lerner index is an ideal measure for testing our predictions about the effect of competition as measured by  $e$ .<sup>34</sup>

The input-cost ratio varies at the firm level, while the share of B2C sales and the Lerner index vary at the industry level. All three variables have annual variation, allowing us to include them in the linear panel models with firm fixed effects that we present in the next section.

We use two different data sets to test related hypotheses developed in Section 4. First, we use *all* the firms with turnover below the current-year VAT registration threshold to examine the choice of voluntary registration. We say that a firm is voluntarily registered if it has never registered before and has a turnover below the VAT threshold, or if it was registered in the previous year and has a turnover below the VAT deregistration threshold. In the main sample, 66.3% of firms have a turnover below the VAT threshold, of which 43.7% are registered for VAT. So, overall, 29.0% of firms in the main sample of companies are voluntarily registered. Second, we focus on firms with turnover in the neighborhood of the registration threshold, i.e. between £10,000 and £200,000, to analyze the extent of bunching at the VAT notch.

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see whether this is true, we predict (out-of-sample) the amount of turnover liable for VAT for unregistered firms, by regressing this variable on the amount of total turnover and a full set of industry and year dummies. We then plot a similar histogram of turnover as in Figure 3 based on actual/predicted turnover liable for VAT for registered/unregistered firm. Bunching below the VAT notch is still present, but much more noisy and imprecise comparing to bunching based on total turnover reported in CT600. The empirical differences suggest that for unregistered firms, they are more likely to rely on the overall turnover figure for their VAT registration decisions.

<sup>34</sup>Other commonly used measures of competition are the four- or five-firm concentration ratio, or the Herfindahl index, but they measure the relative importance of the largest firms in an industry, and are not closely related to the demand elasticity faced by small firms close to the VAT registration threshold.

### 5.3 Summary Statistics

In order to assess whether there is a behavioral response to the VAT registration threshold, we first look at the raw distribution of firms around that threshold. We pool data from the corporation tax records between fiscal years 2004/05 and 2009/10, normalizing turnover such that the threshold is located at zero. The histogram of normalized turnover is shown in Figure 3, where there is clear evidence of excess mass to the left of the registration threshold in an otherwise smooth distribution. The figure indicates that the VAT registration threshold is binding for at least a subset of British firms. However, it is worth noting that the bunching spike is not as sharp as those observed in other bunching studies, in particular those studying firms' responses to notches (e.g., Best et al., 2015; Almunia and Lopez-Rodriguez, 2017; Harju et al., 2016). One possible explanation is that firms that benefit from voluntary registration do not respond in any way to the location of the threshold. Another potential reason is measurement error: as noted above, the registration threshold is set in terms of VAT taxable turnover, but in the corporation tax records we cannot distinguish domestic sales from exports. The latter suggests that our measures of bunching should be interpreted as a lower bound of the true behavioral response.

Table 2 reports summary statistics for companies in the neighborhood of current-year VAT notch, i.e. those with nominal turnover of between £10,000 and £200,000. We report the mean, standard deviation, various percentiles (10th, 50th and 90th) and the number of non-missing observations for the key variables used in empirical analysis. Firms in the final dataset have £73,735 of average turnover and £20,986 of trading profit. The average salary-inclusive input cost ratio (using data from CT600) is 71% of total turnover, while the average salary-exclusive input-cost ratio (using data from FAME for a subsample of firms) is 38%. The average share of B2C sales is 46%, and the average Lerner index is 0.76.<sup>35</sup>

## 6 Results

We present two sets of empirical results. For voluntary registration, we estimate a linear probability model with firm and year fixed effects focusing on firms with turnover below the VAT registration threshold. We include in this regression the share of business-to-consumer

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<sup>35</sup>Recall that the share of B2C sales and the Lerner index vary at the industry-year level, but here we report the firm-year level averages.

sales (B2C), the input-cost ratio (ICR) and the Lerner index as a proxy for the competitiveness of the industry. To analyze bunching, we use graphical evidence and standard nonparametric techniques to demonstrate the existence of excess bunching mass just below the threshold. We then investigate whether the amount of bunching varies with the three key variables mentioned above in the way predicted by the theory.

## 6.1 Voluntary Registration

We examine whether the decision to voluntarily register for the VAT is consistent with the three theoretical predictions stated in Propositions 2 and 3: a firm is more likely to register voluntarily for VAT if it sells mostly to other VAT-registered businesses (as opposed to final consumers), has a larger share of intermediate input costs (relative to total costs), or operates in a more competitive industry.

We evaluate these relationships more formally using a panel regression framework. We model the decision of voluntary registration as a binary choice model of the following form:

$$R_{it} = \alpha_i + \alpha_t + \gamma_1 B2C_{it}^j + \gamma_2 ICR_{it} + \gamma_3 L_{it}^j + \gamma_4 D_{it} + v_{it}, \quad (22)$$

where  $R_{it}$  is a dummy indicator that takes value 1 if the firm is voluntarily registered and zero otherwise.  $B2C_{it}^j$  denotes the share of B2C sales in industry  $j$  where firm  $i$  operates in year  $t$ ,  $ICR_{it}$  denotes the input-cost ratio for firm  $i$  in year  $t$ , and  $L_{it}^j$  is the Lerner index for competitiveness for industry  $j$  in year  $t$ . We calculate this index as the average of one minus the profit margin in each 4-digit industry, using the entire population of corporate tax records for that calculation. Additionally, we control for the distance to the VAT threshold,  $D_{it}$ , defined as the difference between total turnover and the registration threshold in year  $t$ . The time-invariant firm fixed effects and year dummies are denoted by  $\alpha_i$  and  $\alpha_t$ , respectively, and  $v_{it}$  is a random error term.

We estimate equation (22) using a linear probability model, which allows us to include firm fixed effects without a bias due to the incidental parameters problem.<sup>36</sup> The estimation sample includes all firms with turnover below the current-year VAT registration threshold. According to Proposition 2, we expect to obtain  $\gamma_1 > 0$ ,  $\gamma_2 > 0$  and  $\gamma_3 < 0$ .

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<sup>36</sup>The predicted values are all within the (0,1) interval, indicating that the main drawback of the linear probability model is not a concern in this setting.

Table 3 reports the estimation results from the linear probability model.<sup>37</sup> Columns (1)-(3) include the three key variables one at a time, and column (4) includes all three in the regression. The first four columns include year dummies but not firm fixed effects, which allows us to examine the total effect of the industry-level variation in the B2C sales ratio and the Lerner index on the probability of voluntary registration. The estimated coefficients on these two variables are negative and statistically significant both when they enter alone in the regression (columns 1 and 3) and when they enter together (column 4).

In the remaining columns of Table 3, we add firm fixed effects. This absorbs a substantial part of the cross-sectional variation in the industry-level variables and reduces the size of their coefficient estimates, to the point that the coefficient on the share of B2C sales becomes essentially zero, while the coefficient on the Lerner index becomes smaller in absolute value, although still highly significant. The advantage of including firm fixed effects, on the other hand, is that they control for firm-level unobserved determinants of registration that may be correlated with the industry-level variables. The firm fixed effects control for whether a firm has previously been above the registration threshold, and hence partially control for inertia in registration status. In addition, the fixed effects control for whether the firm is an exporter (note that exports are zero-rated in the VAT) and benefits from getting their input costs reimbursed.

To allow for comparisons, column (5) does not include any controls, whereas column (6) controls for distance to the threshold, to account for the fact that size is by itself a predictor of registration status. According to the results from column (6), which is our preferred specification, the likelihood of being voluntarily registered is on average 1.1 percentage points lower as the B2C ratio increases by one standard deviation (s.d.), 0.7 percentage points higher as the input-cost ratio increases by one s.d., and 1.6 percentage points lower as the Lerner index increases by one s.d.

Finally, Column (7) checks the robustness of the results by replacing the salary-*inclusive* input-cost ratio calculated from the corporation tax records with the salary-*exclusive* input-cost ratio calculated from FAME. The latter improves precision in the measurement of the input costs relevant to VAT-registered firms (since labor costs are not deductible), but substantially reduces the sample size given that barely 11 percent of firms report the direct

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<sup>37</sup>The estimation results from a fixed-effects logit model are very similar and are available from the authors upon request.

cost of sales. The coefficient on the input-cost ratio remains positive and highly significant throughout the different specifications. Moreover, the coefficient on the share of B2C sales and the Lerner index are negative and significant at the 5 and 10 percent levels, respectively. In column (8), we repeat the same specification on the same subsample of firms, but using again the salary-*inclusive* cost ratio from the corporation tax records (CT600), finding almost identical results.

**Dynamic Behavior** One potential limitation of the above analysis is that we do not explicitly consider the dynamic behavior of firms. A change in the registration status involves some costs to firms. This raises the possibility that firms who are initially above the registration threshold and later fall below may stay registered simply to avoid the cost of deregistration. Hence, some of the firms who seem to be voluntary registered may just be behaving in this way because of inertia. As noted above, the firm fixed effects partially control for this type of behavior. As a further robustness check, we conduct additional regressions taking into account these dynamic effects. Specifically, we estimate a probit model with random effects where we include a lag of the dependent variable (i.e., whether the firm was registered the previous year), the initial registration status, and the averages of the key explanatory variables. A more detailed explanation of these regressions and the results can be found in the online appendix.

## 6.2 Bunching Evidence

### 6.2.1 Estimation Method

As explained in Section 3, the VAT registration threshold at the cutoff turnover value  $s^*$  will induce excess bunching at the threshold by companies for which voluntary registration is not optimal. From (20), we can write bunching as  $B = \Delta s^* h(s^*)$ , where  $h(s^*)$  is the counterfactual density of firms over the bunching interval, assuming that this is constant. We will express this as a fraction of  $s^*$ , so we let  $b = B/s^*$ .

Our empirical measure of  $b$  is given by

$$b = \frac{\sum_{j=s^*}^{s^*} (c_j - \hat{c}_j)}{s^*}. \quad (23)$$

Here,  $c_j$  is the actual number of firms in each £100 turnover bin, and  $\hat{c}_j$  is the counterfactual bin counts without the notch. The range  $(s_-^*, s_+^*)$  specifies turnover bins around the notch where bunching occurs and are therefore excluded from predicting the counterfactual distribution. Specifically, the lower bound of the excluded turnover region,  $s_-^*$ , is set at the point where excess bunching starts. The upper bound of the excluded region,  $s_+^*$ , is estimated in an iteration procedure to ensure that the excess mass below the VAT notch is equal to the missing mass above.<sup>38</sup> Finally,  $N$  is the number of bins in the excluded range  $(s_-^*, s_+^*)$ .

So, to summarise, equation (23) says that the excess mass is empirically measured by the difference between the predicted and actual mass of firms in the excluded region, divided by the average counterfactual density of firms where bunching occurs.

### 6.2.2 Graphical Evidence

This section presents evidence of bunching below the VAT notch using the main sample of companies with turnover between £10,000 and £200,000. Figure 4 presents bunching around the threshold in each financial year between 2004/05 and 2009/10. Panel A shows the empirical distribution of turnover (blue dots) as a histogram in £1,000 bins and the estimated counterfactual distribution (red line) in 2004-05. Each dot denotes the upper bound of a given bin and represents the number of companies in each turnover bin of £1,000. Similar to [Chetty et al. \(2011\)](#) and [Kleven and Waseem \(2013\)](#), we estimate the counterfactual distribution by fitting a flexible polynomial of order 3 to the empirical distribution, excluding firms in the excluded range close to the VAT notch.<sup>39</sup> The lower bound of the excluded turnover range is demarcated by the vertical dashed line and the VAT notch demarcated by the vertical

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<sup>38</sup>We follow the standard procedure to estimate the counterfactual distribution. By grouping companies into small turnover bins of £100, we estimate the counterfactual distribution around the VAT notch  $s^*$  in the following regression:

$$c_j = \sum_{l=0}^q \beta_l (s_j)^l + \sum_{i=s_-^*}^{s_+^*} \gamma_i I\{j = i\} + \varepsilon_j, \quad (24)$$

where  $c_j$  is the number of companies in turnover bin  $j$ ,  $s_j$  is the distance between turnover bin  $j$  and the VAT notch  $s^*$ ,  $q$  is the order of the polynomial, and  $I\{\cdot\}$  is an indicator function. The error term  $\varepsilon_j$  reflects misspecification of the density equation.

