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The investment effect of taxation: evidence from a corporate tax kink

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Abstract

This paper exploits bunching of firms at a tax kink as quasi-experimental variation to identify the effect of a tax rate change on investment, and explore how this effect interacts with variation in capital depreciation rates. The idea is that firms with a taxable income slightly above the kink have an incentive to reduce their income to bunch at the kink, and increasing investment is one possible strategy for that. This means that bunching of firms should be accompanied by a spike in investment at the kink. Building on the standard bunching framework, I estimate the frequency distribution of firms around the kink, and the share of bunchers with excess investments at the extensive and intensive margin.

I apply this approach to administrative tax return data for the universe of UK firms from 2001-2007, and show that investment by small firms significantly responds to a tax rate change. I find large and significant spikes in the share of capital investors and median capital costs at the 10k kink. The spikes are larger in 2002-2005 when the kink is larger, and for quickly depreciating capital items, which yield larger tax reductions. I estimate that extensive margin investments explain 7.7-19.2% of bunching and intensive margin investments explain 4.3-16.8% of bunching. Evidence from subsample analysis supports the interpretation of the observed behaviour as real investment rather than evasion or avoidance.

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1 Introduction

The impact of tax policy on corporate investment continues to be debated among economists and policymakers. As the corporate income tax is not a tax on pure profits,[1] theory predicts that the tax rate and depreciation allowance schedule should affect firms' investment decisions. A reduction in the tax rate would increase the after-tax return to investment, while an increase in capital depreciation rates would reduce the cost of investment. As investment is much more volatile than other macroeconomic variables and has important multiplier effects on the economy, policymakers have frequently tried to stimulate investment through tax incentives. The 1981 introduction of the investment tax credit by Reagan, the 2002 US bonus depreciation policy,[2] and the zero starting rate for firms with a taxable income below £10k in the UK, in place during 2002-2005, are just a few examples of such stimulus policies.

While the use of investment tax incentives abounds, it is empirically difficult to demonstrate a positive causal effect of tax policy on investment. The line of causality between investment and tax policy runs both ways, as tax reforms are often motivated by sluggish investment, and a host of other macroeconomic variables affects both tax policy and investment. The literature so far has shown that the Hall-Jorgenson *user cost of capital* has a large impact on investment[3], but this estimate confounds the effects of different tax policy parameters, namely the tax rate and capital depreciation allowance. Work attempting to disentangle these effects by examining specific tax parameter changes, such as the bonus depreciation policy found only weak evidence for tax incentive effects (e.g. Cohen & Cummins 2006, House & Shapiro 2008).

This paper exploits bunching of firms at a kink point, a taxable income threshold at which the marginal tax rate changes discontinuously, as quasi-experimental variation. This allows me to identify the effect of a tax rate change on investment, and to explore how this effect interacts with variation in capital depreciation rates. The idea is that firms with a taxable income slightly above the kink have an incentive to reduce their income to bunch at the kink, and increasing investment is one possible strategy for that. Investment translates into capital depreciation allowances, which are deducted from taxable income and can measure up to 100% of the underlying expenditure in the year of purchase, depending on the capital type. If firms move to the kink by increasing investment, bunching should be accompanied by a spike in investment at the kink. My estimation builds on

[1] For the multiple reasons why the corporate income tax is not a tax on pure profits, see Auerbach *et al.* (2010) and Hassett & Hubbard (2002).

[2] Temporary increase in capital depreciation rates.

[3] See Hassett & Hubbard (2002) for a review.

the bunching approach of estimating the elasticity of taxable income (ETI), as developed by Saez (2010) and applied to corporations by Bach (2012) and Devereux *et al.* (2013). In addition to the frequency distribution of firms, I estimate the size of the *investment spike*, i.e. the number of firms with higher than predicted investment levels around the kink. I consider the size of the investment spike at both the extensive margin (share of capital investors) and the intensive margin (median capital costs for investors). This allows me to derive the number of *investment bunchers*, bunchers that moved to the kink inter alia by investing.

I apply this approach to study the investment effect of taxation in the UK, a setting which presents two methodological advantages. First, the UK tax schedule provides a compelling source of variation for my study, featuring a large and salient kink at 10k of taxable income during 2001-2005. The size of the tax rate jump at this kink varies over time from 12.5 to 23.75 percentage points, creating stronger incentives to bunch at the kink in years with a larger tax rate jump. In addition, variation in capital depreciation rates across capital types creates variation in the suitability of different capital investments as instruments for bunching, with investments yielding larger allowances in the year of purchase more suitable for bunching. Combining these two types of variation allows me to distinguish bunching-induced variation in investment around the 10k kink from any other changes in investment that occur around the kink. The second advantage of the UK setting is the availability of administrative tax return data, which covers the universe of UK firms for 2001-2007, and contains precise measures of investment-induced taxable income reductions (capital depreciation allowances).

My empirical findings show that investment by small firms significantly responds to a tax rate change. First, I find large and statistically significant spikes in the share of capital investors and median capital costs at the 10k kink. Consistent with the idea of bunching through investment, the spikes are larger in 2002-2005 when the kink is larger, and also larger for quickly depreciating capital items, which yield larger tax reductions. Second, I quantify the contribution of this investment behaviour to bunching, and find that extensive margin investments explain 7.7-19.2% of bunching and intensive margin investments explain 4.3-16.8% of bunching. Third, I provide evidence supporting the interpretation of the observed behaviour as real investment rather than evasion (over-reporting) or avoidance (transfer pricing, income shifting). The bunching response to the kink is stronger in subsamples characterized by high investment propensity (growing firms, manufacturing and retail sector firms, high cost-margin firms), and weaker in subsamples characterized by high ease of evasion (firms with below median turnover and number of employees). The scope to engage in avoidance schemes like cost manipulation through transfer pricing or shifting income to international tax havens is extremely limited for firms with a taxable income around 10k, as less than 3% of them are members of a group or register any overseas income.

This paper contributes to several strands of literature. First, my paper relates to the large literature estimating Hall-Jorgenson style user cost of capital models. This literature either relies on tax reforms as instruments for user cost of capital changes in a generalized methods of moments estimation (Cummins *et al.* 1994; Cummins *et al.* 1996), or compares forecast errors in investment and the user cost of capital (Auerbach & Hassett 1991). My work echoes this literature's findings of a significant effect of tax policy on investment, but presents two methodological advantages. Contrary to previous studies, which confound the effect of different tax policy parameters, my quasi-experimental design allows me to isolate the effect of a tax rate change, and to explore its interaction with capital allowance rates. In addition, my study uses administrative tax return data, which is more accurately measured than the accounting data used in previous studies, is available for a larger sample of firms, and provides direct measures of capital depreciation allowances claimed.

Second, my work is related to the more recent literature examining the effect of the bonus depreciation policy, using difference-in-difference-type strategies (Cohen & Cummins 2006) or a structural approach (House & Shapiro 2008; Auerbach *et al.* 2008). Contrary to this literature, which remains divided on the stimulating effect of the policy, I provide clear evidence for a positive effect of a tax rate decrease, and show that capital depreciation rates matter for the composition of capital investment.

Third, this paper builds on the use of bunching at kink points to estimate the ETI, an approach developed by Saez (2010), Chetty *et al.* (2011) and Kleven & Waseem (2013), and applied to firms by Bach (2012), Devereux *et al.* (2013) and Best *et al.* (2013). I show how estimating the distribution of taxable income *components* such as investment provides information on the underlying drivers of bunching. This empirical approach is not confined to estimating investment responses only, but can also be used more generally to decompose the response to taxation in contexts with kinked tax schedules.

Finally, my paper contributes to research on the decomposition of taxable income changes, providing the first empirical evidence of real responses by firms. Gordon & Slemrod (2000), Saez (2004) and Devereux *et al.* (2013) find evidence that changes in corporate profit margins in the UK and US are partly due to tax-rate induced income shifting from the corporate to the personal tax base. Almunia & Lopez-Rodriguez (2012) and Seim (2012) argue that responses of Spanish firms to an enforcement notch, and of Swedish personal taxpayers to a wealth tax kink are entirely driven by reporting effects. Similarly, Best *et al.* (2013) show that bunching at the minimum tax kink in Pakistan must be largely driven by evasion. This paper is the first to provide well-identified evidence of a real investment response to taxation.

The paper is organized as follows. Section 2 develops the empirical strategy. Section 3 introduces the context and data. Section 4 presents the empirical results. Section 5 concludes.

2 Empirical Strategy

This section presents a novel empirical strategy for investigating firms' response to taxation. Section 2.1 reviews how bunching at kink points is used to estimate the ETI. Section 2.2 shows that examining the distribution of investment around tax kinks helps to identify the response of investment to a tax rate change.

2.1 Estimating Bunching

As proposed by Saez (2010), I use bunching in the distribution of taxable income around a kink point in the tax schedule to estimate the ETI. Panel A of Figure I illustrates this idea. With a constant marginal tax rate τ_1 and no kink, taxable income π follows a smooth frequency distribution (red dashed line). Now consider the introduction of a higher marginal tax rate τ_2 for profits above some threshold $\pi^\star$ (marked by a black solid line). Assume that firms have a convex cost function (or a concave production function) and maximize after-tax profits. With the new tax regime, all firms with $\pi > \pi^\star$ reoptimize and move to a lower profit level. Firms in some interval $[\pi^\star, \pi^\star + \Delta\pi^\star]$ will no longer find it profitable to produce $\pi > \pi^\star$ and thus move to the kink (black solid line). The new distribution of profits (blue solid line) has a spike at $\pi^\star$ and a lower frequency for $\pi > \pi^\star$.

