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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 and rents in the UK, using a new data-set, and exploiting exogenous variations in property tax rates from reliefs in the UK system: small business rate relief (SBRR), retail relief and empty property relief. We estimate that the retail relief reduces vacancies by 85%, and SBRR relief by up to 49%, while empty property exemption increases them by up to 89%. The effect of retail relief on clusters of urban properties (the "High St") is no different to its overall effect. SBRR increases (decreases) the likelihood that a property is occupied by a small (large) business. We also use data on asking prices for rental properties to study the effect of reliefs on rental rates. Rental rates move in the opposite direction to vacancy rates, except in the case of empty property relief. All these findings are consistent with a novel model of directed search in the commercial property market, also presented in the paper.

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

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1 Introduction

For some time, occupancy rates of retail real estate in many countries have been negatively impacted by the move to online shopping, and the Covid epidemic has exacerbated this trend, with office occupancy rates also being affected, given a probable permanent shift to working at home.[1] Indeed, the IMF has identified these changes in demand for commercial real estate as having "potentially significant implications for financial stability" due to the size of the sector and its heavy reliance on debt funding.[2] However, relatively little is known about the effectiveness of policy tools, particularly reductions in business property taxes, that might alleviate these problems.

In this paper, we study the effect of business property taxes on the utilization of business properties in the UK, using a new data-set, and the non-linearity of the tax schedule 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 relative to online ones. As a result, two important reliefs, the small business rate relief (SBRR), and retail relief, have been introduced in recent years.[3] 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. We also provide a fuller picture of the effect of business rates, by using data on asking prices for rental properties to study the effect of reliefs on rental rates. Rental rates move in the opposite direction to vacancy rates, *except* in the case of empty property relief, consistently with our theoretical model.

Specifically, defining the effective tax rate (ETR) as business tax divided by the rateable value of the property (which estimates the open market rental value in April 2015), a one percentage point reduction in the ETR due to the retail relief reduces the vacancy rate by 0.49 percentage points, which is a reduction of 5.2%. 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 85%.[4]

[1]For example, the overall retail vacancy rate in the UK has risen from 10.9% in Q1 of 2017 to 14.1% in Q1 of 2022 (https://www.localdatacompany.com/).

[2]https://www.imf.org/en/Publications/GFSR/Issues/2021/04/06/global-financial-stability-report-april-2021, accessed 5/6/22.

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

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

We further refine this analysis by using a recent data-set compiled by the UK's Office of National Statistics that officially defines a "High Street" as a group of at least 15 retail units within 150 metres of each other on the same named street in the case of high density residential, or at least 5 retail units within 150m on the same named street in case of low density residential (Office for National Statistics, 2020). In the UK context, a thriving High Street is thought to be particularly important for the quality of life of local residents (Portas (2011)). We find that a one percentage point reduction in the tax rate due to the retail relief reduces the High Street vacancy rate by 4.8%. So, retail relief, while effective overall, does not seem to have been more effective for High Street properties than others.

As for SBRR, this 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.[5] 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 0.26 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 ETR due to SBRR reduces the vacancy rate by 1.0%. So, our estimates imply that SBRR reduces the vacancy rate of properties that qualified for full relief by 49% compared with if there is no relief. Comparing these estimates with those for retail relief, we see that retail relief is clearly the most effective relief for reducing vacancies - per unit of ETR, it has approximately five times the percentage effect on vacancies as SBRR. This is perhaps not surprising, as SBRR is targeted only at a particular type of tenant, and therefore crowds out other tenants.

Finally, a third relief that we study is empty property exemption, which exempts properties from business rates if they have a rateable value of less than £2,900. The relief is at discretion of the local authority, and clearly is different to the other two, as it effectively taxes, rather than subsidises, occupation of the property. We find that one percentage point decrease in the ETR on empty properties via this relief increases the vacancy rate by 3.3%. While some countries and US states have taxes on empty *residential* property, or are thinking of introducing them[6], to our knowledge, the UK is one of the very few in (negatively) taxing vacant business properties.

One might ask at this point why vacancies matter. In the case of UK, one possible

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

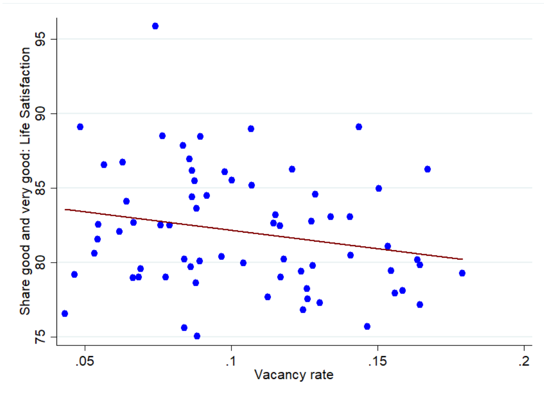
[6]See: https://www.mansionglobal.com/articles/which-u-s-cities-have-a-vacancy-tax-208020

answer is that it 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(a) below, which shows a positive relationship between vacancy rates and the unemployment rate at the local authority level. Another point is that as already mentioned, in the UK, high occupancy rates, especially of retail properties in town and city centres, are thought to have positive "quality of life" externalities for residents. Some evidence for this is reported in Figure 1(b) below, which shows a negative relationship between vacancy rates and share of local residents that reported positive life satisfaction in survey data.

Figure 1: Property vacancy rates, unemployment and life satisfaction

(a) Unemployment

(b) Life satisfaction



Notes: The graphs plot (a) the unemployment rate; (b) life satisfaction (share of respondents that answered good or very good) on the local authority level for 71 local jurisdictions (one outlier jurisdiction is excluded) in England in 2018/2019, both against the vacancy rate of commercial properties. Life satisfaction data is provided by the ONS (Measuring National Well-being: Life Satisfaction). The solid lines represent linear fits.

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.[7] Retail relief was introduced in 2019, and was clearly intended to support "bricks and mortar" retail, and particularly the High Street, in the face of the

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

rapid trend towards online shopping in the UK.[8]

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.

Related Literature. 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.[9] More recently, Enami, Reynolds and Rohlin (2018) show for 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)).

A final related paper is Segú (2020) which uses the introduction of a tax on the value of vacant residential property in selected areas of France in 1999 to identify the causal direct effect of the tax on the vacancy rate; this paper finds a 13% decrease in vacancy rates between 1997 and 2001. Our results are the first, to our knowledge, on the effect of a (negative) tax on empty business property, and we find even larger effects, with the vacancy rate decreasing by over 40% at the rateable value at which empty property relief is withdrawn.

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.[10] 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

[8]For example, the then Chancellor said in his November 2018 Budget speech: "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."(www.gov.uk/government/speeches/budget-2018-philip-hammonds-speech).

[9]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.

[10]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.

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 rents, and also the mix of businesses occupying qualifying properties, which are 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.[11]

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. 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.[12]

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 lengths of three, five, ten and

[11]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.

[12]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).

fifteen years (McCluskey et al., 2016).[13]

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.[14] 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.[15]

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

[13] 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 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.

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

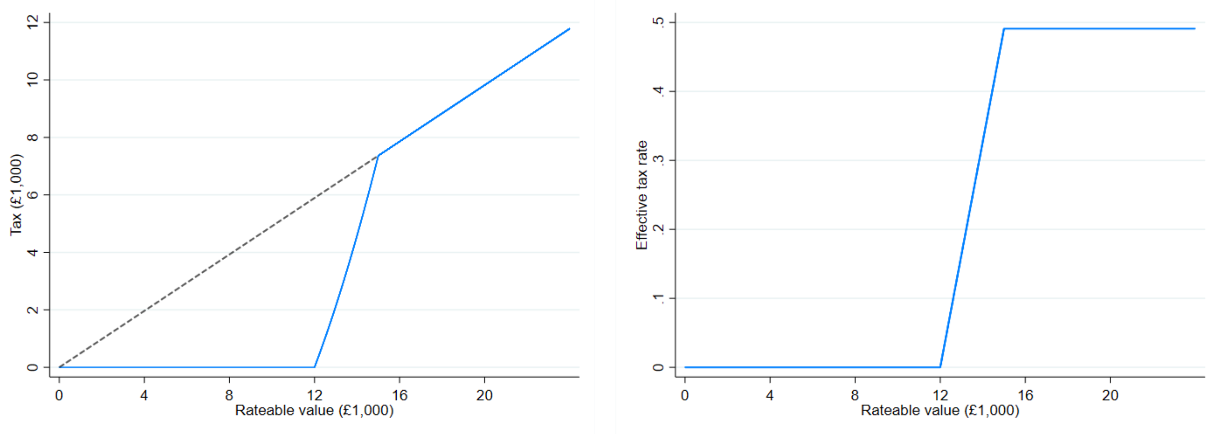
[15] There is a two year gap between the estimated rental rate and the first year it applies to the tax measure, so this rateable value was first used in 2017.

use only one property, *and* where that property has a rateable value below £15,000.[16] Specifically, for property with a rateable value below £12,000, the business rate is zero.[17] 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.[18] 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.[19] 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) ETR



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 ETR for small business. The ETR is defined as (business rate tax - SBRR)/rateable value.

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

[17]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.

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

[19]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.[20]

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 $\tilde{r}_i$ if the property is let, and will have to pay a business rate $T^u(R_i)$ if the property is vacant.

[20]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 without a property generate zero profit, and a business of type j in a type i property has net profit $\Pi(R_i) - \tilde{r}_i - T^o(R_i; j)$ where $\Pi(R_i)$ is sales minus costs other than rent or tax e.g. wages. Note that $\tilde{r}_i$ is set prior to the landlord being matched with the tenant, and it is assumed that it cannot be renegotiated ex post. Thus, $\tilde{r}_i$ 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 $\tilde{r}_i$:
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, Sorting, and Rents

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. It is convenient to state the sorting effect first, as this simplifies the statement of equilibrium vacancies and rents.

Define small (resp. large) landlords to be those with properties to be those that are below (resp. above) the threshold for SBRR. [21] 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-*

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

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. So, we can summarise:

Proposition 1. *In any equilibrium, large businesses do not apply to small properties, and small properties are only let to small businesses.*

To understand rent and 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. The expected profit to the tenant from renting a property of size R_i is $m_i(\Pi(R_i) - \tilde{r}_i - T^o(R_i))$, where m_i is the probability that the tenant manages to let this size of property if it applies, and $T^o(R_i)$ is the business rate payable by the tenant, which by the sorting result of Proposition 1, only depends in equilibrium on the rateable value of the property, not the size of the tenant.[22] 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, we then have the following result, which gives simple formulae for the equilibrium vacancy rate and rent.[23]

Proposition 2. *In any equilibrium, vacancy rates and rents are*

$$v_i = \frac{\rho R_i}{\Pi(R_i) + T^u(R_i) - T^o(R_i)}, \quad \tilde{r}_i = \Pi(R_i) - T^o(R_i) - \frac{\rho R_i}{m(v_i)} \tag{1}$$

where $m(v) = \frac{1-v}{-lnv}, \quad m'(v) > 0.$

The formula for rent follows directly from the condition that the rent on any rented property must leave the tenants indifferent between applying and not i.e. $m_i(\Pi(R_i) - \tilde{r}_i - T^o(R_i)) = \rho R_i$. The vacancy rate balances the marginal gain to the landlord from a slightly lower vacancy rate (higher occupancy rate) to the cost. It is important to note that when calculating these benefits and costs, the landlord effectively internalises the benefits and cost to the tenant as the landlord captures all the surplus through rent-setting, as already remarked. So, the "social" cost of a higher occupancy rate is simply the tenant's outside option ρR_i. The total benefit from occupancy is just $\Pi(R_i)$ plus any tax savings from letting the property rather than leaving it vacant, i.e. $T^u(R) - T^o(R)$.

[22]As small landlords only let to small businesses, if $R < 15, T^o(R) = T^o(R; s)$, and $R \geq 15$, there is no SBRR, so $T^o(R; s) = T^o(R; l) \equiv T^o(R)$.

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

Finally, it should be noted that $v_i, \tilde{r}_i$ are determined recursively, as $\tilde{r}_i$ depends on v_i via the match probability but not vice-versa. This means that; (i) the tax on a vacant property, T^u, has no direct effect on rent, but has an indirect effect via v_i; (ii) the tax on an occupied property, T^o, has both direct effect and indirect effect on rents. Moreover, the indirect effect is that an increase in the vacancy rate (intutively) increases the probability of a match for a particular tenant, which then *increases* the rent from (1). It thus offsets the negative direct effect of T^o on rent.

Note that Proposition 2 gives us a general formula that can be used to look at changes in the vacancy rate or rent at any particular threshold.[24] These observable implications are discussed in much more detail in Section 3.3. For now, it is important to note by inspection of (1) that *both* vacencies and rents "do the work" of adjusting to changes in reliefs: both $v, \tilde{r}$ will jump discontinuously when a relief changes discontinuously. Note also that formula (2) is completely general in that the tax functions $T^u(R), T^o(R)$ capture any interactions between reliefs - for example, retail relief may also apply at the SBRR thresholds.

