Tax and Occupancy of Business Properties: Theory and Evidence from UK Business Rates

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Tax and Occupancy of Business Properties: Theory and Evidence from UK Business Rates*

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Abstract

We study the impact of commercial property taxation on vacancy rates in the UK using regression kink and regression discontinuity designs. We exploit exogenous variations in commercial property tax rates from three different reliefs in the UK business rates system: small business rate relief (SBRR), retail relief and empty property exemption. A simple theoretical framework predicts: (i) relationships between rateable values and taxes, and vacancies; (ii) that SBRR has a sorting effect on the mix of businesses in small properties. Findings consistent with the theory suggest that SBRR increases the likelihood that a property is occupied by a small business, reduces the likelihood that it is occupied by a large business, and reduces the overall likelihood of being vacant. We estimate that the retail relief reduces vacancies by 90%, and SBRR relief by up to 54%.

Keywords: Commercial Property, Vacancy, Occupancy, Property Taxation
JEL Codes: H25, H32, R30, R38.

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1 Introduction

In this paper, we study the effect of business property taxes on the utilization of business properties in the UK, using various property relief schemes to identify the causal effect of the tax on vacancy and occupation rates of properties. These taxes, known as business rates, are set at national level in the UK, and are a significant source of revenue for local government, but also a significant burden on businesses. There has been concern that this burden falls more heavily on small businesses, and more recently, is also creating a disadvantage for "bricks and mortar" retailers vis a vis online ones. As a result, two important reliefs, the small business rate relief (SBRR), and retail relief, have been introduced in recent years.[1] Using regression discontinuity and regression kink designs, we show that these reliefs significantly reduce vacancy rates, and also, in the case of the SBRR, change the mix of businesses occupying properties.

Specifically, defining the effective tax rate as business tax divided by the rateable value of the property, a one percentage point reduction in the tax rate due to the retail relief reduces the vacancy rate by 0.53 percentage points, which is a reduction of 5.5%. As the retail relief gives a substantial rate reduction of about of one-third (about 16 percentage points of rateable value), our estimates imply that the tax reduction given by retail relief reduces the vacancy rate of retail properties by 90%.[2]

The SBRR substantially reduced the cost of business rates for "small" businesses i.e. ones with only one property, but not other businesses, and so one would expect that the effect on the mix of businesses occupying the qualifying properties would be large, but that the overall effect on vacancy rates might be smaller.[3] This is exactly what we find: a one percentage point reduction in the tax rate from the SBRR increases the probability that a small business occupies the property by 0.27 percentage points, and decreases the probability that a large business occupies the property by slightly less.

Overall, this is a small but significant negative effect of the SBRR on the vacancy rate of qualifying properties: a one percentage point reduction in the tax rate due to SBRR reduces the vacancy rate by 1.1%. So, our estimates imply that SBRR reduces the vacancy rate of properties that qualified for full relief by 54% compared with if there is no relief. These results are consistent with our theoretical framework, further described below, which predicts that pound for pound, retail relief is a more effective instrument for reducing vacancies.

One might ask at this point why vacancies matter. One possible answer is that the

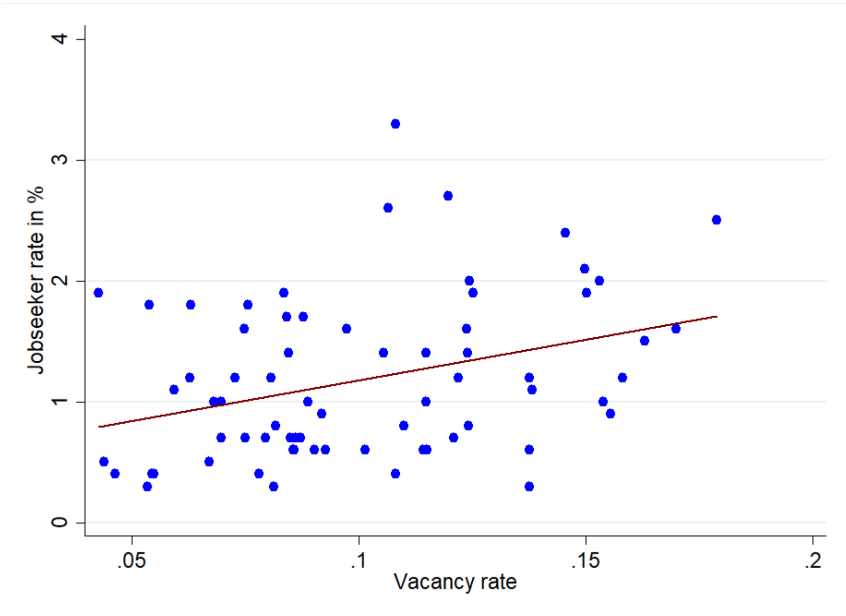
[1] We also study a less important relief, the empty property discount.

[2] In this calculation, and the one below for SBRR, we use the full theoretical reduction in business tax.

[3] Qualifying properties are those with a rateable value of below £15,000.

UK is a densely populated country with strict planning laws, implying that even in the medium run, the supply of business premises is highly inelastic (see Section 2.1). This suggests that vacancy rates could be an important indicator of economic activity; some evidence for this is in Figure 1 below, which shows a positive relationship between vacancy rates and the unemployment rate at the local authority level. Another point is that it is widely accepted that for the UK, high occupancy rates, especially of retail properties in town and city centres, have positive "quality of life" externalities for residents (Portas (2011)).[4]

Figure 1: Relationship vacancy rate and unemployment rate



Note: The figure shows the scatter plot for vacancy rate and jobseeker rate in percentage (measure for the unemployed in the UK) on the local authority level for 73 local jurisdictions in England in 2018/2019. Jobseeker rate is provided by the ONS and is defined as the ratio of individuals claiming jobseeker allowance (unemployment benefits in the UK) to the resident population aged 16-64 estimates. For more information on the vacancy data and the jurisdictions included, see Section 5. The solid lines represent linear fits.

Our results contribute to a relatively small literature on the effects of business property taxes on business activity levels. For the UK, using spatial identification approach, Duranton, Gobillon and Overman (2011) find that business property taxes affect employment growth, but not firm entry.[5] More recently, Enami, Reynolds and Rohlin (2018) show for

[4]Some evidence for this is reported in Figure C1, which shows a negative relationship between vacancy rates and share of local residents that reported positive life satisfaction in survey data.

[5]This study exploits the fact that before 1990, business rates were set locally. However, since that date, they have been set nationally, which means that the only way of identifying the effects of business property taxes in the UK is via discontinuities and kinks in the national tax schedule, as we do here.

the US, using a regression discontinuity design, that school districts that barely passed referenda on property taxes have fewer businesses in the district in the following years, compared to those districts where the referendum barely failed. However, neither of these papers address the determinants of vacancy and utilization rates of existing properties. By contrast, the existing literature on vacancy determination focuses on the dynamic behaviour of vacancies and rents, and to our knowledge, does not study the effects of business taxes on vacancies (Englund et al. (2008), Grenadier (1995)).

Perhaps reflecting the lack of empirical work on the topic, there are, to our knowledge, no theoretical models of the commercial property market where occupancy rates arise endogenously via search and matching frictions.[6] So, to provide a conceptual framework and also specific predictions, this paper begins with a simple theoretical model of this kind. We choose to work with a directed search model, which allows (in our context) businesses to decide which kinds of properties to apply to rent. This seems more appropriate to our setting where information on vacant properties is easily available online or via commercial agents, as discussed in Section 2.1 below. This framework makes specific predictions about the relative size of the causal effects of different reliefs on vacancies, and also the mix of businesses occupying qualifying properties, which are largely confirmed by the empirical results. To our knowledge, this is the first model that combines market frictions with business tax reliefs, and so has wider applicability than just the UK context.

This theoretical analysis is related to a small literature on matching models of the residential housing market. For example, matching models of the housing market date back to Wheaton (1990), and more recently, directed search models of the housing market have been developed e.g. Albrecht, Gautier and Vroman (2016). However, their model does not apply to our case as it only allows for one-sided heterogeneity; in particular, only sellers differ in reservation values.[7]

Finally, our paper has implications for the current lively UK debate on business taxes in the UK. It has long been recognized that business rates disproportionately affect certain types of business. The SBRR was introduced in 2005, in response to concern that for small businesses, business rates represented a higher proportion of overheads and profits than for larger businesses.[8] Retail relief was introduced in 2019, and was clearly intended to

[6]Models with matching frictions are clearly required for the obvious reason that in a frictionless model, market(s) would clear, implying zero vacancy rates, except in the special case where the supply of properties is perfectly elastic.

[7]We need to allow for heterogeneity in both sides of the market to analyse the effect of the SBRR, as this tax discount is only operative when both the landlord and the potential tenant are “small”, as defined in Section 3.1 below. The paper of Albrecht, Gautier and Vroman (2016) also has some additional features that add considerable complexity and are not required for our purposes, such as renegotiation of the posted prices.

[8]Fourth Standing Committee on Delegated Legislation, House of Commons, 8th Feb 2005.

support “bricks and mortar” retail, and particularly the British “High Street”, in the face of the rapid trend towards online shopping in the UK. The then Chancellor (Finance Minister) said in his (November) 2018 Budget speech[9]: “Embedded in the fabric of our great cities, towns, and villages, the High Street lies at the heart of many communities. And it is under pressure as never before as Britain adopts on-line shopping with greater alacrity than any other large economy...for all retailers in England with a rateable value below £51,000, I will cut their business rates bill by one third.”

Our results show that these relief schemes have been effective in achieving their stated goals. Our results also suggest that relief from business rates could be an effective policy tool in other contexts. For example, during the Covid-19 pandemic, business rates relief was given to businesses in the hospitality as well as retail sector, and the rate of relief was increased. Our paper contributes to the understanding of the impact of these policy measures by providing the first clear conceptual analysis of the impact of small business rate relief in the context of UK business rates.

2 Background

2.1 The Commercial Property Market in the UK

Commercial property in the UK accounts for about 10% of UK's net wealth, with value at about £883 billion in 2016 (British Property Federation, 2017). The three major types of commercial property in UK are retail (e.g. high street shops and shopping centres), offices, and industrial (e.g. warehouse and factories). The amount of physical floorspace is quite stable in UK, meaning that occupancy of existing space, rather than creation of new space, is an important determinant of economic activity in any locality.[10]

In the UK, about 55 percent (in terms of value) of commercial property is rented rather than owner-occupied (British Property Federation, 2017). Rents are generally paid quarterly. For renters, the average lease length is at around 7.5 years in 2017 (British Property Federation, 2017), with frequently occurring lease length including three, five, ten and fifteen years (McCluskey et al., 2016). Almost all lease contracts make provision for a review of rent if the lease term is more than five years, usually to the level of prevailing market rent at the time, with an upward only provision (Investment property forum, 2017). Exit strategies such as subletting, or break clauses are quite important

[9] Available at www.gov.uk/government/speeches/budget-2018-philip-hammonds-speech.

[10] The net amount of commercial property floorspace has increased in total by only 0.5% over the last ten years i.e. new construction is effectively covering only the demolition and change in use to residential property (British Property Federation, 2017).

aspects of the lease contract, as the average occupation period is shorter than the average length of leases (McCluskey et al., 2016). There are also rent-free periods offered in some cases as incentive for tenants to sign new leases.

Renters typically search for properties via property letting agents, or online platforms, such as Rightmove, Realla or NovaLoca. Location is considered as one of the most important factor in choice of renting for UK tenants, but cost, size, layout and footfall are also important (Sanderson and Edwards, 2014). In 2016, the cost of renting offices was about 9% of staffing cost of business overall, but much higher at 37% for retailers (British Property Federation, 2017).

2.2 Taxation of Commercial Property in the UK

The business rate is a recurrent tax on commercial property in England and Wales.[11] The tax is charged quarterly to the occupier (e.g. the firm) and based on the rateable value of the property. If the property is not occupied, the owner pays the tax. Rateable value is the open market rental value at a nominal date, currently on 1 April 2015; this rental value is estimated by the Valuation Office Agency (VOA), part of the UK government.[12]

Absent any special reliefs, the actual tax liability is equal to rateable value times a multiplier. The multiplier varies by geographical area (in or outside London) and time period, but differences are small in magnitude; between 2017 and 2019, it was on average around 49%. The multiplier is also slightly lower for properties with rateable value below a threshold, currently £51,000. The multipliers for fiscal years 2010-11 onwards are given in Table C1 in the Appendix.

Businesses, property owners and renters also receive various types of relief, which sum up to around £5 billion in 2019/2020 or 16% of gross revenue (UK Ministry of Housing and Governments, 2021).

First, retail relief is specifically targeted to retail property that has a rateable value below £51,000; for these properties, the amount of business tax payable is reduced by one-third. The loss in tax revenue due to the relief is estimated to be around £500 million (UK Ministry of Housing and Governments, 2021). Granting the relief is at discretion of the local authority but as the costs are born by the national government, jurisdictions have an incentive to grant the relief.

Second, the small business rate relief scheme (SBRR) applies mainly to businesses who use only one property, *and* where that property has a rateable value below £15,000.[13]

[11]Scotland and Northern Ireland have their own systems.

[12]There is a two year gap between the estimated rental rate and the first year it applies to the tax measure, so this rateable value was first used in 2017.

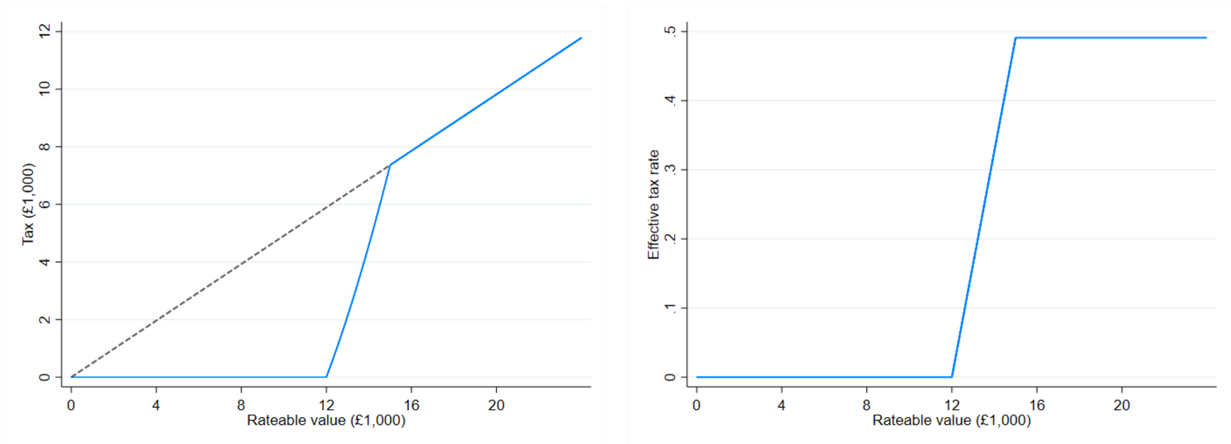
[13]Businesses are not entitled to the small business relief if they use more than one property and the

Specifically, for property with a rateable value below £12,000, the business rate is zero.[14] For properties with a rateable value between £12,000 and £15,000, the business rate increases in proportion to rateable value, with relief tapering to zero once rateable value reaches £15,000.[15] The scheme thus creates two kinks in tax rate in the tax schedule, which we will exploit for identification. Figure 2 plots the tax charge and tax rate as function of rateable value. The SBRR is the single most important relief in the business rate system in England, costing the government £1.9 billion in 2019. (UK Ministry of Housing and Governments, 2021). It is a mandatory relief.

Finally, a third relief that we study is empty property exemption.[16] This relief exempts properties that have a rateable value of less than £2,900 from business rates. Clearly, this relief is different to the other two, as it effectively taxes, rather than subsidises, occupation of the property. The relief is at discretion of the local authority.

Figure 2: Tax and rateable value, small business rate relief

(a) Tax charge (b) Effective tax rate



Note: Panel (a) shows how SBRR is phased out when rateable values increase from £12,000 to £15,000. The solid line in panel (a) shows the business rate payable net of SBRR; the vertical difference between the solid and dotted lines shows the amount of SBRR. Panel (b) shows the effective tax rate for small business. The effective tax rate is defined as (business rate tax - SBRR)/rateable value.

total rateable value of all their properties is greater than £20,000 or if more than one property has a rateable value of more than £2,900.

[14]SBRR has been in place since 2005. Before April 2017, the threshold for the zero charge was £6,000, and for properties above £12,000 the full charge applied.

[15]See www.gov.uk/apply-for-business-rate-relief/small-business-rate-relief

[16]In addition, there is an empty property relief for properties that have been vacant for less than three month (six month for industrial properties).

3 A Theoretical Framework

This Section presents a simple theoretical model of the commercial property market with frictions, the purpose of which is to generate our key predictions. The model is presented as one of a rental market. However, as noted above, almost half of commercial properties are owned, not leased, in the UK. Because the model is static, it equally well applies to the purchase decision, with the rent being interpreted as the purchase price. A key feature of the model is that it features two-sided heterogeneity i.e. both businesses and properties can differ in size; as discussed above, this feature is required to understand the sorting effects induced by the SBRR.[17]

3.1 Model Set-Up

Preliminaries. There are large numbers of landlords, and of businesses. Each landlord owns one property, and each business needs one property to operate. The number of properties is fixed at N. There are an arbitrary number of property types, $i = 1, ..p$, ranked by their rateable value R_i, so $R_1 < R_2 < ...R_p$. The fraction of properties of each type i is ϕ_i. There are also two types of businesses; those that currently have no properties (small, s) or one or more properties (large, l); the numbers of each are N_s, N_l respectively. The number of large business is assumed fixed; these could be e.g. retail chain stores with many properties. The number of small businesses is determined by free entry as explained in Appendix B. The distinction between these business types is important for the SBRR. Both properties and businesses can be in one of two states, matched or unmatched; a matched property is let to a business, unmatched properties are vacant, and unmatched businesses i.e. those without a property do not operate.

Business Rates. We will model the UK business rate system in full detail in order to derive testable predictions. We will assume that firms and properties are in the retail sector as this is the most complex case; Propositions 1 and 2 below also apply to the non-retail sector. To do this, we write the business tax payable on a property of rateable value R, measured in units of one thousand pounds, as $T^u(R)$ if the property is unoccupied, and $T^o(R; j)$ if occupied, where $j = s, l$ records whether the tenant is a large or small business. The functions $T^u(R), T^o(R; j)$ are fully described in Appendix A and just represent algebraically the business rate reliefs, as described in Section 2.2.

Payoffs. Payoffs in each state are as follows. A landlord of type i will get rent r_i if the property is let, and will have to pay a business rate $T^u(R_i)$ if the property is vacant.

[17]The model is loosely based on Shi (2002), which is a model of directed search with two-sided heterogeneity in the labour market. However, there are some significant differences e.g. in our model, the posted rent is not conditional on the business type.

Businesses with a property generate zero profit, and a business of type j in a type i property has net profit $\Pi(R_i) - r_i - T^o(R_i; j)$ where $\Pi(R_i)$ is sales minus costs other than rent or tax e.g. wages. Note that r_i is set prior to the landlord being matched with the tenant, and it is assumed that it cannot be renegotiated ex post. Thus, r_i is independent of the tenant type.

Finally, we assume that the opportunity cost to any business of applying to a property with rateable value R_i is proportional to its rateable value i.e. is ρR_i. This opportunity cost could for example, be the profit from taking the business online, or for a self-employed business person, taking up another occupation.

Order of Events. There is a market friction in that it takes time to match businesses to properties. We capture this by the assumption, standard in the directed search literature, that each business can apply to at most one property. The order of events is as follows:

1. All landlords of type i simultaneously post and commit to rents r_i :
2. Businesses decide which properties to apply to, and landlords choose tenants:
3. Properties are occupied, generate profits, and rents and business rate are paid.

As numbers of both side of the market are large, we consider *symmetric mixed strategy equilibria*, where (a) all businesses of a given type, and all landlords with properties of a given type, use the same strategy; (b) businesses randomize over their applications to properties of a given type; (c) landlords with properties of a given type randomize over choice of tenants. Note that part (c) reflects the fact that as businesses of both types pay the same rent, the landlord does not distinguish between them.

3.2 Equilibrium Vacancy Rates and Sorting

A full statement of the equilibrium conditions of the model, which determine rents, application probabilities, and the number of small firms, is given in Appendix B. Here, we just discuss the equilibrium vacancy rates, and the sorting of firms across properties, which occurs in equilibrium with the SBRR.