<sup>39</sup>As a robustness check we have tried values between 3 and 5 for the order of the polynomial and our results are not significantly changed.

solid line.<sup>40</sup> The next five panels focus on subsequent years during which the VAT notch was increased annually to track inflation. Each panel reports the estimated bunching ratio ( $b$ ) and its standard error in in parenthesis.

Three main findings are worth noting in Figure 4. First, the VAT notch creates evident bunching below the threshold. Excess bunching ranges from 0.82 to 1.29 times the height of the counterfactual distribution, and is strongly significant in all years during the sample period.<sup>41</sup> Second, excess bunching tracks precisely the annual change in the nominal VAT notch due to adjustment to inflation. In each year the excess bunching is concentrated within £2,000 below the VAT. Third, in contrast with the large bunching below the threshold, there is only a small hole in the distribution above the VAT notch. The range of the hole spans from £8,500 to £15,000 above the cutoff, although we do not attempt to estimate the magnitude of optimization frictions implied by the hole given the various reason discussed in section 3.

Kleven (2016) argues that, in the context of the personal income tax, bunching is much more likely to be due to evasion, rather than to real earnings responses. Here, as already noted, both evasion and real responses may be driving observed bunching. We do not to attempt to decompose observed bunching into real and evasion responses because there is no variation that allows us to do that. We focus on bunching heterogeneity along the firm characteristics that our theoretical framework predicts should be related to bunching behavior, namely the share of B2C sales, the input-cost ratio and the Lerner index of competitiveness. In the online appendix, we show some suggestive evidence that the bunching behavior may partly be due to misreporting of turnover.

### 6.2.3 Heterogeneity in Bunching

We have shown a stable distribution of turnover throughout the entire period 2004/05-2009/10, with persistent bunching of companies below the VAT notch in each year. We now explore potential heterogeneity in bunching to see whether the empirical pattern is consistent with the predictions set out in Proposition 5, that firms are more likely to bunch below the VAT notch if the share of B2C sales is high, or the share of input costs is low. We will also investigate the effect of the level of competition in the industry where the firm is located,

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<sup>40</sup>The upper bound of the excluded turnover region is estimated using an iteration procedure to ensure that the area under the estimated counterfactual density is equal the area under the observed density.

<sup>41</sup>Unlike to studies analysing bunching in the taxable income of individuals (Kleven and Waseem, 2013) and corporations (Devereux et al., 2014), we do not find any evident bunching at round numbers.

although that is predicted to have an ambiguous effect theoretically.

First, we explore how companies with different shares of B2C sales respond to the same VAT notch by dividing companies into four quartiles of the B2C share distribution. We estimate annual bunching ratios separately for each quartile, and plot the point estimate of the bunching ratio with the corresponding 95% confidence intervals in Figure 5. There are two interesting findings in Figure 5. First, all bunching estimates are positive and highly significant, even in the lowest B2C quartile where on average between 0.3% and 25.4% of sales are B2C. Second, the estimated bunching ratio tends to increase with the B2C sales ratio. In particular, the estimated bunching ratio for firms in the top quartile (Q4) is significantly larger than for firms in the bottom quartile (Q1). The observed strong aggregate bunching is mainly driven by the behavioral responses of companies in the third and fourth quartiles of the distribution of the share of B2C sales.

Second, we examine how companies with different shares of intermediate input costs respond to the same VAT notch. Again, we look at quartiles of the distribution of this variable. We construct the input-cost ratio information using the *salary-exclusive* measure from company accounts in FAME. As mentioned above, this reduces the available sample size, because it is optional for small and medium-sized companies to disclose this information. To increase the efficiency of this empirical test, we pool observations with non-missing input costs in all years and present bunching evidence with respect to the normalized VAT notch in Figure 6.

Panel A compares the empirical distributions of companies around the normalized VAT notch across quartiles of the input-cost ratio. The densities suggest that the degree of bunching decreases with the input-cost ratio. The distribution of companies in the top quartile (Q4) is quite smooth around the normalized VAT notch, while the distributions in the lower quartiles all exhibit some degree of bunching just below the VAT notch. Panel B quantifies the difference in the extent of bunching by plotting the estimated bunching ratio with the corresponding 95% confidence interval for each input-cost ratio quartile. Quantitatively, the bunching estimate is very small and insignificant for companies in the top quartile of the input-cost ratio distribution. In contrast, the bunching estimates for companies in the lower quartiles of the input-cost ratio are positive and highly significant.

Finally, we examine the extent of bunching depending on the degree of competition in the product market. We measure competition at the industry level using the Lerner index.

Since we define the Lerner index as one minus the average profit margin in the industry, higher values of the index indicate that the industry is more competitive. As in the previous cases, we examine how bunching varies across quartiles of the distribution of the Lerner index in Figure 7. The patterns in Panel A suggest that bunching clearly increases as the Lerner increases. In Panel B, we quantify the difference in the extent of bunching by plotting the bunching estimates with the corresponding 95% confidence interval. All the bunching estimates are significantly different from zero, and there is a substantial increase in the degree of bunching from the second to the fourth quartiles of the distribution, as competition in the product market becomes more intense.

## 7 Conclusions

In this paper, we first developed a conceptual framework which can explain the co-existence of VAT voluntary registration and bunching. We showed that this required (at least) three stages of production, with firms at the intermediate stage selling both to final consumers and to other firms. This framework predicts that voluntary registration is more likely, and bunching is less likely, when (i) the cost of inputs relative to sales is high, (ii) when the proportion of B2C sales is low, or (iii) when the level of product market competition is low. Additionally, evasion opportunities will generally make voluntary registration more likely, while having an ambiguous effect on bunching.

We then brought these predictions to an administrative data-set that is created by linking the population of corporation and VAT tax records in the UK, and showed that the pattern of voluntary registration in the data is consistent with the theory. In particular, voluntary registration is more likely with a low share of B2C sales, a high share of inputs in cost, and more competition in the industry. Moreover, there is clear evidence of bunching at the VAT threshold. Investigating further, we saw that, consistently with the theory, there is a clear pattern of heterogeneity in bunching; the amount of bunching is increasing in the B2C sales ratio, and decreasing in share of ratio of input costs to sales and the amount of competition in the industry.

We also investigated the dynamic behavior of firms around the VAT notch. Specifically, we addressed the concern that voluntary registration may not be an optimizing choice of firms, but simply a failure to deregister, once having been above the threshold and having

registered. Our empirical findings suggest that while there is a considerable amount of persistence in firm behavior, perhaps due to the fixed compliance costs of deregistration, the decision is not entirely driven by inertia; firms change their registration decisions in a way that is consistent with profit maximizing behavior.

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## Tables

Table 1. Value-Added Tax System in the UK

| Fiscal Year                   | Registration Threshold (£) | Deregistration Threshold (£) | Standard Rate (%) | Flat-Rate Scheme Threshold (£) |
|-------------------------------|----------------------------|------------------------------|-------------------|--------------------------------|
| 2001-02                       | 54,000                     | 52,000                       | 17.5              | 100,000                        |
| 2002-03                       | 55,000                     | 53,000                       | 17.5              | 100,000                        |
| 2003-04                       | 56,000                     | 54,000                       | 17.5              | 150,000                        |
| 2004-05                       | 58,000                     | 56,000                       | 17.5              | 150,000                        |
| 2005-06                       | 60,000                     | 58,000                       | 17.5              | 150,000                        |
| 2006-07                       | 61,000                     | 59,000                       | 17.5              | 150,000                        |
| 2007-08                       | 64,000                     | 62,000                       | 17.5              | 150,000                        |
| Apr 1, 2008 -<br>Nov 30, 2008 | 67,000                     | 65,000                       | 17.5              | 150,000                        |
| Dec 1, 2008 -<br>Mar 30, 2009 | 67,000                     | 65,000                       | 15                | 150,000                        |
| Apr 1, 2009 -<br>Jan 1, 2010  | 68,000                     | 66,000                       | 15                | 150,000                        |
| Jan 1, 2010 -<br>Mar 30, 2010 | 68,000                     | 66,000                       | 17.5              | 150,000                        |

*Notes:* the table shows changes in the registration threshold, deregistration threshold, Flat-Rate scheme threshold, and VAT standard rate over recent fiscal years.

For more information on the UK VAT tax system, see <http://www.hmrc.gov.uk/vat/forms-rates/rates/rates-thresholds.htm>.

Table 2. Summary Statistics

| Variable                        | Mean   | St.Dev. | p10    | p50    | p90     | Observations |
|---------------------------------|--------|---------|--------|--------|---------|--------------|
| Total Turnover                  | 73.735 | 48.979  | 19.541 | 60.761 | 151.509 | 714,571      |
| Trading Profit                  | 20.986 | 25.942  | 0.000  | 11.547 | 56.454  | 714,571      |
| Total Input Costs (CT600)       | 52.749 | 44.742  | 11.576 | 36.205 | 124.354 | 714,571      |
| Intermediate Input Costs (FAME) | 30.768 | 33.444  | 2.000  | 17.000 | 81.000  | 80,682       |
| Input-Cost Ratio (CT600)        | 0.71   | 0.27    | 0.29   | 0.77   | 1.00    | 714,571      |
| Input-Cost Ratio (FAME)         | 0.38   | 0.25    | 0.05   | 0.37   | 0.72    | 80,682       |
| Share of B2C Sales              | 0.46   | 0.26    | 0.10   | 0.43   | 0.88    | 714,571      |
| Lerner Index                    | 0.76   | 0.10    | 0.61   | 0.78   | 0.90    | 714,571      |

*Notes:* this table shows the mean, standard deviation, the 10th, 50th (median) and 90th percentiles, and the number of nonmissing observations of the key variables used in the empirical analysis. The top four variables are expressed in thousands of pounds (GBP), where 1 GBP = 1.29 USD as of July 2017. The rest of variables are defined to be in the interval  $[0, 1]$ . Note that we only have data on salary-exclusive input costs for a subset of companies from the FAME dataset. The share of B2C sales denotes the proportion of turnover that comes from sales to final consumers, as opposed to sales to other VAT-registered businesses.