As the excess mass at the kink must equal the (shaded) area below the distribution from which bunchers move to the kink, the excess mass indicates the income change $\Delta\pi^\star$ of the marginal buncher. To see how this translates into an estimate of the ETI, abstract from income effects by assuming that the jump in the marginal tax rate is small, and consider that the compensated elasticity of taxable income π with respect the tax rate τ is

$$\epsilon = \frac{d\pi^\star}{\pi^\star}\frac{(1-\tau)}{d\tau}. \tag{1}$$

Assuming furthermore that the frequency distribution $f(\pi)$ is uniform around the kink, the number of bunchers is

$$B = d\pi^\star f(\pi^\star). \tag{2}$$

Transforming B into an estimate of the excess mass b through $b(\tau_1, \tau_2) = B/f(\pi^\star)$, we can thus approximate[4] ϵ as

$$\epsilon \simeq \frac{b(\tau_1, \tau_2)}{\pi^\star \cdot log\frac{1-\tau_1}{1-\tau_2}}. \tag{3}$$

To implement the estimation empirically, I follow the strategy developed by Chetty *et al.* (2011) and Kleven & Waseem (2013), as illustrated in Panel B of Figure I. The figure shows the empirical frequency (blue curly line) which, due to optimization frictions, does not feature a precise spike but rather diffuse bunching around the kink. I estimate a counterfactual frequency (red solid line) by fitting a q-order polynomial to the frequency counts f_j of firms with a taxble income in bin π_j, excluding an interval $[\pi_L, \pi_U]$ around the kink point (marked by black dashed lines):

$$f_j = \sum_{l=0}^{q} \beta_l(\pi_j)^l + \sum_{k=\pi_L}^{\pi_U} \gamma_k \cdot \mathbf{1}[\pi_j = k] + \sum_{r \in R}[\rho_r + \mu_r \cdot \pi_j] \cdot \mathbf{1}[\frac{\pi_j}{r} \in N] + v_j. \tag{4}$$

The γ_k coefficients allow for different frequencies in the excluded range. As the empirical frequency displays strong round number bunching at low income levels, I control for round number bunching at multiples of $R = \{5k, 10k\}$, and allow these round number effects to change linearly with income. The last term in the equation, v_j, is the error. I account for the fact that bunchers move to the kink from the right by implementing an integration constraint, shifting the counterfactual distribution to the right of the kink upwards, until the area under the counterfactual integrates to the area under the empirical distribution. My empirical specification follows Devereux *et al.* (2013) in that it relies on taxable income bins of £100, a fifth-order polynomial, and an excluded range of $[8k; 12k]$.[5]

The number of bunchers is calculated as the difference between the observed frequency and the predicted frequency $\hat{f}_k$ of equation (4), ignoring the contribution of the γ_k coefficients for the excluded range:

$$B = \sum_{k=\pi_L}^{\pi_U} (f_k - \hat{f}_k). \tag{5}$$

This can be translated into the excess mass b and the elasticity ϵ, by scaling B by the average predicted frequency in the N_k excluded bins:

$$b = \frac{\sum_{k=\pi_L}^{\pi_U} (f_k - \hat{f}_k)}{\sum_{k=\pi_L}^{\pi_U} \hat{f}_k / N_k}. \tag{6}$$

[4]Saez (2010) shows that this approximation also applies to the general case in which the tax rate change at the kink is not small, if one assumes a quasi-linear utility (production) function, so that the compensated and uncompensated elasticities are the same.

[5]See Devereux *et al.* (2013) for robustness checks with different specifications. All estimations rely on a $[3k, 40k]$ estimation range, but the figures in section 4 zoom in on the $[3k, 30k]$ range around the kink.

All standard errors are derived from a bootstrap procedure, which samples from the estimated residuals with replacement.

2.2 Estimating Investment Bunching

This section supplements the bunching framework with an analysis of investment changes, to quantify their contribution to bunching. Investment in capital items is measured by capital depreciation allowances, which capture the extent to which investment reduces taxable income. If firms reduce their taxable income by increasing investment, bunching should be accompanied by an *investment spike* around the kink. The size of the observed spike, combined with the underlying distribution of investment, is used to estimate the number of *investment bunchers*, firms which moved to the kink by increasing their level of investment. The approach is applied to extensive and intensive margin changes in investment in sections 2.2.1 and 2.2.2 respectively.

2.2.1 Extensive Investment Bunching

To detect extensive investment bunching, I investigate whether firms that would not otherwise invest make capital investments to move to the kink. I plot the share s_j of investors, i.e. firms in income bin π_j that report capital depreciation allowance $c_g > 0$ for some capital item g. This plot is illustrated in Panel A of Figure II (blue curly line). In the absence of the kink, the share of investors evolves smoothly as a function of taxable income. Once a kink is introduced, firms intending to bunch start investing in new capital items, move to the kink, and the share of investors spikes at the kink.

To estimate the counterfactual share of investors (red solid line), I fit a q-order polynomial to the share of investors s_j in income bin π_j, excluding bins in an interval $[\pi_L, \pi_U]$ around the kink:

$$s_j = \delta_{01}^E \cdot \mathbf{1}[\pi_j < \pi^\star] + \delta_{02}^E \cdot \mathbf{1}[\pi_j \geqslant \pi^\star] + \sum_{l=1}^{q} \delta_l^E (\pi_j)^l + \sum_{k=\pi_L}^{\pi_U} \theta_k^E \cdot \mathbf{1}[\pi_j = k] + u_j^E. \tag{7}$$

The superscript E denotes the extensive margin, u_j is the error term. The empirical specification (bin size, order of polynomial, excluded range) is as in section 2.1. The only distinction is that this specification allows for different constants above and below the kink. Indeed, in the UK tax system, firms with a gross income below the 10k kink face a 0% tax rate in 2002-2005 and thus have no incentive to claim capital depreciation allowances. The observed share of firms claiming capital allowances is lower below the kink and discontinuously jumps up at the kink.[6]

The number of *extensive investment bunchers* is estimated as the excess number of investors in

[6]Round number investment spikes are controlled for by the control procedure presented in section 4.2.

the bunching range:

$$M^E = \sum_{k=\pi_L}^{\pi_U} (s_k - \hat{s}_k) \cdot f_k, \tag{8}$$

where the counterfactual share of investors is the predicted value from equation (7), ignoring the $\hat{\theta}_k^E$coefficients for the excluded range,

$$\hat{s}_j = \hat{\delta}_{01}^E \cdot \mathbf{1}[\pi_j < \pi^\star] + \hat{\delta}_{02}^E \cdot \mathbf{1}[\pi_j \geqslant \pi^\star] + \sum_{l=1}^{q} \hat{\delta}_l^E (\pi_j)^l. \tag{9}$$

The contribution of extensive investment changes to bunching, and thus to the ETI, is defined as the share of extensive investment bunchers in the total number of bunchers:

$$Cont^E = \frac{M^E}{B}. \tag{10}$$

2.2.2 Intensive Investment Bunching

To detect intensive investment bunching, I investigate whether firms move to the kink by increasing the size of their investment. I consider only investors and base my analysis on the median cost (capital depreciation allowance) C_j of firms in income bin π_j. This choices warrents some explanation. First, I examine the median rather than the mean cost, as the latter is much more noisy and influenced by outliers. Second, I consider only investors, as the share of non-investors is above 90% for most capital items. Examining intensive investments in the full sample would thus require using not the median but different (endogenously chosen) percentiles for different capital items.[7]

As illustrated in Panel B of Figure II, the median cost (blue curly line) evolves smoothly as a function of taxable income in the absence of a kink. Once the kink is introduced, firms intending to bunch increase their investment levels, move to the kink, and the median cost spikes at the kink. Analogously to the previous section, I fit a q-degree polynomial to estimate the counterfactual median cost (red solid line), excluding the bins around the kink:

$$C_j = \sum_{l=0}^{q} \delta_l^I (\pi_j)^l + \sum_{k=\pi_L}^{\pi_U} \theta_k^I \cdot \mathbf{1}[\pi_j = k] + u_j^I. \tag{11}$$

The superscript I denotes the intensive margin. The number of *intensive investment bunchers* is estimated as the excess number of firms with a cost above the counterfactual median:

$$M^I = \sum_{k=\pi_L}^{\pi_U} \sum_{i \in j} \mathbf{1}[\pi_j = k] \cdot \mathbf{1}[c_{ij} \geq \hat{C}_j] - \frac{1}{2} \sum_{k=\pi_L}^{\pi_U} f_k, \tag{12}$$

[7] The median, for instance, is constant at 0 for all capital items except short-life machinery, but the 10th percentile is uninformative for short-life machinery, in which almost all firms invest.

where c_{ij} is the cost of firm i in income bin j, and the counterfactual median is the predicted value from equation (11), ignoring the $\hat{\theta}_k^I$ coefficients for the excluded range,

$$\hat{C}_j = \sum_{l=0}^{q} \hat{\delta}_l^I (\pi_j)^l. \tag{13}$$

The contribution of intensive investment bunching is then defined as the share of intensive investment bunchers in the total number of bunchers:

$$Cont^I = \frac{M^I}{B}. \tag{14}$$

It should be noted that the group of investors obviously confounds firms that invest regardless of the kink and the extensive investment bunchers that invest to move to the kink. The presence of extensive investment bunchers, which most likely have below-median cost levels, would bias the median cost downward for investors in the excluded range. I therefore consider the intensive margin estimates a lower bound on the investment bunching contribution.

3 Context and Data

The UK corporate tax system provides a unique context for applying the new empirical strategy to study the investment response to taxation. Section 3.1 presents the tax system and discusses the sources of identifying variation it provides. Section 3.2 presents the administrative tax return data used in this study.

3.1 UK Corporate Tax System

The corporate income tax in the UK is contributed by approximately 1.5 million registered corporations each fiscal year (1 April in year t until 31 March in $t+1$).[8] In 2011, the corporate income tax in the UK raised £43,763 million, i.e. 10% of total tax revenue and 4% of GDP.[9] Although corporate tax collections are important, the gap between predicted and actual collected tax liabilities is large. The UK tax authority Her Majesty's Revenue and Customs (HMRC) estimates that in 2009 (the most recent tax gap estimates), 9.6% of true corporate tax liabilities remained unpaid (HMRC (2012)).

The UK corporate income tax offers two compelling sources of variation to study the response of investment to tax policy changes. The first source of variation is the tax rate jump (kink) between the first and second brackets in the corporate tax schedule. As Table I shows, the UK corporate tax

[8] Author's estimates.

[9] See http://www.hmrc.gov.uk/statistics/receipts/receipts-stats.pdf.

schedule features five tax brackets, with two large convex kinks, at 10k and 300k of taxable income, and two smaller concave kinks. The kink at 10k is particularly suitable for studying the investment response to taxation. First, in 2002-2005, the 10k kink is larger than any other kink, thus generating strong incentives for bunching.[10] Second, the size of the kink changes over time. In 2001, the kink implies a 12.5 percentage points tax rate change. For 2002-2005, a 0% starting rate is introduced for all firms with a taxable income below 10k, which increases the size of the tax rate jump to 23.75 percentage points and makes the kink more salient. Finally, in 2006, the kink is abolished and the first three tax brackets are merged at a marginal tax rate of 19%.

The second source of variation is the difference in depreciation allowance rates across different capital items, which leads to a differential suitability of capital items for investment bunching. To see why depreciation allowance rates are relevant, consider that the corporate tax base is comprised of turnover net of recurrent investments (salaries, purchases of tradable goods), capital depreciation allowances, deductions (e.g. community investment schemes) and losses carried forward.[11] An increase in recurrent investments translates one-for-one into a reduction of the tax base. To what extent an increase in capital investments translates into a reduction of the tax base depends on the capital depreciation schedule, summarized in Table II. For each capital item purchased, firms deduct a First Year Allowance (FYA) in the year of purchase, and a Writing Down Allowance (WDA) in all following years. The WDA is applied on a reducing balance basis (straight line basis for buildings), until the cost that remains to be claimed is less than £1000, at which time it is written off.