3.3 Empirical Predictions

We will develop testable predictions from Propositions 1 and 2. First, Proposition 2 describes reduced-form relationships between the vacancy rate and rent $v, \tilde{r}$ and R. We can make various predictions about the sign of this reduced-form relationship, which can be straightforwardly tested. 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 both expressions in (1) by R and drop the landlord type subscript to get

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

Here, $r \equiv \tilde{r}/R$ is rent per unit of rateable value, $\pi(R) \equiv \Pi(R)/R$ is the profit per unit of rateable value, and $\tau^u(R) = \frac{T^u}{R}, \tau^o(R) = \frac{T^o}{R}$ are the *ETRs* paid by the tenant of any unoccupied or occupied property. In full, $\tau^o(R) = \tau^o(R; s)$ if both the property and tenant are small, and $\tau^o(R)$ does not depend on tenant type otherwise. We will make the usual assumption in the RDD literature that for fixed ETRs, τ, v, r are continuous in R; from (2), this amounts to assuming that $\pi(R)$ is continuous.

Predictions for reduced form effects of reliefs on v, r. From inspection of (2), it is clear that discontinuities ("jumps") in the tax functions as R increases due to withdrawal

[24]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.

of empty property and retail relief will induce discontinuities in $v(R), r(R)$. Similarly, changes in the slope of the tax function as R increses due to withdrawal of SBRR will induce changes in the slopes of $v(R), r(R)$ with respect to R. These changes are all testable, and so our main empirical predictions, given in Table 1 below, are about the signs of these changes.

Some intuition for these results is as follows. First, consider the retail relief threshold R_r. It is intuitive that at this threshold, there is an upward jump in τ^o of $\frac{\kappa}{3}$ as retail relief is fully withdrawn at this threshold and there are no other reliefs at that threshold. Consequently, from (2), there will be an upward jump in the vacancy rate at this threshold. The effect on rent is a little more complex. First, holding m constant, rent falls by the full amount of the increase in τ^o. But, there is an offsetting feedback effect of withdrawal of relief on m; as τ^o rises, so does v, and as a result m rises because when the property vacancy rate is higher, a business is more likely to be matched with a property. From (2), this causes r to rise. However, as shown in Appendix B.3, the direct effect dominates, so rent is predicted to jump downward.

Table 1: Summary of Empirical Predictions

	Jump at threshold value of R	
	v	r
Empty property relief	-	-
Retail relief	+	-
	Change in slope at threshold value of R	
	v	r
SBRR, lower threshold	+	-
SBRR, upper threshold	-	+

Notes: For retail and empty property reliefs, the table shows the sign of the discontinuity in $v(R), r(R)$ at threshold values of R as R increases. For SBRR, the table shows the sign of the discontinuity in $v'(R), r'(R)$ at threshold values of R as R increases. These signs are established in Appendix B.3.

Now consider the empty property relief threshold R_e. Here, there is an upward jump in $\tau^u(R)$ as the empty property relief is fully withdrawn at this threshold. Consequently, from (2) there will be an downward jump in the vacancy rate at this threshold. The effect on rent is now entirely indirect through the effect of v on m; as described in the previous paragraph, m will fall, leading to a downward jump in rent.

The results on the slope discontinuities at SBRR thresholds are 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. To explain the rent results, note that the change in the slope of the value of relief has a direct effect on how the net profit of the tenant changes as R increases; specifically, the rate of change of net profit decreases at the first threshold, and increases at the second. From (1), this maps directly into the same effects on the change in rent with respect to R. Again, there is an indirect effect via a change in m, but again, this can be shown to be dominated by the direct effect.

Causal Effects of Reliefs. We are also interested in the causal relationship between a change in the ETR τ and v, r, both of which depend on R. 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 ETR as the relief is withdrawn to give a *marginal effect* $\frac{dv}{d\tau}$. The same calculations can be done to obtain $\frac{dr}{d\tau}$, which gives us a measure of the pass-through of taxes to rents.

Table 1 above indicates that for retail relief and SBRR, the marginal effects on vacancies both will be positive.[25] In fact, the theory can be developed further to show the following.[26] Assume that $\pi(R)$ is constant at π; then

$$\frac{dv}{d\tau}|_{R_r} \Big/ \frac{dv}{d\tau}|_{\underline{R}_s} = \frac{(\pi+\kappa)^2}{\pi(\pi+\kappa/3)} > 1 \tag{3}$$

On the left-hand side, we have the ratio of the marginal effect at the retail relief threshold to the marginal effect at the (lower) SBRR threshold. This says that the "bang for the buck" of retail relief in reducing vacancies is greater than for SBRR. This is a testable prediction. The intuition is simply that while retail relief applies to all tenants, SBRR is targeted only at small tenants, and therefore crowds out large tenants.

Sorting. Proposition 1 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,

[25] Of course, empty property relief is different in that it *subsidises* vacancies, so that $\frac{dv}{d\tau}$ will be negative.
[26] This result is available on request from the authors.

the rate of change of occupancy with respect to R should *increase* for large businesses, and *decrease* for small businesses.[27]

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, vacancies and rents 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 or rents with the following equation (for vacancies it is a linear probability model (LPM)):

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

where y_{it} is the outcome of interest. The first outcome is an indicator v_{it} for the property i being vacant in time t, and the second is r_{it}, the rent for property i listed in time t divided by rateable value, as in the theory.[28] 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 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 discussed 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 ETR 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

[27] 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.

[28] We use rent to rateable value ratio as outcome as informed by the theory and empirical prediction in section 3.1 and 3.3. We present the results using level and log of rents in the appendix. All the results are qualitatively and quantitatively similar.

level.[29] 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 ETR paid at an empty property i in time t.

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

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

Since the standard errors for equation (4) and (5) are not directly applicable to $\frac{\partial y}{\partial \tau}$, 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 both a 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.

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

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

where the outcome y_{it} is as in equation (4), 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.[30]

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

[30] With vacancy as outcome, $Post_t$ is an indicator for time on or after the second quarter of 2019, as the retail relief start to apply from April 2019. For rents, our data are property listings on the online property letting platform, Rightmove (see Section 5 for more description). As listings are posted ahead of the time the rental starts (usually about 3 months), $Post_t$ is an indicator for listings posted on and after Jan 2019, as the retail relief was announced on Nov 2018 and would start to apply when the rental for these listings starts.

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

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

where τ_{it} is the observed ETR 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 and the first stage effect on ETR respectively on v, r . We can then calculate the casual effect of the tax on vacancies or rent by taking the ratio of the estimated γ_6 and η_6, as in (6) above for empty property relief.

To increase the efficiency of our estimates, we also estimate in addition specifications for the reduced form equation for vacancies, and the first stage for ETR, that control for local-authority fixed effects (for retail relief, we control for local-authority $\times$ 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

$$E[o^s_{it}|R] = \alpha_0 + \alpha_1(R_i - \underline{R}_s) + \alpha_2(R_i - \underline{R}_s) \times \underline{D}_i \quad (9)$$

$$E[o^l_{it}|R] = \beta_0 + \beta_1(R_i - \underline{R}_s) + \beta_2(R_i - \underline{R}_s) \times \underline{D}_i \quad (10)$$

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 (9)-(10) 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 effect of the SBRR on vacancies and rent, 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

$$E[y_{it}|R] = \gamma_0 + \gamma_1(R_i - \underline{R}_s) + \gamma_2(R_i - \underline{R}_s) \times D_i \tag{11}$$

$$E[y_{it}|R] = \delta_0 + \delta_1(R_i - \bar{R}_s) + \delta_2(R_i - \bar{R}_s) \times D_i \tag{12}$$

where y_{it} is defined above, $R_i - \underline{R}_s, R_i - \bar{R}_s$ 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 (11)-(12) 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, r 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, vacancies and rents. 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 ETR at the two thresholds:

$$E(\tau_{s,it}|R) = \eta_0 + \eta_1(R_i - \underline{R}_s) + \eta_2(R_i - \underline{R}_s) \times D_i \tag{13}$$

$$E(\tau_{it}|R) = \phi_0 + \phi_1(R_i - \bar{R}_s) + \phi_2(R_i - \bar{R}_s) \times D_i \tag{14}$$

where $\tau_{s,it}$ is the observed ETR for property i paid by a small business, where τ_{it} is the observed ETR 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

$$\frac{\partial o^s}{\partial \tau_s} = \frac{\alpha_2}{\eta_2}, \qquad \frac{\partial o^l}{\partial \tau_s} = \frac{\beta_2}{\eta_2} \tag{15}$$

Similarly, the causal effect of tax τ_s on v, r can be calculated at the £12K and £15K thresholds respectively as:

$$\frac{\partial y}{\partial \tau_s}|_{\underline{R}_s} = \frac{\gamma_2}{\eta_2}, \qquad \frac{\partial y}{\partial \tau_s}|_{\bar{R}_s} = \frac{\delta_2}{\phi_2/\omega}, \qquad y = v, r \tag{16}$$

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.[31] Therefore, for calculation of the causal effect from equation (16), we divide ϕ_2 by the share of small businesses among occupiers at the upper kink (ω). We compute the bootstrapped standard errors for these causal estimates.

5 Data

5.1 Business Rates and Vacancies

Publicly available data on business rates at property level is not available at a national level, but is provided some by local authorities in England. We obtained and harmonized the administrative data from 72 local authorities to create a new data-set. These authorities account for 29% of the population (in 2011), 27% of the total number of non-domestic (i.e., commercial) properties and 28% of the floor space of non-domestic properties in England. We plot the area covered in England in Figure C1.

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.[32] Our baseline sample includes the last available quarter for a jurisdiction, which is in most cases the second or third quarter for 2019.[33] It contains 470,870 unique commercial properties.

The key variables in our data are the rateable value of each property and its occupation status. An unoccupied property 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 63 of the jurisdictions included in the sample, we also observe the relief(s) received (in particular the small business rate relief received); and for 38 of the jurisdictions, 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 sample that also contains the final tax charge (i.e. net of any relief and exemption business may receive) as "small" sample - it constitute 52% of the large sample. Table 2 presents summary statistics for

[31] 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 $\frac{d\tau}{dR}_{R\downarrow\bar{R}_s} = \omega\frac{d\tau_s}{dR}_{R\downarrow\bar{R}_s}$.

[32] The data for a particular jurisdiction and quarter is included in our data set if it includes information on (almost) all properties in the jurisdiction and the type of properties. Some jurisdictions do not publish complete business rate data, in that case they are not included in our sample. For a small number of jurisdictions, one of the key variables in our data set are not directly observed but inferred. For more information see Online Appendix N.5.

[33] We exclude from our sample properties that are unlikely to be standalone business (e.g. advertising space, ATMs and telecommunication stations) and public properties (e.g. police station, waste treatment plants or community centres).

both samples (col. 1 and 2). 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 (11.2% compared to 10.1%).

We describe the sub-samples we use to analyze the effect of each of the reliefs on vacancy in the following.

Empty property relief: We use properties with a rateable value around the empty property exemption threshold, with a rateable value between £1,900 and £3,900. We focus on the small sample that includes exact tax charge information to measure precisely how the empty exemption was implemented (the empty property relief is a discretionary relief).

Small business rate relief: The sample includes properties with a rateable value around the two kinks for the small business rate relief (£12,000 and £15,000), 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, there should be no regional heterogeneity in its implementation - information on the implementation of SBRR available from the small sample would apply to the large sample. In both the large and the small sample, we include in the final sub-sample only jurisdictions that provide information on whether occupiers receive the small business rate relief.[34]

Retail relief: The sample for retail relief includes retail and hospitality properties with a rateable value around £51,000, from £41,000-£61,000.[35] Since the empirical approach relies on variation over time, we use data for the second (or third) quarter in 2018 and 2019. Our final sub-sample includes for each jurisdiction one quarter before and one quarter after the introduction of the retail relief.[36]

We report descriptive statistics for each sub-sample in Table 2 col. (3)-(6). 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 suggests 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, retail and hospitality properties and less offices in the SBRR sample compared to the empty exemption

[34]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.

[35]We exclude properties that are not eligible for the retail relief, theses are banks and betting shops, (sport) clubs, camping sites and self-catering accommodation.

[36]If both, second and third, quarter of 2019 are available, we use the second quarter as the retail relief was introduced at the end of the first quarter in 2019 - unless only the third quarter has the tax charge information or this would mean comparing different quarters. Results are similar when using the third quarter, if more than one quarter is observed.

sample.[37]

Table 2: Descriptive statistics - Vacancy sample

	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	470,870	245,852	38,467	7,529	4,042	82,968	41,547
# of counties	72	38	38	35	15	63	31
# of counties in London	11	7	7	3	2	9	5
# of county-quarter	72	38	38	70	30	63	31
Average rateable value	31,057	32,146	2,926	50,029	50,085	12,560	12,547
Median rateable value	8,000	8,000	2,900	49,500	49.627	12,000	12,000
Mean vacancy	0.112	0.101	0.131	0.076	0.073	0.082	0.074
Share of properties							
Office	0.20	0.18	0.22	0	0	0.16	0.15
Shop/Hospitality	0.42	0.43	0.43	1	1	0.46	0.45
Warehouse/Factory	0.21	0.21	0.17	0	0	0.23	0.22

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 ETR.