To understand vacancy rate determination, note first that because landlords can set rents unilaterally, in equilibrium, they extract all the economic surplus from firms that they rent to. In turn, this means that firms renting from a given landlord of type i are indifferent between doing so and taking their outside option ρR_i. Thus, effectively, any landlord can choose their vacancy rate subject to the constraint that they adjust the rent to leave the tenants indifferent between applying and not.

Given these observations, it is then straightforward to derive the optimal vacancy rate for each type of landlord in any equilibrium. This vacancy rate balances the marginal gain to the landlord from a slightly lower vacancy rate to the cost. The cost is simply ρR_i, as the business must be offered a profit of ρR_i to induce them to apply. As regards the marginal gain, note that the landlord extracts all the economic surplus from letting the property due to the fact that they can post the rent. Generally, this surplus is just $\Pi(R_i)$ plus any tax savings from letting the property rather than leaving it vacant. Using the tax function as defined above, these savings can be written $T^u(R) - T^o(R; j)$. So, the overall economic surplus from letting the property, all of which accrues to the landlord, is $\Pi(R_i) + T^u(R) - T^o(R; j)$.

We then have the following result, which gives a very simple formula for the equilibrium vacancy rate.[18] Specifically, it says that the vacancy rate is equal to the ratio of the marginal cost of reducing the vacancy rate, relative to the marginal benefit of doing so.

Proposition 1. *In any equilibrium where a landlord of type i rents to a firm of type j, vacancy rates are*

$$v_i = \frac{\rho R_i}{\Pi(R_i) + T^u(R) - T^o(R; j)} \tag{1}$$

Note that Proposition 1 gives us a general formula that can be used to look at changes in the vacancy rate at any particular threshold.[19] These observable implications are discussed in much more detail in Section 3.3. Note also that formula (2) is completely general in that the tax functions $T^u(R), T^o(R; j)$ capture any interactions between reliefs - for example, retail relief may also apply at the SBRR thresholds.

Now define small (resp. large) landlords to be those with properties to be those that are below (resp. above) the threshold for SBRR. [20] Note first that if the landlord is small, the maximum rent that can be extracted from a type s business is higher than a type l business, because the former tenant will be eligible for SBRR. In any equilibrium, it can be shown that small landlords will always set this higher rent, and as a consequence, large businesses will apply only to large landlords. So, the equilibrium must be *fully* or *semi-segmented*; large businesses will rent only from large landlords, and small businesses are indifferent between large and small landlords and may rent from both. Moreover, all these equilibria are payoff-equivalent for all agents, because (i) small businesses are indifferent between applying to small or large properties; (ii) large landlords are indifferent between letting to large and small businesses.

[18]Propositions 1 and 2 are proved in the Appendix.

[19]For example, at $R = 51$, retail relief is withdrawn, which causes a large fall in $T^u(R) - T^o(R; j)$ at the threshold, and thus - as long as $\Pi(R_i)$ is continuous - there will be an upward jump in v at the threshold as R varies.

[20]These properties may not be physically large; rateable value depends also on location and condition, as well as size.

Proposition 2. *In any equilibrium, large businesses do not apply to small properties, and small properties are only let to small businesses.*

3.3 Empirical Predictions

We will develop testable predictions from Propositions 1 and 2. First, Proposition 1 describes reduced-form relationships between the vacancy rate v and R. We can make various predictions about the sign of this reduced-form relationship, which can be straightforwardly tested. Moreover, we are also interested in the causal relationship between a change in the business tax liability T and v, both of which depend on R. For reasons explained below, in what follows, we will actually look at the *effective tax rate* defined as $\tau = \frac{T}{R}$. So, we will develop predictions about these causal effects of τ on vacancies at the various thresholds.

To proceed, think of R as a continuous variable; we can do this as in the model, there are an arbitrary number of landlord types. Then, divide the denominator and numerator of (1) by R and drop the landlord type subscript to get

$$v(R) \equiv \frac{\rho}{\pi(R) + \Delta\tau(R)}, \quad \Delta\tau(R) \equiv \tau^u(R) - \tau^o(R) \tag{2}$$

Here, $\pi(R) \equiv \Pi(R)/R$ is the profit per unit of rateable value to the tenant. Also, $\tau^0(R)$ is the tax paid by the tenant of any occupied property ; in full, $\tau^0(R) = \tau^0(R; s)$ if both the property and tenant are small, and $\tau^0(R)$ does not depend on tenant type otherwise. We will make the usual assumption in the RDD literature that for fixed $\Delta\tau$, V is continuous in R; from (2), this amounts to assuming that $\pi(R)$ is continuous.

Predictions for $v(R)$. First, consider the retail relief threshold R_r. It is intuitive that at this threshold, there is an downward jump in $\Delta\tau(R)$ to zero as the retail relief is fully withdrawn at this threshold and there are no other reliefs at the retail relief threshold - the exact size of the discontinuity is in (A.16) in Appendix B.3. Consequently, from (2), there will be an upward jump in the vacancy rate at this threshold.

Now consider the empty property relief threshold R_e. By a similar argument, there is an upward jump in $\Delta\tau(R)$ as the empty property relief is fully withdrawn at this threshold - the exact size of the discontinuity is in in (A.19) in Appendix B.3. Consequently, from (2) there will be an downward jump in the vacancy rate at this threshold.

With SBRR, the tax payable is a continuous but kinked function of R, with the kinks at $R = \underline{R}_s, \overline{R}_s$. First, we can obtain predictions about the change in the slope of the reduced-form relationship between v and R at these kink points. Using (2), after straightforward calculations, reported in Appendix B.3, we can show that the change in slope of $v(R)$ at the first kink point is therefore *positive* but the change in slope at the second kink point is *negative*; see equations (A.23), (A.25) in Appendix B.3. It might seem counter-intuitive that the SBRR can have qualitatively different effects on the change in slope at the two kinks. However, this is easily explained by the shape of SBRR. From Figure 2, we see that at the first kink, the rate of change of the value of the relief with respect to R *decreases* (from positive to negative), causing vacancies to rise *faster* (or fall more slowly) as R passes the first kink point. On the other hand, at the second kink, the rate of change of the relief with respect to R *increases* (from negative to zero), causing vacancies to rise *more slowly* (or fall faster) as R passes the second kink point.

Marginal Effects of Reliefs. Here, to estimate the size of the causal tax effect on vacancies of any particular relief, we can divide the size of the change in v at the threshold by the change in the effective tax rate as the relief is withdrawn to give a *marginal effect* $\frac{dv}{d\tau}$. This gives us a way of comparing the "bang for the buck" of retail relief and SBRR in reducing vacancies. Of course, empty property relief is different in that it *subsidises* vacancies, so that $\frac{dv}{d\tau}$ will be negative in this case. Estimates of these marginal effects can be easily derived from our empirical approach and so it is of interest to know what the theory predicts about them.

We cannot make predictions about their *absolute* values, as the formulae for marginal effects - as calculated in Appendix B.3 - contain the parameter ρ, for which we do not have an estimate. However, we can make some predictions about the *relative* size of the different marginal effects, if we are willing to assume that the return per unit of rateable value $\pi(R)$ is constant in R i.e. $\pi(R) \equiv \pi$. Using the formulae (A.17) ,(A.20), (A.28) in Appendix B.3, plus the assumption $\pi(R) \equiv \pi$, the size of the marginal effects can then be ranked as follows:

$$\frac{\partial v}{\partial \tau}|_{R_r} = \frac{\rho}{\pi(\pi + \frac{\kappa}{3})} > -\frac{\partial v}{\partial \tau}|_{R_e} = \frac{\rho}{\pi(\pi + \kappa)} > \frac{\partial v}{\partial \tau}|_{\underline{R}_s} = \frac{\rho}{(\pi + \kappa)^2} \tag{3}$$

In (3), κ is just the business rate multiplier as described in Section 2.2 above.

That is, the use of the retail relief should have the biggest effect on vacancies per unit of effective tax, and the use of SBRR relief should have the smallest effect. Note that here, the marginal effect of the SBRR is calculated at the lower kink only. This is because the theoretical formula for the marginal effect at the upper kink i.e. $\frac{\partial v}{\partial \tau}|_{\bar{R}_s}$ is not really applicable because in the data, a large fraction (more than 50%) of properties at the upper kink are let to large businesses i.e. empirically, there is not really much sorting at the upper kink.[21] This is in contrast to the lower kink, where most properties are let to small businesses.

Sorting. Proposition 2 states that due to SBRR, only small businesses will occupy "small" properties, whereas large properties will be occupied by a mix of small and large businesses. This is obviously a rather extreme prediction generated by the simplicity of the model, and so we test the main insight of the theory here in a looser way by investigating whether small properties are more likely to be occupied by small businesses than large properties. Specifically, we test, using a regression kink design (Card et al. (2015*b*)), how the rate of change of occupancy rates of small properties by small and large businesses with respect to R changes at the £12K threshold. Our prediction is that at this threshold, the rate of change of occupancy with respect to R should *increase* for large businesses, and *decrease* for small businesses.[22]

4 Empirical Approach

4.1 Retail relief and empty property exemption

As discussed in Section 3.3 above, we expect discontinuities in the reduced form relationship between rateable values and vacancies at the thresholds for the retail and empty property reliefs, and we use a RDD to estimate these. In the case of retail relief, there is an additional complication that the standard business rate multiplier also changes at rateable value of £51,000, so we will use a difference-in-discontinuity (Grembi, Nannicini and Troiano, 2016) specification in that case. For this reason, we will start with empty property relief, even though retail relief is a more important and politically salient relief than the former.

To estimate the effect of the empty property relief, we first estimate the reduced form effect on vacancies with the following linear probability model (LPM):

$$E[v_{it}|R] = \alpha_0 + \alpha_1(R - R_e) + \alpha_2(R - R_e) \times D_i + \alpha_3 D_i \tag{4}$$

where v_{it} is an indicator for the property being vacant, and D_i is an indicator for rateable value being above the threshold, R_e. Here, α_3 measures the reduced form effect of the empty property exemption on vacancy rate. In using the LPM we follow the RDD literature with binary outcomes (Shigeoka, 2014; Lindo, Sanders and Oreopoulos, 2010). We

[21] This formula is in the Appendix B as (A.28,(A.29) for non-retail and retail firms respectively.

[22] In making this prediction, we assume, following Card et al. (2015*a*), that holding T fixed, occupancy and vacancy rates are smooth i.e. continuously differentiable functions of R;. this requires that π must be a smooth function of R.

will also use this specification for the other reduced-form estimations that follow. All our LPM estimations perform well in the sense that predicted outcomes are mostly within the unit interval.

The next step is to estimate the causal effect (3) in Section 3.3 above. If there were no other reliefs affecting the business tax, we could just divide α_3 by the change in the effective tax rate on an unoccupied property when the property no longer qualifies, as given by the tax rules, which would be just the multiplier κ, to obtain an estimate of the causal effect. However, in practice, there are other reliefs that make τ differ from the statutory level.[23] To deal with this, we use a fuzzy RDD approach. The first step is to estimate a "first stage" equation giving τ as a function of R;

$$E[\tau_{it}|R] = \beta_0 + \beta_1(R - R_e) + \beta_2(R - R_e) \times D_i + \beta_3 D_i \tag{5}$$

where τ_{it} is the observed effective tax rate paid at an empty property i in time t.

Then, our empirical estimate of the causal effect of the tax on vacancies at this threshold is

$$\frac{\partial v}{\partial \tau}|_{R_e} = \frac{\alpha_3}{\beta_3} \tag{6}$$

This is the empirical estimate of the marginal effect for empty property relief in (3). Since the standard errors for equation (4) and (5) are not directly applicable to $\frac{\partial v}{\partial \tau}$, we bootstrap the standard errors for the causal effect of the tax with (here and in the following) 500 replications.

Also, in this case and also the case of retail relief, both the reduced form and first stage equations are estimated in a bandwidth h of the running variable R i.e. $|R - R_e| < h$. We weight these observations all equally i.e. technically, we use a uniform kernel. We present the estimates using fixed bandwidth and optimal bandwidth calculated following Calonico, Cattaneo and Titiunik (2014*a*,*b*).

We now turn to retail relief. As already remarked, the threshold for retail relief is also the first threshold at which the standard business rate multiplier changes. To deal with this, we use a difference-in-discontinuity approach, by differencing the discontinuity in outcome at the threshold for 2019 (when the retail relief and lower standard multiplier both apply below the threshold) with that in 2018 (when only the lower standard multiplier applies below the threshold). As the change in the standard multiplier at the threshold is the same in both years, the difference of the discontinuities identifies the effect of the retail relief at the threshold. A formal demonstration of this is in Online Appendix B.

[23] These other reliefs would need to be continuous across the threshold.

So, we estimate the following equation on our sample of retail properties:

$$E[v_{it}|R] = \gamma_0 + \gamma_1(R_i - R_r) + \gamma_2(R_i - R_r) \times D_i + \gamma_3 D_i$$
$$\gamma_4(R_i - R_r) \times Post_t + \gamma_5(R_i - R_r) \times D_t \times Post_i + \gamma_6 D_t \times Post_i \quad (7)$$

where v_{it} is an indicator for property i being vacant in time t, D_i is an indicator for property i with rateable value above the threshold ($R_i > R_r$), $Post_t$ is an indicator for quarters during and after 2019 when the retail relief applies.

Similar to the fuzzy RDD approach for the empty property exemption, we also estimate the following equation with respect to the effective tax rate τ:

$$E[\tau_{it}|R] = \eta_0 + \eta_1(R_i - R_r) + \eta_2(R_i - R_r) \times Post_i + \eta_3 Post_i$$
$$+ \eta_4(R_i - R_r) \times D_t + \eta_5(R_i - R_r) \times D_t \times Post_i + \eta_6 D_t \times Post_i \quad (8)$$

where τ_{it} is the observed effective tax rate paid at an occupied property i in time t.

Here, γ_6 and η_6 in equation (7) and (8) estimate the reduced form effect of the retail relief on vacancy rate (Δ_r in (A.16)) and the first stage effect on effective tax rate respectively. We can then calculate the casual effect of the tax on vacancies by taking the ratio of the estimated γ_6 and η_6:

$$\frac{\partial v}{\partial \tau}|_{R_r} = \frac{\gamma_6}{\eta_6}. \quad (9)$$

This is the empirical estimate of the marginal effect for retail relief in (3).

To increase the efficiency of our estimates, we also estimate in addition specifications for the reduced form equation for vacancy, and the first stage for effective tax rate, that control for local-authority fixed effects (for retail relief, we control for local-authority × quarter-year fixed effects). This absorbs any heterogeneity in local economic conditions as, for example, wages or output growth, that may affect vacancies.

4.2 Small Business Rate Relief

In this section, we first explain how we estimate the effect of SBRR on the mix of businesses occupying "small" properties below the £15K threshold. Let o^s_{it} and o^l_{it} be the occupancy rates of properties by small and large businesses respectively i.e. the fractions of properties that are occupied by small and large businesses respectively. We study the behaviour of these rates around the lower threshold for the SBRR only. This is because - as explained in Section 5 below - we only observe the type of business (small or large) for businesses below the £15K threshold.

At this threshold, we implement a regression kink design (RKD) following Card et al. (2015*b*). The first step of this regression kink design is to estimate the reduced-form effect of SBRR on the slope of the relationship between occupancy rates and rateable value, i.e. estimate

$$E[o^s_{it}|R] = \alpha_0 + \alpha_1(R_i - \underline{R}_s) + \alpha_2(R_i - \underline{R}_s) \times \underline{D}_i \tag{10}$$

$$E[o^l_{it}|R] = \beta_0 + \beta_1(R_i - \underline{R}_s) + \beta_2(R_i - \underline{R}_s) \times \underline{D}_i \tag{11}$$

where $R_i - \underline{R}_s$ are rateable values normalized to the threshold, and $\underline{D}_i$, is the indicator for the rateable value being above the threshold, e.g. $\underline{D}_i = 1$ if $R_i > \underline{R}_s$. Equations (10)-(11) are estimated within a bandwidth of h where $|R - \underline{R}_s| < h$ and h is discussed below. Given the discussion in Section 3.3, we expect $\alpha_2 < 0, \beta_2 > 0$.

To estimate the overall effect of the SBRR on vacancies, we are not constrained by the data to only consider the lower threshold of the SBRR. So, we exploit both threshold of $\underline{R}_s = £12,000$ and $\bar{R}_s = £15,000$ as described in Section 3.3. Again, we implement a regression kink design. The first step is to estimate

$$E[v_{it}|R] = \gamma_0 + \gamma_1(R_i - \underline{R}_s) + \gamma_2(R_i - \underline{R}_s) \times D_i \tag{12}$$

$$E[v_{it}|R] = \delta_0 + \delta_1(R_i - \bar{R}_s) + \delta_2(R_i - \bar{R}_s) \times D_i \tag{13}$$

where v_{it} is an indicator of property i is vacant in time t, $R_i - \underline{R}_s, R_i - \bar{R}_s$ are the rateable values normalized to the thresholds, $\underline{D}_i, \bar{D}_i$ are indicators for the rateable value being above the relevant thresholds. Equations (12)-(13) are estimated within a bandwidth of h where $|R - \underline{R}_s| < h$ and $|R - \bar{R}_s| < h$ where h is discussed below.

This specification allows the slope of the relationship between R and v to differ on either side of the kink. Then, the parameters of most interest here are γ_2, δ_2, which measure the change in slope of the relationship between v and R as we pass from left to the right of the thresholds $\underline{R}_s, \bar{R}_s$ respectively. Given the discussion in Section (3.3), we expect that $\gamma_2 > 0$, $\delta_2 < 0$.

With this reduced form effect in hand, we can proceed to the estimate of the causal effect of the tax on occupancy rates and vacancies. As the case of empty property and retail relief, we implement a fuzzy RKD. Specifically, we first estimate the following first stage effect of the tax kink on effective tax rate at the two thresholds:

$$E(\tau_{s,it}|R) = \eta_0 + \eta_1(R_i - \underline{R}_s) + \eta_2(R_i - \underline{R}_s) \times D_i \tag{14}$$

$$E(\tau_{it}|R) = \phi_0 + \phi_1(R_i - \bar{R}_s) + \phi_2(R_i - \bar{R}_s) \times D_i \tag{15}$$

where $\tau_{s,it}$ is the observed effective tax rate for property i paid by a small business, where τ_{it} is the observed effective tax rate for property i paid by any business, and η_2, ϕ_2 give the change in slope of the relationship between τ and R as we pass from left to the right of the thresholds $\underline{R}_s < \bar{R}_s$ respectively. The two dependent variables differ because above the £15K threshold, we are not able to distinguish between small and large businesses. We control in addition for local-authority fixed effects in the estimations to increase efficiency.

Under the assumption that the distribution of unobservable ε that affects vacancy is continuous at the threshold $\underline{R}_s$, the causal effect of tax τ_s on the probability a property occupied by large or small businesses at the £12K threshold can be calculated as

$$\frac{\partial o^s}{\partial \tau_s} = \frac{\alpha_2}{\eta_2}, \quad \frac{\partial o^l}{\partial \tau_s} = \frac{\beta_2}{\eta_2} \tag{16}$$

Similarly, the causal effect of tax τ_s on the overall vacancy rate can be calcuated at the £12K and £15K thresholds respectively as:

$$\frac{\partial v}{\partial \tau}|_{\underline{R}_s} = \frac{\gamma_2}{\eta_2}, \quad \frac{\partial v}{\partial \tau}|_{\bar{R}_s} = \frac{\delta_2}{\phi_2} \tag{17}$$

So, the first term in (17) is the empirical estimate of the marginal effect of SBRR in (3). Note that mechanically, ϕ_2 will be less than η_2, because the effect of SBRR on the change in slope for the tax paid by small business ($\tau_{s,it}$) will be larger than the overall tax (τ_{it}), as the tax paid by large business is unaffected by the upper kink.[24] Therefore, for calculation of the causal effect from equation (17), we multiply ϕ_2 by the share of small businesses among occupiers at the upper kink. We compute the bootstrapped standard errors for these causal estimates.

5 Data

We use open data on business rates at property level provided by each local authority online. We collected and harmonized the administrative data from 73 local authorities.[25] These jurisdictions account for 29% of the population (in 2011), 28% of the total number of non-domestic (i.e., commercial) properties and 35% of the floor space of non-domestic properties in England. We plot the area covered in England in Figure C2.