When considering the use of capital investments for bunching, firms take into account both the FYA and the total depreciation speed of the capital item. The weight given to each of these two determinants depends on the firms' production function and discount factor. Independently of the weights, purchases of short-life machinery (e.g. computers) are most suitable for bunching, as they yield the highest FYA (40%) and highest depreciation speed. As for the other capital items, their ranking in terms of suitability for bunching is ambiguous. For firms valuing the FYA over depreciation speed, purchases of long-life machinery (e.g. electrical systems), which yield a 40% FYA, are most suitable for bunching. For firms valuing depreciation speed over the FYA, investments in cars are most suitable for bunching.

[10] In the presence of optimization frictions, bunching is relatively stronger at larger kinks, as shown in Chetty et al (2011).

[11] Losses thus affect taxable income but are realized in prior periods and cannot be manipulated ex-post to reduce taxable income. Deduction can be used to change taxable income and move to the kink, but my empirical analysis find no evidence of this. Spikes in median deductions or the share of firms claiming deductions at the kink appear only in some subsamples and time periods, and the excess number of firms claiming deductions in the excluded range (deduction bunchers) is not significantly different from 0 when selection effects are controlled for. For more information on how the tax base is derived, see http://www.hmrc.gov.uk/agents/ct/.

A number of exceptions to these rules are worth mentioning. Investments by small and medium firms in short-life machinery received a 50% FYA in 2004, 2006 and 2007. Furthermore, investments by small firms[12] in information and communication technologies (considered short-life machinery) received a 100% FYA in 2000-2003. In addition, a 100% FYA has been in place for specifically designed energy efficient short-life machinery since 1 April 2001 and for low carbon emission cars since 1 April 2002. These exceptions make investments in short-life machinery and cars even more suitable for bunching purposes, compared to investments in other capital assets.

3.2 Data

This study is based on the HMRC CT600 panel including the universe of UK corporate tax returns filed for the years 2001-2007.[13] The dataset provides information on taxable income under different headings (foreign, trading, capital etc.), capital allowances, deductions, losses, tax liablity and after-tax deductions. The accuracy of the data is extremely high, given its administrative nature and the fact that all returns are electronically checked for consistency. The dataset contains approximately 1.5 million obervations per year. An average of 800,000 firms per year have a taxable income between 3k and 40k, the interval relevant for the investment bunching estimations. Only firms that do not report turnover (10.7% of the sample) are dropped.

The investment variables of interest are recurrent investment and capital allowances for short-life machinery, cars, long-life machinery and buildings. Recurrent investment is constructed as the difference between trading turnover and trading income. To measure capital investments, I use the capital allowance variable rather than the underlying expenditure, as the former precisely captures the investment-induced taxable income reduction.[14] The data does not distinguish between the 100% and 40%/50% FYA capital types within the short-life machinery and cars categories. Furthermore, although capital allowances are intended to cover capital purchases for business use only, it cannot be excluded that some (especially small) firms also claim allowances for personal use items (e.g. laptops).

To examine which types of firms are most likely to engange in investment bunching behavior, I

[12]Small firms are distinct from SMEs (cf. footnote 18) and satisfy at least two of the following requirements: turnover of not more than £2.8 (5.6) million, balance sheet total of not more than £1.4 (2.8) million, number of employees of not more than 50 for FYs ending before (after) 30 January 2004. See http://www.hmrc.gov.uk/manuals/camanual/CA23170.htm.

[13]As the 10k kink disappeared in 2006, and capital depreciation rules changed significantly in 2008, the study does not exploit data for post-2007.

[14]Unfortunately, the expenditure data does not provide information on the timing of capital purchases. Such information would help support the hypothesis of bunching through investment, if bunchers are found to implement a disproportionate share of investment at the end of the accounting period, when they can predict that their gross profit is close to, but above, the kink.

combine the CT600 panel with FAME accounting data, which is available for approximately 90% of the CT600 observations. This data is compiled by Bureau van Dijk, based on annual accounts submitted by all tax-registered firms to UK Companies House. Among other things, this data contains information on the company's debt levels and 5-digit SIC industry codes. I aggregate the latter to sectors at the 2-digit level, to achieve subsamples big enough (at least 10% of the full sample) for frequency plots around the 10k kink. I then merge the panel with sector-level data on the share of sales to the final consumer and the median number of employees per firm. These data are compiled by the Office for National Statistics in the Supply and Use Tables and the SME Statistics.[15]

4 Empirical Results

This section builds on the finding of a large behavioral response to the 10k kink, as established by Devereux *et al.* (2013) and shown in Figure III. The excess bunching mass of 12.3 translates into a large elasticity of 0.45 with a standard error of 0.016.[16] An examination of the investment level of firms around the kink sheds light on the anatomy of this behavioral response. Section 4.1 presents evidence that firms move to the kink by increasing investment. Section 4.2, provides estimates of the contribution of this behavior to bunching. Section 4.3 discusses evidence supporting the interpretation of the observed behavior as real investment rather than avoidance or evasion through over-reporting.

4.1 Evidence of Bunching Through Investment

If firms use investments to reduce their taxable income and move to the 10k kink, this should be reflected in a higher share of investors and a higher median capital cost around the kink. Variation in the kink size across time allows us to distinguish the bunching-induced investment changes from any other difference in investment levels between firms around the 10k kink and firms at higher or lower income levels.

[15] To avoid selection of subsamples on outcomes, I searched for the earliest available data. However, the median number of employees per firm is only available starting from 2007. The share of sales to the final consumer is for 2000.

[16] In fact, bunching is strongly asymmetric, suggesting that firms misperceive the kink as a notch, i.e. a jump in the average tax rate. A notch generates a strictly dominated area above the tax bracket cutoff, and should thus be accompanied by bunching below the cutoff and a missing mass above the cutoff (see Kleven & Waseem (2013) for evidence from Pakistan). In the UK data, however, there is no missing mass above the cutoff, and the estimates of bunching and investment bunching with an asymmetric excluded range at 10k are almost identical to the results presented here and thus omitted. The asymmetry of bunching does not appear in the figures shown in Devereux *et al.* (2013), which plot the distribution of taxable income in £1000 bins and rely on the subsample of firms with one-year accounting periods.

Consider first recurrent investments, the largest investment item (on average 97.1% of a firm's costs), and the only one for which an increase translates one-to-one into a reduction in taxable income. Panel A of Figure IV plots the median recurrent cost by taxable income, for 2001, 2002-2005 and 2006-2007. The plots also show the counterfactual median cost, estimated according to equation (13), and the size of the spike at 10k. Note that I consider median costs rather than the share of investors, as the latter is not applicable for recurrent investments, for which all firms register a positive amount (unless one of the underlying variables is missing). The spike size is the difference between the observed and estimated median cost in the 10k bin, scaled by the estimated cost. This proxy of investment bunching is distinct from the number of investment bunchers, estimated in section 4.2, which focuses on the excess number of investors across the entire excluded range, rather than only at the kink.

As Figure IV shows, there is already a statistically significant spike in recurrent investments at 10k in 2001, when the kink at 10k is present but small. The spike size more than doubles in 2002, when the introduction of the 0-% starting rate increases the size of the tax rate jump and the salience of the kink. In addition to the sharp spike at 10k, the 2002-2005 figure also shows higher cost levels for firms with a taxable income $\in [8k, 10k]$, the income interval below the kink which registers a significant excess mass of firms, as shown in Figure III.[17] Finally, the spike size is reduced to a tenth of its previous size in 2006-2007, when the kink disappears. The spike is still statistically significant, however, which could be explained by misperceptions or adjustment costs that prevent bunchers from lowering their cost immediately after the kink is abolished. Also note that overall investments decrease over time.

The time pattern for investments in short-life machinery (Panel B), the most quickly depreciating capital item, is very similar to the pattern for recurrent investments. In 2001, the median capital cost, at 10k, is about twice as high as the estimated counterfactual. The spike increases to quadruple the estimated cost in 2002-2005, and falls back to a level only 30% higher than the estimated cost in 2006-2007. Note that, during 2002-2005, the median cost for most income bins below the kink is 0. This is because firms with a taxable income below 10k pay no tax, and thus have no incentive to claim capital allowances, unless their income gross of capital allowances places them above 10k.[18]

As a second way of distinguishing bunching-induced investment spikes from other changes in in-

[17] See the previous footnote for a discussion of the asymmetric nature of bunching

[18] Just as in the frequency plot in Figure III, the cost plots for 2002-2005 display a spike at 5k, although there is no kink at this point. This spike is present even when dropping firms with a taxable income of exactly 5k, suggesting that the excess mass at 5k is at least partly driven by firms that misperceived 5k as a kink and intentially increased their cost to move there.

vestment levels around the kink, I exploit variation in the rate of capital depreciation across different capital types. If firms invest in order to bunch, they should primarily invest in quickly depreciating capital items like short-life machinery and cars. Figure V provides evidence for differential investment spikes across capital items, distinguishing between the extensive and the intensive margin (Panels A and B respectively). For short-life machinery, both the share of investors as well as the median cost for investors display a large and statistically significant spike at the kink. For cars, there is a significant spike at the extensive margin only. Intensive margin investment bunching is inhibited by the cap on capital allowance for cars at £3000 per year, which means that the median cost is almost constant at £3000. For long-life machinery and buildings, both the share of investing firms as well as the median cost for investors are much more noisy and the pattern of statistical significance of investment spikes is inconsistent. Although the intensive margin spike for long-life machinery and the extensive margin spike for buildings are statistically significant, they are smaller than other spikes at random levels of taxable income. This might suggest that the empirical methodology used in these distributions is not robust enough to accurately determine their statistical significance. Overall, the pattern of significance of investment spikes over time and across capital types supports the hypothesis that firms bunch by investing.

4.2 Estimating the Contribution of Investment Bunching

To estimate the contribution of investment bunching, I calculate the number of investment bunchers, as defined in section 2.2, and their contribution *Cont* to the total number of bunchers. Figures VI and VII show these estimations for short-life machinery, at the extensive and intensive margins respectively. The results for all other capital items are presented in Table III. For recurrent investments, only the intensive margin is applicable. For cars, long-life machinery and buildings, I conduct the estimation for the extensive margin only. This is because the sample of investors for these capital items is too small (less than 15% of the full sample) and the median cost plots are too noisy to credibly estimate intensive margin investment bunching. Note that all contribution estimates are for the period 2002-2005, when the kink is most salient and represents a tax rate jump of 23.75 percentage points.

In the first place, consider the baseline results for extensive investment bunching as shown in Panel A1 of Figure VI. The estimation suggests that investment bunchers represent 19.2% of all bunchers. This result relies on the assumption that the share of investors would evolve smoothly as a function of taxable income if there were no kink, i.e. that the spike in investment at the kink is entirely due to investment bunching behavior. To test this assumption, let $s_{j,t}$ denote the share of investors in income bin j in year t and $s_{j,t-2}$ the share of investors among the *same* group of firms in year $t-2$.[19] Unless bunchers stay at the kink for three consecutive years, there is no reason to expect $s_{j,t-2}$ to spike at the kink. The year $t-2$ is chosen because it is close enough to serve as a reasonable control, but further in the past than year $t-1$, in which the share of investors might be affected by auto-correlation in bunching. Indeed, approximately one-third of all bunchers stay at the kink for more than one year, but only one-sixth of them stay for more than two years. [20]

The joint plot of $s_{j,t}$ and $s_{j,t-2}$ in Panel A2 shows that the share of investors, two years prior to bunching at the kink, also spikes at the kink. This suggests that bunchers might be a selected sample among the firms above the kink. Mechanically, firms with a high investment level (or low profit margin) will require a smaller percentage change in investment to achieve a certain percentage change in profits, to move to the kink. Another possible mechanism to explain the selection effect is adjustment costs. Consider that only firms with sufficiently low adjustment costs move to the kink (e.g. those with good tax advisors), and that this feature is positively correlated with investment propensity. In this case, we would observe an investment spike at the kink, even if bunchers did not change their investment behavior to move to the kink.