5.2 Rent

We use data on all commercial property rental listings on the property letting platform, Rightmove, in 2018 and 2019. For each property rental listing, the data includes address, property type, asking prices and listing date. There are 105,337 (unique) rental listings covering the whole of England.[38] We match the listing data to the business rate data (described in section 5.1) using the address and information on property type. Among the jurisdictions that the business rates data cover, we are able to match 38% of the

[37]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.

[38]We exclude from our sample mixed-use properties and properties with unspecified usage. The data covers approximately 27% of the total number of commercial properties available to rent: at a given point of time there are around 30,000 property listings in the Rightmove data (2018-2019). As there are about 2 million commercial properties in the UK (see Table N.16), 55% of them are owned by investors (British Property Federation, 2017) and therefore could potentially be available to let, an average vacancy rate of 10% (see Table 2) suggest that the total number of commercial properties available to rent would be approximately 110,000.

property listings in the Rightmove data, limited by that for some listings the address is not detailed enough to allow for uniquely identifying a property.[39] Our sample has 11,030 commercial property rental listings with both asking rent and rateable value of the property. Since the rateable value is the annual tax base, the rent refers to the yearly rent.

We construct sub-samples for the empty exemption, the retail relief, and the SBRR, using the same ranges of rateable value as that for the vacancy analysis. For the empty exemption and SBRR sub-samples, we include listings observed in all quarters during 2018-2019.[40] For the retail relief sub-sample, we include listings in all quarters except the fourth quarter of 2018, as there could be partial effect from the announcement of the retail relief on November 2018, given that rental prices could be forward looking. In addition and as for the vacancy retail relief sub-sample, the retail relief rent sub-sample includes only properties in jurisdictions for which we observe at least one property with a rateable value between £41,000 and £61,000 before and one after the introduction of the retail relief.

We provide the descriptive statistics for the full rent sample, and the three sub-samples in Online Appendix Table N.18. The rent sub-samples for the empty reliefs, retail reliefs and SBRR are very similar to the respective vacancy sub-sample. The average (median) rent to rateable value is in all sample above 1 and in the full sample is 1.33 (1.28).[41]

6 Empirical results

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 ETR for empty properties, the average vacancy rate, and rent to rateable value ratio by rateable value from £1,900 to £3,900.

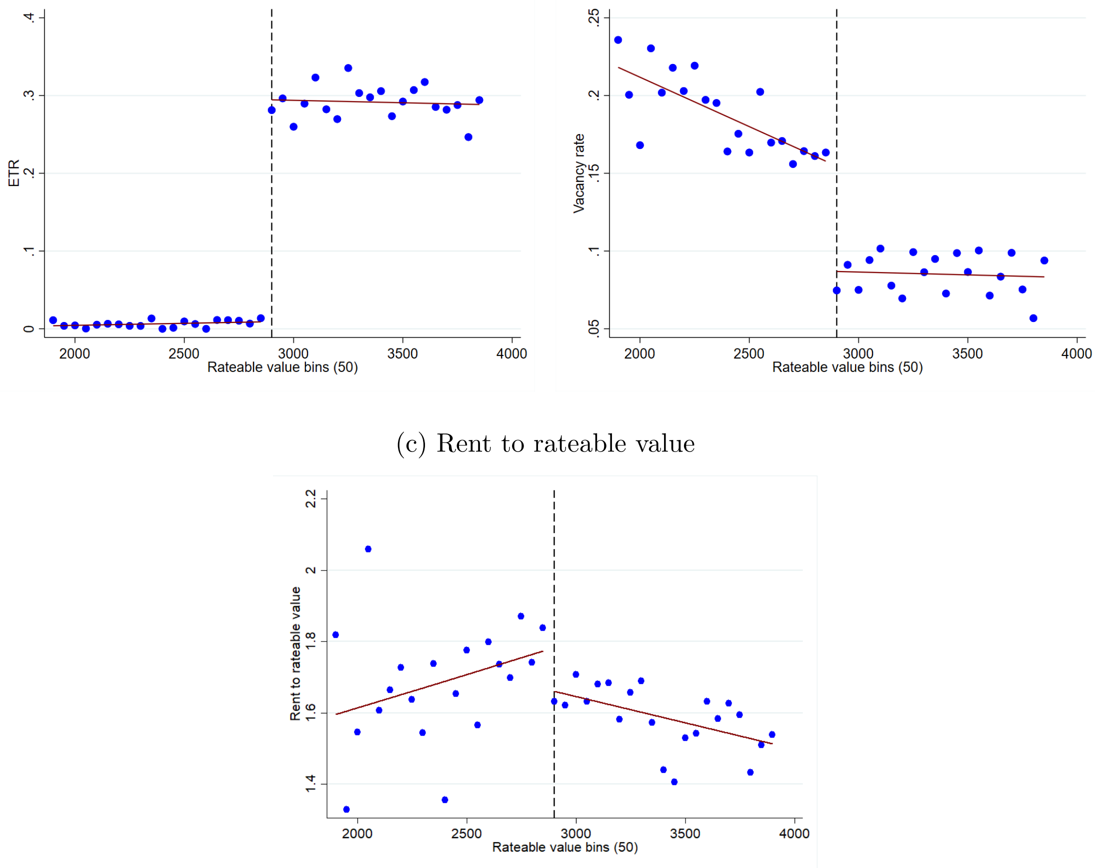
The average ETR for empty properties is close to zero and almost constant with rateable value from £1,900 to £2,900, jumps up substantially at the threshold, and stays constant from £2,900 to £3,900. This is clearly consistent with the description of this

[39] We describe in Online Appendix N.5.2 the details of the matching.

[40] Since Rightmove covers all jurisdictions in England, this should have little impact on the comparability of vacancy and rent results, except for the empty exemption since this exemption is a discretionary relief. As we will show, all jurisdictions included in the vacancy empty exemption sample offer this relief. Thus, our incidence estimate for the empty exemption is a lower bound.

[41] The number of counties is slightly larger in the full rent sample compared to the vacancy sample, as in some jurisdictions vacancy information was not available in the business rates data. The fraction of London counties is very similar (around 15%), and the average rateble value is comparable. The rent sample contains more offices and retail properties. Full descriptive statistics are reported in the Online Appendix N.5.

Figure 3: Graphical evidence for empty property exemption



(a) ETR for empty properties

(b) Vacancy rate

(c) Rent to rateable value

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

relief in Section 2.2. Looking now at panels (b) and (c), we see that the vacancy rate drops sharply at the threshold, as does the rent to rateable value ratio, although the jump in the latter is less pronounced. Both of these jumps are consistent with the model predictions in Table 1.

To confirm there is no other tax change at the threshold, we plot the ETR for occupied properties by rateable value in Figure N.1 in the Online Appendix. Moreover, the number of observations in both the vacancy and the rent sample is smooth around the threshold.[42]

The results of estimating equations (4) and (5) are shown in Table 3. Columns (1)-(2) show the estimate of β_3 in equation (5) where the average ETR of empty properties is the dependent variable. Columns (3)-(6) show the reduced form results, i.e. the estimates

[42]This is also supported by the McCrary test using a bandwidth of £100 and a rateable value range from £500 to £10,000: Vacancy sample point estimate (s.e) is -0.02 (0.02) and rent sample point estimate is -0.16 (0.15).

of α_3 in equation (4) using the vacancy rate (cols. (3)-(4)) and rent to rateable value ratio (cols. (5)-(6)) as the outcome. In columns (1), (3), and (5) we use the optimal bandwidth and in columns (2), (4), and (6) a bandwidth of £250.[43] 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 ETR increases by around 27 percentage points (cols. (1)-(2)), and the average vacancy rate decreases by 6 to 7 percentage points (cols. (3)-(4)) at the threshold.[44] The rent to rateable value ratio decreases at the threshold by 12.2 to 18.5 percentage points, depending on the bandwidth used (cols. (5)-(6)). While the drop is in line with the graphical evidence, the point estimates are less precisely estimated due to the smaller sample size for rent.

The final step in our analysis is to obtain the causal effect of empty property relief on vacancies and rent, (the marginal effect of the change in the ETR on the vacancy), using (6). This is just the ratio of the two estimates of α_3, β_3. For vacancies, this ratio is -0.27, based on the estimates shown in columns (2) and (4). This means that a one percentage point decrease in the ETR via empty property relief increases the vacancy rate by around 0.27 percentage points. Note that empty property relief is qualitatively different from the other reliefs because it incentivizes landlords to leave the property vacant, implying a negative sign.[45] For the rent to rateable value ratio, from the estimates in column (2) and (6), marginal effect of the ETR is -0.46. So, our estimate suggests that a £1 increase the empty relief raises the average rent by 46p. So, our analysis shows that an unintended consequence of empty property relief is that the landlord benefits from it, even if they let the property.

Sensitivity and heterogeneity analysis: We report robustness checks for the vacancy, rent to rateable value ratio and ETR results where we employ a local polynomial regression in higher order, and also that uses alternative kernels, i.e. weighting observations differently. The results are very similar to our baseline estimates (see Table N.1 in the Online Appendix). We also assess whether similar results emerge when using rent or ln rent as a dependent variable (see Table N.2), which is the case. In addition, as robustness checks for vacancy and ETR result, we exclude jurisdictions for which one of

[43] The specification for estimates presented in Table 3 allows for a different linear relationship between rateable value and the outcome variable left and right to the threshold.

[44] 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 their vacant period. Therefore the change in ETR 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.

[45] Bootstrapping standard errors for the ratio gives a standard error of 0.06 (p-value: 0.00).

Table 3: RDD results for empty property exemption

Dep. Var.	ETR		D(Vacant)		Rent/RV	
Properties	Empty		All		All	
Bandwidth	Opt.	250	Opt.	250	Opt.	1,000
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Without local authority fixed effects						
D(RV≥2.9k)	0.280***	0.267***	-0.078***	-0.081***	-0.105*	-0.120**
	(0.019)	(0.032)	(0.012)	(0.019)	(0.054)	(0.058)
Observations	4,293	1,221	20,331	10,274	505	812
Panel B: With local authority fixed effects						
D(RV≥2.9k)	0.267***	0.268***	-0.063***	-0.072***	-0.185**	-0.122*
	(0.026)	(0.029)	(0.012)	(0.016)	(0.083)	(0.067)
Observations	4,542	1,221	14,059	10,274	448	812

Notes: The table reports reduced form estimates for empty property exemption in equation (5) (cols. (1) and (2)) and (4) (cols. (3) to (6)). The dependent variable is the ETR of empty properties (cols. (1) and (2)), an indicator of the property being vacant (cols. (3) and (4))), or the rent to rateable value (cols. (5) and (6)). In cols. (1), (3) and (5) we use the optimal bandwidth and in cols. (2) and (4) a fixed bandwidth of £250 and in col. (6) of £1,000. In all columns we allow for a linear relationship between the rateable value and the outcome variable left and right to the threshold. In Panel A the cols. (1) to (4) are without additional controls and in col. (5) and (6) only with quarter-year and property type fixed effects. In panel B the specifications include in addition local authority fixed effects. In cols. (1) to (4) we use the small vacancy sample and in col. (5) and (6) the rent sample. The optimal bandwidth is estimated following Calonico, Cattaneo and Titiunik (2014*a*). Robust standard errors are clustered at the local authority-rateable value bin (cols. (1) to (4)) or rateable value bin (col. (5) and (6)) and local authority-property type level and are reported in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

the variables (e.g., the vacancy or the tax rate) is not directly observed (see Table N.3). The results are unchanged. To further confirm that the observed vacancy effect at the threshold is due to the empty property exemption, we examine whether similar findings emerge before the revaluation in 2017 when a lower threshold of £2,600 was applied. We find very similar effects for the period before the revaluation for our baseline vacancy results (see Online Appendix N.4 for results and discussion).

Lastly, we assess whether the vacancy effect is different for retail/hospitality properties or properties in- and outside of London (see Table N.4 in the Online Appendix).[46] There is no effect heterogeneity with respect to in- or outside of London, but the effect is suggested to be less strong for retail properties.

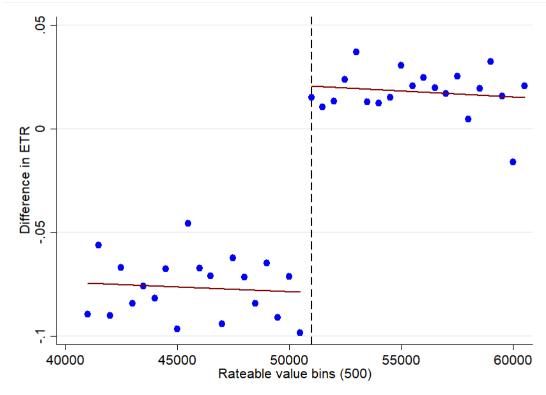
[46] Given the smaller sample size for rent, we are not able to estimate any heterogeneous effect on rents by region or property type, similarly in Section 6.2 and 6.4.