[24] If τ_j is the tax paid by a type j business occupying a property, and ω is the share of properties occupied by a small business, then $\tau = \omega\tau_s + (1-\omega)\tau_l$. Generally, $\frac{d\tau}{dR} = \omega\frac{d\tau_s}{dR} + (\tau_s - \tau_l)\frac{d\omega}{dR}$. At the upper kink, $\tau_s = \tau_l$ and so $\frac{d\tau}{dR}_{R\downarrow\bar{R}_s} = \omega\frac{d\tau_s}{dR}_{R\downarrow\bar{R}_s}$.

[25] The data for a particular jurisdiction and quarter is included in our data set if it includes information on all properties in the jurisdiction and the type of properties. Some jurisdictions do not publish business rate data online, in that case they are not included in our sample.

The data set has a quarterly frequency and we collected it for the time period from the second quarter of 2018 to (and including) the third quarter of 2019. Our baseline sample includes the last available quarter for a jurisdiction, which is in most cases the second or third quarter for 2019. We exclude from our sample properties that are unlikely to be standalone business, for example advertising space, ATMs and telecommunication stations. Our final baseline data set contains 542,695 unique commercial properties.

The key variables in our data are the rateable value of each property and its occupation status. If the property is not occupied, it would be indicated as vacant from the raw data by the local council - in that case we code it as vacant in our data. For 64 of the jurisdictions included in the sample, we also observe the relief(s) received (in particular the small business rate relief received).

In a sub-sample of the data, information on tax charge paid is in addition available (as not all jurisdictions include this information in their data). We refer to our full data sample as "large" sample, and the sub-sample that also contains the final tax charge (i.e. net of any relief business may receive) as "small" sample - it constitute 46% of the large sample. Table 1 presents summary statistics for both samples. While the property type distribution and the rateable value range are suggested to be similar, the vacancy rate is somewhat larger in the large sample (12.5 compared to 10.2%).

Empty property relief: We use properties with a rateable value around the empty property exemption threshold for the empirical analysis of the empty exemption. The descriptive statistics are shown for properties with a rateable value between £1,900 and £3,900. We focus on the sample that includes exact tax charge information (the small sample), so we are able to measure precisely how the empty exemption was implemented (the empty property relief is a discretionary relief).

Small business rate relief: The sample for the small business rate relief includes properties with a rateable value around the two kinks for the small business rate relief (£12,000 and £15,000). The descriptive statistics are shown for properties with a rateable value between £9,000 and £18,000. We use both the small and the large sample in our analysis as the small business rate relief is a mandatory relief. The information on how it is implemented from the small sample applies to the large sample as there should be no regional heterogeneity. In both the large and the small sample, we include only jurisdictions that provide information on whether occupiers receive the small business rate relief.[26]

Retail relief: We focus on retail properties in the analysis of retail relief, and include

[26] We assume that if an occupier claims SBRR that the occupier is a small business, all other occupiers are assumed to be large businesses. This means we are not able to identify small business as occupier of properties with a rateable value above £15,000.

properties with a rateable value around £51,0000. The descriptive statistics are shown for properties with a rateable value between £41,000 and £61,000. Since our empirical approach relies on variation over time, we complement the baseline data (which includes the latest available quarter, in most cases second or third quarter 2019) using data for the second and third quarter in 2018. Our final data set includes for each jurisdiction one quarter before and one quarter after the introduction of the retail relief.[27]

We report descriptive statistics for each sub-sample in Table 1. The vacancy rate is very similar in the retail relief and SBRR sample (around 7 to 8%) but larger in the empty exemption sample (around 13%). This suggest there is variation in vacancy rates at different range of rateable values. The property types differ between the empty exemption and the SBRR sample. There are more industrial properties and less offices in the SBRR sample compared to the empty exemption sample.[28]

Table 1: Descriptive statistics

	All		Empty property	Retail relief		Small business rate relief	
Rateable values (£1,000)			1.9-3.9	41-61		9-18	
Sample	Large	Small	Small	Large	Small	Large	Small
# of observations	542,695	252,144	37,086	7,276	3,555	83,527	38,731
# of counties	73	35	38	34	14	64	29
# of counties in London	11	6	7	3	1	9	4
# of county-quarter	73	35	38	68	28	64	29
Average rateable value	28,893	31,129	2,891	49,839	49,866	12,477	12,454
Median rateable value	7,200	7,500	2,900	49,500	49.500	12,000	12,000
Mean vacancy	0.125	0.102	0.133	0.075	0.074	0.082	0.074
Office	0.18	0.17	0.24	0	0	0.16	0.16
Shop/Hospitality	0.38	0.39	0.43	1	1	0.46	0.45
Warehouse/Factory	0.21	0.20	0.18	0	0	0.25	0.25

Notes: The table shows the summary statistics for the full sample (cols. (1) and (2)), the empty property exemption sample (col. (3)), the retail relief sample (cols. (4) and (5)) and the small business retail relief sample (cols. (6) and (7). For the full sample, the small business rate relief sample and the retail relief sample, descriptive statistics are shown for the large and the small sample. The large sample includes information on vacancy and rateable value and the small sample includes in addition information on the effective tax rate.

[27]If more than one quarter is available, we use the second quarter. Results are similar when using the third quarter, if more than one quarter is observed.

[28]Rateable values are reported with varying degree of precision at different range of rateable values. Up to £2,500, the rateable value is at precision of £25, between £2,500 and £5,000 at precision of £50, between £5,000 and £10,000 at precision of £100, between £10,000 and £50,000 at precision of £250 and above £51,000 at precision of £500. For analysis that requires us to bin the data by rateable value, we use bin width of £50, £250 and £500 for empty exemption, SBRR and retail relief sub-sample respectively.

6 Empirical results

In the following we report our empirical results. We start with the empty property exemption, then discuss the retail relief and finish with the small business rate relief.

6.1 Empty Property Exemption

We present the results for the impact of the empty property exemption on vacancy rates using RDD as outlined in Section 4.1. Figure 3 plots the average effective tax rate (ETR) for empty properties and the average vacancy rate by rateable value from £1,900 to £3,900.

The average ETR for empty properties is close to zero and almost constant with rateable value from £1,900 to £2,900, jumps up substantially at the threshold and stays constant from £2,900 to £3,900. The jump of the ETR for empty properties at the threshold is close to 30 percentage points. The average vacancy rate decrease from £1,900 to £2,900, drops sharply at the threshold and stays constant until £3,900. The drop of the vacancy rate at the threshold is by around 7 to 8 percentage points.

To confirm there is no other tax change at the threshold, we plot the ETR for occupied properties by rateable value in Figure C3 in the Appendix. Moreover, the number of observations is smooth around the threshold.[29]

The results of estimating equation (4) and (5) are shown in Table 2. Columns (1) to (3) show the reduced form results, i.e. the estimates of α_3 in equation (4) using the vacancy rate as the outcome. Also, columns (4) to (6) show the estimate of β_3 in equation (5) where the average ETR of empty properties is the dependent variable. In columns (1), (2), (4) and (5) we use the optimal bandwidth and in columns (3) and (6) a bandwidth of £250. In columns (2) and (5) we allow for a different quadratic relationship between rateable value and the outcome variable left and right to threshold, and in all other columns we allow for a different linear relationship between rateable value and the outcome variable left and right to the threshold. Panel A reports the estimates for specifications without controls and Panel B reports the estimates controlling for local authority fixed effects. The estimates are similar in both panels and we refer to the estimates in Panel B in the following.

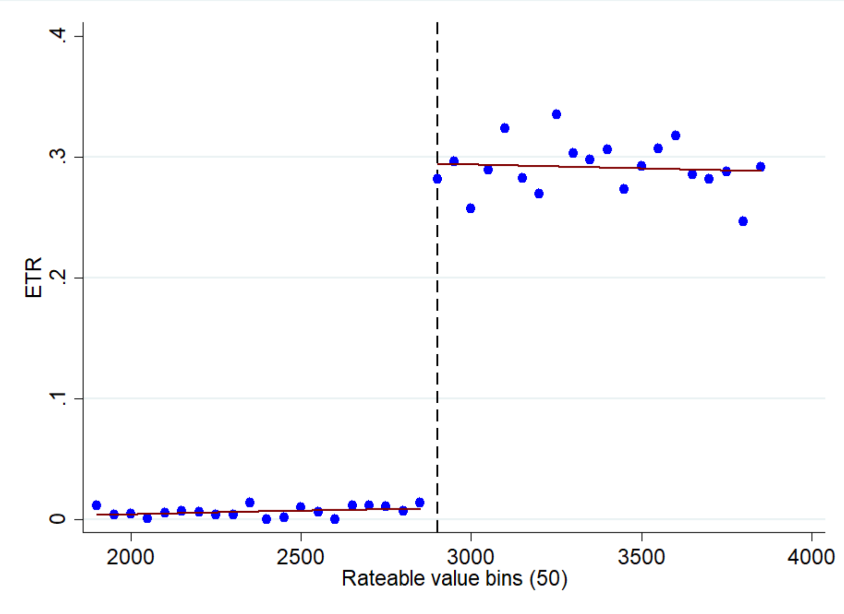
In line with the graphical evidence, we find that the average vacancy rate decreases by around 7 percentage points (cols. (1) to (3)) and the average ETR increases by around 27 percentage points at the threshold.[30] The final step in our analysis is to obtain the

[29] This is also supported by the McCrary test (point estimate (s.e): -0.019 (0.020)), using a bandwidth of £100 and a rateable value range from £500 to £10,000.

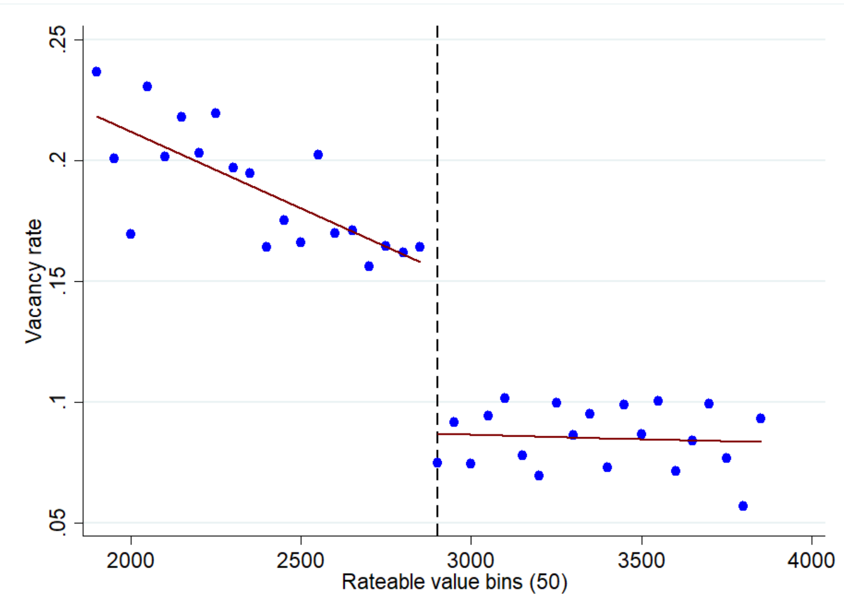
[30] In the absence of the empty exemption (i.e. above the £2,900 threshold), empty properties are not required to pay business rates in the first three months of its vacant period. Therefore the change in ETR

Figure 3: Graphical evidence for empty property exemption

(a) ETR for empty properties



(b) Vacancy rate



Note: The graphs plot (a) the effective tax rate for empty properties and (b) the vacancy rate by rateable value from £1,900 to £3,900 with bin width £50 using the small sample. The dashed line indicates the rateable value threshold for the empty property exemption and the solid lines represent linear fits.

at the threshold equals the full multiplier weighted by the share of properties empty for more than three months (measured above the threshold). This explains why the increase in the ETR for empty properties at the threshold is smaller than the magnitude of the multiplier.

causal effect of empty property relief on vacancies (the marginal effect of the change in the ETR on the vacancy). From equation (6), this is just the ratio of the two estimates of α_3, β_3. This ratio is -0.23, based on the estimates shown in columns (1) and (3). This means that a one percentage point decrease in the ETR via empty property relief increases the vacancy rate by around 0.23 percentage points. Note that empty property relief is qualitatively different to the other reliefs, because it incentives landlords to leave the property vacant, implying a negative sign.[31]

Table 2: RDD results for empty property exemption

Dep. Var.	D(Vacant)			ETR		
Properties	All			Empty		
Regression	Lin.	Quad.	Lin.	Lin.	Quad.	Lin.
Bandwidth	Optimal	Optimal	250	Optimal	Optimal	250
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Without local authority fixed effects						
D(RV≥2.9k)	-0.078***	-0.084***	-0.089***	0.275***	0.263***	0.260***
	(0.013)	(0.018)	(0.023)	(0.019)	(0.026)	(0.034)
Observations	19,860	25,348	8,465	3,749	4,626	1,007
Panel B: With local authority fixed effects						
D(RV≥2.9k)	-0.064***	-0.077***	-0.078***	0.281***	0.264***	0.262***
	(0.012)	(0.016)	(0.019)	(0.019)	(0.023)	(0.033)
Observations	14,042	24,953	8,465	4,626	5,057	1,007

Notes: The table reports reduced form estimates for empty property exemption in equation (4) (cols. (1) to (3)) and (5) (cols.(4) to (6)). The dependent variable is an indicator of the property being vacant (cols. (1) to (3)) or the effective tax rate (cols. (4) to (6)). In cols. (1), (2), (4) and (5) we use the optimal bandwidth and in cols. (3) and (6) as fixed bandwidth of £250. In cols. (2) and (5) we allow for a quadratic relationship between the rateable value and the outcome variable left and right to the threshold and in all other columns we allow for a different linear relationship between rateable value and outcome variable left and right to the threshold. In Panel A the specifications are without additional controls; in Panel B the specifications include local authority fixed effects. In all specifications the small sample is used. The optimal bandwidth is estimated following Calonico, Cattaneo and Titiunik (2014*a*). Robust standard errors are clustered at the local authority-rateable value bin and local authority-property type level and are reported in parentheses. *, **, *** indicate statistical significance at the 10,5 and 1% level.

Sensitivity analysis: We report robustness checks where we employ a local polynomial regression in higher order, and also that uses alternative kernels, i.e. weighting

[31] Bootstrapping standard errors for the ratio gives a standard error of 0.05 (p-value: 0.00).

observations differently. The results are reported in Table C4. We find that the choice of the polynomial order or the kernel has little impact on the estimates and that the results are very similar to our baseline results.

To further confirm that the observed effect at the threshold is due to the empty property exemption, we examine whether similar findings emerge at the lower threshold of £2,600 that applied before the revaluation in 2017. The sample available before the revaluation in 2017 is much smaller and includes only 10 jurisdictions. Figure N.1 in the Online Appendix plots the vacancy rate by rateable values in 2016 and 2019 for the sample of jurisdictions included, and we find a similar discontinuous drop in vacancy rate at the £2,600 threshold using the 2016 data as at the £2,900 threshold using the 2019 data. Table N.1 in the Online Appendix presents the estimates of equation (4) and (5) using £2,600 as the threshold and the 2016 data and using £2,900 as the threshold and using the 2019 data, and we find very similar effects for before and after the revaluation and with respect to our baseline results.[32]

Heterogeneity analysis: We inspect if there is any heterogeneous effect by property types or by jurisdictions. We estimate equation (4) and (5) on the sample with only shops and hospitality properties (see Table C5 panel A). The implied marginal effect is very similar to the baseline result that includes all property types.[33] This suggest that the effect of the empty property exemption is similar for different property types. When we estimate equation (4) and (5) on the sub-sample of properties in London and outside of London separately, we also find that the implied marginal effect is very similar (see Table C5 panel B and C).

6.2 Retail Relief

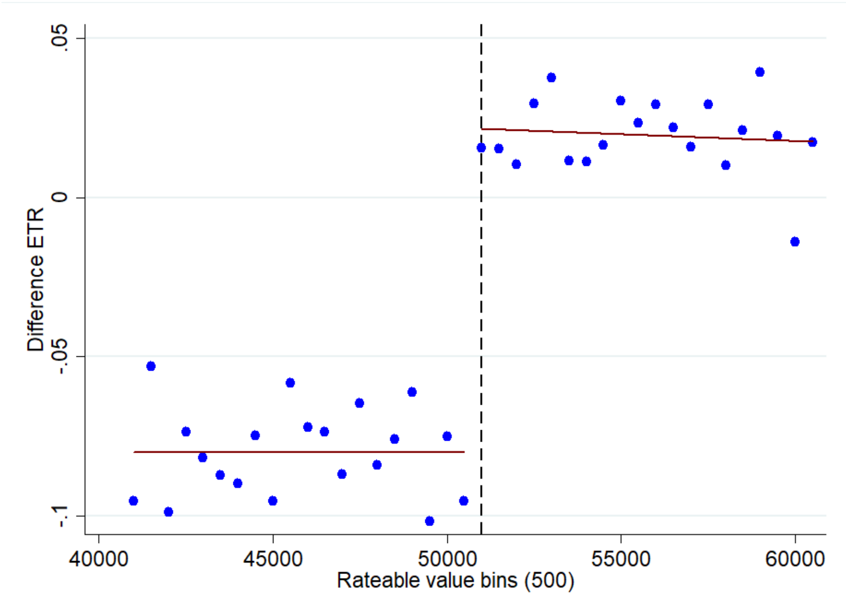
We turn to the results for the impact of the retail relief on the vacancy rate of properties. As explained in section 4.1, we use a difference-in-discontinuity approach to estimate the causal effect of the tax relief for retail properties. As for the empty property exemption, we start with the graphical analysis using retail properties with a rateable value between £41,000 and £61,000. Figure 4 plots for each rateable value bin (with bin width £500), the difference in vacancy rate and effective tax rate between 2018 and 2019.

[32]The threshold rising from £2,600 to £2,900 implies that properties with rateable values between £2,600-£2,900 would become eligible for the empty property exemption after 2017. This suggest they are more likely to be vacant than before. Figure N.1 supports this - properties with a rateable value between £2,600 and £2,900 had a higher likelihood to be empty in 2019 than in 2016.

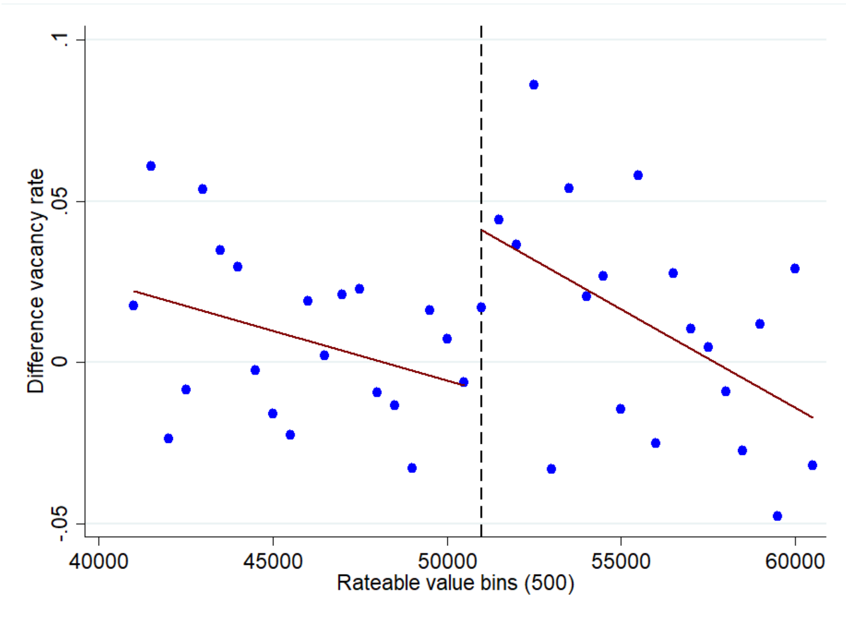
[33]The marginal effect when using all properties is reported in Table 6 and is 0.23. The implied marginal effect when using only shops and hospitality properties is 0.18 (= (0.068/0.38)) using a fixed bandwidth of £250 (see Table C5 panel A.)

Figure 4: Graphical evidence for retail relief

(a) Difference in ETR for occupied properties (2019-2018)



(b) Difference in vacancy rate (2019-2018)



Note: The graphs plot (a) the difference in the effective tax rate for occupied properties between 2019 and 2018 and (b) the difference in the vacancy rate between 2019 and 2018 by rateable value from £41,000 to £61,000 with bin width £500. The dashed line indicates the rateable value threshold for the retail relief and the solid lines represent linear fits.