Independently of the mechanism driving it, the selection effect should be controlled for in the estimation. For Panel A2, I estimate the number of extensive investment bunchers by subtracting from the previous estimate in equation (8) the control difference between the observed and counterfactual share of investors in $t-2$:

$$M_C^E = \sum_{k=\pi_L}^{\pi_U} [(s_{j,t} - \hat{s}_{j,t}) - (s_{j,t-2} - \hat{s}_{j,t-2})] \cdot f_{k,t}. \tag{15}$$

Subscript C marks all estimates that control for selection effects. The contribution of extensive investment bunching is defined as

$$Cont_C^E = \frac{M_C^E}{B}. \tag{16}$$

Controlling for the selection effect makes the contribution estimate drop to 7.7%. However, this estimate is possibly downward biased because some firms stay at the kink for more than two consecutive years, so that $s_{j,t-2}$ may be affected by investment bunching in $t-2$. I therefore consider the baseline estimate an upper bound and the control estimate a lower bound on the true contribution of investment bunching.

[19] The "full" sample thus considers all firms that report at least three consecutive observations.

[20] The share of investors in $t+1$ is not a good counterfactual, since investments are measured by capital depreciation allowances, so that investment bunchers in t will also be observed as investors in $t+1$, when they continue to depreciate their capital purchase from year t.

To verify the robustness of these results, I implement a second estimation for the sample of one-time bunchers only (Panel B of Figure VI). This allows me to use as counterfactual the share of investors in $t-1$, which should be unaffected by past investment bunching behavior, because I eliminate firms with a taxable income in $[8k, 12k]$ for at least two consecutive years (approximately 13% of the sample). The baseline estimation for this sample (Panel B1) suggests that investment-bunchers represent 37% of all bunchers. This estimate drops to 24.9% only when the selection effect is controlled for (Panel B2). Obviously, these results apply only to one-time bunchers, which might rely on "crude" strategies like investment bunching to a larger extent than more sophsticated repeat bunchers.[21] However, the results for this sample confirm that the investment bunching contribution remains significant even when the selection effect is controlled for.

As Figure VII shows, the estimates for the contribution of intensive investment bunching display a qualitatively similar variation across estimation strategies, but are overall smaller (though statistically significant).[22] In the full sample, intensive investment bunchers represent between 16.8% (baseline estimation) and 4.3% (control estimation) of the total number of bunchers. In the sample of one-time bunchers, the estimates are again slightly higher, ranging from 20.3% (baseline) to 10.2% (control).

Table III shows the estimation results for all investment items. Most contribution estimates are statistically significant only without the selection effect control. The contribution estimates are largest for recurrent investments (45%) and lowest for long-life machinery and buildings (below 2%). With the control, however, all estimates lose significance in at least one of the samples. The control estimates are significant for recurrent investments in the full sample, and for long-life machinery in the sample of one-time bunchers. However, these estimates are statistically significant only at the 10% level, and economically insignificant, as they indicate an investment bunching contribution of below 2%.

Emphasizing the more conservative results for the full sample, I conclude that investments in short-life machinery are an instrument for bunching for a moderate fraction of up to 19.2% of

[21] Also notice that the estimates are potentially upward biased because $s_{j,t-1}$ changes discontinuously at $12k$, the upper bound of the excluded range. This is because restricting the sample to one-time bunchers means eliminating a disproportionately large number of observations in the $[8k, 12k]$ interval, compared to bins outside the bunching interval, and the remaining observations have a different investment level than the full sample.

[22] To see how I control for the selection effect in the intensive margin estimation, note that the number of firms in the bunching range is different for period t and the control $t-x$, $x \in \{1, 2\}$. Therefore, contrary to section 2.2.2, I estimate not the number of investment bunchers but rather the *share* of investment bunchers among the firms in the bunching range, m_t^I and m_{t-x}^I: $m_t^I = 1/F_{C,t} \cdot \left\{\sum_{k=\pi_L}^{\pi_U} \sum_{i \in j} \mathbf{1}[\pi_j = k] \cdot \mathbf{1}[c_{ij,t} \geq \hat{C_{j,t}}] - \frac{1}{2} F_{C,t}\right\}$, and accordingly for m_{t-x}^I, with $F_{C,t} = \sum_{k=\pi_L}^{\pi_U} f_{k,t}$, the total number observations within the bunching range in year t, in the relevant sample. The contribution of intensive investment bunching is defined as $Cont_C^I = \frac{(m_t^I - m_{t-x}^I) \cdot F_{C,t}}{B_{C,t}}$.

bunchers, and that extensive investments play a larger role than intensive investments. The results do not provide evidence for investment bunching through items other than short-life machinery. It is possible, however, that firms use large-scale changes in capital investments to approach the kink, and fine-tune their bunching behavior with recurrent investments. The latter may be too small to be picked up by the estimation strategy used.

4.3 Distinguishing Avoidance, Evasion and Investment

The empirical analysis has so far been agnostic about whether the observed investment spikes at the kink constitute avoidance (e.g. transfer pricing manipulation), evasion (e.g. over-reporting), or real investment. While it is not possible to cleanly decompose the investment spikes into these components, this section discusses preliminary evidence suggesting that the spikes mainly represent a real investment increase. The argument is threefold.

First, it is unlikely that the firms considered in this study engage in tax avoidance strategies such as cost manipulation through transfer pricing or shifting income to international tax havens. The firms in the sample are small and/or relatively unprofitable. Only 0.12% of them register any overseas income, 0.20% register double taxation relief and 6.1% are member of a group.[23] This means that the scope for engaging in tax avoidance schemes is very limited, as most of these schemes rely on international business activity or group membership.

Second, an examination of the context suggests that evasion is unlikely to explain a large part of bunching. Tax compliance in the UK is relatively high compared to many other countries, and tax-registered corporations need to publish accounts and emit VAT receipts to their clients. This means that over-reporting investment would require sophisticated disclosure strategies. Moreover, although the audit probability for small firms is negligible, the cost of an audit is high, and may include the cost of cooperating with auditors, potential penalties, and reputational damage.

To test empirically for the presence of evasion, I examine bunching behavior in subsamples of firms with high *ease of evasion.* If a large part of investment and thus bunching is driven by evasion (over-reporting), we should expect firms with better evasion opportunities to respond more strongly to the kink. Based on previous findings in the tax evasion literature, I consider firm size, the need for financial intermediation and the share of sales to the final consumer as key determinants of the ease of evasion. Kleven *et al.* (2009) develop an agency model in which firms with a large number of employees find it more difficult to sustain a collusion agreement on evasion.[24] Turnover is

[23] Author's calculation.
[24] Kumler *et al.* (2012) find evidence from Mexico that supports this theory.

another measure of firm size and often used by tax inspectors to determine the level of enforcement (accounting requirements, audit frequency), as discussed in Almunia & Lopez-Rodriguez (2012). Gordon & Li (2009) provide a model in which firms that rely on formal credit are more tax compliant, as financial sector transactions are observable to the government.[25] Finally, firms find it easier to evade sales to the final consumer, which are not covered by the VAT paper trail, rather than to evade sales to other (VAT compliant) firms.[26]

Panel A of Table IV displays excess mass and elasticity estimates for the following subsamples: firms with low (below median) turnover, low number of employees, no debt (dummy)[27], and high (above median) share of sales to the final consumer, as compared to the full sample. Although theory predicts that firms in these subsamples can evade taxes with relative ease, the bunching estimates for firms with low turnover and number of employees are significantly lower than those for the full sample. The estimates for firms without debt are not significantly different from the full sample. This provides evidence against the hypothesis that most bunchers move to the kink through over-reporting of costs.[28] However, the fact that firms with a high share of sales to the final consumer bunch significantly more than the full sample suggests that part of the response to the kink might be driven by output evasion, which this group of firms can practice with relative ease.

If avoidance and evasion are not the key drivers of bunching, the investment spikes must constitute real investment. To support this argument, Panel B of Table IV displays bunching estimates for subsamples of firms with different degrees of *investment propensity*, as compared to the full sample. The evidence is consistent with the hypothesis of bunching through investment. The smallest excess mass is registered by the financial sector, which works with financial rather than physical capital and thus has less opportunity for bunching through real investment. The capital intensive manufacturing sector and the stock-intensive retail sector, on the other hand, register a significantly higher excess mass at the kink than the full sample does. The excess mass is also significantly higher for firms with a high (above median) cost margin, high short-life machinery capital investments, high recurrent investments and for growing firms (though the latter difference is significant only at the 10% level). It should also be mentioned that there is no evidence for inter-temporal shifting in investments, so that the investment spikes can be interpreted as an overall increase in investment,

[25] This argument is consistent with cross-country evidence by Bachas & Jensen (2013).

[26] Pomeranz (2013) supports this argument with experimental evidence from Chile.

[27] Firms for which the FAME data does not report any long-term or short-term loans or debt are coded as having no debt.

[28] The estimates for the contribution *Cont* of investment to bunching are more noisy due to the smaller sample size and thus omitted. Qualitatively, however, the size of these estimates evolves in similar ways as the excess mass estimates when comparing subsamples to the full sample.

rather than a reallocation of investment across years.[29]

Although care was taken to avoid selection on outcomes (e.g. conditioning subsamples on observables in $t-1$), the results of this heterogeneity study obviously rely on correlations and cannot be interpreted as causal evidence. Besides, even though heterogeneity across subsamples is consistent with bunching through investment, it is not clear whether these investments are for business purposes or personal use items. For instance, a plumbing business with a taxable income of 12k may move to the kink by purchasing a computer, which could be used both for bookkeeping purposes and for leisure activities. This interpretation of bunching-induced investments as private consumption is supported by the fact that bunching-induced investments do not seem to stimulate growth. Investment bunchers (and bunchers in general) do not grow faster in the years after they bunch, compared to firms below or above the bunching range.[30]

5 Conclusion

This paper has presented a novel empirical strategy for examining the investment effect of tax policy changes. I exploit bunching of firms at a tax kink to examine how a tax rate change affects firms' investment decisions, and how this effect interacts with variation in capital depreciation rates across capital types. Building on the bunching approach proposed by Saez (2010), I estimate the frequency distribution of firms around the kink, and the number of firms with excess investments at the intensive and extensive margin. This allows me to calculate the share bunchers that changed their investment levels to move to the kink. This empirical approach is widely applicable to the study of the underlying drivers of taxable income responses to kinked choice sets.