6.2 Retail Relief

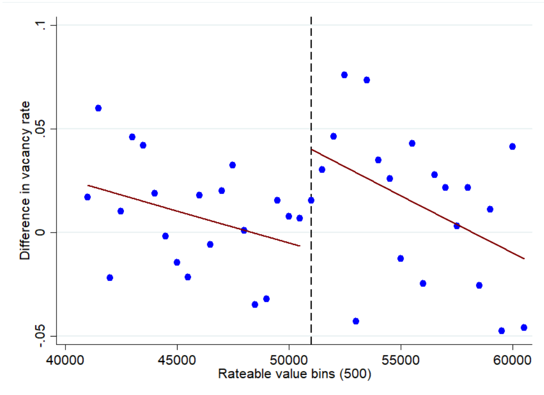
We turn to the results for the impact of the retail relief on the vacancy rate of properties and rents. As explained in section 4.1, we use a difference-in-discontinuity approach to estimate the causal effect of the tax relief for retail properties. As for the empty property exemption, we start with 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 the vacancy rate, rent (divided by rateable value), and ETR between 2018 and 2019.

Figure 4: Graphical evidence for retail relief

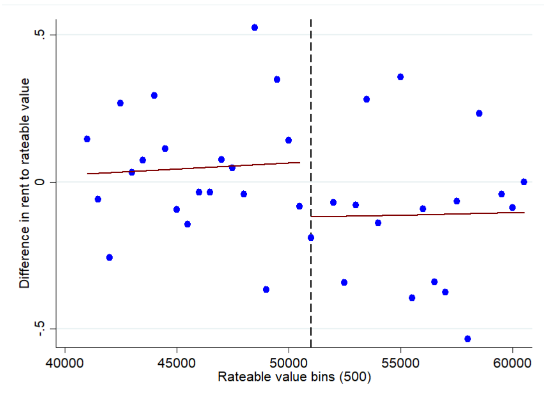
(a) Difference in ETR for occupied properties



(b) Difference in vacancy rate



(c) Difference in rent to rateable value



Notes: The graphs plot (a) the difference in the average ETR for occupied properties between 2019 and 2018, (b) the difference in the average vacancy rate between 2019 and 2018 and (c) the difference in the average rent to rateable value 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 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 5 percentage points, and decreases thereafter again. The rent to rateable value ratio is constant up to £51,000 and decreased on the right of the threshold.

The number of observations in both samples are smooth around the threshold both before and after the introduction of the retail relief (see Figure N.2 in the Online Appendix). This is also indicated by the results of the McCrary test.[47]

Table 4: Difference-in-discontinuity results for retail relief

Dep. Var.	ETR		D(Vacant)			Rent/RV	
Sample	Small		Large		Small		
Properties	Occupied		All			All	
Bandwidth	Optimal	10,000	Optimal	10,000	10,000	10,000	20,000
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Without local authority fixed effects							
D(R≥51k)*Post	0.102***	0.099***	0.037*	0.046**	0.046**	-0.091	-0.115**
	(0.011)	(0.010)	(0.023)	(0.019)	(0.023)	(0.071)	(0.050)
Observations	3,404	3,746	5,393	7,529	4,042	247	462
Panel B: With local authority fixed effects							
D(R≥51k)*Post	0.099***	0.099***	0.038*	0.048**	0.049**	-0.094	-0.150***
	(0.009)	(0.008)	(0.022)	(0.019)	(0.022)	(0.084)	(0.047)
Observations	3,180	3,746	5,286	7,529	4,042	247	462

Notes: The table reports reduced form estimates for the retail relief in equation (8) (cols. (1) and (2)) and (7) (cols. (3) to (7)). The dependent variable is the ETR of occupied properties (cols. (1) and (2)), an indicator for property is vacant (cols. (3) to (5)) or the rent to rateable value ratio (cols. (6) and (7)). In cols. (1) and (3) we use the optimal bandwidth, which is the average of the optimal bandwidth for 2018 and 2019. In col. (2), (4), (5) and (6) we use a fixed bandwidth of £10,000 and in col. (7) of £20,000. Cols. (1), (2) and (5) use the small vacancy sample, cols. (3) and (4) the large vacancy sample, and cols. (6) and (7) the rent sample. In Panel A the specification in cols. (1) to (5) is without additional controls, and in col. (6) and (7) only with quarter-year fixed effects; in panel B the specifications in cols. (1) to (5) include local authority × quarter-year fixed effects and in cols. (6) and (7) quarter-year and local authority 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 (cols. (1) to (5)) or local authority and rateable value bin level (cols. (6) and (7)) and are reported in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table 4 reports the estimates for the effect of retail relief using the difference-in-discontinuity approach. Columns (1)-(2) 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

[47]The McCrary test results (Point estimate (s.e.)) using a bandwidth of £500 and a rateable value range from £16,000 to £86,000 are: Large vacancy sample for 2018 -0.07 (0.08) and for 2019 -0.07 (0.08), small vacancy sample for 2018 -0.03 (0.12) and for 2019 0.00 (0.11) and for the rent sample for 2018 -0.47 (0.37) and for 2019 -0.39 (0.35).

relative increase in the tax rate by 10 percentage points. Columns (3) to (7) report the estimate of γ_6 in reduced form equation (7) for vacancy and rent to rateable value ratio. Panel A and B report the estimates for specification without controls and that controlling for local authority $\times$ quarter-year fixed effects respectively. The estimates in both panels are highly similar and thus we focus on the following estimates in panel B. Columns (3)-(5) present the results for vacancy rate. Column (3) 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 the threshold by 3.8 percentage points. Column (4) uses a fixed bandwidth of £10,000 and estimates a relative increase in the vacancy rate of 4.8 percentage points. When using the small sample, the estimate for γ_6 is 4.9 percentage points (col. (5)). Columns (6)-(7) present the results for the rent to rateable value ratio. It suggests that the retail relief reduces the rent to rateable value ratio by -0.094 to -0.150, with imprecise estimates due to the smaller sample size with the listing data.

The final step in our analysis is to obtain the causal effect of retail relief on vacancies and rents, which is in each case just the ratio of the two estimates of γ_6, η_6. For vacancies, this ratio is 0.49 based on the estimates using the small sample with fixed bandwidth £10,000 i.e. cols. (2) and (5).[48] This means that a one percentage point decrease in the ETR via retail relief decreases the vacancy rate by around 0.49 percentage points. Similarly, for the rent to rateble value ratio ($\frac{\partial r}{\partial \tau}$), it is -0.95. It suggests that a £1 retail relief for retail properties increases the rent for newly listed properties by £0.95, indicating that most of the relief is passed to the landlord.

Sensitivity Analysis: We report robustness checks for vacancy and ETR where we employ a local polynomial regression in higher order and also use an alternative kernel. The results are reported in Table N.5 (and illustrated in Figure N.3) in the Online Appendix. The difference in the estimates for 2018 and 2019 are very similar to the estimates in Table 4 but less precisely estimated. In Table N.6 we present robustness checks varying the bandwidth and using a quadratic regression for the rent regressions. In addition, we use rent and ln rent as dependent variables (see Table N.7). Lastly, we re-run our baseline specification excluding jurisdictions for which a particular variable (e.g., the vacancy or the tax rate) is not directly observed (see Table N.8). Overall, the results are very similar to our baseline estimates.

6.3 Retail Relief and the High St

In this section, we focus on the effect of retail relief on High Street vacancy. This question is of particular policy relevance for the UK, because of the perceived social benefits of

[48] The bootstrapped standard error is 0.24 (p-value of 0.04).

having a thriving High St in UK cities and towns. To do this, we exploit recent work by ONS and Ordnance Survey that aims to locate the "High Streets" in the UK. Informally, "High Street" typically refers to a cluster of retail properties, but until now, there has been no official definition on what constitutes a High Street. However, ONS and Ordnance Survey have recently proposed some official definitions of the High Street using their mapping of retail clusters in UK.

They define a high street as a group of at least 15 retail units within 150 metres of each other on the same named street in the case of high density residential or at least 5 retail units within 150m on the same named street in the case of low density residential (Office for National Statistics, 2020). We use this data and the postcode information in our property level data set to form a sub-sample of High Street properties using this definition. We also check the robustness of the results with our own definition of the High St, which includes retail properties in all postcodes with more than the median number of such properties.

Table 5 shows our estimates of the effect of retail relief on the occupancy of High St (cols. (1) and (2)) and non-High St (cols. (3) and (4)) properties. Columns (1) and (3) present the results using the ONS's preferred definition of the High Street. In columns (2) and (4) we use our definition of properties in postcodes that have above the median number of retail units.

Overall, there is little evidence that the semi-elasticity of vacancies with respect to retail relief is larger for High St properties compared to non High St properties, whether we use the official definition or our definition. In particular, the point estimates for the vacancy rate are somewhat higher for the High St properties using the official definition, but so is the vacancy rate and the change in tax, so overall, there is very little difference in the semi-elasticity of vacancies with respect to the relief.[49]

6.4 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 businesses 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 businesses by rateable value from £6,000 to £21,000 (with bin width of £250). The ETR faced by small businesses is zero with rateable value 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

[49]The semi-elasticity for High St properties based on the official definition is 4.8 (=(0.059/(0.114*0.109)) and for non High St properties 5.2 (=0.040/(0.084*0.091)).

Table 5: Difference-in-discontinuity results for retail relief: High Street properties

High Street Def.	1	2	1	2
	High St		Non-High St	
	(1)	(2)	(3)	(4)
Panel A: Vacancy rate				
D(R≥51k)*Post	0.059**	0.048**	0.040	0.044
	(0.023)	(0.023)	(0.032)	(0.034)
Observations	4,804	5,298	2,501	2,007
Panel B: ETR occupied properties				
D(R≥51k)*Post	0.114***	0.102***	0.084***	0.107***
	(0.009)	(0.010)	(0.013)	(0.014)
Observations	2,351	2,536	1,190	1,005

Notes: The table reports reduced form estimates for the retail relief in equation (7). Cols. (1) and (3) use the official high street definition, cols. (2) and (4) uses our definition. The official High street definition is at least 15 retail units within 150m on the same named street in the case of high density residential or at least 5 retail units within 150m on the same named street in case of low density residential. Our High street definition is postcodes with more than the median number of retail units (8). All specifications use a fixed bandwidth of £10,000 and include local authority × quarter-year fixed effects. Cols. (1) and (2) use the large sample, all other columns the small sample. The sample differs from the baseline estimation sample as no postcode information is available for properties one jurisdiction (Kingston upon Hull). Panel A shows the reduced form results using the vacancy rate as dependent variables and panel B the first stage result using the effective average tax rate of non-empty properties as dependent variable. The McCrary test suggest for all subsamples a smooth distribution around the threshold. 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.

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

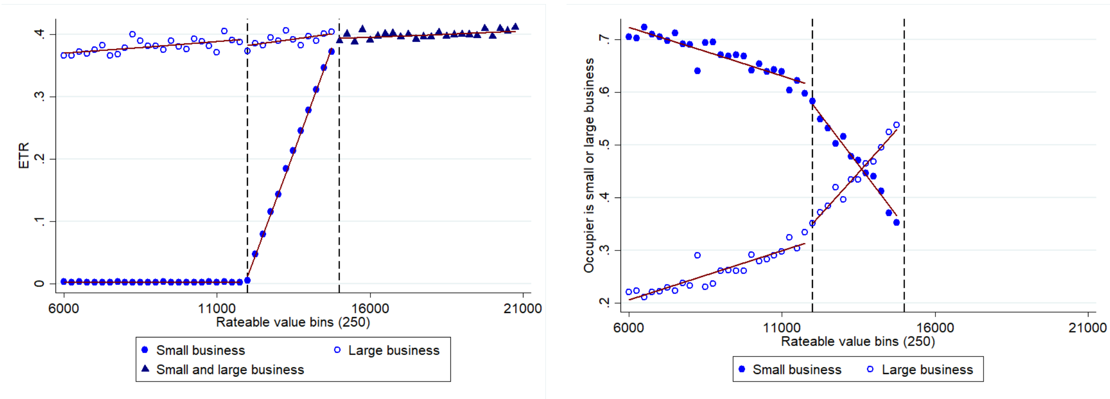
The almost flat ETR schedule faced by large businesses in Figure 5 (a) suggests no other confounding policy changes at rateable value of £12,000-15,000. Further, Figure N.4 shows that the density distribution for rateable value from £6,000 to £21,000 is in both samples smooth around the two thresholds and that there is no change in the slope of the density.[50]

Figure 5 (b) plots the share of properties occupied by small business (o_s) and by

[50]The results of the McCrary tests (point estimate (s.e.) using a bandwidth of £250 and a rateable value range from £3,000 to £21,00 are in line with the graphical observations : Large vacancy sample first kink -0.01 (0.02) and second kink: 0.03 (0.03)), small vacancy sample first kink -0.04 (0.03) and second kink: 0.05 (0.04)), rent sample first kink -0.10 (0.09) and second kink 0.13 (0.10)). The estimates for a discontinuous change in the slope of the density distribution at the thresholds using a bandwidth of £2,000 and the number of observations are: Large vacancy sample first kink -107 (97) and second kink 107 (82), small vacancy sample first kink -61 (66) and second kink 57 (50), rent sample first kink -6 (11) and second kink -8 (10).

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

(a) ETR for occupied properties (b) Occupancy by type of business



Notes: The graphs plot (a) the ETR 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.

large business (o_l) by rateable value bins, 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 suggests when SBRR phases out, properties have less chance of being occupied by small businesses. Occupancy by large businesses increases with rateable value on the left of the £12,000 threshold and increases at a faster rate on the right of the £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.