The difference in the ETR for occupied properties before and after the introduction of the retail relief stays largely constant with rateable value up to £51,000, jumps at the threshold by around 10 percentage points, and stays then again almost constant up to

£61,000. The difference in the vacancy rate decreases with rateable value up to £51,000, jumps up at the threshold by around 4 to 5 percentage points and decreases thereafter again.

The number of observations around the threshold is suggested to be smooth, both before and after the introduction of the retail relief (see Figure C4). This is also indicated by the results of the McCrary test (point estimate (s.e.) for 2018: -0.04 (0.07) and for 2019: -0.05 (0.08)).

Table 3: Difference-in-discontinuity results for retail relief

Dep. Var.	D(Vacant)				ETR	
Properties	All				Occupied	
Sample	Large		Small		Small	
Bandwidth	Optimal	10,000	Optimal	10,000	Optimal	10,000
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Without local authority fixed effects						
D(R≥51k)*Post	0.038	0.051***	0.053**	0.054**	0.101***	0.103***
	(0.024)	(0.020)	(0.024)	(0.024)	(0.011)	(0.011)
Observations	4,991	7,136	3,404	3,409	2,800	3,158
Panel B: With local authority fixed effects						
D(R≥51k)*Post	0.039*	0.052***	0.051**	0.056**	0.096***	0.100***
	(0.023)	(0.019)	(0.026)	(0.024)	(0.010)	(0.009)
Observations	4,988	7,136	2,660	3,409	2,701	3,158

Notes: The table reports reduced form estimates for the retail relief in equation (7) (cols. (1) to (4)) and (8) (cols. (5) and (6)). The dependent variable is an indicator for property is vacant (cols. (1) to (4) or the effective tax rate of empty properties (cols. (5) and (6)). In cols. (1), (3) and (5) we use the optimal bandwidth, which is the average of the optimal bandwidth for 2018 and 2019. In col. (2), (4) and (6) we use a fixed bandwidth of £10,000. Cols. (1) and (2) use the large sample, all other columns the small sample. In Panel A the specification is without additional controls; in Panel B the specification includes local authority × quarter-year fixed effects. The optimal bandwidth is estimated following Calonico, Cattaneo and Titiunik (2014*a*). Robust standard errors are clustered at the local authority-rateable value bin level and are reported in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.

Table 3 reports the estimates for the effect of retail relief using the difference-in-discontinuity approach. Columns (1) to (4) report the estimate of γ_6 in reduced form equation (7). Panel A and B report the estimates for specification without controls and that controlling for local authority × quarter-year fixed effects respectively. The estimates in both panels are highly similar and thus we focus in the following on the estimates in panel B. Column (1) uses the optimal bandwidth with the large sample – it suggests a relative increase in the vacancy rate on the right compared to the left of threshold by 3.9 percentage points. Column (2) uses a fixed bandwidth of £10,000 and estimates a relative increase of vacancy rate of 5.2 percentage points. When using the small sample, the estimates for γ_6 are 5.1 and 5.6 percentage points respectively (columns (3) and (4)). Columns (5) and (6) report the estimate of η_6 in equation (8) for the ETR using the optimal bandwidth and a fixed bandwidth of £10,000. They suggest a relative increase in the tax rate by close to 10 percentage points.

The final step in our analysis is to obtain the causal effect of retail relief on vacancies. From equation (9), this is just the ratio of the two estimates of γ_6, η_6. This ratio is 0.53 based on the estimates using the small sample with fixed bandwidth £10,000 (cols. (4) and (6)).[34] This means that a one percentage point decrease in the ETR via retail relief decreases the vacancy rate by around 0.53 percentage points.

Sensitivity Analysis: We report some robustness checks where we employ a local polynomial regression in higher order and also use an alternative kernel. The results are reported in Table C6 (and illustrated in Figure C5). The difference in the estimates for 2018 and 2019 are very similar but less precisely estimated.

Heterogeneity analysis: Finally, we include postcode fixed effects and find very similar results (see Table C7 panel A). We also estimate equation (7) and (8) on a sub-sample of High Street retail/hospitality properties (see Table C7 panel B). We classify a property as on the High Street if it is located in a postcode with number of retail/hospitality properties in the postcode above the median in our sample.[35] In both cases, the results are almost unchanged although less precisely estimated.

6.3 Small business rate relief

We turn now to the results for the small business rate relief (SBRR). We start with the impact of the relief on the occupancy rate by small and large business and come then to the impact of the relief on the overall vacancy rate.

Figure 5 (a) plots the ETR faced by small and large business and the vacancy rate of properties by rateable value from £6,000 to £21,000 (with bin width of £250). The ETR faced by small business is zero up to £12,000 and increases then steadily up to £15,000. This represents the phasing out of SBRR as rateable values increase above the £12,000

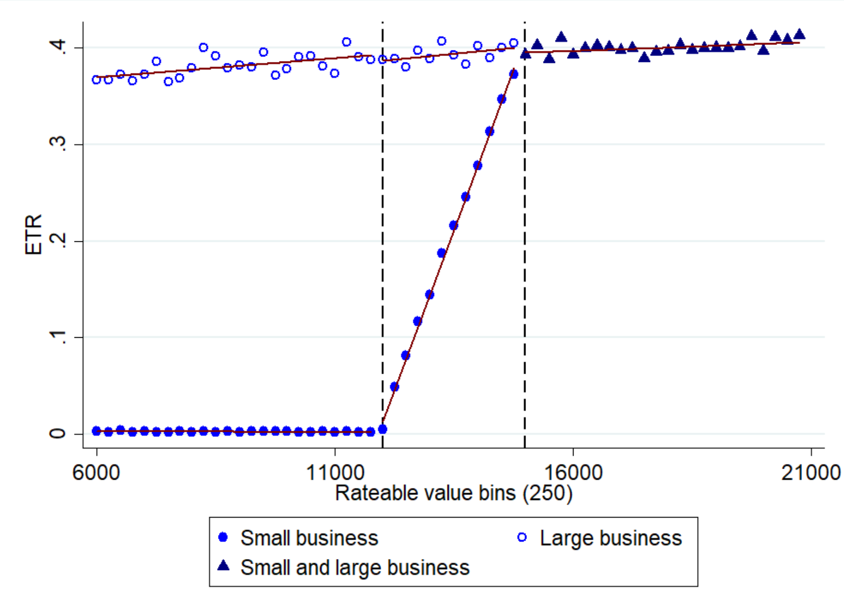
[34] The bootstrapped standard error is 0.27 (p-value of 0.06).

[35] ONS (2020) discusses that it is necessary to identify location of high streets in the UK by clusters of retail properties because there is no official definition. The median number of retail/hospitality properties in a postcode in our sample is 7.

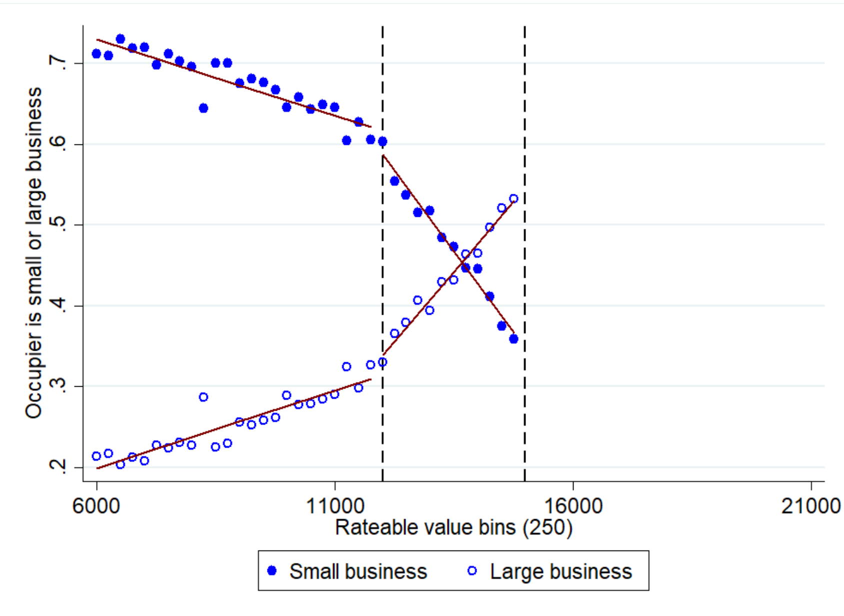
threshold. The ETR faced by large business, in contrast, is much higher at about 0.4 and remains at similar level between £12,000-£15,000. When rateable value is greater than £15,000, small and large businesses pay the same tax.

Figure 5: Graphical evidence for SBRR: ETR and occupancy by type of business

(a) ETR for occupied properties

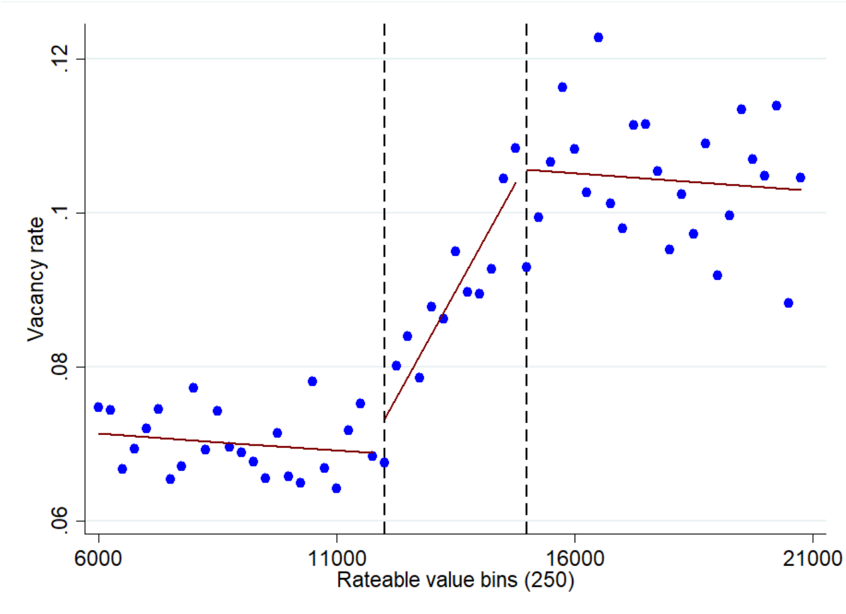


(b) Occupancy by type of business



Note: The graphs plot (a) the effective tax rate for small and large business and (b) the chance that a property is occupied by small or large business by rateable value from £6,000 to £21,000 with bin width £250. The dashed lines represent the two kinks of the SBRR and the solid lines represent linear fits.

Figure 6: Graphical evidence for SBRR: Vacancy rate



Note: The graph plots the vacancy rate by rateable value from £6,000 to £15,000 with bin width £250. The solid lines represent linear fits of the relation between rateable value and vacancy rate.

Figure 5 (b) plots the share of properties occupied by small business (o_s) by rateable values from £6,000 to £15,000. Occupancy by small businesses decreases with rateable value on the left of the £12,000 threshold. On the right of £12,000 threshold, it decreases at a faster rate. This suggest when SBRR phases out, properties have less chance of being occupied by small business. Figure 5 (b) plots the share of properties occupied by large business (o_l). Occupancy by large business increases at a faster rate on the right of £12,000 threshold compared to the left of the threshold. This is a highly similar pattern to that for occupancy by small business, while exhibiting opposite effect of τ_s on o_l. Overall, Figure 5 provides clear graphical evidence that the SBRR increases the chance of a property that it is occupied by a small business and reduces the chance that it is occupied by a large business.

In Figure 6, the vacancy rate is almost constant from rateable value of £6,000 to £12,000. It increases in the range of £12,000-15,000 relative to that on the left of £12,000 threshold, implying an increase in the slope at the £12,000 threshold. The graphical evidence suggests that when SBRR phases out, the likelihood that a property is vacant increases. In addition, vacancy is again almost constant with rateable value on the right of the £15,000 threshold compared to in the range of £12,000-15,000. This suggest that the slope becomes flatter. This is additional evidence that the increase in slope between £12-15,000 is closely related to SBRR. Overall, Figure 6 provides strong evidence that SBRR is an important determinant of property vacancy, and that the tax for small business occupier τ_s increases the overall chance a property is vacant (v).

The almost flat ETR schedule faced by large business in Figure 5 (a) suggests no other confounding policy changes at rateable value of £12,000-15,000. Further, Figure C7 shows that the density distribution for rateable value from £6,000 to £21,000 is smooth around the two thresholds and that there is no change in the slope of the density.[36]

Table 4: RKD results for SBRR: Occupancy rate by small and large business

Dep. Var.	D(Occupied by small business)			D(Occupied by large business)		
Sample	Large	Small		Large	Small	
	(1)	(2)	(3)	(4)	(5)	(6)
Bandwidth	3,000	3,000	2,500	3,000	3,000	2,500
Panel A: Without local authority fixed effects						
R * D(1Kink)	-0.054***	-0.050***	-0.036***	0.043***	0.034***	0.023**
	(0.006)	(0.007)	(0.009)	(0.006)	(0.008)	(0.010)
Panel B: With local authority fixed effects						
R * D(1Kink)	-0.054***	-0.050***	-0.036***	0.043***	0.034***	0.024***
	(0.004)	(0.005)	(0.008)	(0.006)	(0.006)	(0.008)
Observations	63,807	29,845	24,664	63,807	29,845	24,664

Notes: The table reports estimates of equation (10) (cols. (1) to (3)) and of equation (11) (cols. (4) to (6)). The dependent variable is an indicator of the property being occupied by a small business (col. (1) to (3)) or by a large business (cols. (4) to (6)). $R * D(1kink)$ represents the change in relationship between vacancy and rateable value above the threshold at £12,000. Cols. (1), (3), (4) and (6) use a fixed bandwidth of £3,000 and all other columns a fixed bandwidth of £2,500. Cols. (1) and (4) use the large sample, all other columns the small sample. In Panel A the specification is without additional controls; in Panel B the specification includes local authority fixed effects. Robust standard errors are clustered at the local authority-rateable value bin and local authority-property type level and are reported in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.

Table 4 columns (1) to (3) report the reduced form estimate of equation (10) for small businesses. At bandwidth £3,000 and £2,500 (col. (1) for the large sample and cols. (2) and (3) for the small sample), the estimates of the change in slope coefficient α_2 for o^s is negative and statistically significant at the £12,000 threshold. Similarly, columns (4) to

[36]Given that the distribution is non-linear, we also plot (ln) number of observations, which gives a similar picture. The results of the McCrary tests are in line with the graphical observations (point estimate (s.e.) for the first kink: -0.027 (0.020) and for the second kink: 0.029 (0.027)). The estimates for a discontinuous change in the slope of the density distribution at the thresholds are -86 (94) for the first kink and 110 (84) for the second the second kink (using a bandwidth of £2,000 and the number of observations).

(6) reports the reduced form estimate of equation (11) for large businesses. At bandwidth £3,000 and £2,500, the estimates of the change in slope coefficient β_2 for o^l is positive and statistically significant at the £12,000 threshold. In both cases, this is consistent with the graphical evidence shown in Figure 5.

Table 5: RKD results for SBRR: Vacancy rate

Dep. Var.	D(Vacant)				ETR	
Properties	All				Occupied by small business	
Sample	Large		Small		Small	
	(1)	(2)	(3)	(4)	(5)	(6)
Bandwidth	3,000	2,500	3,000	2,500	3,000	2,500
Panel A: First Kink (£12,000)						
R*D(1kink)	0.011***	0.008***	0.016***	0.013***	0.135***	0.136***
	(0.002)	(0.003)	(0.002)	(0.004)	(0.003)	(0.003)
Observations	64,096	52,892	29,845	24,664	17,455	14,481
Panel B: Second Kink (£15,000)						
R * D(2Kink)	-0.008**	-0.008**	-0.012**	-0.012*	-0.121***	
	(0.003)	(0.004)	(0.005)	(0.006)	(0.010)	
Observations	40,417	33,038	18,599	15,240	4,869	

Notes: The table reports estimates of equation (12) (cols. (1) to (4)) and (14) (cols. (5) and (6)) in panel A and of equation (13) (cols. (1) to (4)) and (15) (cols. (5)) in panel B. The dependent variable is an indicator for the property being empty (cols.(1) to (4)) or the effective tax rate of properties occupied by small businesses (cols. (5) and (6) for Panel A) or of properties occupied by small and large business (cols. (5) and (6) for Panel B). Panel A reports the results for the first kink, and Panel B for the second kink. $R*D(1kink)$ and $R*D(2kink)$ represents the change in relationship between vacancy and rateable value above the threshold at £12,000 and £15,000 respectively. Cols. (1), (3) and (5) use a fixed bandwidth of £3,000 and all other columns a fixed bandwidth of £2,500 (except for column (5) in panel B which uses a bandwidth of £1,000). Cols. (1) and (2) use the large sample, all other columns the small sample. Panel B col. (5) reports the estimate of ϕ_2 of equation (13) divided by the share of small businesses at the threshold (0.37) as described in section (4). All specifications include local authority fixed effects. Robust standard errors are clustered at the local authority-rateable value bin and local authority-property type level and are in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.

Table 5 reports the reduced form estimate of equation (12) and (13) on the vacancy rate (cols. (1) to (4)) controllinig for local authority fixed effects.[37] Panel A reports the

[37] The results for the specifications without local authority fixed effects are almost identical while less precisely estimated, as for the empty exemption and the retail relief. See Table C8 in Appendix.

results for the estimate of γ_2 of equation (12) for the first kink. At bandwidth of £3,000 and at bandwidth of £2,500 (col. (1) and (2)), the change in slope coefficient for vacancy at the £12,000 threshold is positive and statistically significant. The estimate remains similar when we use only the small sample in column (3) and (4). Similarly, panel B reports the results for the estimate of δ_2 of equation (13). It shows that the change in slope coefficient for the vacancy at the £15,000 threshold is negative and statistically significant.

Finally, Table 5 also reports the estimates of equation (14) and (15) on effective tax rate for small business. Panel A columns (5) and (6) report the first stage estimate of η_2 of equation (14) for the kink at £12,000. The estimate shows a positive change in slope as indicated in Figure 5 (a) – the change in slope estimate is around 0.14 and statistically significant. Panel B reports estimate of ϕ_2 of equation (15), scaled by the share of small business at the £15,000 threshold. The implied change in the slope coefficient for the ETR for small business is 0.12 (see column (5)).

Combining the estimate for the occupancy rate by small business (col. (4) of Table 4 panel B) with the change in ETR at the £12,000 threshold (col. (6) of Table 5) gives -0.27, the estimate for the causal effect of tax rate for small business on occupancy by small business. The bootstrapped standard error is 0.07 (p-value: 0.00). This means that a one percentage reduction in the tax for small business increase the chance a qualifying property is occupied by small business by 0.27 percentage points. Similarly, the estimate for the effect of tax for small business on the occupancy by large business is 0.17. This suggest that a one percentage reduction in the tax rate for small business reduces the chance a qualifying property is occupied by a large business by 0.17 percentage points. Thus, the tax rate for small business has an opposing effect on occupancy by large business compared to by small business.

Combining the reduced form estimate on vacancy with the first stage estimate (cols. (4) and (6) of Table 5 panel A) gives the estimate for the causal effect of tax on small business on vacancy at the £12,000 kink, which is 0.09. This means that a 1 percentage point decrease in tax rate for small business decreases vacancy by about 0.10 percentage points. The bootstrapped standard error for the ratio is 0.03 (p-value: 0.00). The estimate of the effect of tax for small business on vacancy at the £15,000 threshold is also 0.10 (cols. (4) and (5) of Table 5 panel B).[38]

Sensitivity analysis: Table C9 reports the results when using a local linear regression for the RKD with optimal bandwidth. The results are in general very similar to our

[38]Since we have to estimate the change in slope for the ETR very locally, bootstrapping standard errors is not possible.

baseline results, although the estimates for the upper kink are less precisely estimated when using the alternative kernels that gives more weights to observations closer to the threshold.

In addition, to confirm that our findings are driven by the SBRR kinks, and not other unobserved factors around the £12,000 and £15,000 threshold, we conduct robustness check exploiting that the SBRR kinks are at £6,000 and £12,000 before the revaluation in 2017. Figure N.2 in the Online Appendix plots the vacancy rate by rateable value with data from 2016 for jurisdictions for which the data is available. While the set of jurisdictions with the data available is small, we find that there are kinks for the vacancy rate at £6,000 and £12,000. Table N.2 in the Online Appendix reports the RKD estimates for the change in slope at £6,000 and £12,000, and shows similar evidence as our baseline results. We also check if this sub-sample of jurisdictions gives comparable results when using 2019 data to our baseline findings, the results are very similar to our baseline estimates.[39]

Heterogeneity analysis: Table C10 panel A1 reports the results when including only shops and hospitality properties, and the marginal effect is suggested to be somewhat stronger for these properties.[40] The results are almost unchanged when controlling for property fixed effects (panel A2 in Table C10), and are also very similar on the sub-sample with only High Street retail/hospitality properties (and controlling for postcode fixed effects, see panel A3).