Using tax return data for UK corporations, I provide the first micro-evidence that investment by small firms significantly responds to a tax rate change. Bunching at the 10k kink is accompanied by spikes in the share of capital investors and the median capital cost at the kink. These spikes are larger in 2002-2005 when the kink is larger, and for quickly depreciating capital items, which yield larger tax reductions. I estimate that extensive margin investments explain 7.7-19.2% of bunching and intensive margin investments explain 4.3-16.8% of bunching. The fact that the response to the kink is stronger among firms with a high investment propensity and weaker among firms with a high ease of evasion supports the interpretation of the investment spikes as real investment response

[29] The $t+1$ share of investors (median cost), by taxable income bins in year t, does not exhibit a downward spike, as would be expected if firms shift investments from year $t+1$ to t. Besides, Devereux *et al.* (2013) also fail to find evidence of inter-temporal profit shifting.

[30] I test for this by plotting the growth rate in $t+1/2/3$ by taxable income bins in year t. I find that firms located at or around the kink do not register higher growth rates than firms above or below the bunching range.

rather than evasion through over-reporting.

The findings imply that the introduction of the zero starting rate for UK firms with a taxable income below 10k not only encouraged incorporation by firms below the kink, as examined by Devereux & Liu (2013), but also investment by firms just above the kink. This evidence of locally important investment effects suggests that tax rate changes can be used to stimulate investment. The analysis also confirms that capital depreciation rates matter for the composition of investment, as firms only use investment in short-lived capital items in response to tax rate changes. However, bunching through investment appears to be a small firms phenomenon. The 300k kink in the UK tax schedule also features a significant bunching mass but no investment spikes.

More work remains to be done to understand whether tax-induced investments are productive, or whether small firms exploit the low levels of tax enforcement they face to claim capital allowances for the purchase of private consumption goods. Work in this area would help shed light on the long-run growth effects of tax-induced investments. I also aim to extend the empirical framework to derive an estimate of the elasticity of investment with respect to the tax rate. Moreover, while the proposed empirical approach takes a step towards decomposing taxable income responses, it leaves a large part of the bunching mass at the kink unexplained. The approach should be further developed to identify evasion and avoidance, and explain the share of bunching that is not driven by investment.[31]

[31] I aim to provide some evidence on evasion behavior in the future, by combining the tax return data with administrative audit and penalty reports. HMRC is in the process of preparing these data for disclosure.

Table I: UK Corporate Tax Schedule

Taxable income	**2000-2001**	**2002-2005**	**2006**	**2007**	**2008-2010**
0-10k	10	0	19	20	21
10k-50k	22.5	23.75	19	20	21
50k-300k	20	19	19	20	21
300k-1,500k	32.5	32.75	32.75	32.5	29.75
>1,500k	30	30	30	30	28

Notes: The table shows how the marginal corporate tax rate (in percent) has varied across tax brackets (rows) and across fiscal years (columns). The tax is applied to taxable corporate profits, defined as turnover from different income sources, net of recurrent investments, capital depreciation allowances for different of capital items, deductions (e.g. corporate venture scheme relief) and losses carried forward from previous years. For more information on the tax base, see http://www.hmrc.gov.uk/agents/ct/. For more information on the tax rate schedule, see http://www.hmrc.gov.uk/statistics/ct-receipts/table-a6.pdf.

Table II: UK Capital Depreciation Schedule

	Short-life Machinery	**Cars Cars**	**Long-life Machinery**	**Industrial Buildings**
First Year Allowance	40%	25%/100%	40%	24%
Writing Down Allowance	25%	25%	6%	4%

Notes: The table shows how the capital depreciation schedule varies across capital items, for fiscal years 2001-2007. All capital purchases give rise a to a First Year Allowance (FYA) in the year of purchase, and a Writing Down Allowance (WDA) in the years following the year of purchase. All items are depreciated according to a reducing balance allowance, except for industrial buildings, which are depreciated on a straight line basis. A reducing balance allowance is applied every year to the remaining balance of unclaimed expenditure. Once the balance of unclaimed expenditure is less than £1000, it can be depreciated immediately, under the small pool allowance rule. A straight line allowance means that the same amount of allowance for an expenditure is claimed every year until the total expenditure has been claimed. For more information on capital allowance rates, see http://www.hmrc.gov.uk/statistics/ct-receipts/table-a5.pdf. For more information on capital allowance rules, see http://www.hmrc.gov.uk/manuals/pimmanual/pim3005.htm and http://www.hmrc.gov.uk/capital-allowances/getstarted.htm.

Table III: Estimating Investment Bunching

	Full Sample				One-time Bunchers			
			Baseline	With Control			Baseline	With Control
Investment item	N	Bunchers B	*Cont*	*Cont*	N	Bunchers B	*Cont*	*Cont*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recurrent Investments	2507423	120689	.238	.018	2182426	55127	.458	-.062
		(2714)	(.01)	(.01)		(11606)	(.06)	(.01)
Short-life machinery I	1479976	85461	.168	.043	1295667	54086	.203	.102
		(1949)	(.00)	(.01)		(8990)	(.02)	(.01)
Short-life machinery E	2558590	122343	.192	.077	2226960	62457	.37	.249
		(2783)	(.01)	(.02)		(10200)	(.12)	(.04)
Cars	2558590	122343	.046	-.002	2226960	62457	.08	-.009
		(3023)	(.0049)	(.009)		(7237)	(.012)	(.012)
Long-life machinery	2558590	122343	.01	.0026	2226624	63823	.013	.007
		(2824)	(.0021)	(.003)		(7965)	(.005)	(.004)
Buildings	2558590	122343	.013	.0001	2226624	63823	.019	-.001
		(2695)	(.0026)	(.005)		(14665)	(.005)	(.006)

Notes: The table presents the results of estimating the contribution of investment changes to bunching at the 10k kink, for different investment items (rows). The estimations are for 2002-2005, when the 10k kink represents a tax rate jump from 0% to 23.75%. The results for recurrent investments and for short-life machinery (I) are for intensive margin investment changes. All other results are for the extensive margin. Columns (1)-(4) present the results for the full sample of firms for which at least three consecutive observations exist. The control strategy for this sample uses the share of investors/median cost in $t-2$ to control for selection in the group of bunchers. Columns (5)-(8) present the results for the sample of one-time bunchers, eliminating all firms with taxable income $\in [8k, 12k]$ for two consecutive years. The control strategy for this sample uses the share of investors/median cost in $t-1$ to control for selection in the group of bunchers. Columns (1) and (5) present the sample size, columns (2) and (6) present the number of bunchers B, and columns (3)-(4) and (7)-(8) present the contribution *Cont* of investment to bunching, with and without controlling for selection effects. The number of bunchers B is estimated as shown in Figure III, by fitting a flexible polynomial to the observed frequency distribution of firms. B is the difference between the observed and estimated frequency, in an excluded range around the kink, as in equation (5). The estimation of the contribution of investment bunching *Cont* is as shown in Figures VI and VII. I calculate the investment bunchers M^E (M^I) as the excess number of investors, i.e. the difference between the observed and counterfactual share of investors (median cost) in the excluded range, according to equation (8) (equation (12)). For the specification with control, I compare the observed share/median cost to the control counterfactual, according to equation (15) (footnote 21). The contribution is estimated as $Cont = M/B$. Bootstrapped standard errors are shown in parantheses. Source: HMRC.

Table IV: Evidence for Bunching through Investment

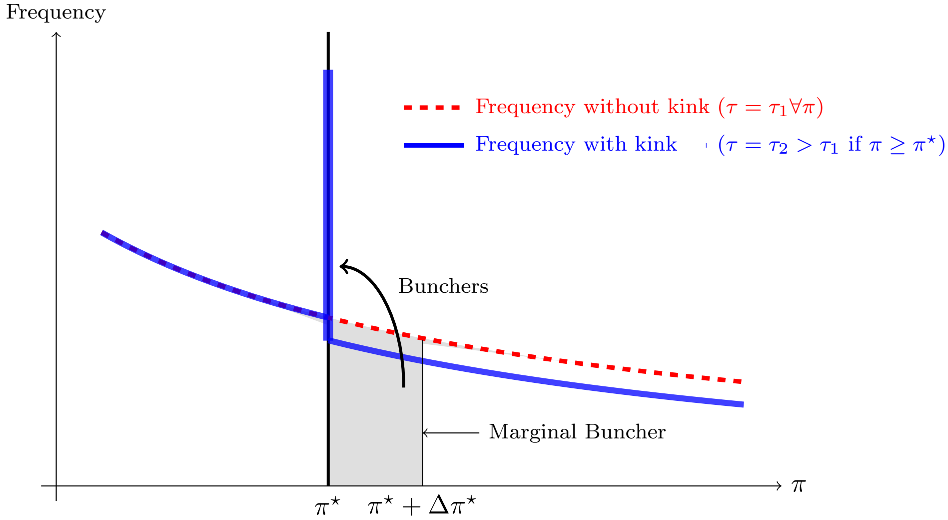
Panel A: Ease of Evasion Indicators			
Sample	Share	b	ϵ
	(1)	(2)	(3)
Full	1	12.3	.45
		(.4)	(.016)
Low turnover	.50	8.3	.30
		(.2)	(.009)
Low number of employees	.46	10.2	.38
		(.4)	(.013)
No debt	.92	12.1	.45
		(.4)	(.014)
High share of sales to final consumer	.45	14.5	.53
		(.5)	(.019)

Panel B: Investment Propensity Indicators			
Sample	Share	b	ϵ
	(1)	(2)	(3)
Manufacturing sector	.12	14.4	.53
		(.5)	(.018)
Retail sector	.12	14.4	.53
		(.7)	(.025)
Service sector	.17	13.1	.48
		(.5)	(.019)
Financial sector	.48	10.2	.38
		(.4)	(.014)
Growing	.43	12.8	.48
		(.5)	(.018)
Low profit margin in $t-1$	.50	16	.59
		(.7)	(.027)
High capital investments in $t-1$	.47	17.7	.65
		(.7)	(.026)
High recurrent investments in $t-1$	.44	15.7	.58
		(.7)	(.028)