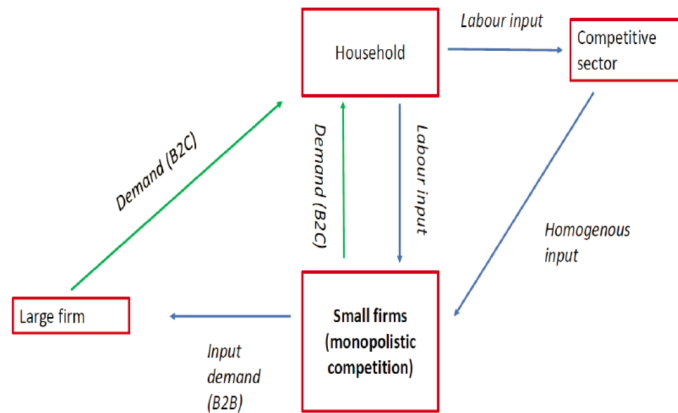
Table 3. Determinants of Voluntary VAT Registration

|                       | (1)                  | (2)                 | (3)                  | (4)                  | (5)                  | (6)                  | (7)                  | (8)                  |
|-----------------------|----------------------|---------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Share of B2C Sales    | -0.137***<br>(0.005) |                     |                      | -0.016***<br>(0.006) | 0.001<br>(0.004)     | 0.000<br>(0.004)     | -0.041**<br>(0.016)  | -0.041**<br>(0.016)  |
| Input-Cost Ratio      |                      | 0.023***<br>(0.004) |                      | 0.073***<br>(0.004)  | 0.006***<br>(0.002)  | 0.044***<br>(0.002)  | 0.025***<br>(0.009)  | 0.036***<br>(0.009)  |
| Lerner Index          |                      |                     | -0.557***<br>(0.014) | -0.579***<br>(0.017) | -0.116***<br>(0.026) | -0.130***<br>(0.026) | -0.156*<br>(0.088)   | -0.164*<br>(0.088)   |
| Distance to Threshold |                      |                     |                      |                      |                      | -0.002***<br>(0.000) | -0.001***<br>(0.000) | -0.001***<br>(0.000) |
| Observations          | 478,973              | 478,973             | 474,339              | 474,339              | 474,339              | 474,339              | 53,455               | 53,455               |
| Year FE               | Yes                  | Yes                 | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  |
| Firm-FE               | No                   | No                  | No                   | No                   | Yes                  | Yes                  | Yes                  | Yes                  |
| Cost-Ratio Source     | n/a                  | CT600               | n/a                  | CT600                | CT600                | CT600                | FAME                 | CT600                |

*Notes:* this table presents estimation results from the binary choice model of VAT registration based on equation (22). The dependent variable is the binary indicator of VAT registration status that takes on the value 1 if a firm is voluntarily registered for VAT and zero otherwise. Columns (1)-(4) present results from the linear probability model without firm-fixed effects, and columns (5)-(8) present results by adding firm-fixed and additional firm-level control variables, such as distance to the registration threshold. \*, \*\*, \*\*\* denotes significance at 10%, 5% and 1%, respectively. Standard errors are clustered at firm level.

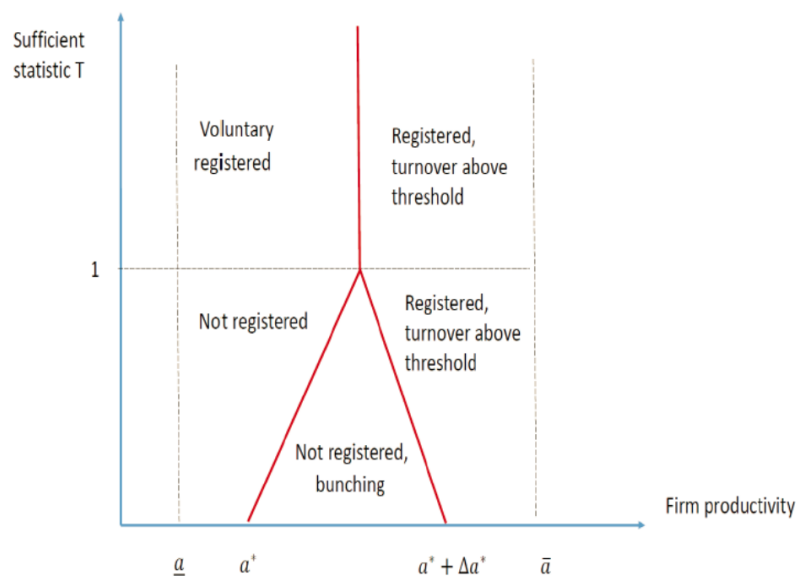
# Figures

Figure 1. Structure of the Economy



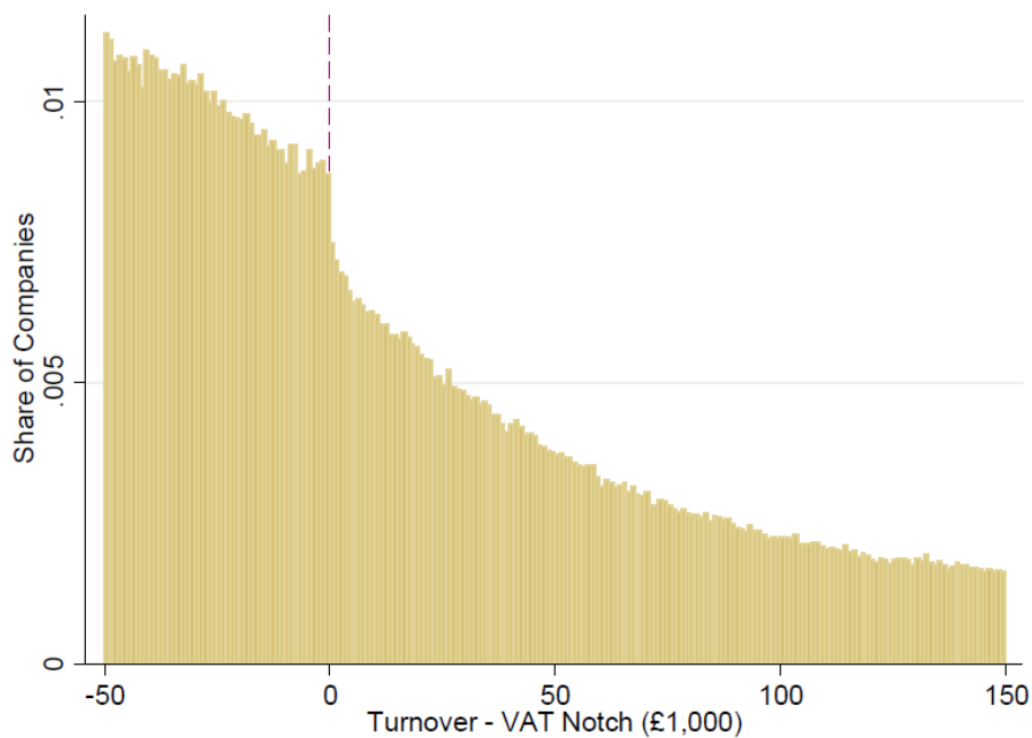
*Notes:* this figure shows the key features of the economy in which we model behavioral responses of firms with respect to the VAT threshold, including voluntary registration and bunching.

Figure 2. Summary of Theoretical Results



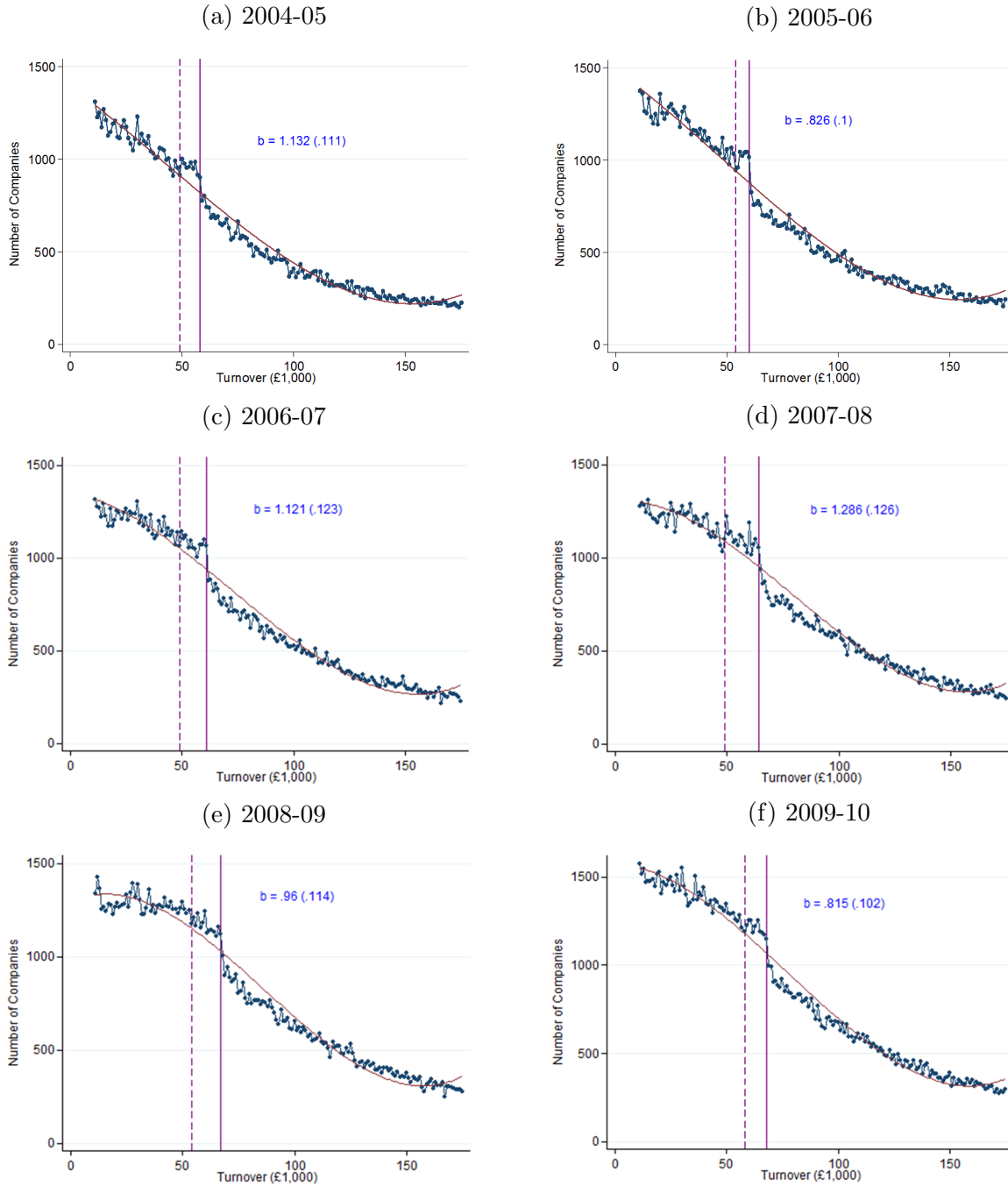
*Notes:* this figure shows how firms of productivity types  $a$  behave as the VAT sufficient statistic  $T$  varies.