Further, Table C10 reports the results using only jurisdictions in- (panel B) and outside of London (panel C). The results do not suggest a large difference between these two types of jurisdictions, similar to the evidence presented for the empty property exemption.

7 Discussion

In this section we discuss the implication of our estimates by calculating the semi-elasticities of vacancy with respect to tax ($\epsilon = \frac{1}{v}\frac{\partial v}{\partial \tau}$) for each of empty property exemption,

[39]See Online Appendix Table N.2 panel A for the RKD estimates for the change in slope at £6,000 and £12,000 before the revaluation in 2017, and panel B for the estimates of equation (12), (13), (10) and (11) after the 2017 revaluation on this sub-sample. For this sample, the data does not allow us to estimate the change in the ETR as the ETR information is not available for some jurisdictions. With the kink at £6,000 and £12,000, the relief phases out over £6,000 instead of over £3,000 (from £12,000 to £15,000), we expect the slope change in the ETR at both the lower and upper kink to be half the size of our baseline estimates after the revaluation. Since the reduced form effects on vacancy and occupancy by small and large business for 2016 are half of the ones for 2019, this means we obtain very similar marginal effects using before and after the revaluation data.

[40]While the first stage estimate using the effective tax rate as dependent variable is similar to our baseline results, the reduced form estimate on vacancy rate is larger.

small business rates relief and retail relief. We also discuss how the ratios of the estimated marginal effects compare to the ones implied by the theory. Our estimates for the semi-elasticities, reported in Table 6, allow us to calculate the overall effect of the tax reduction for each of the reliefs and to compare the sizes of the effects.

The semi-elasticity of vacancy with respect to tax on empty property is -2.8, suggesting a 1 percentage point reduction in the tax increases vacancy by 2.8%. The empty exemption gives full relief to eligible empty properties. Assuming this induces a change in the ETR of 27 percentage points as estimated in section 6.1, this means the empty property exemption increases the chance that eligible properties are empty by 76% (0.27 * -2.8) of the vacancy rate in the absence of the relief.

The small business rate relief reduces the tax rate of eligible property, if occupied by a small business, from 0.49 to full relief. With a semi-elasticity of 1.1, this implies that the vacancy rate is $54\% (= 0.49 * 1.1)$ lower under the full relief measure.

The retail relief reduces the tax rate for retail property by about 16 percentage points ($\frac{1}{3} * 0.49$). With a semi-elasticity of 5.5, this implies a reduction in the vacancy rate by 90% of the baseline in the absence of the relief. This overall effect applies to property around the retail relief threshold, as our RDD estimates are the local effect of tax on vacancy around the £51,000 threshold.

Table 6: Semi-elasticities from the three natural experimental variations

	RDD/RKD Estimates		Marginal	Vacancy	Semi-
	Vacancy	ETR	effect	rate	elasticity
	dv	$d\tau$	$\frac{dv}{d\tau}$	v^+	$\frac{1}{v}\frac{dv}{d\tau}\vert_+$
Empty exemption	-0.064	0.281	-0.23	0.081	-2.8
SBRR (£12,000)	0.013	0.136	0.10	0.054	-
SBRR (£15,000)	-0.012	-0.121	0.10	0.091	1.1
Retail relief	0.051	0.096	0.53	0.097	5.5

Notes: The table report the semi-elasticity of vacancy rates with respect to tax for the empty property exemption, retail discount and small business rate relief (lower kink and upper kink). Col. (1) shows the reduced form estimate on vacancy rate, col. (2) the first stage estimate on the ETR. Col. (3) reports the marginal effects and col. (4) the vacancy rate of the right limit of the threshold and col. (5) the semi-elasticity. We do not calculate the semi-elasticity for the SBRR at the first kink as the vacancy rate at this threshold is influenced by the SBRR.

The relative magnitude of the marginal effects for the three policies is in line with the theoretical prediction in section 3.3. The estimated marginal effect (in absolute terms) for the retail relief is the largest (0.53), it is greater than the marginal effect of empty property exemption in absolute terms (0.23), and the marginal effect for the SBRR at the lower kink is the smallest (0.10). This is predicted by equation (3).

8 Conclusion

In this paper, we study the impact of commercial property taxation on vacancy and occupancy rates. We develop a directed search model for the commercial property rental market to illustrate the role of the taxation on commercial property vacancy rates. The empirical part presents the results for three policy instruments that affect the tax burden for empty and occupied commercial properties.

We find that the taxation of occupied and the non-taxation of empty properties increases vacancy rates. The size of the effects is found to be substantial. This has two implications. First, occupied properties generate economic activity and therefore tax revenue (e.g., corporate income tax, VAT and personal income tax). The non-zero extensive margin response documented in this paper implies, therefore, a fiscal externality of business rate reliefs and exemptions, which has to be taken into account when evaluating the cost-effectiveness of them. Second, our results suggest that business rate reliefs and exemptions are potentially an effective tool to attract economic activity.

In addition, our results suggest that changing the tax burden only for some occupiers/occupier types (small business) creates a sorting effect, while still affecting overall vacancy. This may have substantial and complex efficiency implications. Large chains, for example, may have a higher productivity but may offer less product variety.

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Appendices

A The Tax Function

Here, we fully describe the tax functions. First, consider an unoccupied property. If $R \leq 2.9$, empty property relief applies, so $T^u(R) = 0$, and otherwise, $T^u(R) = \kappa(R)R$ where $\kappa(R)$ is the multiplier that applies at rateable value R.

Now consider an occupied property. If $R > 51$, no reliefs apply, so $T^o(R; j) = \kappa(R)R$. If $15 < R \leq 51$, only retail relief applies, so $T^o(R; j) = \frac{2}{3}\kappa(R)R$. If $R \leq 15$, both retail relief and SBRR apply. In this case, $T^o(R; l) = \frac{2}{3}\kappa(R)R$, as large businesses are not eligible for retail relief. However, if the property is let to a small business, both retail relief and SBRR can be claimed, so $T^o(R; s) = \frac{2}{3}(\kappa(R)R - \sigma(R))$, where $\sigma(R)$ is the value of SBRR, and is given by:

$$\sigma(R) = \begin{cases} \kappa(60 - 4R), & \underline{R}_s < R < \overline{R}_s \\ \kappa R, & R \leq \underline{R}_s \end{cases} \tag{A.1}$$

Equation (A.1) says that relief is full at $R = 12$ and is linearly withdrawn so that it is zero at $R = 15$, as shown in the vertical difference between the dotted line and the solid line in Figure 2 (a) above.

B Theoretical Results

B.1 Equilibrium Conditions

The endogenous variables to be determined in equilbrium are (i) rents r_i; (ii) two probability vectors $(p_{i,j}, p_{i,j})_{i \in P}$, $j = s, l$, where $p_{i,j}$ is the probability that a type j business applies to a particular type i property. We will solve not for these probability vectors, but for queue lengths. Define the *queue length* $q_{i,j} = p_{i,j}N_j$ to be the the expected number of type j businesses that apply to a given type i property. Also, define the *vacancy rate* for a property of type i, v_i as the probability that no businesses of either type apply to a type i property, which is

$$v_i = (1 - p_{i,s})^{N_s}(1 - p_{i,l})^{N_l} = \left(1 - \frac{q_{i,s}}{N_s}\right)^{N_s} \left(1 - \frac{q_{i,l}}{N_l}\right)^{N_l} \tag{A.2}$$

As numbers on both sides of the market are large, we let $N, N_s, N_l \to \infty$, which gives

$$v_i = e^{-(q_{i,s}+q_{i,l})} \equiv v(q_{i,s} + q_{i,l}) \tag{A.3}$$

So the vacancy rate for a type i property is negatively related to the aggregate queue length $q_{i,s} + q_{i,l}$, as we might expect.

Next, m_i is the probability that a particular business is matched with type i property. This is just the probability that the property is not vacant, $1 - v_i$, times the probability that the particular business gets the property, out of all businesses who apply. The latter probability is the inverse of the aggregate queue length at the property so

$$m_i = \frac{1 - v_i}{q_{l,s} + q_{i,l}} \equiv m(q_{i,s} + q_{i,l}) \tag{A.4}$$

A business of type j has an expected profit

$$m_i(\Pi(R_i) - r_i - T^o(R_i; j)) \tag{A.5}$$

from applying to type i property. This is the probability of getting the property, m_i, times the profit from using the property, minus rent and business tax paid. So, if the landlord of type i is to induce any applications from a type j business, (A.5) must be greater or equal to the opportunity cost of applying to a property, which is ρR_i. However, it can never be strictly greater, by the argument of Shi (2002).[41] So, $q_{i,j}$ satisfies:

$$q_{i,j} = \begin{cases} \in (0, \infty), & m_i(\Pi(R_i) - r_i - T^o(R_i; j)) = \rho R_i \\ 0, & m_i(\Pi(R_i) - r_i - T^o(R_i; j)) < \rho R_i \end{cases} \tag{A.6}$$

i.e. if the business is indifferent about applying, the queue length is indeterminate (and thus can be chosen by the landlord); otherwise, it is zero.

A landlord of type i has expected payoff of

$$(1 - v_i)r_i - v_i T^u(R_i), \quad i \in P \tag{A.7}$$

i.e. rent if the property is let, and payment of the business rate for vacant properties if it is not. A landlord chooses $r_i, q_{i,s}, q_{i,l}$ to maximize (A.7) subject to (A.6) and (A.3). So, in the end, conditional on N_s, equilibrium is fully described by the solution $r_i, q_{i,s}, q_{i,l}$ to the landlord's choice problem. Moreover, all of our results hold conditional on any value of N_s, so the solution for N_s is relegated to the Not-For-Publication Appendix C.4.

B.2 Proof of Propositions 1 and 2

In this section, we provide a full characterisation of equilibrium, which will establish Propositions 1 and 2 in the text as well as other results.

(a) Consider the problem facing the small landlord i.e. one whose property is eleigible for SBRR first. From (A.6), the maximum rent that a small landlord can charge a type s business, while still attracting applications, is

$$\overline{r}_{i,s} = \Pi(R_i) - T^o(R_i; s) - \frac{\rho R_i}{m_i}. \tag{A.8}$$

The maximum rent a small landlord can charge a type l business, while still attracting applications, is only

$$\overline{r}_{i,l} = \Pi(R_i) - T^o(R_i; l) - \frac{\rho R_i}{m_i}. \tag{A.9}$$

So, as $T^o(R_i; s) < T^o(R_i; l)$, it follows from (A.8), (A.9) that $\overline{r}_{i,s} > \overline{r}_{i,l}$. So, in any equilibrium, the small landlord will always set $r_i = \overline{r}_{i,s}$, and $q_{i,l} = 0$; that is, only small businesses will be induced to apply. This means that large businesses will apply only to large landlords. So, the large landlords must offer the large (and small) businesses utility of ρR_i by setting

$$\overline{r}_i = \Pi(R_i) - T^o(R_i) - \frac{\rho R_i}{m_i} \tag{A.10}$$

where $T^o(R_i)$ is the tax paid by *both* types of businesses if they rent a large property. So, the equilibrium must be *fully* or *semi-segmented*; large businesses apply only to large landlords i.e. $q_{i,l} = 0$ if i is a small landlord, and small businesses are indifferent between large and small landlords and may apply to both. This establishes Proposition 2.

(b) Consider a small landlord. It is convenient to work with one minus the vacancy probability, $o(q) = 1 - v(q)$, which we call the *occupancy rate*. Also, we know that this landlord will set $r_s = \overline{r}_{i,s}$. Then we can rewrite (A.7) as:

$$\begin{aligned} R_s &= o(q_{i,s})(\overline{r}_{i,s} + T^u(R_i)) - T^u(R_i) \qquad \text{(A.11)} \\ &= o(q_{i,s}) \left(\Pi(R_i) + T^u(R_i) - T^o(R_i; s) - \frac{\rho R_i}{m_i} \right) - T^u(R_i) \\ &= o(q_{i,s}) \left(\Pi(R_i) + T^u(R_i) - T^o(R_i; s) \right) - q_{i,s}\rho R_i - T^u(R_i) \end{aligned}$$

[41] For suppose $m_i(\Pi(R_i) - r_i - T_j(R_i)) > \rho R_i$. Then all type j businesses would apply to the type i landlord, implying $q_{i,j} \to \infty$ as the number of businesses becomes large. Then $m_i = 0$, contradicting the initial inequality above.

where in the second line we substitute out $\overline{r}_{s,s}$ using (A.8), and in the third line, we use the fact that $o(q) = qm(q)$. This is now a function only of $q_{i,s}$. So, the problem for the small landlord is to choose the queue $q_{i,s}$ to maximize (A.11). The first-order condition is

$$o'(q_{i,s})(\Pi(R_i) + T^u(R_i) - T^o(R_i; s)) = \rho R_i \tag{A.12}$$

(c) Consider a large landlord. This landlord can induce a queue of businesses of *either* type by offering at least $\overline{r}_i$ as defined in (A.10) above. So, for such a landlord, we can rewrite (A.7) as

$$\begin{aligned} R_l &= o_l(q_{i,s} + q_{i,l})(\overline{r}_i + T^u(R_i)) - T^u(R_i) \\ &= o(q_{i,s} + q_{i,l}) \left(\Pi(R_i) + T^u(R_i) - T^o(R_i; j) - \frac{\rho R_i}{m(q_{i,s} + q_{i,l})} \right) - T^u(R_i), \ j = s, l \\ &= o(q_{i,s} + q_{i,l}) \left(\Pi(R_i) + T^u(R_i) - T^o(R_i; j) \right) - (q_{i,s} + q_{i,l}), \rho R_i - T^u(R_i), \ j = s, l \end{aligned} \tag{A.13}$$

where the second line we substitute out $\overline{r}_i$ using (A.10), and in the third line, we again use the fact that $o(q) = qm(q)$. Note also that here, the landlord is indifferent between both types of tenant as both have to be compensated for the same amount of tax $T^o(R_i; s) = T^o(R_i; l)$.

Note the difference between (A.11) and (A.13); in the latter, the aggregate queue can include small businesses who apply to the large property i.e. $q_{i,s}$ can be positive. But, as $q_{i,s}, q_{i,l}$ only enter as a sum, only this sum is determined in equilibrium. So, the problem for the landlord of a type s property is to choose the aggregate queue $q_{i,s} + q_{i,l}$ to maximize (A.13). The FOC for this choice is

$$o'(q_{i,s} + q_{i,l})(\Pi(R_i) + T^u(R_i) - T^o(R_i; j)) = \rho R_i, j = s, l \tag{A.14}$$

(d) Now note that $o'(q) = e^{-q} = v(q)$. Making this substitution in (A.12), (A.14), we can solve for the vacancy rates for small and large landlords. Both these vacancy rates can be expressed in the form (1) above, which proves Proposition 1. To check that this is an equilibrium, we need to check that small businesses are indifferent between applying to small and large properties. It is easy to check from (A.8), (A.10), that the rents charged drive their profits down to ρR_i, the entry cost, whichever landlord they apply to, so this indifference condition is certainly satisfied. □

B.3 Derivation of Formulae for Marginal Effects

First, consider the retail relief threshold $R_r = 51$. There are no other reliefs at this threshold, so

$$\lim_{R \downarrow R_r} \Delta\tau(R) = 0, \qquad \lim_{R \uparrow R_r} \Delta\tau(R) = \frac{1}{3}\kappa \tag{A.15}$$

Here, κ is the business rate multiplier.[42] So from (2),(A.15), we see that the upward jump in v at the threshold is

$$\Delta_r = \lim_{R \downarrow R_r} v(R) - \lim_{R \uparrow R_r} v(R) = \frac{\rho}{\pi(R_r)} - \frac{\rho}{\pi(R_r) + \frac{1}{3}\kappa} > 0 \tag{A.16}$$

To estimate the size of the causal tax effect on vacancies of retail relief, we can divide Δ_r by the change in τ^o, the effective tax rate on occupied properties at the threshold; this change measures the size of relief at the threshold. This change is $\frac{\kappa}{3}$, so:

$$\frac{\partial v}{\partial \tau}|_{R_r} = \frac{3}{\kappa} \left(\frac{\rho}{\pi(R_r)} - \frac{\rho}{\pi(R_r) + \frac{\kappa}{3}} \right) = \frac{\rho}{\pi(R_r)(\pi(R_r) + \frac{\kappa}{3})} \tag{A.17}$$

[42] In practice, this κ is actually the reduced multiplier below 51K, but the difference between the reduced and standard multipliers is very small and we ignore it in the formulae, but we do include it in the numerical simulations.

Next, consider the empty property threshold of $R_e = 2.9$. The theory predicts that all occupied properties around this threshold will be let to small businesses and thus attract SBRR at the full amount, so

$$\lim_{R \downarrow R_e} \Delta\tau(R) = -\kappa, \qquad \lim_{R \uparrow R_e} \Delta\tau(R) = 0 \tag{A.18}$$

That is, for properties just below the threshold, SBRR and empty property relief just cancel each other out. So, from (1), (A.18) the downward jump in the vacancy rate at the threshold is:

$$\Delta_e = \lim_{R \downarrow R_e} v(R) - \lim_{R \uparrow R_e} v(R) = \frac{\rho}{\pi(R_e) + \kappa} - \frac{\rho}{\pi(R_e)} < 0 \tag{A.19}$$

To get the marginal effect, we divide by the change in τ^u, the effective tax rate on empty properties at the threshold, which is κ. So, the causal effect is:

$$\frac{\partial v}{\partial \tau}|_{R_e} = \frac{1}{\kappa}\left(\frac{\rho}{\pi(R_e) + \kappa} - \frac{\rho}{\pi(R_e)}\right) = -\frac{\rho}{\pi(R_e)(\pi(R_e) + \kappa)} \tag{A.20}$$

We now turn to computation of the marginal effects of SBRR. We first compute the left-hand and right-hand derivatives of v with respect to R at the two kink points. Note first if $12 \leq R \leq 15$, from the properties of the tax function, $\Delta\tau(R)$ will depend on whether the firm is non-retail or retail:

$$\Delta\tau(R) = \begin{cases} \kappa + \sigma(R)/R, & non-retail \\ \frac{\kappa}{3} + \frac{2}{3}\sigma(R)/R, & retail \end{cases} \tag{A.21}$$

So, we need to compute the derivatives separately for the two cases; we just give the calculations for non-retail firms, and report the corresponding results for retail firms. From (2), using (A.1),(A.21) left-hand and right-hand derivatives of $v(.)$ as R approaches $\underline{R}_s$ from below and above are, respectively:

$$\frac{dv^-}{dR}|_{\underline{R}_s} = \frac{-\pi'(\underline{R}_s)\rho}{(\pi(\underline{R}_s) + \kappa)^2}, \quad \frac{dv^+}{dR}|_{\underline{R}_s} = \frac{-(\pi'(\underline{R}_s) - 60\kappa(\underline{R}_s)^{-2})\rho}{(\pi(\underline{R}_s) + \kappa)^2} \tag{A.22}$$

So, by inspection of (A.22), the theoretical prediction of the change in slope of $v(R)$ at the first kink point is *positive*,

$$\underline{\Delta}_s = \frac{dv^+}{dR}|_{\underline{R}_s} - \frac{dv^-}{dR}|_{\underline{R}_s} = \frac{60\kappa(\underline{R}_s)^{-2}\rho}{(\pi(\underline{R}_s) + \kappa)^2} > 0 \tag{A.23}$$

In the same way, using From (2), using (A.1),(A.21) we can calculate that the left-hand and right-hand derivatives of $v(.)$ as R approaches $\overline{R}_s$ from below and above are, respectively:

$$\frac{dv^-}{dR}|_{\overline{R}_s} = \frac{-(\pi'(\overline{R}_s) - 60\kappa(\overline{R}_s)^{-2})\rho}{(\pi(\overline{R}_s))^2}, \quad \frac{dv^+}{dR}|_{\overline{R}_s} = \frac{-\pi'(\overline{R}_s)\rho}{(\pi(\overline{R}_s))^2} \tag{A.24}$$

By inspection of (A.24), the theoretical prediction of the change in slope at the second kink point is therefore *negative* i.e.