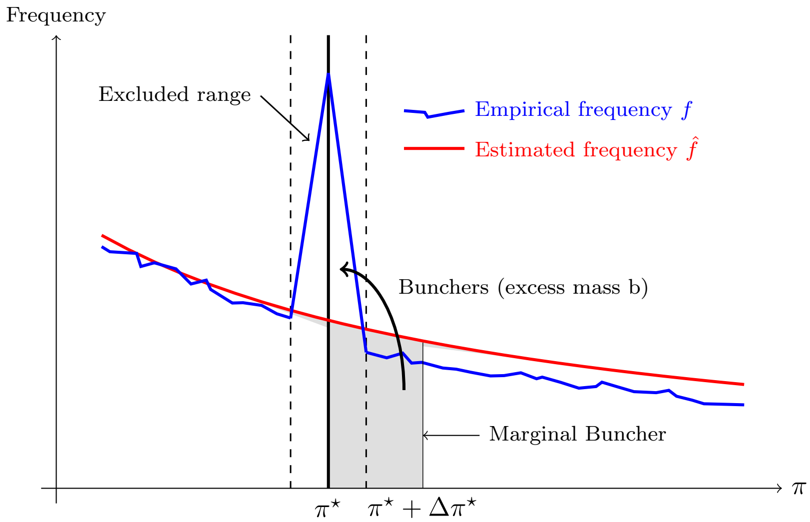
Notes: The table shows estimates of the excess mass b at the 10k kink (column (2)) and the elasticity of taxable income ϵ (3), for different subsamples of firms. Column (1) shows the share of the subsample within the sample of firms with a taxable income $\in [3k, 40k]$. The estimations are for 2002-2005, when the 10k kink represents a tax rate jump from 0% to 23.75%. "Low" and "high" refers to firms below and above the sample median on the specified observable characteristics. Firms for which the FAME data does not report any long-term or short-term loans or debt are coded as having no debt (dummy). The sector categorization is based on 2-digit SIC industry codes. Growing firms are those with an above-median growth rate in turnover between $t-1$ and t. Recurrent and capital investments (for short-life machinery) are scaled by turnover. The excess mass b is the excess frequency in the excluded range around the kink, in proportion to the average counterfactual frequency in the excluded range, as estimated following equation (6). The details of this estimation are explained in the footnotes to Figure III. The elasticity of taxable income ϵ is estimated using equation (3). The estimation of the contribution of investment bunching $Cont$ is calculated as shown in Panel B2 of Figure VI, for the preferred specification (extensive margin, control specification II). The contribution is $Cont = M_c^E/B$, where B is the number of bunchers and M_C^E the number of investment bunchers, i.e. the difference between the observed and control counterfactual share of investors in the excluded range, according to equation (15). Bootstrapped standard errors are shown in parantheses. Source: HMRC.

Figure I: Estimating Bunching

A: Theory



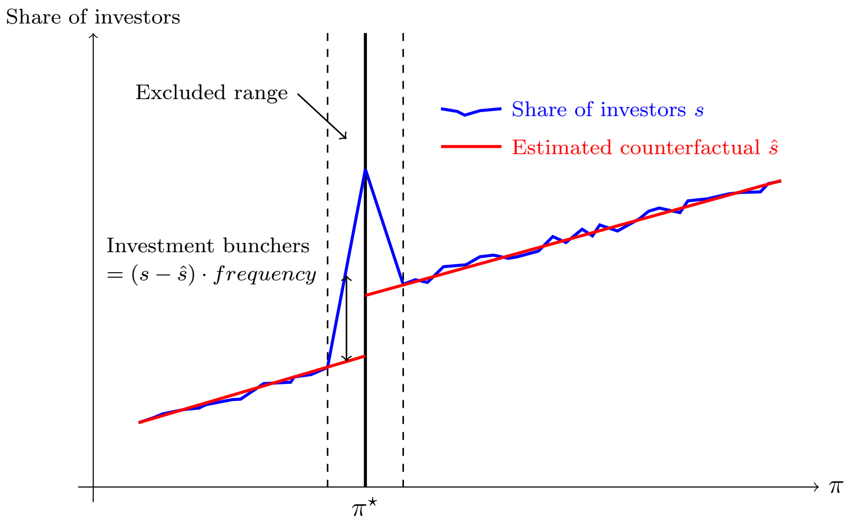
B: Empirical Implementation



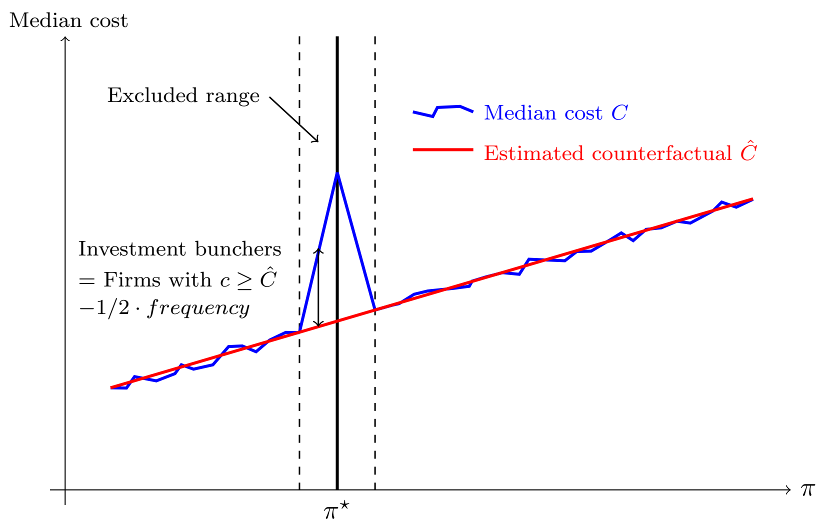
Notes: The figure illustrates the theoretical underpinning (Panel A) and empirical implementation (Panel B) of the bunching strategy to estimate the elasticity of taxable income. As Panel A shows, when there is no kink and all firms pay marginal tax rate $\tau = \tau_1$, independently of their taxable income, the frequency distribution of firms is smooth (red dotted line). Now consider that a kink is introduced at income level $\pi^\star$ (marked by a black vertical line), so that firms pay tax rate $\tau_2 > \tau_1$ for all units of income $\pi > \pi^\star$. Assuming that firms have a convex cost function, firms with income in some interval $[\pi^\star, \pi^\star + \Delta\pi^\star]$ move to the kink. Firms at higher income levels also re-optimize and decrease their income, but do not move all the way to the kink. The new frequency distribution (blue solid line) features a spike at the kink and a lower frequency above the kink. The size of the excess mass at the kink is equal to the interval (shaded area) from which firms move to the kink, and thus indicates the income change $\Delta\pi^\star$ of the marginal buncher. Panel B shows the empirical frequency distribution (blue curly line) when there is a kink at $\tau^\star$. In practice, optimization frictions prevent firms from moving straight to the kink, so that bunching takes the form of a diffuse excess mass around the kink, rather than a spike. The empirical implementation consists in fitting a counterfactual frequency $\hat{f}$ (red solid line) as flexible polynomial to the observed frequency f, excluding the range around the kink in which bunching takes place (marked by black dashed lines). The details of the estimation are shown in equation (4). Estimating the excess mass b between the empirical and the estimated frequency in the excluded range allows us to approximate the elasticity of taxable income as $\epsilon = b / [\pi^\star \cdot log(1 - \tau_1, 1 - \tau_2)]$.