Figure 3. Turnover Distribution around the Registration Notch



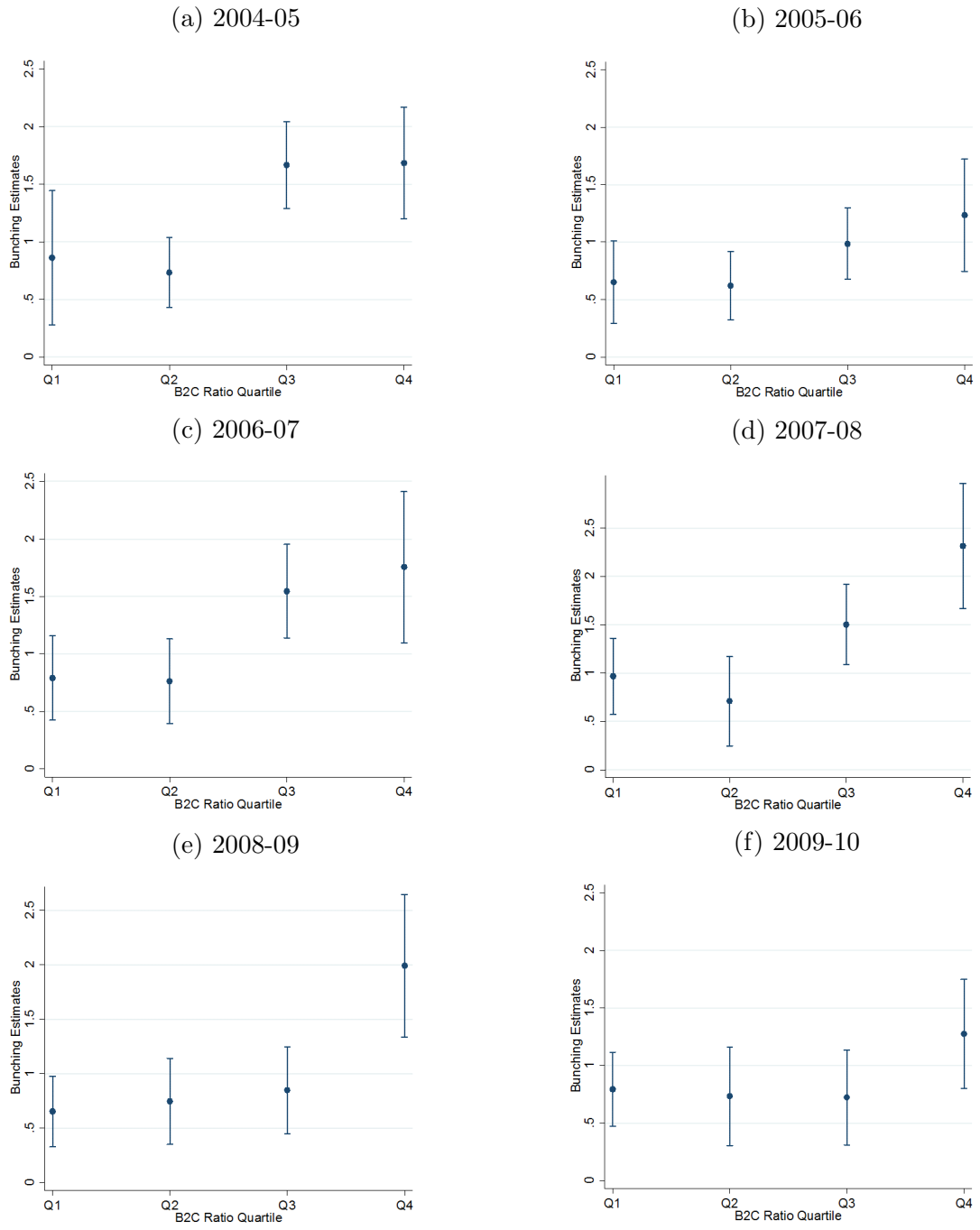
*Notes:* this figure shows the histogram of companies within the neighborhood of turnover net of current-year VAT registration threshold (normalized VAT notch) by pooling data between 2004/05-2009/10. The bin width is £1,000 and the dashed line denotes the normalized VAT notch.

Figure 4. Bunching at the VAT Notch, Annual Data



*Notes:* this figure shows the observed distribution (solid-dotted line) and the estimated counterfactual distribution (solid-smooth line) of turnover for each year in 2004/05-2009/10. The counterfactual is a three-order polynomial estimated as in eq. (24). The excluded ranges around the VAT notch are demarcated by the vertical-dashed lines, and the VAT notch is demarcated by the vertical solid line. Bunching  $b$  is excess mass in the excluded range around the VAT notch relative to the average counterfactual frequency in this range. Standard errors are shown in parentheses.

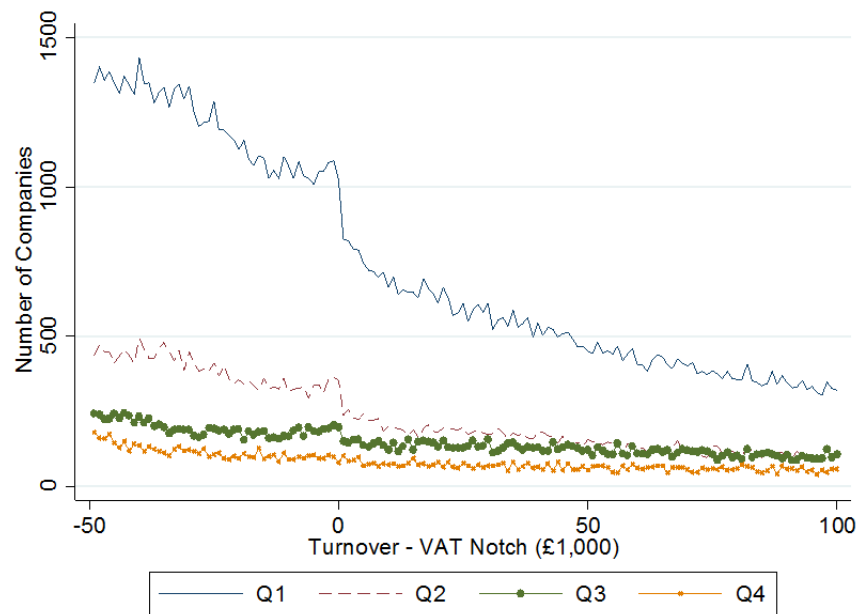
Figure 5. Bunching across Quartiles of the B2C Distribution



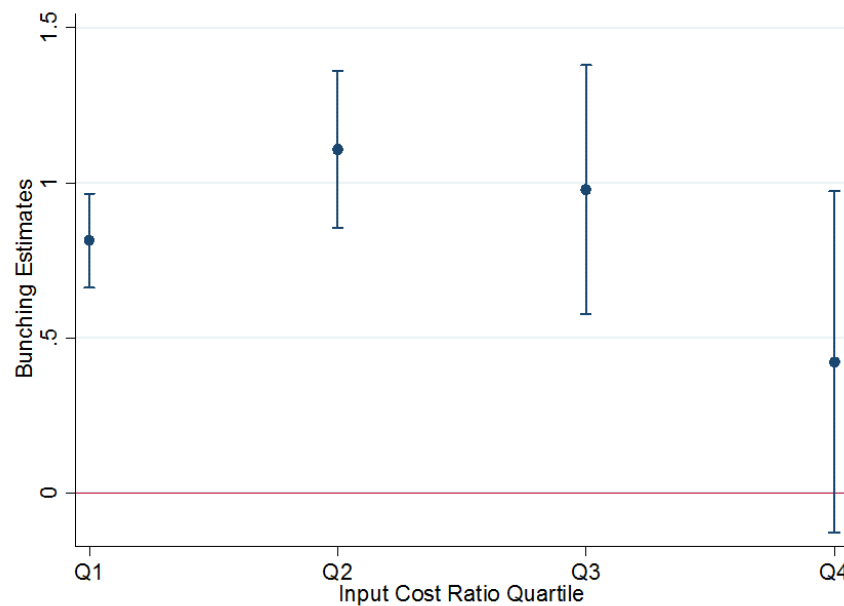
*Notes:* the figure plots the point estimate of the bunching ratio  $b$  with the corresponding 95% confidence intervals across four different quartiles of industry-level B2C sales ratio in each year during 2004/05-2009/10.

Figure 6. Bunching across Quartiles of the Input-Cost Ratio Distribution

(a) Bunching Evidence



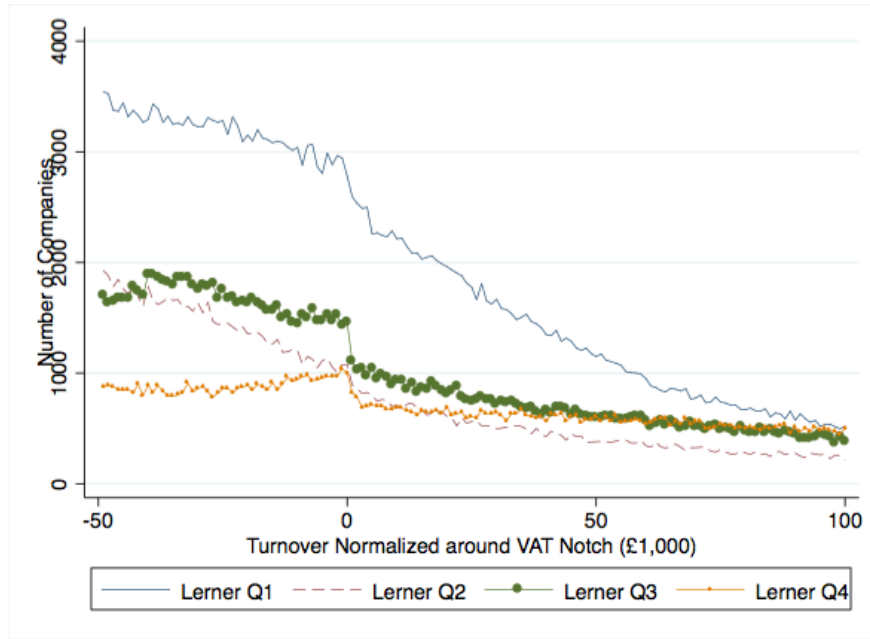
(b) Bunching Estimates



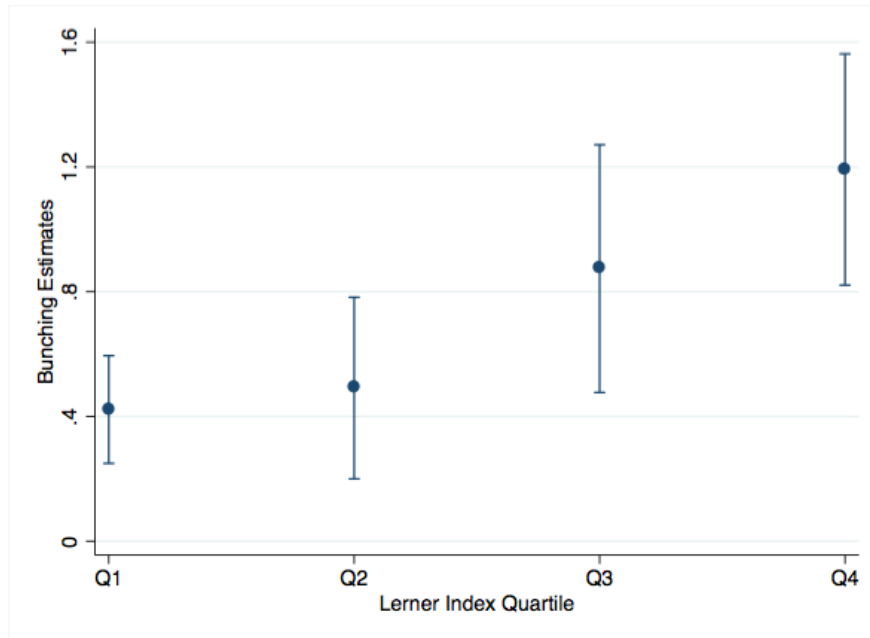
*Notes:* the figure shows the observed distribution of turnover across four different quartiles of input cost ratio within the neighborhood of normalized VAT notch in 2004/05-2009/10 in Panel A. Panel B then plots the point estimate of the bunching ratio  $b$  and the corresponding 95% confidence intervals across the four quartiles of input cost ratio by pooling all the data in the sample years.

Figure 7. Bunching across Quartiles of the Lerner Index Distribution

(a) Bunching Evidence



(b) Bunching Estimates



*Notes:* the figure shows the observed distribution of turnover across four different quartiles of the Lerner index around the VAT notch in 2004/05-2009/10 in Panel A. Panel B then plots the point estimate of the bunching ratio  $b$  and the corresponding 95% confidence intervals across the four quartiles of the Lerner index by pooling all the data in the sample years.