$$\overline{\Delta}_s = \frac{dv^+}{dR}|_{\overline{R}_s} - \frac{dv^-}{dR}|_{\overline{R}_s} = \frac{-60\kappa(\overline{R}_s)^{-2}\rho}{(\pi(\overline{R}_s))^2} < 0 \tag{A.25}$$

Next, denoting $\frac{d\tau^-}{dR}, \frac{d\tau^+}{dR}$ to be the left-hand and right-hand derivatives of the effective tax rate on occupied properties $\tau^o(R) = \kappa - \sigma(R)/R$ at a point, from (A.1), we can calculate

$$\frac{d\tau^+}{dR}|_{\underline{R}_s} - \frac{d\tau^-}{dR}|_{\underline{R}_s} = 60\kappa(\underline{R}_s)^{-2} \tag{A.26}$$

$$\frac{d\tau^+}{dR}|_{\bar{R}_s} - \frac{d\tau^-}{dR}|_{\bar{R}_s} = -60\kappa(\overline{R}_s)^{-2} \tag{A.27}$$

Then, dividing (A.23), (A.25), by (A.26), (A.27), respectively, we finally get the causal effects:

$$\frac{\partial v}{\partial \tau}|_{\underline{R}_s} = \frac{\underline{\Delta}_s}{60\kappa(\overline{R}_s)^{-2}} = \frac{\rho}{(\pi(\underline{R}_s) + \kappa)^2} > 0 \tag{A.28}$$

$$\frac{\partial v}{\partial \tau}|_{\overline{R}_s} = \frac{\overline{\Delta}_s}{-60\kappa(\overline{R}_s)^{-2}} = \frac{\rho}{(\pi(\overline{R}_s))^2} > 0 \tag{A.29}$$

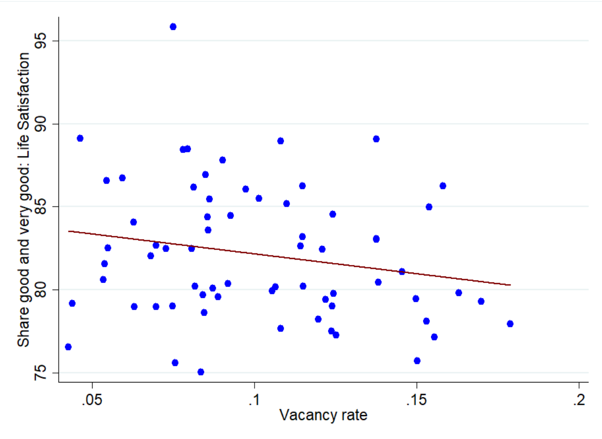
Finally, it can be checked that the causal effects for retail firms are the same, except that

$$\frac{\partial v}{\partial \tau}|_{\overline{R}_s} = \frac{\rho}{(\pi(\overline{R}_s) + \frac{\kappa}{3})^2} > 0 \tag{A.30}$$

C Additional Figures and Tables

C.1 Descriptive statistics

Figure C1: Relationship between vacancy rate and life satisfaction



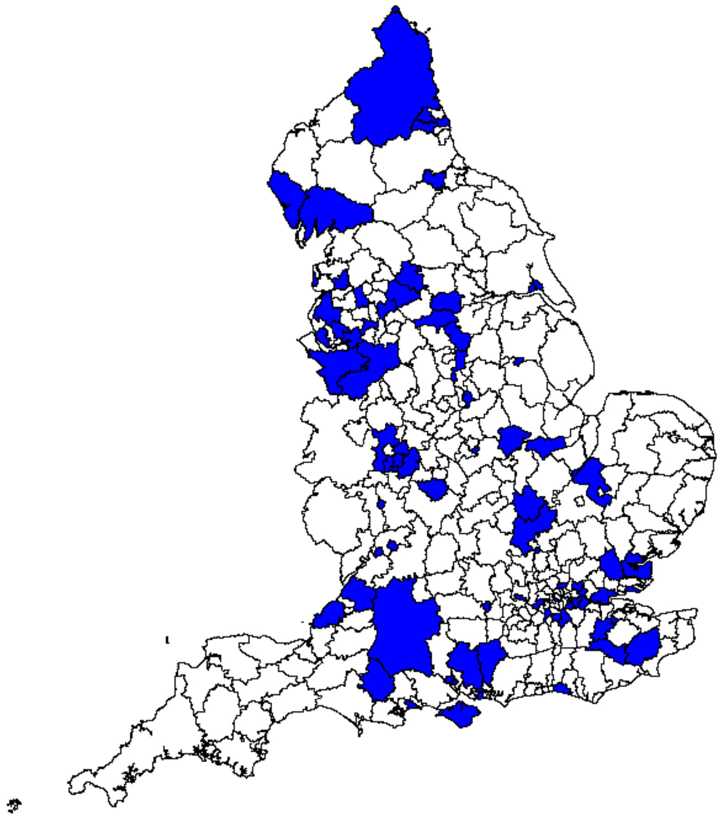
Note: The figure shows the scatter plot for vacancy rate and life satisfaction (share of respondents that answered good or very good) on the local authority level for 73 local jurisdictions in England in 2018/2019. Life satisfaction data is provided by the ONS (Measuring National Well-being: Life Satisfaction). For more information on the vacancy data and the jurisdictions included, see Section 5. The solid line represents linear fit.

Table C1: Business rate multiplier

Year	Small business multiplier	Multiplier
2010-2011	40.7	41.4
2011-2012	42.6	43.3
2012-2013	45.0	45.8
2013-2014	46.2	47.1
2014-2015	47.1	48.2
2015-2016	48.0	49.3
2016-2017	48.4	49.7
2017-2018	46.6	47.9
2018-2019	48.0	49.3
2019-2020	49.1	50.4
2020-2021	49.9	51.2

Notes: The table reports the small business multiplier and (normal) multiplier for jurisdictions in England outside of London. Small business multiplier applies for properties with rateable value below £51,000. Small business rate relief applies on top of the small business multiplier. Source: https://www.gov.uk/calculate-your-business-rates.

Figure C2: Local authorities in sample



Note: The map indicates in blue color the local authorities in England included in the data ("large sample"). Data on local authority boundaries are from ONS.

Table C2: Descriptive statistics for jurisdictions included

Sample (# jurisdictions)	All jurisdictions (326)		Empty exemptions (38)		Retail relief (34)		SBRR (64)	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Residents								
Population in thsd	163	125	204	195	216	158	215	195
Share pop. > 65 yrs	17	17	17	17	17	17	16	16
Share pop. < 16 yrs	19	19	19	19	19	19	19	19
Commercial properties								
Number	5,993	4,575	7,118	6,780	8,021	6,025	7,566	6,580
Number per 1,000 pop	46	35	36	34	36	35	35	34
Floor space	1,705	1,303	2,095	1,598	2,238	1,598	2,268	1,784
Floor space per 1,000 pop	13	10	10	9	10	10	11	11
Labor market								
Employment in thsd	83	62	98	88	106	87	101	87
Jobseeker per 1,000 pop	5	4	6	4	7	5	6	5
Wages (gross)	29,505	28,757	29,363	28,456	28,950	28,888	29,472	28,911
Firms								
# local units	8,401	65,23	9,863	9,540	10,327	8,550	9,881	8,780
# local units per 1,000 pop	64	51	50	48	49	47	48	46
# enterprises	7,242	5,468	8,391	8,205	8,790	7,030	8,399	7,045
# enterprises per 1,000 pop	55	44	43	42	42	41	40	39
Share of local units with ... in %								
0-4 employees	72	72	71	73	70	70	71	70
5-9 employees	13	13	13	13	14	14	13	13
10-19 employees	8	8	8	7	8	8	8	8
20-49 employees	5	5	5	5	5	5	5	5
50-99 employees	2	2	2	2	2	2	2	2
100 or more employees	1	1	1	1	1	1	1	1
Share of enterprises with ... in %								
0-4 employees	78	78	78	79	77	77	78	78
5-9 employees	11	11	11	11	12	12	11	11
10-19 employees	6	6	6	5	6	6	6	6
20-49 employees	3	3	3	3	3	3	3	3
50-99 employees	1	1	1	1	1	1	1	1
100 or more employees	1	1	1	1	1	1	1	1
Share of enterprises with ... in %								
£0-49k turnover	15	15	15	15	14	14	15	14
50-99k turnover	23	23	24	23	24	23	24	23
100-199k turnover	32	32	33	32	32	32	33	33
200-499k turnover	13	13	13	13	13	13	13	13
500-999k turnover	7	7	7	7	8	7	7	7
1,000k-1,999k turnover	4	4	4	4	4	4	4	4
2,000k-4,999k turnover	3	3	3	3	3	3	3	3
5,000k and more turnover	2	2	2	2	2	2	2	2

Notes: The table reports descriptive statistics on the jurisdiction level for 2019. Cols. (1) and (2) include all jurisdictions in England, cols. (3) and (4) the jurisdictions included in the empty exemption sample, cols. (5) and (6) the jurisdictions included in the retail relief sample and cols. (7) and (8) the jurisdictions included in the SBRR sample. Data on residents, labor market and firms are from ONS local authority level data.

Table C3: Semi-elasticities from the three natural experimental variations - All main results

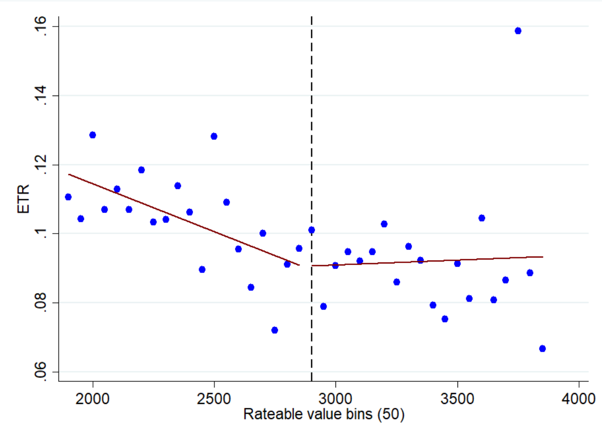
	RDD/RKD Estimate				Level of Dependent Variable			Semi-elasticity			
	Vacancy	Occupancy		ETR	Vacancy	Occupancy		Vacancy	Occupancy		
		small business	large business			small business	large business		all	small business	large
	dv	do_s	do_l	$d\tau$	v	o_s	o_l	$\frac{1}{v}\frac{dv}{d\tau}\|_+$	$\frac{1}{o}\frac{do}{d\tau}\|_+$	$\frac{1}{o_s}\frac{do_s}{d\tau}\|_+$	$\frac{1}{o_l}\frac{do_l}{d\tau}\|_+$
Empty property exemption (£2,900)											
All properties	-0.064			0.281	0.081			-2.8	0.25		
Retail properties	-0.068			0.384	0.048			-3.7	0.19		
Small business rates relief $\underline{R}_s$ (£12,000)											
All properties	0.013	-0.036	0.024	0.136	0.091	0.580	0.366	1.1	-0.11	-0.46	0.48
Retail properties	0.019	-0.044	0.027	0.122	0.090	0.640	0.310	1.7	-0.17	-0.56	0.70
Small business rates relief $\underline{R}_s$ (£15,000)											
All properties	-0.012			0.121	0.091			1.1	-0.11		
Retail properties	-0.018			0.128	0.090			1.6	-0.15		
Retail relief (£51,000)											
Retail properties	0.051			0.096	0.097			5.5	-0.59		

Notes: The table reports the results of our main specifications (vacancy rate, occupancy rate by type of business and ETR), the level of the dependent variables (measured at the right limit of the threshold/kink) and the implied semi-elasticities. We use the vacancy of the right limit of the 15,000 threshold also for the 12,000 threshold to allow a comparison of the semi-elasticities for the two kinks.

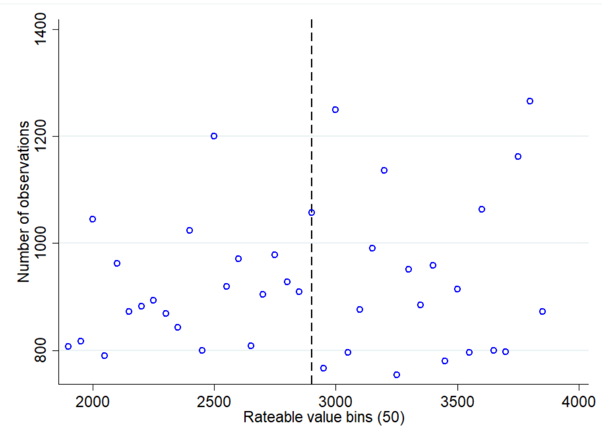
C.2 Additional results for empty property exemption

Figure C3: Validity of RDD for empty property exemption

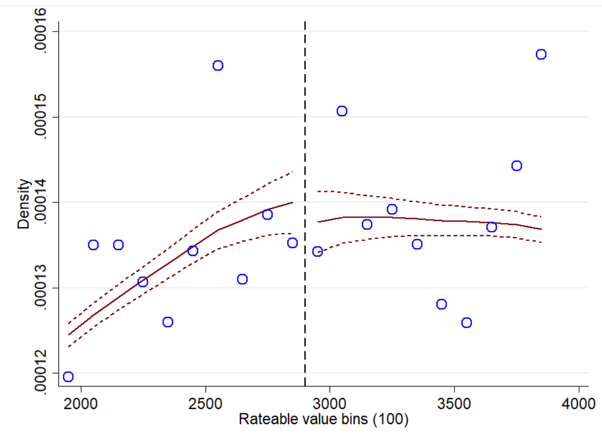
(a) ETR for occupied properties



(b) Number of properties



(c) McCrary test



Note: The graphs plot (a) the effective tax rate for occupied properties, (b) the number of observations and (c) the estimated density function for the McCrary test by rateable value group using the small sample. Bin width is £50 in (a) and (b) and £100 in (c). The dashed line indicates the rateable value threshold for the empty property exemption and the solid lines represent linear fits in (a) and polynomial fits in (c).

Table C4: Sensitivity analysis: RDD for empty property exemption

Dep. Var.	D(Vacant)			ETR		
Properties	All			Empty		
Local regression	Linear		Quadratic	Linear		Quadratic
Kernel	Triang.	Epan.	Triang.	Triang.	Epan.	Triang.
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Without local authority fixed effects						
Conventional	-0.073***	-0.074***	-0.083***	0.272***	0.273***	0.278***
	(0.009)	(0.009)	(0.014)	(0.013)	(0.013)	(0.014)
Bias-corrected	-0.076***	-0.077***	-0.086***	0.268***	0.268***	0.275***
	(0.010)	(0.010)	(0.016)	(0.015)	(0.015)	(0.015)
Observations	28,974	26,898	25,348	4,022	3,749	8,514
Bandwidth	784	715	685	819	772	1,702
Panel B: With local authority fixed effects						
Conventional	-0.069***	-0.071***	-0.073***	0.281***	0.282***	0.266***
	(0.009)	(0.009)	(0.014)	(0.010)	(0.010)	(0.016)
Bias-corrected	-0.070***	-0.072***	-0.076***	0.280***	0.282***	0.261***
	(0.011)	(0.011)	(0.016)	(0.012)	(0.011)	(0.017)
Observations	26,898	23,265	26,898	7,035	7,255	5,397
Bandwidth	716	609	709	1,415	1,458	1,089

Notes: The table reports reduced form estimates using local regressions to control for the relationship between rateable value and outcome variable left and right to the threshold. The dependent variable is an indicator of the property being vacant (cols. (1) to (3)) or the effective tax rate (cols. (4) to (6)). Each cell shows an RDD estimate. Panel A shows the results of specifications without local authority fixed effects and panel B with local authority fixed effects. The first row for each panel shows the conventional RDD estimate and the second row the bias-corrected estimate with robust standard errors. In cols. (1), (3), (4) and (6) we use a Triangular kernel and in cols. (2) and (4) an Epanechnikov angular kernel. In cols. (1), (2), (4) and (5) we use a local linear and in cols. (3) and (6) a local quadratic regression. The bandwidths are the optimal bandwidths calculated following Calonico, Cattaneo and Titiunik (2014*a*). *, **, *** indicate statistical significance at the 10,5 and 1% level.

Table C5: Heterogeneity analysis: RDD results for empty property exemption

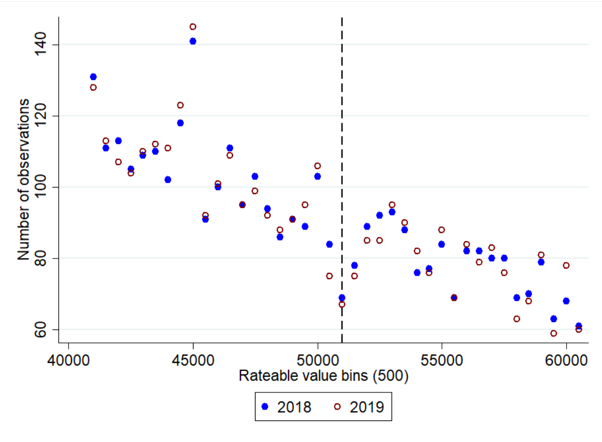
Dep. Var.	D(Vacant)		ETR	
Properties	All		Occupied	
Bandwidth	Optimal	250	Optimal	250
	(1)	(2)	(3)	(4)
Panel A: Retail/hospitality properties				
D(RV≥2.9k)	-0.048***	-0.068**	0.358***	0.384***
	(0.016)	(0.029)	(0.025)	(0.049)
Observations	7,171	3,630	1,954	290
Panel B: Jurisdictions inside London				
D(RV≥2.9k)	-0.072*	-0.041	0.262***	0.327***
	(0.041)	(0.052)	(0.066)	(0.074)
Observations	2,021	1,258	242	169
Panel C: Jurisdictions outside London				
D(RV≥2.9k)	-0.069***	-0.075***	0.276***	0.264***
	(0.012)	(0.011)	(0.022)	(0.025)
Observations	13,055	17,044	3,098	2,136

Notes: The table reports reduced form estimates for impact heterogeneity of empty property exemption. Panel A shows the results for shops and hospitality properties, panel B (C) for jurisdiction inside (outside) of London. The dependent variable is an indicator of the property being vacant (cols. (1) and (2)) and the ETR of occupied properties (cols. (3) and (4)). In cols. (1) and (3) we use the optimal bandwidth and in cols. (2) and (4) a fixed bandwidth of £250. In all specifications, we allow for a linear relationship between the rateable value and the outcome variable left and right to the threshold, include local authority fixed effects and use the small sample. The optimal bandwidths are calculated following Calonico, Cattaneo and Titiunik (2014*a*). Panel A: The McCrary tests suggests a smooth distribution around the threshold (point estimate (s.e.): 0.015 (0.029)). The vacancy rate is 0.048 at the right limit of the threshold. Panel B and C: The McCrary tests suggests a smooth distribution around the threshold ((point estimate (s.e.): in London 0.04 (0.07) and outside of London: 0.01 (0.02)). The vacancy rate is in (outside of) London 0.092 (0.081) at the right limit of the threshold. Robust standard errors are clustered at the local authority-rateable value bin and local authority-property type level and are reported in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.