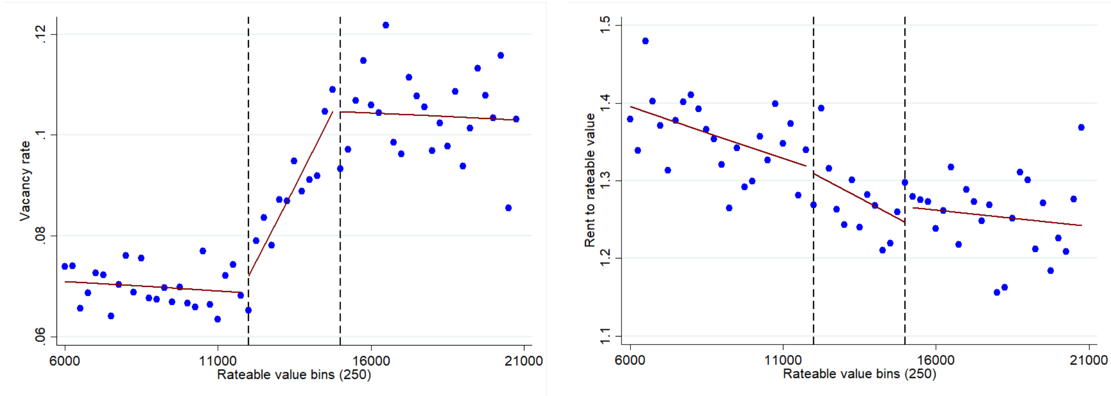
In Figure 6 (a), the vacancy rate is almost constant from rateable value of £6,000 to £12,000. It increases in the range of £12,000-15,000 relative to that on the left of the £12,000 threshold, implying an increase in the slope at the £12,000 threshold. The graphical evidence suggests that when SBRR 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 suggests 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 (a) 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).

Figure 6 (b) plots the rent to rateable value ratio by rateable values. On the left

Figure 6: Graphical evidence for SBRR

(a) Vacancy rate

(b) Rent to rateable value



Notes: The graphs plot (a) the vacancy rate and (b) the rent to rateable value 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.

of the £12,000 threshold, the rent to rateable value ratio decreases with rateable value, and it decreases at a faster rate compared to the left of the threshold. To the right of the £15,000 threshold, the relationship between rent to rateable value ratio with rateable value becomes more flat compared to that between £12-15,000. This suggests that an increase in the tax for small business occupier τ_s decreases the average rent of a property.

Table 6 columns (1) to (3) report the reduced form estimate of equation (9) 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 (6) reports the reduced form estimate of equation (10) 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 7 first reports the estimates of equation (13) and (14) on ETR for small business. Panel A columns (1) and (2) report the first stage estimate of η_2 of equation (13) 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 0.135 and statistically significant. Panel B reports estimate of ϕ_2 of equation (14), 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 0.158 (see column (1)).

Table 7 reports the reduced form estimate of equation (11) and (12) on the vacancy rate (cols. (3) to (5)) and rent to reateable value ratio (cols. (6) to (7)) controlling

Table 6: 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)	-0.051***	-0.045***	-0.035***	0.040***	0.028***	0.021*
	(0.006)	(0.008)	(0.010)	(0.007)	(0.009)	(0.011)
Panel B: With local authority fixed effects						
R * D(1Kink)	-0.051***	-0.045***	-0.035***	0.041***	0.028***	0.021**
	(0.005)	(0.007)	(0.008)	(0.006)	(0.008)	(0.009)
Observations	64,468	32,354	27,664	64,468	32,354	27,664

Notes: The table reports estimates of equation (9) (cols. (1) to (3)) and of equation (10) (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), (2), (5) 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.

for local authority fixed effects.[51] Panel A reports the results for the estimate of γ_2 of equation (11) for the first kink. At bandwidth of £3,000 and at bandwidth of £2,500 (col. (3) and (4)), 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 (5). Similarly, panel B reports the results for the estimate of δ_2 of equation (12). It shows that the change in slope coefficient for the vacancy at the £15,000 threshold is negative and statistically significant.

Finally, Table 7 also reports the reduced form estimates for rents to rateable value ratio in columns (6)-(7). There is a statistically negative change in the slope between the outcome and rateable value, at the lower kink £12,000 (panel A), consistent with the prediction from the model. On the other hand, we do not find the change in slope at the upper kink £15,000 to be statistically significant (panel B).

Combining the estimate for the occupancy rate by small business (col. (3) of Table 6 panel B) with the change in ETR at the £12,000 threshold (col. (2) of Table 7) gives -0.26, the estimate for the causal effect of tax rate for small business on occupancy by

[51]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 N.9 in Appendix.

Table 7: RKD results for SBRR: Vacancy rate, ETR and rent to rateable value

Dep. Var.	ETR		D(Vacant)			Rent/RV	
Properties	Occupied by small business		All				
Sample	Small		Large		Small		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Bandwidth	3,000	2,500	3,000	2,500	2,500	3,000	2,500
Panel A: First Kink (£12,000)							
R*D(1kink)	0.135***	0.135***	0.011***	0.009***	0.014***	-0.040**	-0.039**
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.015)	(0.016)
Observations	18,968	16,080	64,468	55,126	27,664	2,382	2,058
Panel B: Second Kink (£15,000)							
R * D(2Kink)	-0.158***		-0.010***	-0.008**	-0.014***	0.021	-0.002
	(0.005)		(0.003)	(0.003)	(0.005)	(0.021)	(0.020)
Observations	6,714		40,807	35,920	17,926	1,676	1,524

Notes: The table reports estimates of (13) (cols. (1) and (2)) and of equation (11) (cols. (3) to (7)) in panel A and of equation (14) (cols. (1)) and (12) (cols. (3) to (7)) in panel B. The dependent variable is the ETR of properties occupied by small businesses (cols. (1) and (2) for panel A) or of properties occupied by small and large business (cols. (1) for panel B), an indicator for the property being empty (cols. (3) to (5)) or the rent to rateable value ratio (cols. (6) and (7)). 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 (6) use a fixed bandwidth of £3,000 and all other columns a fixed bandwidth of £2,500 (except for column (1) in panel B which uses a bandwidth of £1,000). Cols. (1), (2) and (5) use the small sample, all other columns the large sample. Panel B col. (1) reports the estimate of ϕ_2 of equation (12) divided by the share of small businesses at the threshold (0.38) as described in section (4). All specifications include local authority fixed effects, and col. (6) and (7) in addition quarter-year and property type fixed effects. Robust standard errors are clustered at the local authority-rateable value bin (cols. (1) to (5)) or rateable value bin (cols. (6) and (7)) and local authority-property type level and are in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

small business. The bootstrapped standard error is 0.08 (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 0.26 percentage points. Similarly, the estimate for the effect of tax for small business on the occupancy by large business is 0.15. The bootstrapped standard error is 0.08 (p-value: 0.06). 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 0.15 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.

(2) and (5) of Table 7 panel A) gives the estimate for the causal effect of tax on small business on vacancy at the £12,000 kink, which is 0.10. 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 very similar with 0.09 (cols. (1) and (5) of Table 7 panel B).[52] If we compare this to the marginal effect of retail relief of 0.49, we see that retail relief has much more "bang for the buck", consistent with our theoretical prediction in equation (3).

Similarly, we combine the reduced form estimate on rents and the first stage estimate to calculate the marginal effect of ETR on rent to rateable value ratio (col. (2) and (7) Panel A), it is -0.29 at the lower threshold. This suggest that a £1 increase in the small business rates relief to the small business increase the average rent by 29p. At the upper kink, the estimates are small and statistically insignificant, suggesting the small business rates relief does not have a clear effect on the rents. This could be because, with the sorting effect, properties are occupied by large businesses in a majority at the threshold for the upper kink. As they are not eligible for the SBRR, any rent changes would be through the indirect effect resulting from vacancy change as discussed in Section 3.3, which could be harder to detect given the smaller rent sample.

Sensitivity and heterogeneity analysis: We report sensitivity results for ETR, occupancy by type of business, and vacancy rate where we use a local linear regression for the RKD with optimal bandwidth (see Table N.10 in the Online Appendix). The results are in general very similar to our baseline results, although sometimes less precisely estimated. Further, we assess whether similar results emerge when using rent or ln rent (see Table N.11) and find consistent results. In addition, we re-run our baseline specification excluding jurisdictions for which a particular variable (e.g., vacancy rate or the tax charge) is not directly observed (see Table N.12). The point estimate change only very little. Further, 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 statutorily at £6,000 and £12,000 before the revaluation in 2017 (see Figure N.6 and Table N.15 in the Online Appendix). Again, our findings hold.

Lastly, we assess effect heterogeneity with respect to the type of properties and if the properties are in- or outside of London. While there is little difference between properties in- and outside of London, the effect seems to be stronger for retail properties, both at

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

the first and second kink (see Table N.13 in the Online Appendix).

7 Policy Implications and Conclusions

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

For policy purposes, vacancies are of primary interest, so it is helpful to present our estimates of the causal effects on vacancies both in absolute and proportional forms, the latter being the semi-elasticity of vacancies with respect to the tax ($\epsilon = \frac{1}{v}\frac{\partial v}{\partial \tau}$) for each of empty property exemption, small business rates relief and retail relief. These estimates are given in Table C2 of the Appendix. Note that for retail relief and SBRR, the values tell us how much vacancies fall (rise) when the relief is introduced (removed), whereas the reverse is true for empty property relief. In fact, empty property relief is intended as an instrument for subsidising very small landlords, and is clearly not meant to reduce vacancies.

Comparing just the other two reliefs, we see from Table C2 that while both reliefs have substantial effects, the retail relief is clearly the most effective relief for reducing vacancies - it has approximately five times the effect on vacancies (both in absolute and proportional terms) as SBRR. This is perhaps not surprising, as SBRR is targeted only at a particular type of tenant, and therefore crowds out other tenants. This crowding out effect may have unintended efficiency implications; large chains, for example, may have a higher productivity but may offer less product variety.

Finally, as occupied properties generate economic activity and therefore tax revenue (e.g., corporate income tax, VAT and personal income tax), our results imply a fiscal externality of business rate reliefs and exemptions on the corporate tax and VAT base, which has to be taken into account when evaluating the cost-effectiveness of them.

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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 equilibrium are (i) rents $\tilde{r}_i$; (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

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

from applying to a 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).[53] So, $q_{i,j}$ satisfies:

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

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

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

i.e. rent if the property is let, and payment of the business rate for vacant properties if it is not. A landlord chooses $\tilde{r}_i, q_{i,s}, q_{i,l}$ 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 $\tilde{r}_i, q_{i,s}, q_{i,l}$ to the landlord's choice problem. Moreover, all of our results hold conditional on any value of N_s; the solution for N_s is at the end of this section of the Appendix.

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 eligible 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 $\tilde{r}_i = \overline{r}_{i,s}$, 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

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

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 1.

(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 $\tilde{r}_s = \overline{r}_{i,s}$. Then we can rewrite (A.7) as:

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

[53] 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 2. 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.
(e) The final step is to solve 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

$$N \sum_{i \in P} \phi_i p_{i,j} = 1,\ \ j = s, l \tag{A.15}$$

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

$$\sum_{i \in P} \phi_i q_{i,j} = n_j,\ \ n_j = \frac{N_j}{N},\ \ j = s, l \tag{A.16}$$

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:

$$q_i = \ln \left(\frac{\rho R_i}{\Pi(R_i) + \Delta T(R_i)} \right),\ i \in S,\ \ q_i = \ln \left(\frac{\rho R_i}{\Pi(R_i)} \right),\ i \in L. \tag{A.17}$$

Now summing (A.16) across business types, we get

$$\sum_{i \in P} \phi_i (q_{i,s} + q_{i,l}) = n_s + n_l \tag{A.18}$$

Combining (A.17), (A.18), using the fact that $q_i = q_{i,s} + q_{i,l}$, we see that

$$n_s + n_l = \sum_{i \in S} \phi_i \ln \left(\frac{\rho R_i}{\Pi(R_i) + \Delta T(R_i)} \right) + \sum_{i \in L} \phi_i \ln \left(\frac{\rho R_i}{\Pi(R_i)} \right) \tag{A.19}$$

The RHS of (A.19) is fixed, and moreover, n_l is fixed. So, n_s is determined by (A.19). □

B.3 Derivation of Results in Table 1

To lighten notation, we introdiuce the following shorthand for right-hand and left-hand limits of v, r at thresholds:

$$\lim_{R \downarrow R_z} x(R) \equiv \overline{x}(R_z), \quad \lim_{R \uparrow R_z} x(R) \equiv \underline{x}(R_z), \quad x = v, r, \quad z = e, r, s$$

where e, r, s refer to empty property relief, retail relief, and small business rate relief respectively.
Empty Property Relief. Here we can write the vacancy rate as a function of R as

$$v(R) = \frac{\rho}{\pi(R) + \tau(R)}, \quad \tau(R) = \begin{cases} 0, & R \leq R_e \\ \kappa & R > R_e \end{cases} \tag{A.20}$$

as properties at this threshold get full SBRR if let. So, the change in v at the threshold is

$$\overline{v}(R_e) - \underline{v}(R_e) = \frac{\rho}{\pi(R_e) + \kappa} - \frac{\rho}{\pi(R_e)} < 0.$$

Now, from (1), we can write

$$r(R) = \pi(R) - \frac{\rho}{m} \equiv \pi(R) + f(v), \; f(v) = \rho \frac{\ln v}{1 - v} \tag{A.21}$$

as any properties let will get full SBBR relief. Also, note that f is increasing in v. So, the change in rent at R_e is

$$\overline{r}(R_e) - \underline{r}(R_e) = f(\overline{v}(R_e)) - f(\underline{v}(R_e)) < 0$$

as $\overline{v}(R_e)) < \underline{v}(R_e)$ from (A.20).