Online Appendix  
Not Intended for Journal Publication

”VAT Notches, Voluntary Registration and Bunching:  
Theory and UK Evidence”

July 2017

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## A Appendix

**Proof of Proposition 1.** First, assume only B2C sales i.e.  $\lambda = 1$ . in this case, the firm chooses  $p_C, p_B$  to maximize (11) subject to (12),(13). This is easily solved to give price as a mark-up over cost i.e.  $p_C = \frac{e_C}{e_C-1}c(I; a)$  and thus profit for non-registered and registered firms respectively is

$$\pi(0; a) = B_C(c(0, a))^{1-e_C}, \quad \pi(1; a) = B_C(c(1, a))^{1-e_C} \frac{1}{(1+t)^{e_C}} \quad (\text{A.1})$$

where  $B_C = A_C \left( \frac{e_C-1}{e_C} \right)^{e_C} \frac{1}{e_C-1}$ . So, we only need show that  $\pi(0; a) > \pi(1; a)$ . But, from (A.1), (10), this holds iff

$$\left( \frac{c(0, a)}{c(1, a)} \right)^{1-e_C} = (1 + \omega t)^{1-e_C} > \frac{1}{(1+t)^{e_C}}$$

Now note that as  $e_C > 1$ ,

$$(1 + \omega t)^{1-e_C} \geq (1+t)^{1-e_C} > (1+t)^{-e_C}$$

as required.

Next, assume only B2B sales i.e.  $\lambda = 0$ . Then, it is easily checked profit is  $(p - c(I; a))A_B p^{-e_B}$ . So, here, the argument is even simpler; cost is decreasing, and therefore profit is increasing, if  $I = 1$ .  $\square$

**Proof of Proposition 2.** (a) If registered, the firm chooses  $p_C, p_B$  to maximize (11) subject to (12),(13) when  $I = 1$ . This is easily solved to give prices as a mark-up over cost i.e.  $p_C = \frac{e_C}{e_C-1}c(I; a)$ ,  $p_B(a) = \frac{e_B}{e_B-1}c(I; a)$ . Substituting these formulae back into the profit function (11), and using  $A_C = 1, A_B = (1+t)^{-e_B} \left( \frac{e-1}{e} \right)^e$ , we can derive the following formula for maximized profit:

$$\pi(1; a) = (\lambda B_C (1+t)^{-e_C} c(1; a)^{1-e_C} + (1-\lambda) B_B c(1; a)^{1-e_B}) \quad (\text{A.2})$$

Next, if not registered, the firm chooses  $p_C, p_B$  to maximize (11) subject to (12),(13) when  $I = 0$ , subject also to the constraint  $p_C x + p_B y \leq s^*$  that the total value of sales is below the threshold. Now consider voluntary registration. A necessary and sufficient condition for this is that profit with registration is greater than profit without, ignoring the constraint that sales be below the threshold. We will assume that a firm will register if indifferent, to break the tie. Solving this problem ignoring the threshold, following the steps for the registered firm, we get maximised profit of

$$\pi(0; a) = (\lambda B_C c(0; a)^{1-e_C} + (1-\lambda) B_B c(0; a)^{1-e_B}) \quad (\text{A.3})$$

Then, the voluntary registration condition is  $\pi(1; a) \geq \pi(0; a)$ . After some simple rearrangement, using (A.2),(A.3), this reduces to (16).

(b) We only need show that the RHS of (16) is increasing in  $\lambda$  and decreasing in  $\omega$ . The statement for  $\lambda$  is obvious by inspection. For  $\omega$ , note first that  $1 + \Delta_c \equiv 1 + \omega t$  is increasing in  $\omega$ . So, both  $(1 + \Delta_c)^{1-e_C}$ ,  $(1 + \Delta_c)^{1-e_B}$  are decreasing in  $\omega$  as  $e_C, e_B > 1$ . Finally, note that as  $\Delta_c > 0$ ,  $e_B > 1$ ,  $1 - (1 + \Delta_c)^{1-e_B} > 0$ . So, the RHS of (16) is decreasing in  $\omega$  as required.

(c) If  $e_B = e_C = e$ , (16) rearranges to

$$\frac{\lambda(1+t)^{-e} + (1-\lambda)B}{\lambda + (1-\lambda)B} (1 + \Delta_c)^{e-1} > 1, A = \frac{B_B}{B_C} = (1+t)^{-e} \left(\frac{e-1}{e}\right)^e \quad (\text{A.4})$$

But then from (15), it is clear that the first term on the left-hand side of (A.4) is  $1 - \Delta_d$ , so we obtain (18), as required.  $\square$

**Proof of Proposition 4.** (i) First, we characterise the relationship between firm type and sales, under the assumption that the firm does not have to register for VAT. From (12), the optimal price and total sales (B2C and B2B) of a non-registered firm are;

$$p(a) = \frac{e}{e-1} c(0; a) = \frac{1 + \Delta_c a}{e-1}, s(a) = (\lambda + (1-\lambda)A_B)(p(a))^{-e} \quad (\text{A.5})$$

Combining these two expressions to substitute out  $p(a)$ , we see that the relationship we need between firms type and sales is:

$$s = (\lambda + (1-\lambda)A_B) \left(\frac{e(1 + \Delta_c)}{e-1}\right)^{1-e} a^{e-1} \quad (\text{A.6})$$

(ii) We now write the indifference condition (19) that determines  $a^* + \Delta a^*$  explicitly in the space of sales. To To lighten notation, and using  $e_C = e_B = e$ , define

$$A_0 = \lambda + (1-\lambda)A_B, A_1 = \lambda(1+t)^{-e} + (1-\lambda)A_B$$

First, from (A.2), and using the restriction that  $e_C = e_B = e$ , a firm that registers has maximized profit:

$$\pi(1; a) = A_1 \left(\frac{e}{1-e}\right)^{-e} \frac{a^{e-1}}{1-e} \quad (\text{A.7})$$

Next, the profit from being just at the VAT threshold for an  $a$ -type when constrained is

$$\pi(0; a) = s^* - \frac{1 + \Delta_c s^*}{a p} \quad (\text{A.8})$$

But solving for  $p$  from the constraint  $A_0 p^{1-e} = s^*$ , we get  $p = \left(\frac{s^*}{A_0}\right)^{-1/(e-1)}$ . Substituting this back into (A.8), and using  $a = a^* + \Delta a^*$ , we get

$$\pi(0; a^* + \Delta a^*) = s^* - \frac{1 + \Delta_c}{A_0^{1/(e-1)}(a^* + \Delta a^*)} (s^*)^{e/(e-1)} \quad (\text{A.9})$$

Also combining (A.6), evaluated at  $a = a^* + \Delta a^*$ , and (A.9), we get:

$$\begin{aligned} \pi(0; a^* + \Delta a^*) &= s^* - \frac{1 + \Delta_c}{A_0^{1/(e-1)}(a^* + \Delta a^*)} (s^*)^{e/(e-1)} \\ &= s^* - (s^*)^{e/(e-1)} \left(\frac{e-1}{e}\right) (s^* + \Delta s^*)^{1/(1-e)} \end{aligned} \quad (\text{A.10})$$

Again using (A.6), evaluated at  $a = a^* + \Delta a^*$ , in (A.7), we get:

$$\begin{aligned} \pi(1; a^* + \Delta a^*) &= A_1 \left(\frac{e}{1-e}\right)^{-e} \frac{1}{1-e} (a^* + \Delta a^*)^{e-1} \\ &= \frac{A_1}{A_0} \left(\frac{e}{1-e}\right)^{-e} \frac{1}{1-e} \left(\frac{e(1+\Delta_c)}{e-1}\right)^{e-1} (s^* + \Delta s^*) \\ &= \frac{T}{e} (s^* + \Delta s^*) \end{aligned} \quad (\text{A.11})$$

So, using (A.11), (A.10), the indifference condition  $\pi(1; a^* + \Delta a^*) = \pi_0(0; a^* + \Delta a^*)$  becomes

$$s^* - (s^*)^{e/(e-1)} \left(\frac{e-1}{e}\right) (s^* + \Delta s^*)^{1/(1-e)} - \frac{T}{e} (s^* + \Delta s^*) = 0 \quad (\text{A.12})$$

After some simplification of (A.12) (divide through by  $s^*$ , then  $1 + \frac{\Delta s^*}{s^*}$ , and multiply by  $e$ ) we get (21) as required.  $\square$

**Proof of Proposition 5.** First, (21) can be rewritten as

$$f(x, e) - T(\lambda, \omega, e) = 0, f(x) \equiv ex - (e-1)x^{e/(e-1)}, x = \frac{1}{(1 + \Delta s^*/s^*)} \quad (\text{A.13})$$

So, from (A.13):

$$\frac{dx}{d\lambda} = \frac{T_\lambda}{f_x}, \quad \frac{dx}{d\omega} = \frac{T_\omega}{f_x}, \quad \frac{dx}{de} = \frac{T_e - f_e}{f_x} \quad (\text{A.14})$$

Moreover, note that

$$f_x = e(1 - x^{1/(e-1)}) > 0 \quad (\text{A.15})$$

because  $x < 1$ , and  $e > 1$ , so  $x^{1/(e-1)} < 1$ . Also, we know that  $T_\lambda < 0$ ,  $T_\omega > 0$  and so from (A.14), (A.15), we conclude that  $\frac{dx}{d\lambda} < 0$ ,  $\frac{dx}{d\omega} > 0$ . As  $x$  is an inverse measure of bunching, it follows that as  $\lambda$  increases,  $\Delta s^*$  rises, and  $\omega$  rises,  $\Delta s^*$  falls.

Finally, from (A.14),

$$f_e = x - x^{e/(e-1)} - (e-1) \frac{d(x^{e/(e-1)})}{de} = x - x^{e/(e-1)} - \frac{\ln x}{e-1} x^{e/(e-1)}$$

So, for  $f_e > 0$ , we require

$$x^{-1/(e-1)} > 1 + \frac{\ln x}{e-1}$$

But as  $x < 1$ ,  $\ln x < 0$ , so we require  $x^{1/(e-1)} < 1$ , which certainly holds as  $x < 1$  and  $1/(e-1) > 0$ . So, we conclude that  $f_e > 0$ . It then follows from (A.14), (A.15), that  $\frac{dx}{de} < 0$  as long as  $T_e < 0$ . But then bunching increases if  $T_e < 0$ , as claimed.  $\square$

### The Elasticity of Value-Added

If  $\sigma = 0$ , a firm uses  $\frac{\omega}{a}$  units of the input per unit of output. So, the value added of a registered "small" firm is the value of output minus the value of inputs used i.e.;

$$VA = p_C x + p_B y - \frac{\omega}{a} (x + y)$$

Now assuming A1 and  $e_C = e_B$ , and using the mark-up expressions for prices, i.e.  $p_C = p_B = \frac{e}{e-1} \frac{1}{a}$ , the firm's value-added is

$$\begin{aligned} VA &= \frac{1}{a} \left( \frac{e}{e-1} - \omega \right) (x + y) \\ &\propto \lambda(1+t)^{-e} + (1-\lambda) \left( \frac{e-1}{e} \right)^e (1+t)^{-e} \end{aligned}$$

So, the elasticity of  $VA$  with respect to  $1+t$  is  $e$ , as claimed.