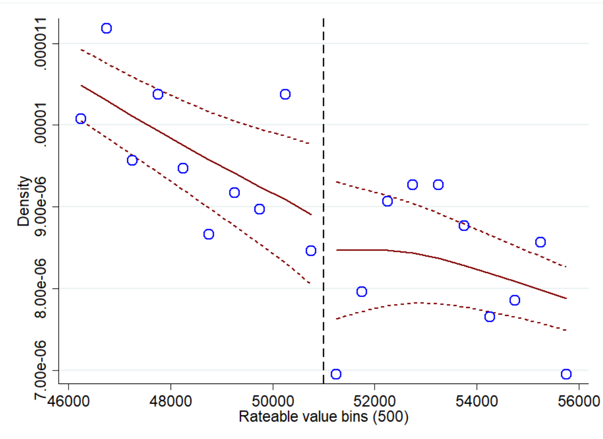
C.3 Additional results for retail relief

Figure C4: Validity of RDD for retail relief

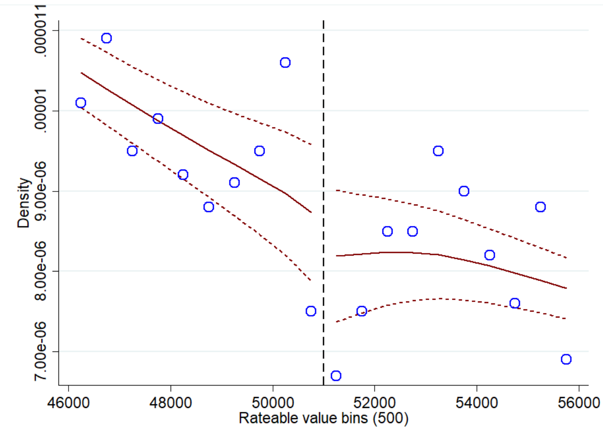
(a) Number of properties 2018 and 2019



(b) McCrary test 2018



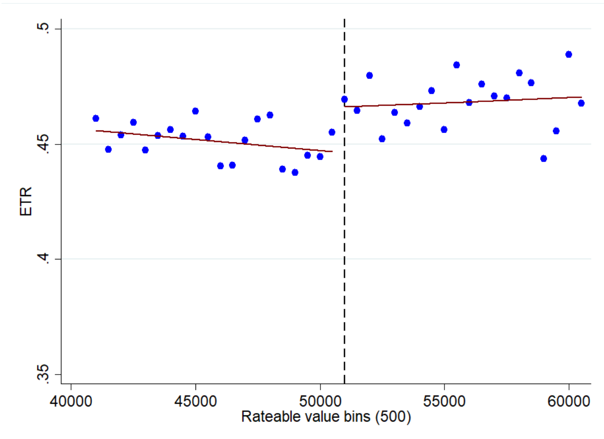
(c) McCrary test 2019



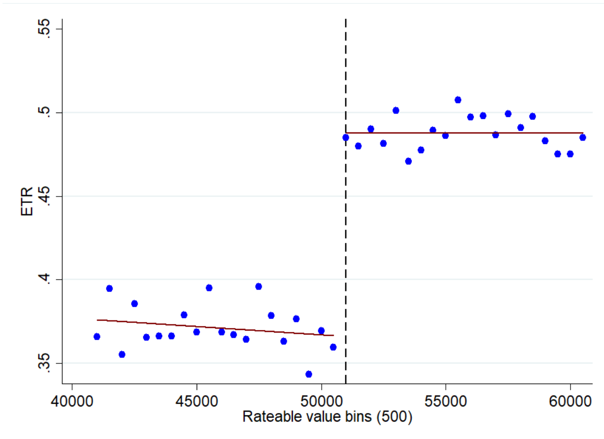
Note: The graph plots (a) the number of observations in 2018 and 2019 and the estimated density function for the McCrary test (b) for 2018 and (c) for 2019 by rateable value from £41,000 to £61,000 with bin width £500 using the large sample. The dashed line indicates the rateable value threshold for the retail relief and the solid lines represent polynomial fits.

Figure C5: Graphical evidence for retail relief: 2018 vs 2019

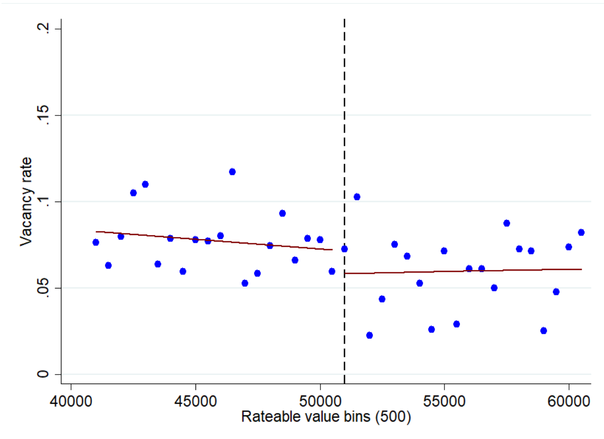
(a) ETR of occupied properties 2018



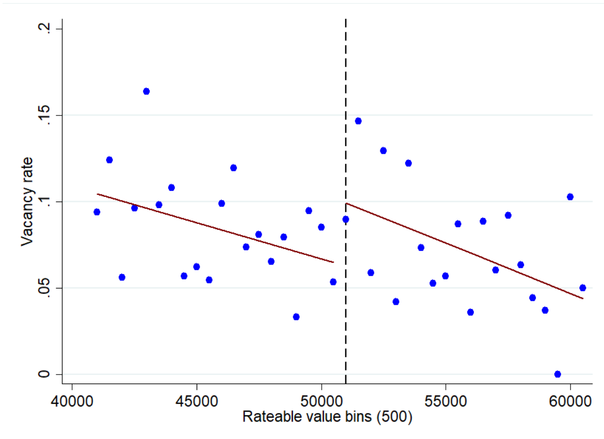
(b) ETR of occupied properties 2019



(c) Vacancy rate 2018



(d) Vacancy rate 2019



Note: The graphs plot the average effective tax rate for occupied properties in (a) 2018 and (b) 2019 and the average vacancy rate in (c) 2018 and and (d) 2019 by rateable value from £41,000 to £61,000 with bin width £500 using the large sample. The dashed line indicates the rateable value threshold for the retail relief and the solid lines represent linear fits.

Table C6: Sensitivity analysis: RDD for retail relief, Local linear regression for 2018 and 2019

Dep. Var.	D(Vacant)				ETR	
Properties	All				Occupied	
Sample	Large		Small			
Year	2019	2018	2019	2018	2019	2018
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A1: Local linear regression & Without local authority fixed effects						
Conventional	0.032	-0.010	0.054*	0.005	0.121***	0.018**
	(0.023)	(0.019)	(0.029)	(0.024)	(0.011)	(0.008)
Bias-corrected	0.040	-0.007	0.063*	0.011	0.124***	0.021**
	(0.027)	(0.023)	(0.034)	(0.028)	(0.013)	(0.010)
Observations	2,850	3,372	1,700	2,058	1,392	2,284
Bandwidth	7,833	9,254	9,774	11,857	8,742	13,752
Panel A2: Local linear regression & With local authority fixed effects						
Conventional	0.036	-0.009	0.052*	0.005	0.123***	0.018*
	(0.023)	(0.019)	(0.029)	(0.025)	(0.010)	(0.009)
Bias-corrected	0.045*	-0.004	0.060*	0.011	0.124***	0.020*
	(0.026)	(0.022)	(0.034)	(0.029)	(0.012)	(0.011)
Observations	2,850	3,569	1,667	2,024	1,710	1,895
Bandwidth	7,936	9,929	9,207	11,603	10,046	11,693
Panel B1: Local quadratic regression & Without local authority fixed effects						
Conventional	0.047*	-0.005	0.057	0.011	0.124***	0.021**
	(0.026)	(0.022)	(0.037)	(0.034)	(0.013)	(0.011)
Bias-corrected	0.054*	-0.001	0.054	0.009	0.126***	0.023*
	(0.029)	(0.025)	(0.043)	(0.038)	(0.014)	(0.012)
Observations	5,146	6,087	2,244	2,112	2,505	3,231
Bandwidth	13,821	16,072	12,866	12,190	15,135	18,509
Panel B2: Local quadratic regression & With local authority fixed effects						
Conventional	0.049*	-0.004	0.057	0.008	0.124***	0.021*
	(0.026)	(0.023)	(0.037)	(0.035)	(0.011)	(0.011)
Bias-corrected	0.056*	-0.000	0.054	0.005	0.125***	0.022*
	(0.029)	(0.026)	(0.042)	(0.039)	(0.013)	(0.012)
Observations	5,072	5,470	2,322	2,059	3,161	3,179
Bandwidth	13,612	14,707	12,722	11,888	17,505	18,292

Notes: The table reports reduced form estimates using local regressions to control for the relationship between rateable value and outcome variable left and right to the threshold. The dependent variable is an indicator of the property being vacant (cols. (1) to (4)) or the effective tax rate (cols. (5) and (6)). Cols. (1) and (2) use the large sample, and all other columns the small sample. In cols. (1), (3) and (5) we use the 2019 data and in cols. (2), (4) and (6) we use the 2018 data. Each cell shows an RDD estimate. In panel A1 and A2, we use a Triangular kernel and a local linear regression and in panel B1 and B2 a Triangular Kernel and a local quadratic regression. Panel A1 and B1 show the results of specifications without local authority fixed effects and panel A2 and B2 the results of specifications with local authority fixed effects. The first row for each panel shows the conventional RDD estimate and the second row the bias-corrected estimate with robust standard errors. The bandwidths used for estimation are the optimal bandwidths following Calonico, Cattaneo and Titiunik (2014*a*). *, **, *** indicate statistical significance at the 10,5 and 1% level.

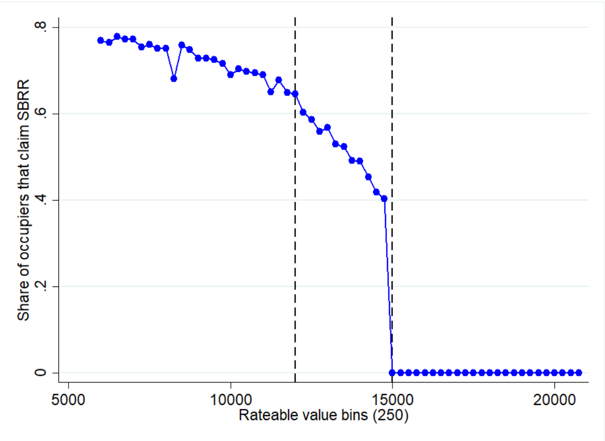
Table C7: Difference-in-discontinuity results for retail relief: High Street properties

Dep. Var.	D(Vacant)				ETR	
Properties	All				Occupied	
Sample	Large		Small		Small	
Bandwidth	Optimal	10,000	Optimal	10,000	Optimal	10,000
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: All properties in jurisdictions with postcodes and postcode FE						
D(R≥51k)*Post	0.042	0.055**	0.038	0.048*	0.099***	0.104***
	(0.027)	(0.023)	(0.030)	(0.028)	(0.013)	(0.011)
Observations	4,612	6,602	2,378	3,056	2,389	27,98
Panel B: High Street properties in jurisdictions with postcodes and postcode FE						
D(R≥51k)*Post	0.049	0.057**	0.050	0.058*	0.094***	0.102***
	(0.031)	(0.026)	(0.036)	(0.034)	(0.013)	(0.011)
Observations	3,714	5,307	1,886	2,411	1,878	2,196

Notes: The table reports reduced form estimates for the retail relief in equation (7). The dependent variable is an indicator for the property being vacant (cols. (1) to (4) or the effective tax rate of empty properties (cols. (5) to (6)). In cols. (1), (3) and (5) we use the optimal bandwidth (as estimated for the full sample), which is the average of the optimal bandwidth for 2018 and 2019. The optimal bandwidth is estimated following Calonico, Cattaneo and Titiunik (2014*a*). In cols. (2), (4) and (6) we use a fixed bandwidth of £10,000. Cols. (1) and (2) use the large sample, all other columns the small sample. All specifications include local authority × quarter-year and postcode fixed effects. Panel A shows the results for all retail/hospitality properties in jurisdictions with postcodes and panel B shows the results for "High Street" retail/hospitality properties (retail/hospitality properties in postcodes with at least 7 (the median) retail/hospitality properties). Robust standard errors are clustered at the local authority-rateable value bin level and are reported in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.

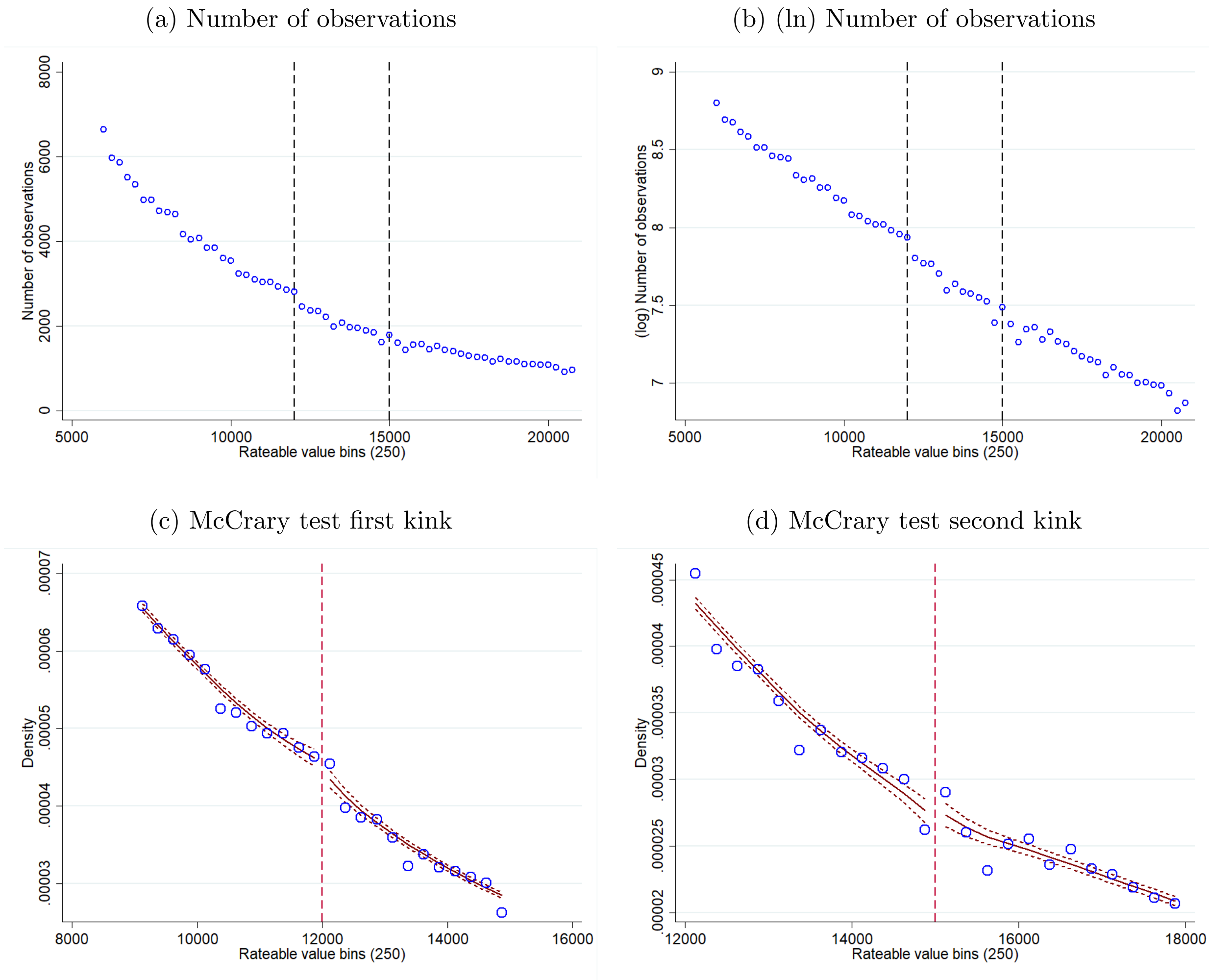
C.4 Additional Results for SBRR

Figure C6: Share of occupiers that claim SBRR



Note: The figure shows the share of occupiers that claim SBRR by rateable value from £6,000 to £21,000 with bin width £250 using the large sample.

Figure C7: Validity of RKD for SBRR



Note: The graphs plot (a) the number of observations, (b) (ln) number of observations, and the estimated density function for the McCrary test for the first kink (c) and second kink (d) by rateable value group with bin width £250 using the large sample. The dashed lines indicate the two kinks for the small business rate relief and the solid lines represent polynomial fits.

Table C8: RKD results for SBRR: Vacancy rate - Without controls

Dep. Var.	D(Vacant)				ETR	
Properties	All				Occupied by small business	
Sample	Large		Small		Small	
	(1)	(2)	(3)	(4)	(5)	(6)
Bandwidth	3,000	2,500	3,000	2,500	3,000	2,500
Panel A: First Kink (£12,000)						
R*D(1kink)	0.011***	0.008**	0.016***	0.013***	0.134***	0.135***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
Observations	64,096	52,892	29,845	24,664	17,455	14,481
Panel B: Second Kink (£15,000)						
R * D(2Kink)	-0.007	-0.007	-0.012**	-0.012*	-0.123***	
	(0.004)	(0.005)	(0.006)	(0.007)	(0.019)	
Observations	40,417	33,038	18,599	15,240	4,869	

Notes: The table reports estimates of equation (12) and (14) in panel A and of equation (13) and (15) in panel B. The dependent variable is an indicator for the property being empty (cols.(1) to (4)) or the effective tax rate of properties occupied by small businesses (cols. (5) and (6) for Panel A) or of properties occupied by small and large business (cols. (5) and (6) for Panel B). Panel A reports the results for the first kink, and Panel B for the second kink. $R * D(1kink)$ and $R * D(2kink)$ represents the change in relationship between vacancy and rateable value above the threshold at £12,000 and £15,000 respectively. Cols. (1), (3) and (5) use a fixed bandwidth of £3,000 and all other columns a bandwidth of £2,500 (except for column (5) in panel B which uses a bandwidth of £1,000). Cols. (1) and (2) use the large sample, all other columns the small sample. Panel B cols. (5) and (6) report the estimate of ϕ_2 of equation (13) divided by the share of small businesses at the threshold (0.37) as described in section (4). Robust standard errors are clustered at the local authority-rateable value bin and local authority-property type level and are in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.

Table C9: Sensitivity analysis: RKD for SBBR

	First Kink (£12,000			Second Kink (£15,000)		
Dep. Var.	D(Vacant)	D(Occupied) by small business	D(Occupied) by large business	ETR	D(Vacant)	ETR
Properties		All		Occupied by small business	All	Occupied by small business
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A1: Uniform kernel & Without local authority fixed effects						
Conventional	0.008***	-0.052***	0.043***	0.148***	-0.010***	-0.168***
	(0.001)	(0.004)	(0.004)	(0.005)	(0.003)	(0.040)
Bias-corrected	0.011***	-0.045**	0.030	0.151***	-0.013**	-0.133***
	(0.002)	(0.019)	(0.019)	(0.005)	(0.005)	(0.043)
Observations	111,470	73,719	68,699	5,124	44,483	4,869
Bandwidth	4,868	3,536	3,208	975	3,238	907
Panel A2: Uniform kernel & With local authority fixed effects						
Conventional	0.008***	-0.052***	0.044***	0.146***	-0.011***	-0.163***
	(0.001)	(0.004)	(0.004)	(0.004)	(0.003)	(0.040)
Bias-corrected	0.011***	-0.039**	0.026	0.151***	-0.015***	-0.128***
	(0.002)	(0.018)	(0.018)	(0.006)	(0.005)	(0.045)
Observations	100,411	73,719	65,552	5,119	44,464	4,867
Bandwidth	4,429	3,517	3,089	0,784	3,173	0,873
Panel B1: Triangular kernel & Without local authority fixed effects						
Conventional	0.010***	-0.056***	0.041***	0.156***	-0.002	-0.178***
	(0.003)	(0.016)	(0.014)	(0.007)	(0.009)	(0.032)
Bias-corrected	0.012**	-0.061**	0.039	0.162***	0.003	-0.163***
	(0.005)	(0.027)	(0.024)	(0.009)	(0.015)	(0.053)
Observation	67,627	34,212	34,226	3,695	25,691	6,352
Bandwidth	3,078	1,537	1,603	694	1,845	1,088
Panel B2: Triangular kernel & With local authority fixed effects						
Conventional	0.010***	-0.052***	0.038***	0.155***	-0.001	-0.168***
	(0.003)	(0.014)	(0.013)	(0.007)	(0.009)	(0.035)
Bias-corrected	0.011**	-0.053**	0.034	0.160***	0.006	-0.149***
	(0.005)	(0.025)	(0.023)	(0.010)	(0.015)	(0.053)
Observation	64,094	34,214	34,230	3,701	25,691	6,352
Bandwidth	2,967	1,595	1,631	704	1,826	1,069

Notes: The table reports reduced form estimates using local linear regressions. The dependent variable is an indicator of the property being vacant (cols. (1) and (4)), an indicator variable for the property being occupied by a small business (col. (2)) or large business col. ((3)) or the effective tax rate of properties occupied by small business (cols. (4) and (6)). Col. (6) reports the estimate of ϕ_2 of (13) divided by the share of small businesses at the threshold (0.37) as described in section (4). Each cell shows an RKD estimate. The sample is in cols. (1), (2), (3) and (5) the large and in cols. (4) and (6) the small sample. Panel A1 and A2 show the results when using a uniform kernel, panel B1 and B2 when using triangular kernel. Panel A1 and B1 report the results for specification without local authority fixed effects and panel A2 and B2 the results for specifications with local authority fixed effects. For each panel, the conventional RKD estimate and the bias-corrected RKD estimate with robust standard errors is shown. The bandwidths used for estimation are the optimal bandwidths following Calonico, Cattaneo and Titiunik (2014*a*). *, **, *** indicate statistical significance at the 10,5 and 1% level.