Retail Relief. Here, at this threshold, empty property relief or SBRR does not apply, so we can write the vacancy rate as a function of R as

$$v(R) = \frac{\rho}{\pi(R) + \kappa - \tau(R)}, \quad \tau(R) = \begin{cases} \frac{2\kappa}{3}, & R \leq R_r \\ \kappa & R > R_r \end{cases} \tag{A.22}$$

So, the change in v at the threshold is

$$\overline{v}(R_r) - \underline{v}(R_r) = \frac{\rho}{\pi(R_r)} - \frac{\rho}{\pi(R_r) + \frac{\kappa}{3}} > 0$$

Now, it is convenient to write rent as a function of both τ and R :

$$r(\tau; R) \equiv \pi(R) - \tau + f(v(\tau)), \; v(\tau) = \frac{\rho}{\pi(R) + \kappa - \tau} \tag{A.23}$$

where $f(v)$ is defined in $(A.21)$ above. So, from (A.23) ;

$$\overline{r}(R_R) - \underline{r}(R_R) = r(\kappa; R_R) - r\left(\frac{2\kappa}{3}; R_R\right) = \int_{2\kappa/3}^{\kappa} \big(-1 + f'(v)v'(z)\big)\, dz \tag{A.24}$$

Also, from (A.21), (A.22):

$$f'(v) = \frac{\rho}{v(1-v)^2} \left(1 - v + v \ln v\right), \; v'(z) = \frac{v^2}{\rho}$$

So, after some simplification:

$$-1 + f'(v)v'(z) = -1 + \frac{1}{(1-v)^2} \left(1 - v + v^2 \ln v\right) \equiv g(v) \tag{A.25}$$

Now, it is easy to check that $1-v+\ln v^2 \leq 0$ for all $v \in [0,1]$, implying $g(v) < 0$ for all $v \in [0,1]$. So, from (A.24), (A.25), $\overline{r}(R_R) < \underline{r}(R_R)$ as required.

SBRR. Here, we need to study the slopes of v, r with repect to R at the threshold, not the discontinuities. W.l.o.g, we do this assuming that the firm does not claim retail relief as well. As the property is not entitled to empty property relief and the SBRR threshold, the vacancy function is

$$v(R) = \frac{\rho}{\pi(R) + \kappa - \tau(R)}, \quad \tau(R) = \begin{cases} 0, & R \leq \underline{R}_s \\ \kappa - \kappa(\frac{60}{R} - 4) & \underline{R}_s < R \leq \overline{R}_s \\ \kappa & R > \overline{R}_s \end{cases} \tag{A.26}$$

So, from (A.26), the left- and right-hand derivatives of $v(R)$ at $\underline{R}_s$ are

$$\left.\frac{\partial v^-}{\partial R}\right|_{\underline{R}_s} = \frac{-\pi'(\underline{R}_s)\rho}{(\pi(\underline{R}_s) + \kappa)^2}, \quad \left.\frac{\partial v^+}{\partial R}\right|_{\underline{R}_s} = \frac{-(\pi'(\underline{R}_s) - 60\kappa \underline{R}_s^{-2})\rho}{(\pi(\underline{R}_s) + \kappa)^2} \tag{A.27}$$

respectively. So, from (A.27), the change in the slope of v at the lower threshold is

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

So, the slope of the vacancy function increases at the lower threshold, as claimed. In the same way, we can calculate

$$\left.\frac{\partial v^+}{\partial R}\right|_{\overline{R}_s} - \left.\frac{\partial v^-}{\partial R}\right|_{\overline{R}_s} = -\frac{60\kappa}{\overline{R}_s^2} \frac{\rho}{(\pi(\overline{R}_s))^2} = -\frac{60\kappa}{\rho \overline{R}_s^2} \frac{(v(\overline{R}_s))^2}{\rho} < 0 \tag{A.29}$$

So, the slope of the vacancy function decreases at the upper threshold, as claimed.

We now turn to look at the slopes of the rent function. We can define

$$r(R) \equiv \pi(R) - \tau(R) + f(v(R))$$

where $f(v)$ and $\tau(R)$ are defined in (A.21), (A.26) above respectively. So,

$$\frac{\partial r}{\partial R} = \begin{cases} \pi'(R) - \frac{60\kappa}{R^2} + f'(v)\frac{\partial v}{\partial R}, & \underline{R}_s < R \leq \overline{R}_s \\ \pi'(R) + f'(v)\frac{\partial v}{\partial R}, & \text{otherwise} \end{cases}$$

So, letting $v(\underline{R}_s) = \underline{v}$ to lighten notation, the change in $\frac{\partial r}{\partial R}$ at $\underline{R}_s$ is

$$\begin{aligned} \left.\frac{\partial r^+}{\partial R}\right|_{\underline{R}_s} - \left.\frac{\partial r^-}{\partial R}\right|_{\underline{R}_s} &= -\frac{60\kappa}{(\underline{R}_s)^2} + f'(\underline{v}) \left(\left.\frac{\partial v^+}{\partial R}\right|_{\underline{R}_s} - \left.\frac{\partial v^-}{\partial R}\right|_{\underline{R}_s} \right) \\ &= \frac{60\kappa}{(\underline{R}_s)^2} \left(-1 + f'(\underline{v}) \frac{(\underline{v})^2}{\rho} \right) \\ &= \frac{60\kappa}{(\underline{R}_s)^2} g(\underline{v}) < 0 \end{aligned}$$

where in the second line, we use (A.28). In the same way, letting $v(\overline{R}_s) = \overline{v}$ to lighten notation, the change in $\frac{\partial r}{\partial R}$ at $\overline{R}_s$ is

$$\begin{aligned} \left.\frac{\partial r^+}{\partial R}\right|_{\overline{R}_s} - \left.\frac{\partial r^-}{\partial R}\right|_{\overline{R}_s} &= \frac{60\kappa}{(\overline{R}_s)^2} + f'(\overline{v}) \left(\left.\frac{\partial v^+}{\partial R}\right|_{\overline{R}_s} - \left.\frac{\partial v^-}{\partial R}\right|_{\overline{R}_s} \right) \\ &= \frac{60\kappa}{(\overline{R}_s)^2} \left(1 - f'(\overline{v}) \frac{(\overline{v})^2}{\rho} \right) \\ &= -\frac{60\kappa}{(\overline{R}_s)^2} g(\overline{v}) > 0 \end{aligned}$$

where in the second line, we use (A.29).

C Additional Figures and Tables

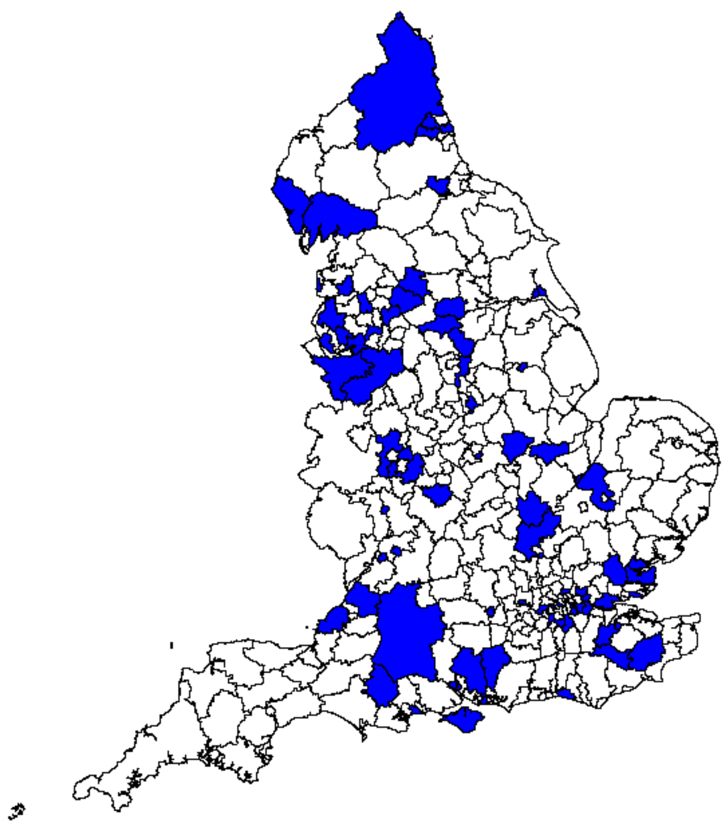
C.1 Descriptive statistics

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. The business rate tax, before any reliefs, equals the multiplier/100 times the rateable value. 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 C1: 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: 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	-0.072			0.268	0.082			-3.3	0.29		
Retail properties	-0.052			0.389	0.048			-2.8	0.14		
Small business rates relief $\underline{R}_s$ (£12,000)											
All properties	0.014	-0.035	0.021	0.135	0.090	0.557	0.394	1.2	-0.11	-0.47	0.39
Retail properties	0.017	-0.057	0.041	0.121	0.091	0.638	0.316	1.5	-0.15	-0.74	1.07
Small business rates relief $\underline{R}_s$ (£15,000)											
All properties	-0.014			0.158	0.090			1.0	-0.10		
Retail properties	-0.019			0.158	0.091			1.3	-0.13		
Retail relief (£51,000)											
Retail properties	0.049			0.099	0.095			5.2	-0.54		

Notes: The table reports the results of our main specifications (vacancy rate, occupancy rate by type of business and ETR), the mean level of the dependent variables (measured at the right limit of the respective threshold/kink) and the implied semi-elasticities. Since the vacancy at the lower kink is affected by the SBRR, we use the vacancy at the second kink also for the first kink to allow a comparison of the semi-elasticities for the two kinks. Estimates in col (1) and (4) are from Table 3, 4 and 7. Estimates in column (2)-(3) are from Table 6. Values in col (5)-(7) are calculated using the respective sample for the reliefs. Col. (8)-(11) are calculated using estimates in col (1)-(7).

N Online Appendix

In this online appendix we present tables and figures for additional empirical results. The online appendix consists of five parts.

The first, second and third part of the online appendix present additional tables and figures for empirical results for empty property exemption (Appendix N.1), retail relief (Appendix N.2) and SBRR (Appendix N.3). The additional empirical results in all three parts are based on the same sample as used for the results reported in the paper.

The fourth part of the online appendix (Appendix N.4) presents tables and figures for comparing the empirical results for properties' occupation status for empty relief and SBRR using data before the 2017 revaluation and after the 2017 revaluation.

In the last part of the online appendix (Appendix N.5), we describe the data used in the empirical analysis in detail.

N.1 Additional results for empty property exemption

In this appendix section, we report tables and figures for additional empirical results for the empty property exemption. Figure N.1 plots the ETR for occupied properties by rateable value, the number of observations and the estimated density for the vacancy sample and the rent sample. The figures shows that the number of observations are smooth around the threshold in both samples and that the ETR of occupied properties does not change discontinuously at the threshold. This suggests there is no selection around the threshold.

Table N.1 report robustness checks where we employ a local polynomial regression in higher order, and also that uses alternative kernels, i.e. weighting observations differently. 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.

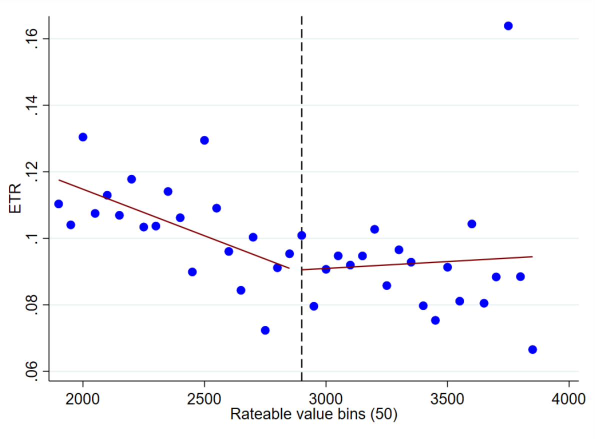
Table N.2 reports the results when we use rent or ln rent as dependent variable. The estimates are in line with the baseline results. Panel A reports the estimates on the reduced form effect of the empty relief threshold using level of rent as outcome. The estimated reduction in rents of around £300 at the threshold is equivalent to a decrease of 10.3% of the rateable value at the threshold (10.3% = 300/2900). Panel B reports the estimates using ln rent as outcome. The estimated decrease in rents of 8% at the threshold translates - given the average rent at the threshold of £5,200 - into an absolute reduction of rents of £410, or 14% of the rateable value at the threshold.