### Proof that Voluntary Registration is Not Possible in the de Paula and Scheinkman (2010) Model

We follow the notation of their paper. There are two kinds of firms, upstream firms, and downstream firms. An informal downstream firm is by definition, not registered for VAT, and get gets profit  $\pi_N = \max_{x \leq \bar{x}} \{\theta^d x^\alpha - p_i x\}$ , where  $x$  is sales,  $\bar{x}$  is the registration threshold, and  $p_i$  is the price of the input of bought from an upstream informal firm. If this firm registers, it gets profit  $\pi_R = \max_x \{(1-\tau)(\theta^d x^\alpha - p_f x)\}$ , where  $\tau$  is the rate of VAT, and  $p_f > p_i$  is the cost of buying from the formal sector. Voluntary registration involves registering at a turnover (say  $x_0 < \bar{x}$ ), giving profit  $(1-\tau)(\theta^d x_0^\alpha - p_f x_0)$ . But then, as  $\tau > 0$ ,  $p_f > p_i$ ;

$$\pi_R = (1-\tau)(\theta^d x_0^\alpha - p_f x_0) < \theta^d x_0^\alpha - p_f x_0 < \theta^d x_0^\alpha - p_i x_0 \leq \pi_N$$

so that the downstream firm can do better by not registering. Now consider an upstream firm in their model. This firm gets  $\pi_N = \min \theta_u, \bar{x}$  if not registered, and  $\pi_R = (1-\tau)\theta_u$  if registered. So, such a firm registers voluntarily iff  $\theta_u < \bar{x}$ . But, for such a firm,  $\pi_N = \theta_u > (1-\tau)\theta_u = \pi_R$ ; again, the downstream firm can do better by not registering.

## General Proof that Voluntary Registration is not Possible with Only B2C Sales

Consider a firm facing a residual demand function from final consumers of  $x(q)$ , where  $q$  is the consumer price. This covers both the cases of monopoly, where  $x(\cdot)$  is also the actual demand curve, and monopolistic competition, where  $x(\cdot)$  is demand for that firm's product, taking the prices of all other firms as fixed. Assume all sales are to final consumers i.e. B2C. If a firm is registered for VAT, profit is then

$$\pi_R(p) = px(p(1+t)) - c(x(p(1+t)), w, r)$$

where  $p$  is the producer price, and  $c(x, w, r)$  is the cost function given output  $x$ , and prices of labour and the intermediate input  $w, r$ . This is completely general cost function that includes the constant returns CES cost function in the paper as a special case. If the firm is not registered for VAT, profit is

$$\pi_N(p) = px(p) - c(x(p), w, r(1+t))$$

Then, we have

$$\begin{aligned} \pi_R &= \max_p \{px(p(1+t)) - c(x(p(1+t)), w, r)\} \\ &= \max_q \left\{ \frac{q}{1+t} x(q) - c(x(q), w, r) \right\} \\ &= \frac{1}{1+t} \max_q \{qx(q) - (1+t)c(x(q), w, r)\} \\ &< \max_q \{(q - c(x(q), w, r(1+t)))\} \\ &= \pi_N \end{aligned}$$

So, with only B2C sales, no firm would ever wish to register voluntarily.

## B Theoretical Framework with VAT Evasion

Here, we model the simplest and most common form of VAT evasion, under-reporting of sales. This has two aspects. First, a non-registered firm can hide a share of sales, for example by using cash transactions. It is widely believed that the VAT chain makes it more difficult to conceal sales to other registered businesses, so we will assume that only that a share  $\nu_N$  of B2C sales can be hidden. Then, sales can be as high as  $s^* + \nu_N px$  without registering for VAT.

We also allow registered sellers can use this strategy, albeit at a higher cost of detection. So, suppose that such a seller does not charge VAT on some proportion  $\nu_R$  of B2C sales  $px$ . The total cost of  $x$  units of the good to the household, if purchased from a registered seller, will be

$$\nu_R xp + (1 - \nu_R)xp(1+t) = xp(1 + (1 - \nu_R)t).$$

That is, the household faces an average price of  $p(1 + (1 - \nu_R)t)$ , and the firm continues to get revenue  $p$  on every unit sold to the household.

We will assume that  $\nu_N, \nu_R$  are exogenously fixed, both for simplicity, and also because there are some analytical issues in endogenizing them.<sup>42</sup> The main qualitative points will extend to the endogenous case.<sup>43</sup> We will assume that  $0 \leq \nu_R \leq \nu_N < 1$ , reflecting the fact that non-registered firms are less likely to be audited than registered ones.

It is then easily verified that for voluntary registration, the analysis proceeds much as before except that the VAT sufficient statistic becomes

$$T(\nu) = (1 - \Delta_d(\nu_R))(1 + \Delta_c)^{e-1}, \quad \Delta_d(\nu_R) = \frac{\lambda(1 - (1 + (1 - \nu_R)t)^{-e})}{\lambda + (1 - \lambda)A_B} \quad (\text{B.16})$$

Thus, with evasion, the output VAT effect depends on  $\nu_R$  and is smaller than without evasion i.e.  $\Delta_d(\nu_R) < \Delta_d(0)$ . This is intuitive; with some VAT evaded on sales, output VAT becomes less of a burden. It then follows that  $T$  is increasing in  $\nu_R$  i.e. voluntary registration is more likely, the greater the opportunities for evasion, as measured by  $\nu_R$ .

As regards bunching, evasion has two opposing effects. First, evasion relaxes the constraint imposed by the VAT threshold, as the tax authority only observes  $1 - \nu_N$  of B2C sales, and so the firm can in fact produce over the threshold without registering. Second, as just discussed, if  $\nu_R > 0$ , evasion makes registration less costly, because output VAT becomes less of a burden.

Both of these effects appear formally as follows. With evasion, we show below that the term  $T$  in the bunching equation (21) is replaced by

$$\hat{T}(\nu_N, \nu_R) = \frac{(1 - \nu_N)\lambda + (1 - \lambda)A_B}{\lambda + (1 - \lambda)A_B} T(\nu_R) \quad (\text{B.17})$$

and in particular, positive bunching will occur when  $\hat{T}(\nu_N, \nu_R)$  is less than 1.<sup>44</sup> An increase in  $\nu_N$  has the expected effect of lowering  $\hat{T}$  and thus increasing bunching, as a higher  $\nu_N$  makes it less costly for the firm to hold its observed sales under the threshold. An increase in  $\nu_R$  has the opposite effect of reducing bunching, via the fact that  $T(\nu_R)$  rises; this captures the effect that evasion reduces the burden of output VAT.

Note that, with evasion, the qualitative effects of  $\lambda$  and  $\omega$  on  $T$  do not change, and so our predictions about the determinants of voluntary registration do not change; this is clear by inspection from (B.16). This is also true of bunching; it is seen by inspection that  $\hat{T}$  is decreasing in  $\lambda$ , and increasing in  $\omega$ , as is  $T$ . So, our key empirical predictions are robust to the presence of evasion. We can summarize as follows:

**Proposition b.1** *An increase in evasion by non-registered firms,  $\nu_N$ , increases bunching. An increase in evasion by registered firms,  $\nu_R$ , raises the likelihood of voluntary registration*

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<sup>42</sup>For example, suppose that the registered firm chooses  $\nu_R$  to maximize profit minus evasion cost  $g(\nu_R)$ . It is easily verified that optimized profit is convex in  $\nu_R$ , as it only depends on  $\nu_R$  via the term  $(1 + t(1 - \nu_R))^{-e}$ , which is a convex function of  $\nu_R$ . So, to have an interior solution,  $g(\cdot)$  also has to be sufficiently convex in  $\nu_R$ . But then, a closed-form solution for  $\nu_R$  cannot be found.

<sup>43</sup>For example, suppose the cost of evasion is linear in  $\nu$ , up to a limit  $\bar{\nu} < 1$ . Then, as profit is convex in  $\nu$ , as explained in the previous footnote, and the evasion cost is small, the firm will always choose  $\bar{\nu}$ , so that it is effectively exogenous.

<sup>44</sup>For a formal proof, see below.

and reduces bunching. Moreover, evasion does not affect our qualitative predictions about the effects of  $\lambda$ , the fraction of B2C sales, and input-cost ratio,  $\omega$ , on voluntary registration and bunching.

### Derivation of the Bunching Equation with Evasion

The proof follows the proof of Proposition 4 in the paper, with the following changes. First, we define  $A_0$ ,  $A_1$  as

$$A_0(\nu) = \lambda(1 - \nu_N) + (1 - \lambda)A_B, \quad A_1(\nu) = \lambda(1 + (1 - \nu_R)t)^{-e} + (1 - \lambda)A_B$$

As in (A.2) in the paper, any firm that registers has maximized profit:

$$\pi(1; a) = A_1(\nu_R) \left( \frac{e}{1 - e} \right)^{-e} \frac{a^{e-1}}{1 - e} \quad (\text{B.18})$$

Next, the payoff from being on the VAT threshold for an  $a$ -type when constrained is now

$$\pi(0; a) = (s^* + \nu px) - \frac{1 + \Delta_c (s^* + \nu px)}{a} \frac{1}{p} \quad (\text{B.19})$$

This is because the firm can actually produce and sell  $s^* + \nu px$  with a threshold  $s^*$  because sales  $\nu px$  are "cash" and thus not observable by the tax authority. Solving for  $p$  from the definition that non-concealed sales must be equal to  $s^*$  i.e.  $((1 - \nu_N)\lambda + (1 - \lambda)A_B)p^{1-e} = s^*$ , we get:

$$p = \left( \frac{s^*}{(1 - \nu_N)\lambda + (1 - \lambda)A_B} \right)^{-1/(e-1)}$$

Combining this with the fact that  $x = \lambda p^{1-e}$ , we get

$$s^* + \nu px = s^* \frac{\lambda + (1 - \lambda)A_B}{(1 - \nu_N)\lambda + (1 - \lambda)A_B} \equiv \mu s^*$$

Substituting this back into (B.19), and setting  $a = a^* + \Delta a^*$ , we get

$$\pi(0; a^* + \Delta a^*) = \mu \left( s^* - \frac{1 + \Delta_c}{(A_0(\nu_N))^{1/(e-1)} (a^* + \Delta a^*)} (s^*)^{e/(e-1)} \right) \quad (\text{B.20})$$

Also observed non-cash sales map into type by

$$s^* + \Delta s^* = A_0(\nu_R) \left( \frac{e(1 + \Delta_c)}{e - 1} \right)^{1-e} (a^* + \Delta a^*)^{e-1} \quad (\text{B.21})$$

Combining (B.20) and (B.21), we get:

$$\begin{aligned}
\pi(0; a^* + \Delta a^*) &= \mu \left( s^* - \frac{1 + \Delta_c}{(A_0(v_N))^{1/(e-1)}(a^* + \Delta a^*)} (s^*)^{e/(e-1)} \right) \\
&= \mu \left( s^* - (1 + \Delta_c) (s^*)^{e/(e-1)} \left( \frac{e-1}{e(1 + \Delta_c)} \right) (s^* + \Delta s^*)^{1/(1-e)} \right) \\
&= \mu \left( s^* - (s^*)^{e/(e-1)} \left( \frac{A_0(v_R)}{A_0(v_N)} \right)^{1/(e-1)} \left( \frac{e-1}{e} \right) (s^* + \Delta s^*)^{1/(1-e)} \right)
\end{aligned} \tag{B.22}$$

Now using (B.21) in (B.18), we get:

$$\begin{aligned}
\pi(1; a^* + \Delta a^*) &= A_1(v_R) \left( \frac{e}{1-e} \right)^{-e} \frac{1}{1-e} (a^* + \Delta a^*)^{e-1} \\
&= \frac{A_1(v_R)}{A_0(v_R)} \left( \frac{e}{1-e} \right)^{-e} \frac{1}{1-e} \left( \frac{e(1 + \Delta_c)}{e-1} \right)^{e-1} (s^* + \Delta s^*) \\
&= \frac{A_1(v_R)(1 + \Delta_c)^{e-1} (s^* + \Delta s^*)}{A_0(v_R) e} \\
&= T(v_R) \frac{(s^* + \Delta s^*)}{e}
\end{aligned} \tag{B.23}$$