Figure II: Estimating Investment Bunching

A: Extensive Margin

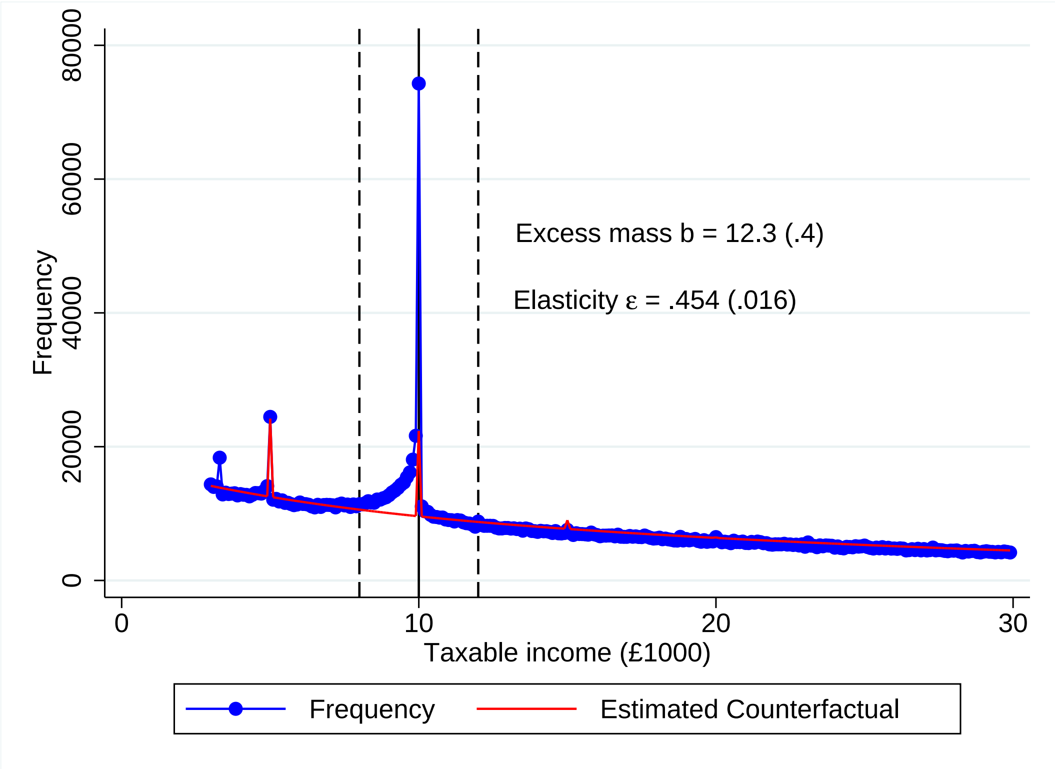


B: Intensive Margin



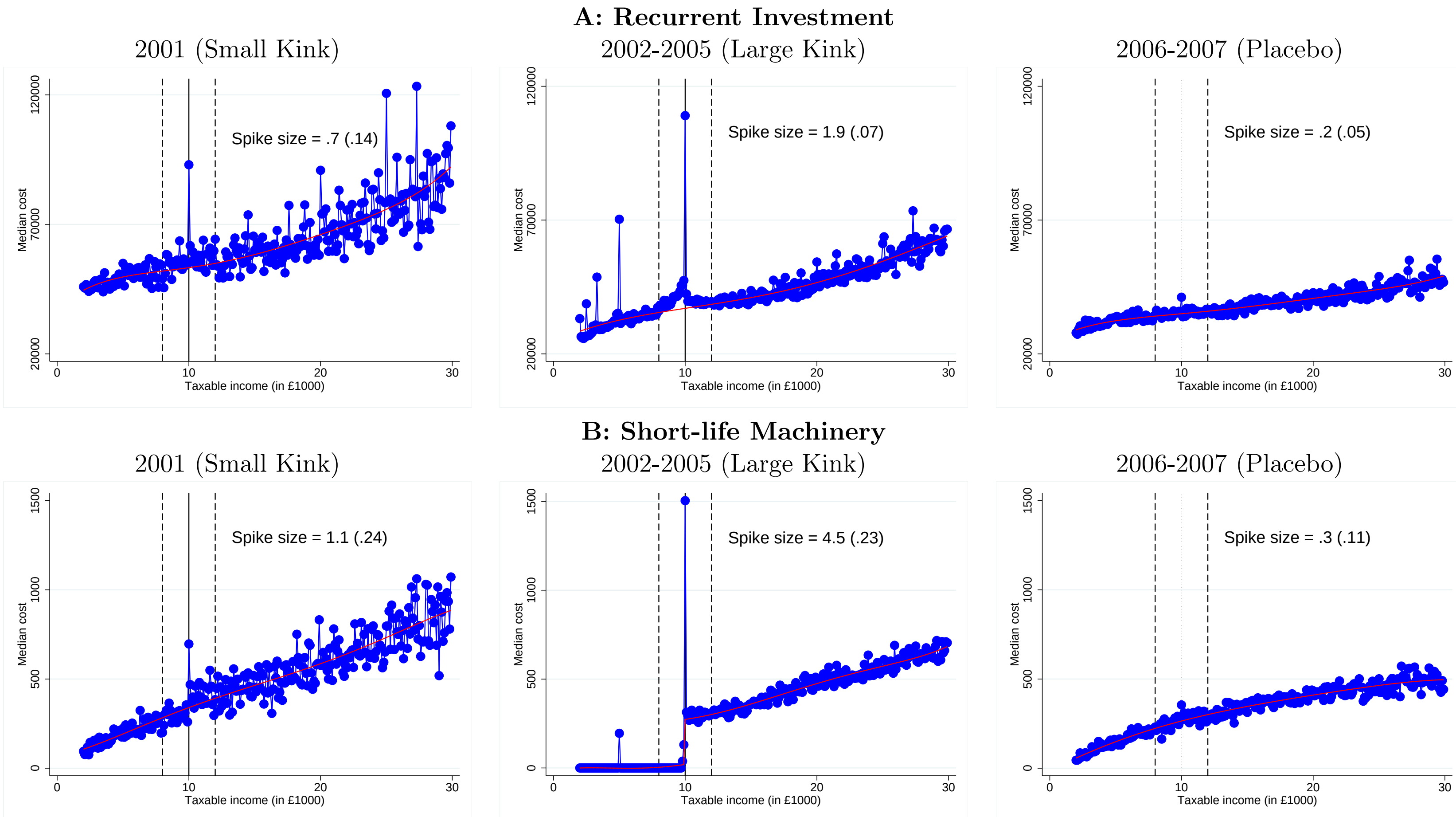
Notes: The figure illustrates the empirical estimation of investment bunching, for extensive and intensive margin investment changes. Panel A considers the extensive margin. It plots the share of investors s (firms claiming positive capital depreciation allowances, blue curly line) evolves smoothly as a function of taxable income outside of the excluded range (marked by black dashed lines) but features a spike at the kink $\pi^\star$ (marked by a black solid line). Due to optimization frictions, this spike is located not only at the kink, but also covers income levels just below and above the kink, within the excluded range. The fact that s is lower to the left of the excluded range is due to a particularity of the UK tax system and is shown here to facilitate an understanding of the empirical results. During 2002-2005, firms below the kink face a 0% tax rate, and thus have no incentive to claim capital allowances for their investments, unless their gross income would place them above the kink. The empirical strategy consists of estimating the counterfactual share of investors $\hat{s}$ (red solid line) by fitting a flexible polynomial to the observed share s, excluding a range around the kink, as shown in equation (7). The number of extensive investment bunchers is estimated as suggested in equation (8), as the excess number of investors, i.e. the difference between the observed and counterfactual share of investors in the excluded range. Panel B is similar to Panel A, but considers the intensive margin of investment changes. It shows the observed median cost C (capital depreciation allowance) for the sample of investors (blue curly line) and the counterfactual median cost $\hat{C}$ (red solid line), estimated according to equation (11). See section (2.2.2) for a discussion of why I consider the median cost to examine intensive investment bunching. The number of intensive investment bunchers is estimated as the excess number of firms with above median capital costs in the excluded range, as show in equation (12).

Figure III: Bunching at 10k



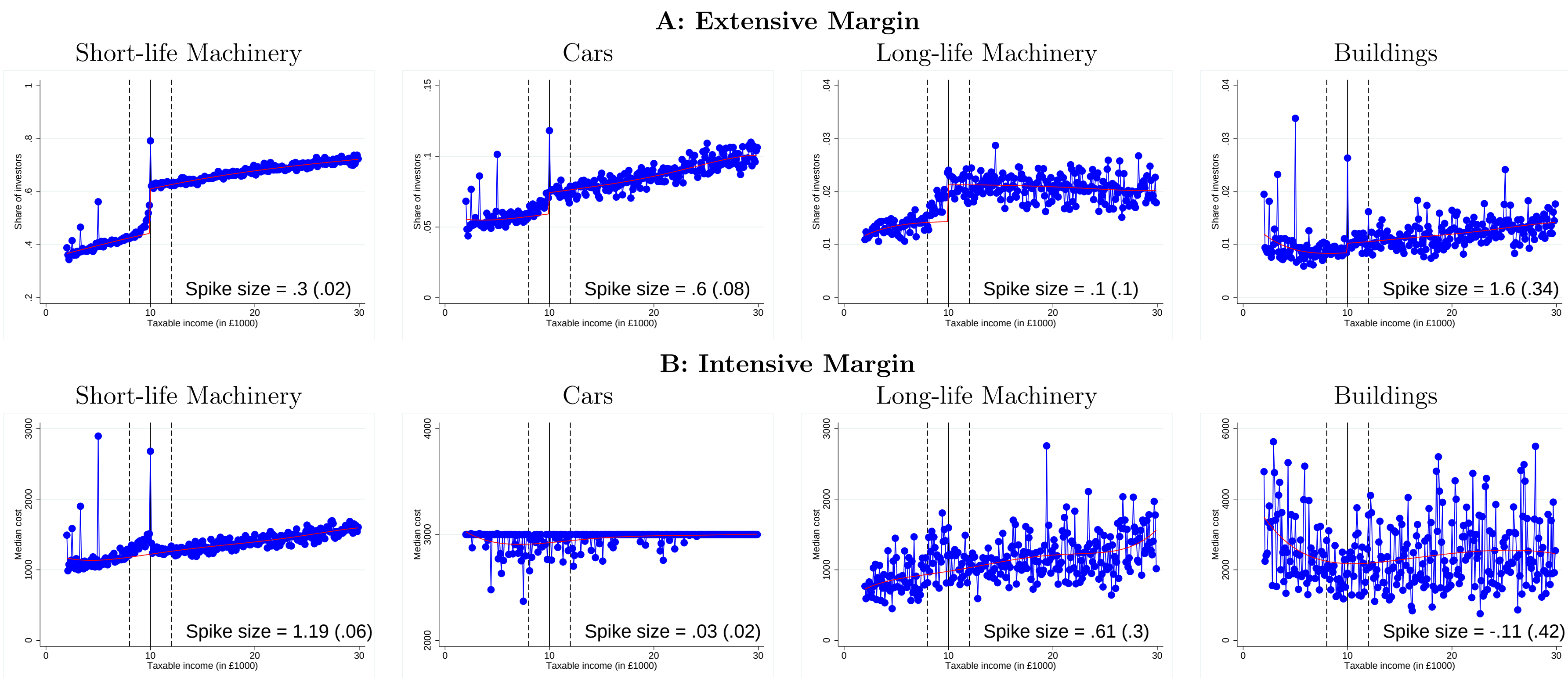
Notes: The figure presents the empirical frequency (blue dotted line) and the estimated counterfactual (red solid line) of firms around the 10k kink, for fiscal years 2002-2005. During this period, the marginal tax rate is 0% for incomes below 10k and 23.75% for incomes above 10k. The counterfactual is estimated from equation (4), by fitting a flexible polynomial to the observed frequency, excluding a range around the kink. The kink is marked by a vertial solid line; the exluded range is marked by vertical dashed lines. The bin size (£100) and degree of polynomial (5) are chosen to optimize the fit, as in Devereux *et al.* (2013). The estimation allows for round number effects at multiples of 10k up to 20k, and at multiples of 5k, interacted with taxable income. Excess mass b is the excess frequency in the excluded range around the kink, in proportion to the average counterfactual frequency in the excluded range, as estimated following equation (6). The elasticity of taxable income ϵ is estimated using equation (3). Bootstrapped standard errors are shown in parantheses. Source: HMRC.

Figure IV: Investment Spikes Across Time



Notes: The figure shows plots of the median cost (blue dotted line) by taxable income bins (bin size £100) and the estimated counterfactual median cost (red solid line). Panel A shows median recurrent costs and Panel B shows median costs (capital allowance claims) for short-life machinery, for the years 2001, 2002-2005 and 2006-2007 respectively. In 2001, the 10k kink represented a jump in the marginal tax rate from 10% to 22.5%. In 2002-2005, the jump was from 0% to 23.75%. In 2006-07, there was no kink and the marginal tax rate was 19% for all firms with a taxable income below 50k. The counterfactual median cost is estimated from equation (11), by fitting a 5th-order polynomial to the observed median cost, excluding a range around around the kink. For short-life machinery in 2002-2005, the specification allows for different constants above and below the kink. The kink is marked by a vertial solid line (vertical dotted line in 2006-2007, when there is no kink); the excluded range is marked by vertical dashed lines. The spike size is the difference between the observed and counterfactual median cost in the income bin centered at 10k, minus a randomly drawn estimated residual, and scaled by the counterfactual median cost at the kink. Bootstrapped standard errors are shown in parantheses. Source: HMRC.

Figure V: Investment Spikes Across Capital Items

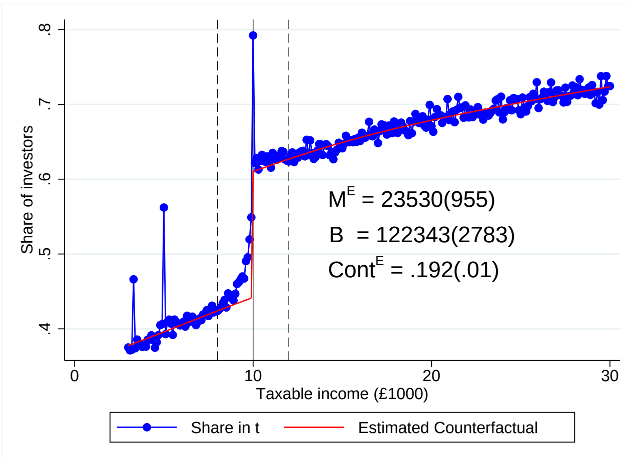


Notes: The figure examines investment changes around the 10k kink at the extensive margin (Panel A) and the intensive margin (Panel B). Panel A plots the share of investors (firms with positive capital allowance claims) and Panel B plots the median cost (capital allowance claims for investors, blue dotted line), by taxable income (bin size £100). The plots also show an estimated counterfactual (red solid line). For Panel A, the counterfactual median cost is estimated from equation (7), by fitting a 5th-order polynomial to the observed median cost, excluding a range around the kink. The estimation allows for different constants for income bins above and below 10k. The counterfactual for Panel B is estimated in a similar way, using equation (11). All figures are for 2002-2005, when the kink represents a tax rate jump from 0% to 23.75%. The kink is marked by a vertial solid line; the excluded range is marked by vertical dashed lines. The spike size is the difference between the observed and counterfactual share of investors (median cost) in the income bin at 10k, minus a randomly drawn estimated residual, and scaled by the counterfactual share of investors (median cost) at the kink. Bootstrapped standard errors are shown in parantheses. Source: HMRC.