Table N.3 reports sensitivity results where we exclude jurisdictions for which the vacancy variable or the tax charge information is not directly observed but inferred. Cols. (1) and (3) show the results when excluding jurisdictions for which the vacancy was inferred from relief and exemption information and cols. (2) and (4) show the results when excluding jurisdictions for which the charge was calculated using gross charge and relief and exemption information. For both sub-samples, the implied marginal effect and the implied semi-elasticity (since the vacancy rate right to the threshold is almost unchanged) is very similar.

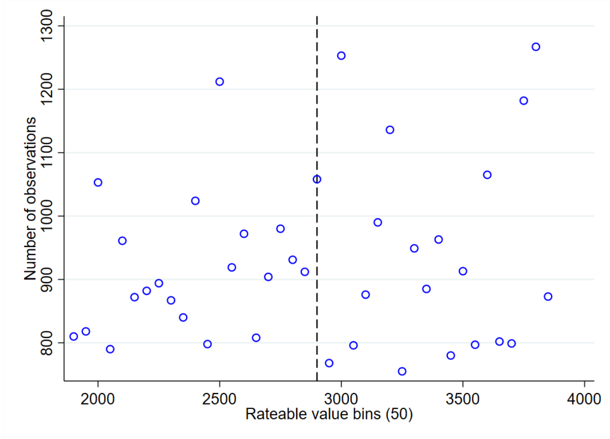
Table N.4 reports heterogeneity results on vacancy. In panel A, we use only shops and hospitality properties. The implied semi-elasticity for vacancy is very similar to the baseline result that includes all property types. The marginal effect for vacancy for all properties (reported in Table C2) is 0.27. The implied marginal effect for shops and hospitality properties is 0.13 (= (0.052/0.389)) using a fixed bandwidth of £500 (see Table N.4 panel A, columns (2) and (4)). Since the vacancy rate for shops and hospitality properties is less than half of the vacancy rate for all properties, the implied semi-elasticity is less strong for retail properties. In addition, the table shows the results for properties in London (panel B) and outside of London (panel C). Here, the implied semi-elasticity is very similar.

Figure N.1: Validity of RDD for empty property exemption

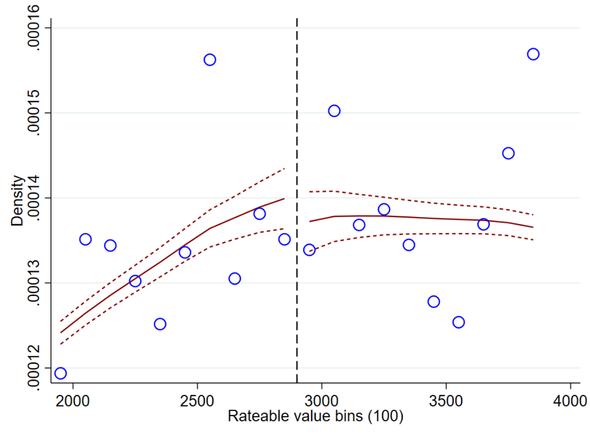
(a) ETR for occupied properties



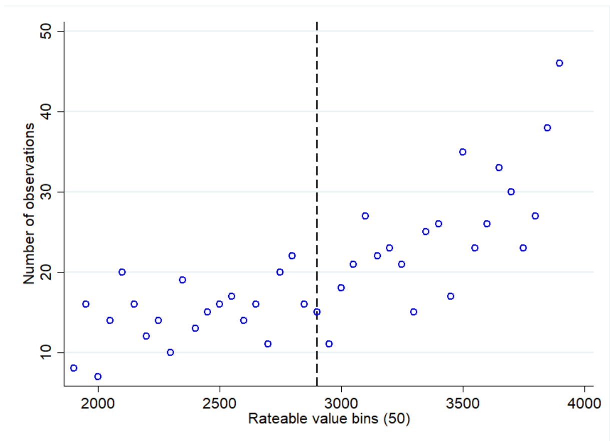
(b) Number of properties - Vacancy sample



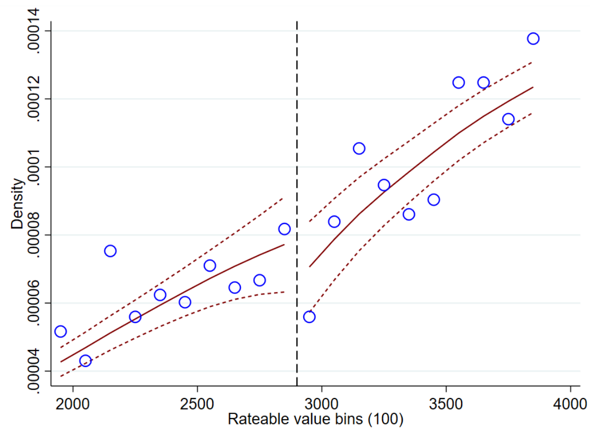
(c) McCrary test - Vacancy sample



(d) Number of observations - Rent sample



(e) McCrary test - Rent sample



Note: The graphs plot (a) the average ETR 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 vacancy sample and (d) the number of observations and (e) the estimated density function for the McCrary test by rateable value group using the rent sample. The rateable value range is £1,900 to £3,900, and the bin width is £50 ((a), (b) and (d)) or £100 ((c) and (e)). The dashed line indicates the rateable value threshold for the empty property exemption and the solid lines represent linear fits.

Table N.1: RDD for empty property exemption - Local regressions

Dep. Var.	Without local authority FE			With local authority FE		
Local regression	Linear		Quadratic	Linear		Quadratic
Kernel	Triang.	Epan.	Triang.	Triang.	Epan.	Triang.
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ETR						
Conventional	0.274***	0.275***	0.279***	0.278***	0.278***	0.268***
	(0.013)	(0.013)	(0.013)	(0.011)	(0.011)	(0.015)
Bias-corrected	0.270***	0.271***	0.276***	0.275***	0.276***	0.263***
	(0.015)	(0.015)	(0.015)	(0.013)	(0.013)	(0.017)
Observations	4,370	4,113	8,844	5,301	4,888	6,076
Bandwidth	895	845	1,795	1,071	996	1,212
Panel B: Vacancy						
Conventional	-0.072***	-0.072***	-0.083***	-0.068***	-0.070***	-0.074***
	(0.008)	(0.009)	(0.013)	(0.009)	(0.009)	(0.013)
Bias-corrected	-0.074***	-0.075***	-0.087***	-0.070***	-0.072***	-0.077***
	(0.010)	(0.010)	(0.016)	(0.011)	(0.011)	(0.015)
Observations	30,361	27,352	28,597	26,926	23,289	28,597
Bandwidth	818	749	755	721	612	767
Panel C: Rent to rateable value						
Conventional	-0.110	-0.110	-0.132	-0.180***	-0.186***	-0.166*
	(0.075)	(0.073)	(0.099)	(0.064)	(0.068)	(0.086)
Bias-corrected	-0.108	-0.089	-0.159	-0.179**	-0.195**	-0.187*
	(0.095)	(0.091)	(0.117)	(0.084)	(0.087)	(0.101)
Observations	708	678	974	644	539	937
Bandwidth	907	890	1,234	829	713	1,177

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 the ETR of empty properties (panel A), an indicator of the property being vacant (panel B), or the rent to rateable value ratio (panel C). Each cell shows an RDD estimate with standard errors reported in parenthesis. The first row for each panel shows the conventional RDD estimate and the second row the bias-corrected estimate with robust standard errors. Cols. (1) to (3) show the results without local authority fixed effects and cols. (4) to (6) with local authority fixed effects. In panel C we additionally control for quarter-year and property type fixed effects. In cols. (1), (3), (4) and (6) we use a Triangular kernel and in cols. (2) and (4) an Epanechnikov 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 N.2: RDD for empty property exemption - Rent or ln rent as outcome

Dep. Var.	Without local authority FE		With local authority FE	
Bandwidth	Optimal	1,000	Optimal	1,000
	(1)	(2)	(3)	(4)
Panel A: Rent				
D(RV≥2.9k)	-337**	-288*	-596**	-287
	(133)	(155)	(229)	(199)
Observations	587	812	522	812
Panel B: ln Rent				
D(RV≥2.9k)	-0.080	-0.081**	-0.118**	-0.085*
	(0.048)	(0.039)	(0.057)	(0.044)
Observations	461	812	486	812

Notes: The table reports reduced form estimates for empty property exemption. The dependent variable is rent (panel A), or ln rent(panel B). In cols.(1) and (3) we use the optimal bandwidth and in cols. (2) and (4) we use a fixed bandwidth of £1,000. Cols. (1) and (2) include quarter-year and property type fixed effects. Cols. (3) and (4) in addition local authority fixed effects. The optimal bandwidth is estimated following Calonico, Cattaneo and Titiunik (2014*a*). Robust standard errors are clustered at the rateable value bin and local authority-property type level and are reported in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N.3: RDD for empty property exemption - Sensitivity checks on the sample

Dep. Var.	D(Vacant)		ETR	
Properties	All		Empty	
W/o jurisdictions with not directly observed	Vacancy	Charge	Vacancy	Charge
	(1)	(2)	(3)	(4)
D(R≥51k)*Post	-0.081***	-0.078***	0.255***	0.268***
	(0.017)	(0.019)	(0.032)	(0.031)
Observations	8,811	7,899	1,037	1,003

Notes: The table reports reduced form estimates for the empty exemptions excluding jurisdictions for which a particular variable is not directly observed. The dependent variable is an indicator of the property being vacant (cols. (1) and (2)) or the ETR of empty properties (cols. (3) and (4)). All cols. use the small sample and a fixed bandwidth of £250. In cols. (1) and (3), we exclude jurisdictions for which the vacancy is not directly observed, in cols. (2) and (4) we exclude jurisdictions for which the charge is not directly observed. There are no jurisdictions for which the rateable value is not directly observed. 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 N.4: RDD results for empty property exemption - Heterogeneity analysis

Dep. Var.	D(Vacant)		ETR	
Properties	All		Empty	
Bandwidth	Optimal	500	Optimal	500
	(1)	(2)	(3)	(4)
Panel A: Retail/hospitality properties				
D(RV≥2.9k)	-0.053***	-0.052***	0.353***	0.389***
	(0.014)	(0.011)	(0.028)	(0.039)
Observations	8,050	8,817	1,472	805
Panel B: Jurisdictions inside London				
D(RV≥2.9k)	-0.076*	-0.046	0.257***	0.317***
	(0.047)	(0.052)	(0.051)	(0.074)
Observations	1,619	1,347	294	177
Panel C: Jurisdictions outside London				
D(RV≥2.9k)	-0.079***	-0.075***	0.280***	0.266***
	(0.014)	(0.010)	(0.021)	(0.025)
Observations	11,504	18,542	3,385	2,293

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 empty 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 £500. 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.): 0.02 (0.03)). The vacancy rate is 0.05 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 -0.05 (0.06) and outside of London: -0.02 (0.02)). The vacancy rate is in (outside of) London 0.10 (0.08) 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.

N.2 Additional results for retail relief

In this appendix section, we report tables and figures for additional empirical results for the retail relief. Figure N.2 plots the number of observations in 2018 and 2019 and the estimated density for 2018 and 2019 in the vacancy sample and in the rent sample. The number of observations is in both samples smooth around the threshold, both before and after the introduction of the retail relief.

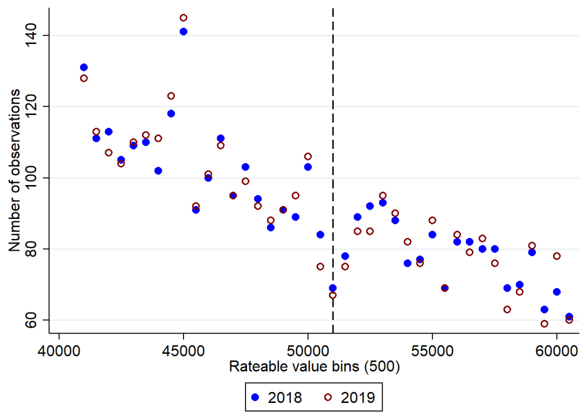
As a robustness check, we employ regression discontinuity design using data for 2018 and using data for 2019 separately to estimate the discontinuity at the threshold for each of the two years. Figure N.3 shows the graphical analysis for all outcome variables, and Table N.5 reports the results for vacancy and ETR. The difference in the estimates for 2018 and 2019 are very similar to that in Table 4 but less precisely estimated. Due to the small sample size for the rents, we do not run the analysis separately for 2018 and 2019 but only vary the bandwidth (cols. (1) and (2) of Table N.6) and use a quadratic instead of a linear regression (col. (3)). While the point estimates do vary due to the small sample size, they centre around 0.1.

Table N.7 reports results when using rent or ln rent as dependent variable. The estimates are comparable to our baseline results. Panel A reports the estimates for reduced form equation for retail relief using level of rent as outcome. We estimate an absolute reduction in rents at the threshold of around £6,000. This is equivalent to a reduction in rents to rateable at the threshold of 12%. Panel B reports the estimates using ln rent as outcome. The reduction in rents is estimated to be around 10%. Given an average rent of £55,000 left to the threshold, this translate in absolute reduction of around £5,500 in rent or 11% of rent to rateable value.