So, using (B.23),(B.24), the indifference condition  $\pi(1; a^* + \Delta a^*) = \pi_0(0; a^* + \Delta a^*)$  becomes

$$s^* - (s^*)^{e/(e-1)} \left( \frac{e-1}{e} \right) (s^* + \Delta s^*)^{1/(1-e)} - \frac{T(v_R)}{\mu} \frac{(s^* + \Delta s^*)}{e} = 0 \tag{B.25}$$

After some simplification of (B.25) (divide through by  $s^*$ , then  $1 + \frac{\Delta s^*}{s^*}$ , and multiply by  $e$ ) we get (21) in the paper with the tax term  $\frac{T(v_R)}{\mu}$  as required.  $\square$

## C Evidence of Bunching via Turnover Misreporting

In this section, we provide some suggestive evidence on the extent of bunching due to turnover misreporting. When bunching is due to a decrease in real output, we expect companies to reduce their input costs in proportion, so that the distribution of input-cost ratio for non-registered companies should be smooth around the VAT notch. When bunching is due to turnover misreporting, we conjecture that the non-registered companies are less likely to under-report their input costs and wage expenses. Both costs are deductible for corporation taxes and the latter is subject to third-party reporting. In other words, the gain from under-reporting the deductible costs is considerably smaller than the gain from under reporting the turnover to avoid VAT registration. If the majority of companies bunch via turnover misreporting, we would expect to see a higher average input-cost ratio for the non-registered group just below the VAT notch, relative to that for the registered group.

Figure A.1 pools all observations in the sample period and plots the distribution of average input-cost ratio for registered and non-registered companies in £1,000 turnover bins,

respectively. In Panel A, the input-cost ratio is salary exclusive and represents the share of direct cost of sales relative to total turnover. The solid blue line shows the average input cost relative to sales for registered companies within each turnover bin of £1,000 normalized by the current-year VAT notch, and the dashed blue line shows the average input cost ratio for the unregistered companies. Consistent with the theory, voluntary registers incur a much larger input cost as indicated by their average input-cost ratio which is consistently larger than that for the non-registered companies below the VAT notch. On the other hand, there is no evident increase in the average input-cost ratio just below the VAT notch for the non-registered group. The distribution is relatively smooth and continues to increase with turnover above the VAT notch.

In comparison, Panel B plots the distribution of average input-cost ratio *inclusive* of salary, for registered and non-registered companies, respectively. There is striking difference between the two input-cost ratio series just below the VAT notch. The two series move in parallel directions until the average input-cost ratio for the non-registered companies starts to increase drastically just below the VAT notch. The sharp increase in the salary-inclusive cost ratio can be partly attributed to the fixed nature of salary cost which takes longer to adjust than variable costs of input. On the other hand, the sharp increase is also consistent with the fact that salary is subject to third-party reporting and thus it is more costly/difficult for small businesses to underreport salary expenses. Overall, Panel A and B in Figure A.1 provide suggestive yet not conclusive evidence that part of bunching is due to turnover misreporting.

## D Dynamic Regressions of Voluntary Registration

In this section, we investigate the importance of inertia in driving VAT registration by analyzing the dynamic behavior of firms when they cross the registration and deregistration thresholds. First, we compute a transition probability matrix for firms changing their registration states in Table A.1, which shows the probability of being registered or not registered  $t$  years after initially being in a given state.<sup>45</sup> For example, the entry in the first cell of the matrix, 89.3%, shows that of all the firms that were initially registered in 2004/05, 89.3% remain registered a year later.

Table A.1 shows that there is considerable persistence in registration status. On the other hand, comparing to the registered firms, this persistence does decline substantially over time for non-registered firms. For example, only 88% of initially non-registered firms remain unregistered after 5 years, whereas 97% of registered firms remain registered after 5 years. The difference in persistence is due to the fact that the majority of firms are growing over our sample, and so will tend to stay above the registration threshold once they cross it.

Next, we investigate to what extent the registration decision is driven by persistence in turnover versus the costs of changing registration status. To answer this question, we

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<sup>45</sup>Changes in the transition probability could also be driven by attrition, therefore we focus on a balanced sample of firms that we observe throughout the sample period.

augment equation (22) as follows:

$$R_{it} = \gamma_0 + \gamma_1 R_{i,t-1} + \gamma_2 (1 - R_{i,t-1}) IR_{it} + \gamma_3 R_{i,t-1} ID_{it} + \gamma_4 B2C_{it}^j + \gamma_5 ICR_{it} + \gamma_6 L_{it}^j + \gamma_7 D_{it} + \rho_t + \phi_i + \nu_{it} \quad (\text{D.26})$$

where  $R_{it}$  is a dummy indicator that takes value 1 if the firm is currently registered and zero otherwise, as defined previously in Section 6.1. In addition,

$$IR_{it} = \begin{cases} 1, & Y_{it} \geq Z_t \\ 0, & Y_{it} < Z_t \end{cases}, \quad ID_{it} = \begin{cases} 1, & Y_{it} \geq Z'_t \\ 0, & Y_{it} < Z'_t \end{cases},$$

where  $Z_t, Z'_t$  are the registration and deregistration thresholds at time  $t$ ,  $Y_{it}$  denotes the current-period turnover, so  $IR_{it}$  and  $ID_{it}$  are dummy indicators recording whether the firm is above the registration and deregistration thresholds respectively at time  $t$ . All the other variables are defined as before, and  $\nu_{it}$  is the error term. We estimate equation (D.26) in a fixed-effect Probit model, and augment the estimation equation with the initial registration status  $R_{i0}$  and the mean characteristics of all the time-varying regressors (Wooldridge, 2005).

So, if firm registration decision was entirely backward-looking and ignores its current turnover relative to  $Z_t, Z'_t$ , we would expect the coefficients  $\gamma_2$  to  $\gamma_5$  to be insignificant. However, we expect most firms to comply with the VAT law. Specifically, we expect firms to register when they are initially not registered and their turnover passes above the threshold. Such a firm has a value 1 for the term  $(1 - R_{i,t-1})IR_{it}$  and so we expect to find a positive  $\gamma_2$ .

The VAT legislation also requires firms to stay registered if they are registered in the previous year and their current turnover is above the deregistration threshold. Such a firm will have a value of 1 for  $R_{i,t-1}ID_{it}$ . So, we also expect to find that  $\gamma_3 > 0$ . On the other hand, if the firm remains registered simply due to the cost of deregistration such that whether crossing the deregistration threshold plays no role in the registration behavior, we would expect to find that  $\gamma_3 = 0$ .

Finally, we already know from our analysis of voluntary registration that the registration decision is significantly affected by the industry B2C ratio  $B2C_{it}^j$ , the firm input cost ratio  $ICR_{it}$ , and the industry-level Lerner index  $L_{it}^j$ , so we expect  $\gamma_4, \gamma_5$  and  $\gamma_6$  to be positive.

Table A.2 reports the full results from estimating equation (D.26) using a fixed-effects Probit model, following Wooldridge (2005). For ease of interpretation, Table A.3 reports the relevant average partial effects, which refer to the effect on the mean probability of registration after averaging the unobserved heterogeneity across all firms in the sample. For example, to calculate the APE of a discrete change of  $ID$  from 0 to 1, we first compute the average predicted probability of registration at fixed values of  $R_{t-1} = 1, ID_t = 0$  and  $R_{t-1} = 1, ID_t = 1$ , respectively, across all firms in the sample. We then take the difference between the two average probabilities to obtain the average partial effect of  $ID$ . We use a similar procedure to compute the average partial effect of a one-standard-deviation increase in  $B2C_{it}^j, ICR_{it}$ , and  $L_{it}^j$ , noting that the one-standard-deviation increase applies to their mean characteristics in addition to the time-varying values. Column (1) shows the mean predicted probability of VAT registration at fixed value of  $R_{t-1}, ID_t, IR_t$ , the mean predicted probability across all firms in the sample and that for one-standard-deviation increase

in  $B2C_{it}^j$ ,  $ICR_{it}$ , and  $L_{it}^j$ . Column (2) shows the average partial effects of these variables by taking the difference in the mean predicted probabilities given the change in their value. For example, for firms that are registered in the previous year, falling below the deregistration threshold lowers the probability of being currently registered by 5 percentage points. Alternatively, for firms that are not registered in the previous year, going above the registration threshold increases their probability of registration by 70.4 percentage points. These findings suggest that the registration decision is not entirely driven by the cost of deregistration or inertia.

Finally, the short-run partial effects of the share of B2C sales and the input cost ratio in the dynamic model are considerably smaller than the static estimates in section 6.1. A one standard deviation increase in the B2C ratio and the Lerner index reduces the probability of registration by 0.1 and 0.25 percentage points, respectively, and there is no significant change in the probability of registration for one standard deviation increase in the input cost ratio.

Overall, we see that while there is a considerable amount of persistence in firm behavior, the registration decision is not entirely driven by inertia due to fixed cost of deregistration. Firms respect the legal registration requirement, and at the same time change their registration decisions in a way that is consistent with profit maximization behavior depicted in Section 3. The probability of registration is also affected significantly by the more fundamental determinants of VAT registration. The positive coefficient estimates and partial effects of  $R_{it-1}ID_{it}$ , the B2C ratio and the input-cost ratio provides supportive evidence that the VAT registration decision is rational and relates to the fundamental determinants of VAT registration as predicted by the theory in Section 4.

## Appendix Tables

Table A.1. Transition Matrix of VAT Registration Status

|                     | $R_t = 1$<br>$ID_t = 1$<br>(1) | $R_t = 1$<br>$ID_t = 0$<br>(2) | $R_t = 0$<br>$IR_t = 1$<br>(3) | $R_t = 0$<br>$IR_t = 0$<br>(4) |
|---------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| $t = 1$             |                                |                                |                                |                                |
| $R_0 = 1, ID_0 = 1$ | 89.34%                         | 10.61%                         | 0.03%                          | 0.02%                          |
| $R_0 = 1, ID_0 = 0$ | 20.50%                         | 79.30%                         | 0.01%                          | 0.19%                          |
| $R_0 = 0, IR_0 = 1$ | 4.18%                          | 1.14%                          | 78.46%                         | 16.22%                         |
| $R_0 = 0, IR_0 = 0$ | 1.45%                          | 1.59%                          | 6.15%                          | 90.80%                         |
| $t = 2$             |                                |                                |                                |                                |
| $R_0 = 1, ID_0 = 1$ | 85.35%                         | 14.45%                         | 0.07%                          | 0.12%                          |
| $R_0 = 1, ID_0 = 0$ | 25.49%                         | 73.55%                         | 0.03%                          | 0.93%                          |
| $R_0 = 0, IR_0 = 1$ | 6.30%                          | 1.63%                          | 71.25%                         | 20.82%                         |
| $R_0 = 0, IR_0 = 0$ | 3.23%                          | 2.71%                          | 7.22%                          | 86.83%                         |
| $t = 3$             |                                |                                |                                |                                |
| $R_0 = 1, ID_0 = 1$ | 81.30%                         | 18.03%                         | 0.13%                          | 0.54%                          |
| $R_0 = 1, ID_0 = 0$ | 26.71%                         | 71.35%                         | 0.07%                          | 1.88%                          |
| $R_0 = 0, IR_0 = 1$ | 8.03%                          | 2.19%                          | 65.21%                         | 24.58%                         |
| $R_0 = 0, IR_0 = 0$ | 4.85%                          | 4.02%                          | 6.90%                          | 84.23%                         |
| $t = 4$             |                                |                                |                                |                                |
| $R_0 = 1, ID_0 = 1$ | 76.14%                         | 21.71%                         | 0.55%                          | 1.60%                          |
| $R_0 = 1, ID_0 = 0$ | 26.34%                         | 68.85%                         | 0.32%                          | 4.48%                          |
| $R_0 = 0, IR_0 = 1$ | 7.67%                          | 3.13%                          | 59.76%                         | 29.44%                         |
| $R_0 = 0, IR_0 = 0$ | 5.65%                          | 4.82%                          | 5.99%                          | 83.55%                         |
| $t = 5$             |                                |                                |                                |                                |
| $R_0 = 1, ID_0 = 1$ | 67.61%                         | 29.57%                         | 0.32%                          | 2.50%                          |
| $R_0 = 1, ID_0 = 0$ | 22.50%                         | 72.21%                         | 0.18%                          | 5.11%                          |
| $R_0 = 0, IR_0 = 1$ | 7.34%                          | 4.60%                          | 52.71%                         | 35.35%                         |
| $R_0 = 0, IR_0 = 0$ | 5.37%                          | 6.14%                          | 5.34%                          | 83.15%                         |

*Notes:* this table shows in each cell the probability of changing from registration status in year  $t$  to year  $t + 1$ .