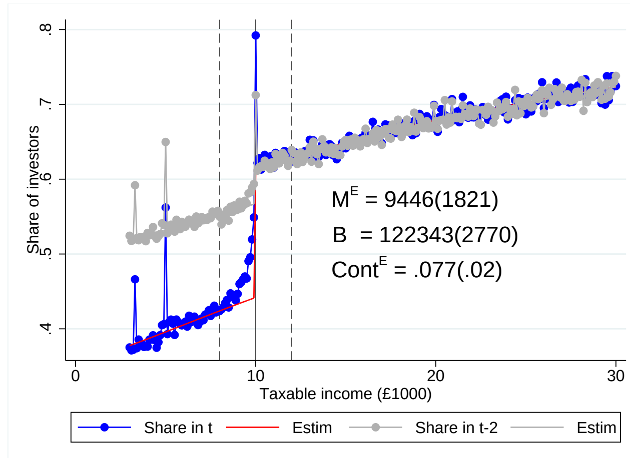
Figure VI: Estimating Extensive Investment Bunching

A: Full Sample

A1: Baseline

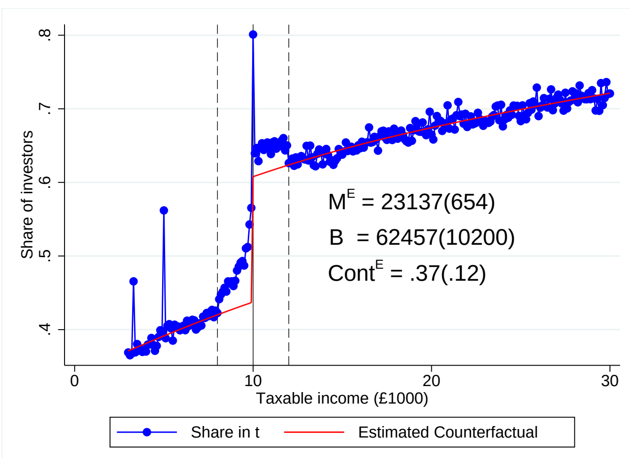


A2: With Control

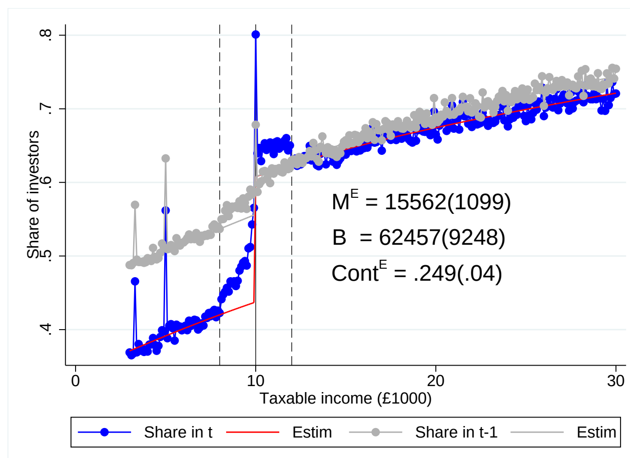


B: One-time Bunchers

B1: Baseline

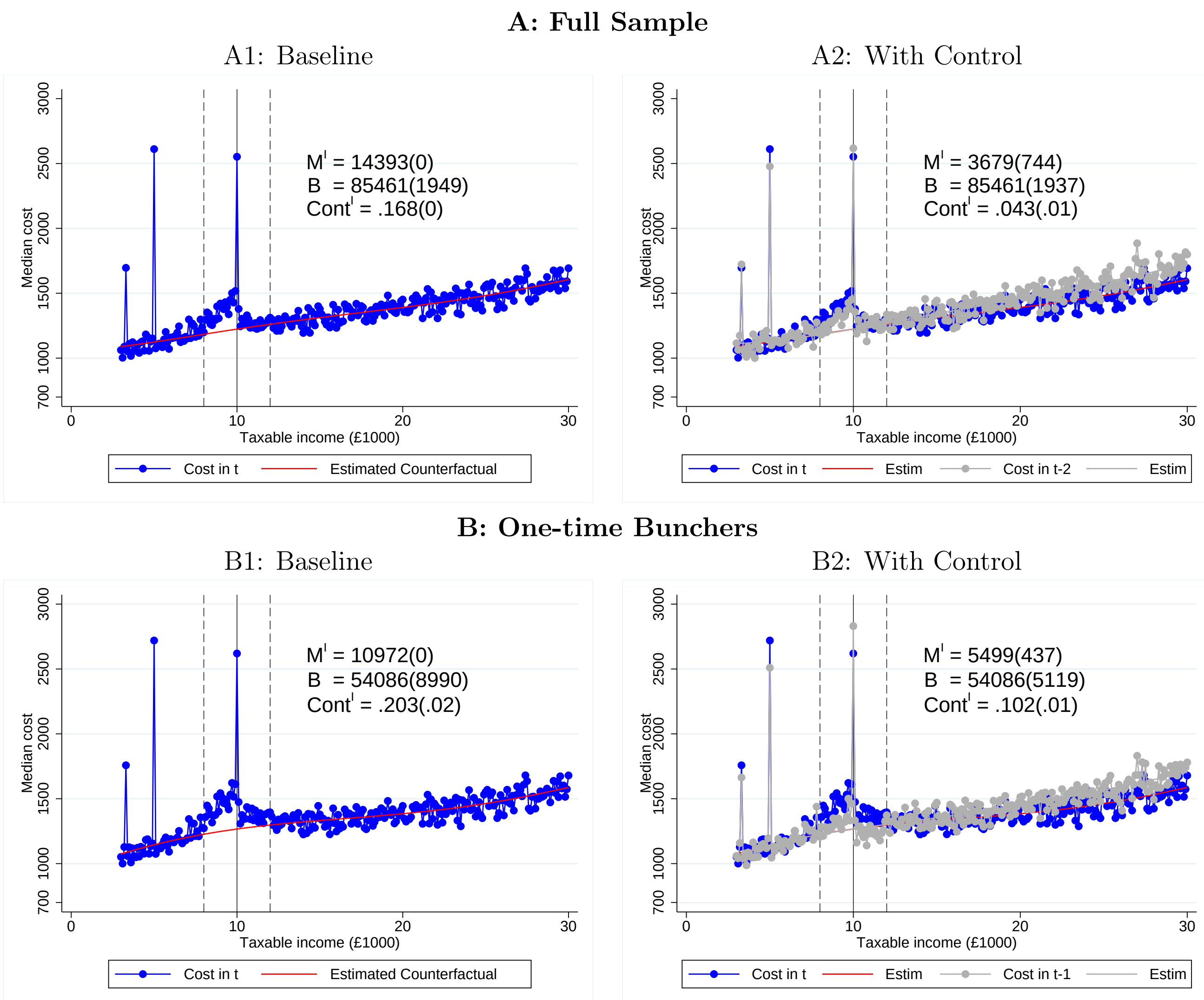


B2: With Control



Notes: The figure displays results for estimating the contribution of investment in short-life machinery to bunching, focusing on extensive margin changes in investment. The data are for 2002-2005, when the 10k kink represents a tax rate jump from 0% to 23.75%. The kink is marked by a vertical solid line; the excluded range is marked by vertical dashed lines. In the full sample (Panel A), I use the share of investors in $t-2$ to control for selection in the group of bunchers. Panel A1 plots the share of investors (firms with positive capital allowance claims for short-life machinery) in year t by income bins in year t (blue dotted line, bin size £100), and its estimated counterfactual (red solid line). The counterfactual is estimated by fitting a flexible polynomial to the observed share, excluding a range around the kink, as shown in equation (7). Panel A2 is identical to Panel A1, and also plots the control share of investors in $t-2$ by income bins in t (grey dotted line), and its estimated counterfactual (grey solid line). The number of extensive margin *investment bunchers* (excess investors) M^E is the difference between the observed and counterfactual number of investors in the excluded range for Panel A1 (equation (8)), and the difference between the observed and the control counterfactual number of investors in the excluded range for Panel A2 (equation (15)). The number of bunchers B is estimated as shown in Figure III, by fitting a flexible polynomial to the observed frequency distribution of firms. B is the difference between the observed and estimated frequency, in the excluded range, as in equation (5). The contribution of extensive margin investment to bunching is $Cont^E = M^E/B$. Bootstrapped standard errors are shown in parantheses. In the sample of one-time bunchers (Panel B), in which I eliminate all firms with a taxable income $\in [8k, 12k]$ for two consecutive years, I use the share of investors in $t-1$, by income bins in t, to control for selection in the group of bunchers. Everything else is as in Panel A. Source: HMRC.

FIGURE VII: ESTIMATING INTENSIVE INVESTMENT BUNCHING



Notes: The figure displays results for estimating the contribution of investment in short-life machinery to bunching, focusing on intensive margin changes in investment. The data are for 2002-2005, when the 10k kink represents a tax rate jump from 0% to 23.75%. The kink is marked by a vertial solid line; the excluded range is marked by vertical dashed lines. In the full sample (Panel A), I use the median cost in $t-2$ to control for selection in the group of bunchers. Panel A1 plots the median cost for investors (firms with positive capital allowance claims for short-life machinery) in year t, by income bins in year t (blue dotted line, bin size £100), and its estimated counterfactual (red solid line). The counterfactual is estimated by a fitting a flexible polynomial to the observed median cost, excluding a range around the kink, as shown in equation (11). Panel A2 is identical to Panel A1, and also plots the control median cost in $t-2$ by income bins in t (grey dotted line), and its estimated counterfactual (grey solid line). The number of intensive margin *investment bunchers* (excess investors) M^I is excess number of firms with a cost (capital allowance claim) above the counterfactual median in the excluded range for Panel A1 (equation (12)), and the excess number of firms with a cost above the control counterfactual median in the excluded range for Panel A2 (see footnote 21). The number of bunchers B is estimated as shown in Figure III, by fitting a flexible polynomial to the observed frequency distribution of firms. B is the difference between the observed and estimated frequency, in the excluded range, as in equation (5). The contribution of intensive margin investment to bunching is $Cont^I = M^I/B$. Bootstrapped standard errors are shown in parantheses. In the sample of one-time bunchers (Panel B), in which I eliminate all firms with a taxable income $\in [8k, 12k]$ for two consecutive years, I use the share of investors in $t-1$, by income bins in t, to control for selection in the group of bunchers. Everything else is as in Panel A. Source: HMRC.

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