Table C10: RKD results for SBRR: Heterogeneity

	First kink				Second kink	
Dep. Var.	D(Vacant)	D(Occ.) by small business	D(Occ.) by large business	ETR	D(Vacant)	ETR
Properties	All	All	All	Occ. by small business	All	Occ. by small business
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A1: Retail/hospitality properties						
R * D(Kink)	0.019***	-0.044***	0.027*	0.122***	-0.018*	0.128***
	(0.007)	(0.015)	(0.014)	(0.004)	(0.009)	(0.044)
Observations	11,188	11,188	11,188	7,291	6,806	2,408
Panel A2: Retail/hospitality properties with postcode FE						
R * D(1Kink)	0.020**	-0.049**	0.029	0.124***	-0.008	0.097
	(0.010)	(0.018)	(0.018)	(0.006)	(0.017)	(0.093)
Observations	6,935	6,935	6,188	4,108	3,699	811
Panel A3: High Street retail/hospitality properties with postcode FE						
R * D(Kink)	0.017	-0.053***	0.036*	0.121***	-0.022	0.111*
	(0.011)	(0.019)	(0.020)	(0.008)	(0.017)	(0.057)
Observations	5,599	5,599	6,188	4,108	3,699	811
Panel B: Jurisdictions inside London						
R * D(Kink)	0.014	-0.044***	0.034	0.133***	-0.039	-0.148
	(0.011)	(0.013)	(0.011)	(0.009)	(0.006)	(0.088)
Observations	3,459	3,459	3,459	2,280	2,093	648
Panel C: Jurisdictions outside London						
R * D(Kink)	0.013**	-0.035***	0.021	0.136***	-0.007	-0.114***
	(0.004)	(0.009)	(0.011)	(0.003)	(0.006)	(0.011)
Observations	21,205	21,205	21,205	12,201	13,147	4,221

Notes: The table reports reduced form results for impact heterogeneity of SBRR. Panel A1 to A3 show the results for retail/hospitality properties and panel B (C) for jurisdictions in (outside of) London. The dependent variable is an indicator of the property being vacant (cols. (1) and (4)), occupied by a small (col. (2)) or large (col. (3)) business or the effective tax rate of properties occupied by small business (cols. (4) and (6)). Cols. (1) to (4) present the results for the first kink and cols. (5) and (6) for the second kink. $R * D(kink)$ represents the change in relationship between vacancy and rateable value above the first (cols. (1) to (4)) or the second (cols. (5) and (6)) kink. In all specifications, we use a bandwidth of £2,500 and the small sample. Panel A1, B and C3 include local authority fixed effects and panel A2 and A3 postcode fixed effects. Panel A1 includes all retail/hospitality properties, panel A2 only the ones in jurisdictions with postcodes, and panel A3 only High street properties. Panel A1: The McCrary test suggests a smooth distribution around the threshold and no change in the slope of the distribution around the two kinks is indicated (based on a bandwidth of £2,000 and using the number of observations). The vacancy is 0.092 at the upper kink. Panel B and C: The McCrary test suggests a smooth distribution around the threshold and no change in the slope of the distribution (based on a bandwidth of £2,000 and using the number of observations), except for the second kink inside of London. The vacancy rate in (outside of) London is 0.14 (0.084). Robust standard errors are clustered at the local authority-rateable value bin and local authority-property type level and are reported in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.

Online Appendix

A Solving for N_s

First, the probabilities that any business applies to a property must add up to unity. Also, $\phi_s N p_{i,j}$ is the probability that a type j business applies to *some* type i property, as there are $\phi_i N$ such properties. So, the adding-up condition requires

$$N \sum_{i \in P} \phi_i p_{i,j} = 1, \ j = s, l \tag{N.1}$$

Multiplying through both sides by $\frac{N_j}{N}$ and using the definition of $q_{i,j} = p_{i,j} N_j$, we get:

$$\sum_{i \in P} \phi_i q_{i,j} = n_j, \ n_j = \frac{N_j}{N}, \ j = s, l \tag{N.2}$$

These conditions will ultimately determine n_s once $q_{i,j}$ are determined, as n_l is fixed.

First, we use (A.3) to write the aggregate queue length $q_i = q_{i,s} + q_{i,l}$ as a function of v_i, namely $q_i = lnv_i$. Combining this with (2), we get:

$$q_i = \ln\left(\frac{\rho R_i}{\Pi(R_i) + \Delta T(R_i)}\right), \ i \in S, \quad q_i = \ln\left(\frac{\rho R_i}{\Pi(R_i)}\right), \ i \in L. \tag{N.3}$$

Now summing (N.2) across business types, we get

$$\sum_{i \in P} \phi_i (q_{i,s} + q_{i,l}) = n_s + n_l \tag{N.4}$$

Combining (N.3), (N.4), using the fact that $q_i = q_{i,s} + q_{i,l}$, we see that

$$n_s + n_l = \sum_{i \in S} \phi_i \ln\left(\frac{\rho R_i}{\Pi(R_i) + \Delta T(R_i)}\right) + \sum_{i \in L} \phi_i \ln\left(\frac{\rho R_i}{\Pi(R_i)}\right) \tag{N.5}$$

Note that the RHS of (N.5) is fixed, and moreover, n_l is fixed. So, n_s is determined by (N.5). $\square$

B Identification for retail relief

In this section we provide the identification assumption and derivation for identifying the effect of the retail relief using the difference-in-discontinuities approach. Under the retail relief, we can write the effective tax rate as

$$\tau^o = \begin{cases} \kappa, & \text{if } R < R_r, t = 2018. \\ 2/3\kappa, & \text{if } R < R_r, t = 2019. \\ (\kappa + d), & \text{if } R \geq R_r, t = 2018, 2019. \end{cases}$$

where κ and $\kappa+d$ are the standard multipliers for properties below and above the threshold respectively.

We consider an empirical model for the observed vacancy v as $v_{it} = V(\tau^o(R_{it})R_i, R_i) + \epsilon_{it}$. $V(\tau^o_{it}R_i, R_i)$ is the empirical analogue of the vacancy function in Proposition 1. τ^o is the effective tax rate for occupied property and R_i is rateable value of the property. τ^u is implicit and omitted as there is no change in the tax rate for empty property around the retail relief threshold. ϵ_{it} is unobserved error term.

For $t = 2018, 2019$, denote the left and right limit of expected vacancy at the threshold as $v_t^- = \lim_{R\to R_r^-} E(v|R,t)$ and $v_t^+ = \lim_{R\to R_r^+} E(v|R,t)$ respectively. If the distribution of ϵ is continuous at the threshold, which implies $\lim_{R\to R_r^+} E(\epsilon|R,t) = \lim_{R\to R_r^-} E(\epsilon|R,t)$, then the difference-in-discontinuities estimator on vacancy, Δ_v, is

$$\begin{aligned}
\Delta_v &= v^+_{2019} - v^-_{2019} - (v^+_{2018} - v^-_{2018}) \\
&= V((\kappa+d)R_r, R_r) - V(\frac{2}{3}\kappa R_r, R_r) - (V((\kappa+d)R_r, R_r) - V(\kappa R_r, R_r)) \\
&= V(\kappa R_r, R_r) - V(\frac{2}{3}\kappa R_r, R_r)
\end{aligned} \tag{N.6}$$

The estimator Δ_v therefore identifies the reduced form effect of the retail relief at the threshold on vacancies i.e. Δ_r in (A.16) above.

Similar to the fuzzy RDD approach for the empty property exemption, our fuzzy difference-in-discontinuity approach identifies the tax effect on vacancy $\frac{\partial v}{\partial \tau}|_{R=R_r} = \frac{V(\kappa R_r, R_r) - V(\frac{2}{3}\kappa R_r, R_r)}{\frac{1}{3}\kappa}$ for the retail relief. Allowing for imperfect implementation, that the retail relief is given to property below the threshold with probability p, the effective tax rate is

$$\tau^o = \begin{cases} \kappa, & \text{if } R < R_r, t = 2018. \\ 2/3\kappa, \text{with prob } p & \text{if } R < R_r, t = 2019. \\ \kappa, \text{with prob } 1-p & \text{if } R < R_r, t = 2019. \\ (\kappa+d), & \text{if } R > R_r, t = 2018, 2019. \end{cases}$$

We assume the distribution of unobservable ϵ is continuous across the threshold R_r, which implies $\lim_{R\to R_r^+} E(\epsilon|R,t) = \lim_{R\to R_r^-} E(\epsilon|R,t)$.

$$
\begin{aligned}
v_{2019}^+ &= \lim_{R\to R_r^+} E(v|R,2019) = V((\kappa+d)R_r, R_r) + E(\epsilon|R_r,2019)\\
v_{2019}^- &= \lim_{R\to R_r^-} E(v|R,2019) = pV(\frac{2}{3}\kappa R_r, R_r) + (1-p)V(\kappa R_r, R_r) + E(\epsilon|R_r,2019)\\
v_{2018}^+ &= \lim_{R\to R_r^+} E(v|R,2018) = V((\kappa+d)R_r, R_r) + E(\epsilon|R_r,2018)\\
v_{2018}^- &= \lim_{R\to R_r^-} E(v|R,2018) = V(\kappa R_r, R_r) + E(\epsilon|R_r,2018)
\end{aligned}
$$

Therefore

$$
\begin{aligned}
v_{2019}^+ - v_{2019}^- - (v_{2018}^+ - v_{2018}^-) &= -pV(\frac{2}{3}\kappa R_r, R_r) - (1-p)V(\kappa R_r, R_r) + V(\kappa R_r, R_r)\\
&= p(V(\kappa R_r, R_r) - V(\frac{2}{3}\kappa R_r, R_r))
\end{aligned}
$$

Next, denote the left and right limit of tax at the threshold in period t as $\tau_t^- = \lim_{R\to R_r^-} \tau^o(R,t)$ and $\tau_t^+ = \lim_{R\to R_r^-} \tau^o(R,t)$. We can identify the change in the effective tax at the threshold as

$$
\begin{aligned}
\Delta_\tau = \tau_{2019}^+ - \tau_{2019}^- - (\tau_{2018}^+ - \tau_{2018}^-) = (\kappa+d) - p(\frac{2}{3}\kappa) - (1-p)(\kappa)\\
- ((\kappa+d) - \kappa) = p\frac{1}{3}\kappa
\end{aligned}
$$

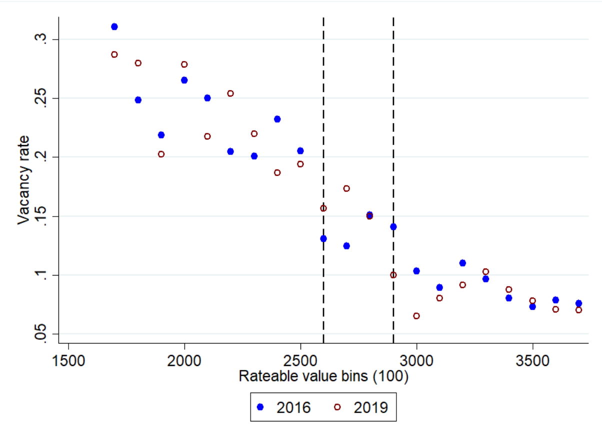
Therefore

$$
\begin{aligned}
\frac{\Delta_v}{\Delta_\tau} = \frac{v_{2019}^+ - v_{2019}^- - (v_{2018}^+ - v_{2018}^-)}{\tau_{2019}^+ - \tau_{2019}^- - (\tau_{2018}^+ - \tau_{2018}^-)} = \frac{V(\kappa R_r, R_r) - V(\frac{2}{3}\kappa R_r, R_r)}{\frac{1}{3}\kappa} &= R_r\frac{\partial v}{\partial T}|_{R=R_r}\\
&= \frac{\partial v}{\partial \tau}|_{R=R_r} \quad \text{(N.7)}
\end{aligned}
$$

This implies equation (9) as γ_6 in equation (7) implements Δ_v and η_6 in equation (8) implements Δ_τ.

C Additional empirical results

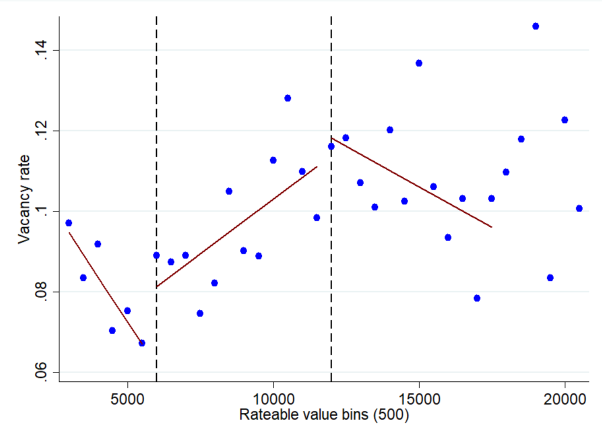
Figure N.1: Graphical evidence for empty property exemption: Comparison before (2016, threshold of £2,600) and after revaluation (2019, threshold of £2,900)



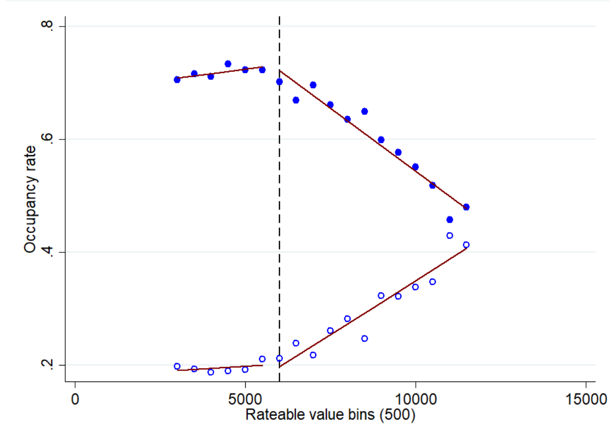
Note: The graphs plot the vacancy rate before the revaluation (2016) and after the revaluation (2019) using the same set of jurisdictions. These include Barnsley, Bedford, Bexley, Blackburn with Darwen, Darlington, Isle of Wight, Rochdale, South Tyneside, Walsall and Worcester. The dashed lines indicate the empty property exemption thresholds before and after revaluation. The McCrary test indicates no sorting at the thresholds. The point estimate (s.e.) for before the revaluation is 0.03 (0.03) and after the revaluation -0.04 (0.06).

Figure N.2: Graphical evidence for SBRR: Comparison before (kinks at £6,000 and £12,000) and after revaluation (kinks at £12,000 and £15,000)

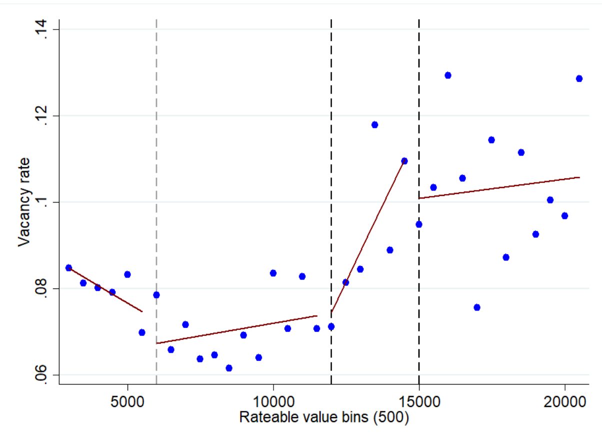
(a) Vacancy rate before revaluation, kinks at £6,000 and £12,000



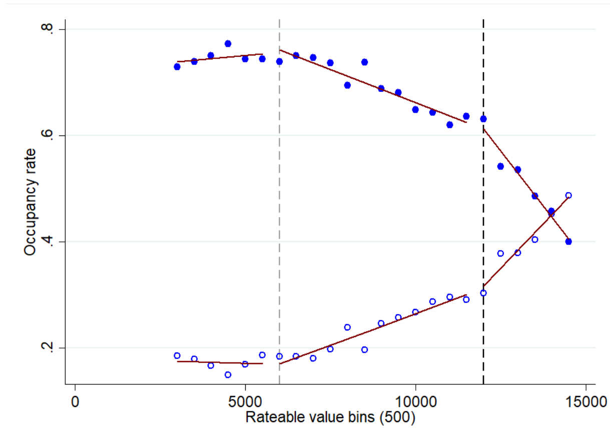
(b) Occupancy by type of business before revaluation, kinks at £12,000 and £15,000



(c) Vacancy rate after revaluation, kink at £6,000



(d) Occupancy by type of business before revaluation, kink at £12,000



Note: The graphs plot (a) the vacancy rate and (b) the occupancy rate by type of business before the revaluation (April 2017) and (c) the vacancy rate and (d) the occupancy rate by type of business after the revaluation using the same set of jurisdictions. These are Barnsley, Bedford, Bexley, Blackburn with Darwen, Darlington, Isle of Wight, Rochdale, South Tyneside, Walsall and Worcester. The dashed line indicates the rateable value thresholds for the SBRR and the solid lines represent linear fits. The McCrary test indicates no sorting at the kinks. The point estimates (s.e.) for before the revaluation are 0.02 (0.04) and 0.01 (0.06) and after the revaluation -0.01 (0.06) and 0.10 (0.09). Moreover, no change in the slope is indicated.

Table N.1: RDD results for empty property exemption, before and after the revaluation

Dep. Var.	D(Vacant)					
Properties	All					
Sample	Before revaluation			After revaluation		
Threshold	£2,600			£2,900		
Bandwidth	Optimal	500	1.75-3.75	Optimal	500	1.75-3.75
	(1)	(2)	(3)	(4)	(5)	(6)
D(RV≥2.6k)	-0.047	-0.062**	-0.074***			-0.020
	(0.031)	(0.030)	(0.022)			(0.024)
D(RV≥2.9k)			-0.025	-0.059***	-0.059***	-0.061**
			(0.031)	(0.018)	(0.018)	(0.024)
Observations	6,004	4,987	9,909	4,955	4,955	9,890

Notes: The table reports reduced form estimates for empty property exemption for before and after revaluation using the same set of jurisdictions. These include Barnsley, Bedford, Bexley, Blackburn with Darwen, Darlington, Isle of Wight, Rochdale, South Tyneside, Walsall and Worcester. The threshold for the empty property exemption before the revaluation was £2,600 and after £2,900. The dependent variable is an indicator of the property being vacant. In cols. (1) and (4) we use the optimal bandwidth, in cols. (3) and (5) a bandwidth of £500 and in cols. (3) and (6) properties with a rateable value between £1,750 and £3,750 (bandwidth of £1,000 around the average threshold of £2,750). In all specifications we allow for a linear relationship between the rateable value and the outcome variable left and right to the threshold. In all specifications, local authority fixed effects are included and the small sample is used. The optimal bandwidths are calculated following Calonico, Cattaneo and Titiunik (2014*a*). Robust standard errors are clustered at the local authority-rateable value bin and local authority-property type level and reported in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.

Table N.2: RKD results for SBRR, before and after the revaluation

	First kink			Second kink
Dep. Var.	D(Vacant)	D(Occupied by) small business	D(Occupied by) large business	D(Vacant)
	(1)	(2)	(3)	(4)
Panel A: Before the revaluation, Kinks at £6,000 and £12,000				
R * D(1Kink)	0.009**	-0.028***	0.019***	
	(0.004)	(0.003)	(0.003)	
R * D(2Kink)				-0.010
				(0.012)
Observations	12,957	12,957	12,957	4,091
Panel B: After the revaluation, Kinks at £12,000 and £15,000				
R * D(1Kink)	0.018*	-0.054***	0.036***	
	(0.009)	(0.010)	(0.006)	
R * D(2Kink)				-0.014
				(0.012)
Observations	5,485	5,485	5,485	3,250

Notes: The table reports reduced form results for the SBRR for before and after the revaluation using the same set of jurisdictions. These include Barnsley, Bedford, Bexley, Blackburn with Darwen, Darlington, Isle of Wight, Rochdale, South Tyneside, Walsall and Worcester. The dependent variable is an indicator of the property being vacant (cols. (1) and (4)), occupied by a small business (col. (2)) or occupied by a large business (col. (3)). $R * D(1kink)$ represents the change in relationship between vacancy and rateable value above the first threshold and $R * D(2kink)$ above the second threshold. All specifications use a bandwidth of £2,500. Panel A shows the results for before the revaluation and panel B for after the revaluation. All specifications include local authority fixed effects. Robust standard errors are clustered at the local authority-rateable value bin and local authority-property type level and are reported in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.