Table A.2. Determinants of VAT Voluntary Registration: Probit Model

|                               | (1)                  | (2)                  | (3)                  | (4)                  | (5)                  | (6)                  | (7)                  | (8)                  | (9)                  |
|-------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Lagged Registration (Rt-1)    | 3.436***<br>(0.030)  | 3.048***<br>(0.032)  | 3.780***<br>(0.023)  | 3.436***<br>(0.026)  | 3.400***<br>(0.027)  | 3.400***<br>(0.027)  | 3.394***<br>(0.027)  | 3.392***<br>(0.027)  | 3.390***<br>(0.027)  |
| Initial Reg Status (R0)       | 1.387***<br>(0.083)  | 1.474***<br>(0.080)  | 0.551***<br>(0.023)  | 0.670***<br>(0.053)  | 0.939***<br>(0.057)  | 0.943***<br>(0.057)  | 0.976***<br>(0.058)  | 0.941***<br>(0.057)  | 0.965***<br>(0.057)  |
| R*ID                          |                      | 1.804***<br>(0.052)  |                      | 1.519***<br>(0.044)  | 0.825***<br>(0.048)  | 0.823***<br>(0.048)  | 0.830***<br>(0.048)  | 0.825***<br>(0.048)  | 0.818***<br>(0.048)  |
| (1-R)*IR                      |                      |                      | 4.931***<br>(0.158)  | 5.066***<br>(0.172)  | 4.622***<br>(0.183)  | 4.618***<br>(0.182)  | 4.644***<br>(0.184)  | 4.604***<br>(0.181)  | 4.617***<br>(0.183)  |
| Distance to Threshold         |                      |                      |                      |                      | -0.015***<br>(0.000) | -0.015***<br>(0.000) | -0.016***<br>(0.001) | -0.015***<br>(0.000) | -0.016***<br>(0.001) |
| Average Distance to Threshold |                      |                      |                      |                      | 0.003***<br>(0.000)  | 0.003***<br>(0.000)  | 0.004***<br>(0.000)  | 0.003***<br>(0.000)  | 0.004***<br>(0.000)  |
| Share of B2C Sales            |                      |                      |                      |                      |                      | 0.405***<br>(0.086)  |                      |                      | 0.371***<br>(0.088)  |
| Average Share of B2C Sales    |                      |                      |                      |                      |                      | -0.739***<br>(0.089) |                      |                      | -0.453***<br>(0.094) |
| Input-Cost Ratio              |                      |                      |                      |                      |                      |                      | 0.284***<br>(0.045)  |                      | 0.270***<br>(0.045)  |
| Average Input-Cost Ratio      |                      |                      |                      |                      |                      |                      | -0.451***<br>(0.051) |                      | -0.283***<br>(0.052) |
| Lerner Index                  |                      |                      |                      |                      |                      |                      |                      | -0.322<br>(0.498)    | -0.201<br>(0.506)    |
| Average Lerner Index          |                      |                      |                      |                      |                      |                      |                      | -0.787<br>(0.514)    | -0.722<br>(0.529)    |
| Constant                      | -2.162***<br>(0.031) | -2.194***<br>(0.031) | -2.057***<br>(0.012) | -2.091***<br>(0.025) | -1.728***<br>(0.024) | -1.575***<br>(0.025) | -1.627***<br>(0.028) | -0.882***<br>(0.051) | -0.982***<br>(0.060) |
| $\ln \sigma_u$                | -0.849***<br>(0.103) | -0.694***<br>(0.091) | -1.745***<br>(3.860) | -2.893***<br>(0.439) | -1.838***<br>(0.180) | -1.827***<br>(0.178) | -1.769***<br>(0.171) | -1.844***<br>(0.180) | -1.782***<br>(0.172) |
| Observations                  | 399,816              | 399,816              | 399,816              | 399,816              | 399,816              | 399,816              | 399,816              | 399,816              | 399,816              |
| Chi-sq stat B2C               |                      |                      |                      |                      |                      | 186.765              |                      |                      | 6.029                |
| Chi-sq p-val B2C              |                      |                      |                      |                      |                      | 0.000                |                      |                      | 0.010                |
| Chi-sq stat Cost Ratio        |                      |                      |                      |                      |                      |                      | 37.972               |                      | 0.186                |
| Chi-sq p-val Cost Ratio       |                      |                      |                      |                      |                      |                      | 0.000                |                      | 0.666                |
| Chi-sq stat Lerner            |                      |                      |                      |                      |                      |                      |                      | 285.344              | 101.096              |
| Chi-sq p-val Lerner           |                      |                      |                      |                      |                      |                      |                      | 0.000                | 0.000                |
| Year FE                       | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  | Yes                  |
| Firm-FE                       | No                   | No                   | No                   | No                   | No                   | No                   | No                   | No                   | No                   |
| Cost Ratio Source             | CT600                | CT600                | CT600                | CT600                | CT600                | CT600                | CT600                | CT600                | CT600                |

Notes: this table presents the coefficient estimates from the dynamic estimation of VAT registration in equation (D.26) in a fixed-effect Probit model.

Table A.3. Determinants of VAT Voluntary Registration: Average Partial Effects

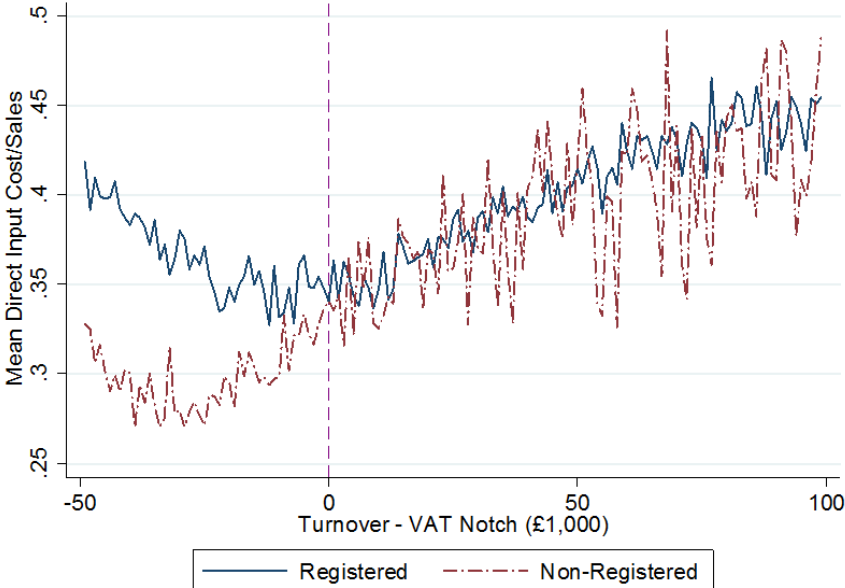
| Evaluated at:              |            | Mean $\Pr(\widehat{R}_t = 1)$ | Average Partial Effect |
|----------------------------|------------|-------------------------------|------------------------|
|                            |            | (1)                           | (2)                    |
| $R_{t-1} = 1$              | $ID_t = 1$ | 0.984                         |                        |
| $R_{t-1} = 1$              | $ID_t = 0$ | 0.934                         | 0.050***               |
| $R_{t-1} = 0$              | $IR_t = 1$ | 0.993                         |                        |
| $R_{t-1} = 0$              | $IR_t = 0$ | 0.289                         | 0.704***               |
| Average in the sample:     |            | 0.646                         |                        |
| $B2C + \sigma_{B2C}$       |            | 0.645                         | -0.001**               |
| $ICR + \sigma_{ICR}$       |            | 0.646                         | 0.000                  |
| $Lerner + \sigma_{Lerner}$ |            | 0.620                         | -0.025***              |

*Notes:* this table presents the partial effects of the key variables of interest from the dynamic estimation of VAT registration in equation (D.26). The partial effects are based on the coefficient estimates reported in column 9 of Table A.2.

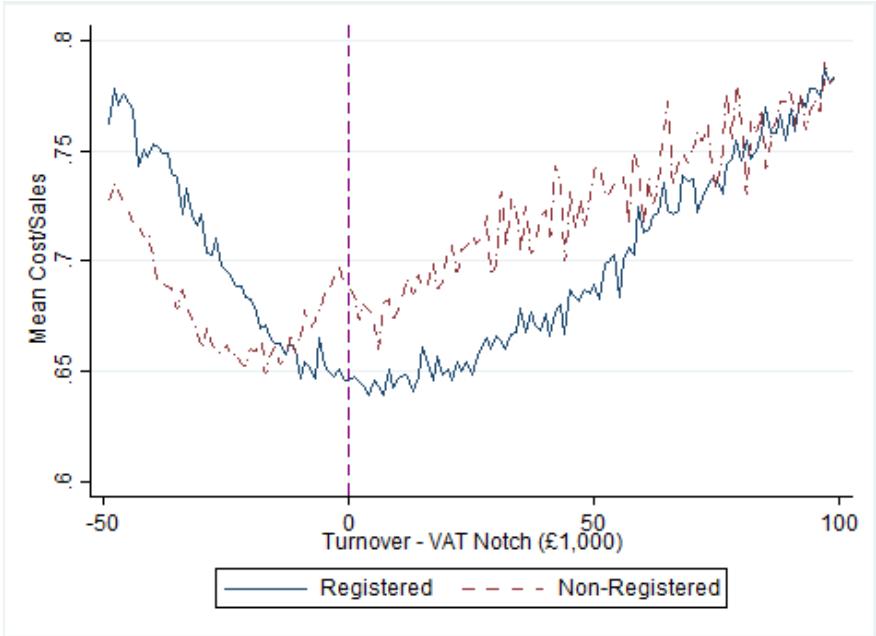
# Appendix Figures

Figure A.1. Bunching via Turnover Misreporting

(a) Distribution of Direct Input-Cost Ratio



(b) Distribution of Salary-Inclusive Cost Ratio



Notes: the figure plots separately the average input cost ratio for registered and non-registered firms with a turnover in the neighborhood of normalized VAT notch during 2004/05-2009/10. Panel A uses the input cost ratio calculated from FAME and exclude the salary expenses. Panel B uses the input cost ratio calculated from the corporation tax records and includes salary expenses in the overall cost.