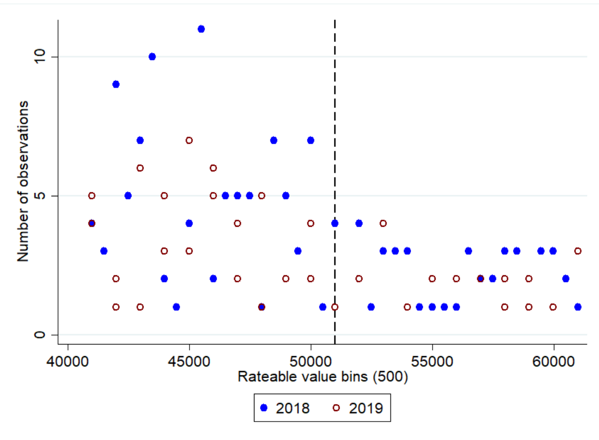
Table N.8 reports sensitivity results where we exclude jurisdictions for which either vacancy, tax charge, rateable value or the property type is not directly observed but inferred or imputed. We described how we infer/impute the variables in data appendix N.5. Cols. (1) and (5) show the results when excluding jurisdictions for which the rateable value is not directly observed, cols. (2) and (6) the results when excluding jurisdictions for which the vacancy is not directly observed, cols. (3) and (7) the results when excluding jurisdictions for which the charge is not directly observed, and cols. (4) and (8) the results when excluding jurisdictions for which the property type is not directly observed. The implied marginal effect of tax on vacancy (the ratio of vacancy rate and ETR estimates) is in all cases very similar to that of our baseline specification.

Figure N.2: Validity of RDD for retail relief

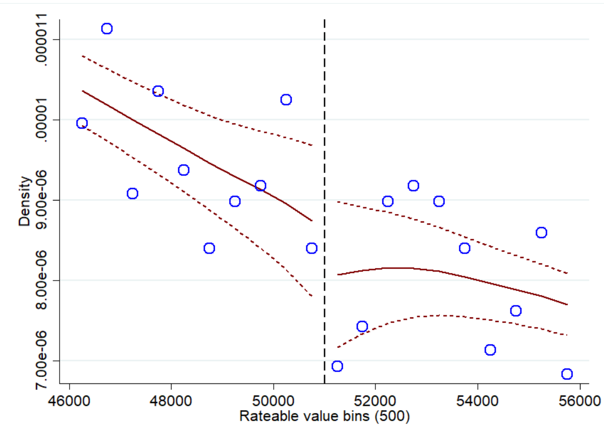
(a) Number of observations - Vacancy sample



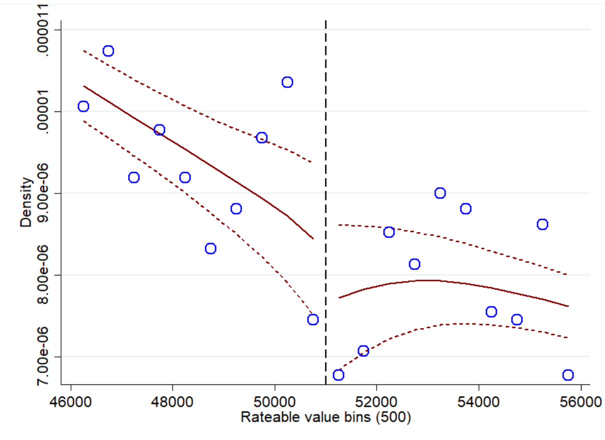
(b) Number of observations - Rent sample



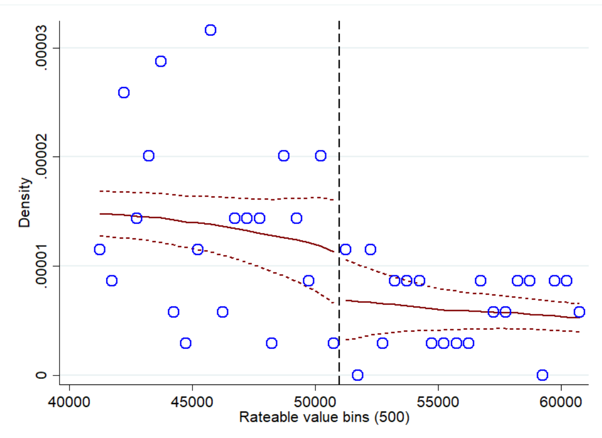
(c) McCrary test 2018 - Vacancy sample



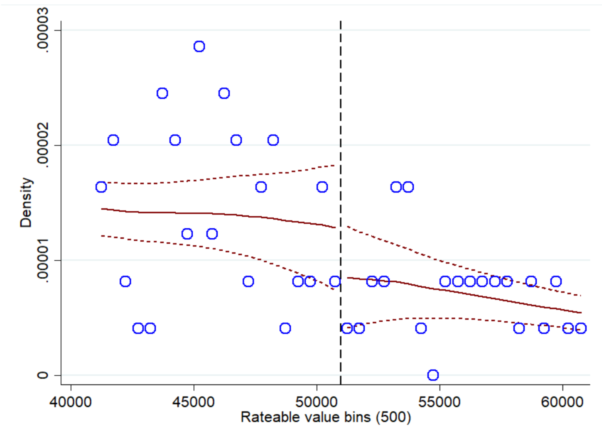
(d) McCrary test 2019 - Vacancy sample



(e) McCrary test 2018 - Rent sample



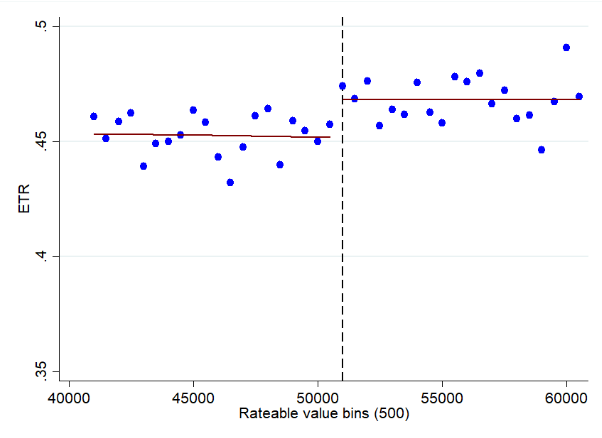
(f) McCrary test 2019 - Rent sample



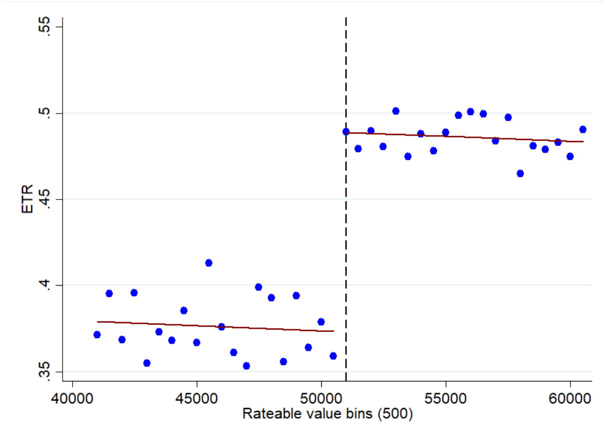
Note: The graph plots the number of observations in 2018 and 2019 in the (a) vacancy sample and the (b) rent sample, and the estimated density function for the McCrary test for (c) 2018 and for (d) 2019 by rateable value using the large vacancy sample and the same for (e) 2018 and (f) 2019 by rateable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

Figure N.3: Graphical evidence for retail relief: 2018 vs 2019

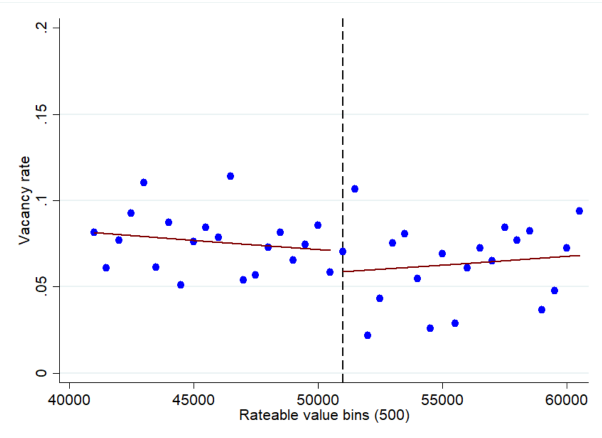
(a) ETR of occupied properties 2018



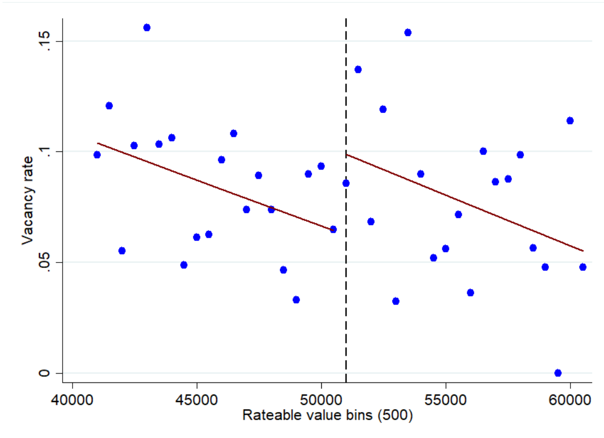
(b) ETR of occupied properties 2019



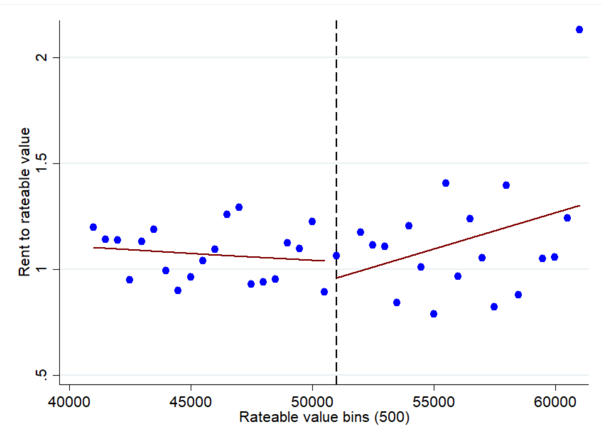
(c) Vacancy rate 2018



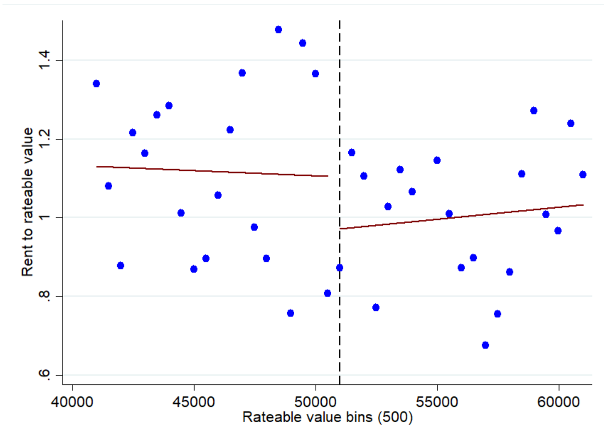
(d) Vacancy rate 2019



(e) Rent to rateable value 2018



(f) Rent to rateable value 2019



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

Table N.5: RDD for retail relief - Local regressions for ETR and Vacancy

Dep. Var.	ETR		D(Vacant)			
Properties	Occupied		All			
Sample	Small		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	0.115***	0.015*	0.033	-0.010	0.039	0.001
	(0.010)	(0.009)	(0.020)	(0.018)	(0.026)	(0.022)
Bias-corrected	0.117***	0.016	0.040*	-0.006	0.040	0.004
	(0.011)	(0.011)	(0.024)	(0.021)	(0.032)	(0.026)
Observations	1,953	1,977	3,765	4,135	2,022	2,683
Bandwidth	10,561	10,726	10,215	11,233	10,198	13,293
Panel A2: Local linear regression & With local authority fixed effects						
Conventional	0.119***	0.016*	0.032	-0.010	0.042	0.002
	(0.010)	(0.009)	(0.021)	(0.018)	(0.026)	(0.022)
Bias-corrected	0.121***	0.017	0.039	-0.008	0.045	0.005
	(0.012)	(0.011)	(0.025)	(0.022)	(0.031)	(0.026)
Observations	1,611	1,813	3,379	3,818	2,050	2,650
Bandwidth	8,901	9,985	9,015	10,258	10,484	13,089
Panel B1: Local quadratic regression & Without local authority fixed effects						
Conventional	0.116***	0.015	0.039*	-0.004	0.019	-0.014
	(0.011)	(0.010)	(0.023)	(0.021)	(0.038)	(0.035)
Bias-corrected	0.117***	0.016	0.043	-0.001	0.009	-0.021
	(0.013)	(0.012)	(0.027)	(0.024)	(0.043)	(0.039)
Observations	3,334	3,418	6,542	6,526	2,207	2,359
Bandwidth	17,218	17,336	16,824	16,760	11,082	11,936
Panel B2: Local quadratic regression & With local authority fixed effects						
Conventional	0.121***	0.017*	0.041*	-0.005	0.022	-0.010
	(0.011)	(0.010)	(0.023)	(0.021)	(0.038)	(0.034)
Bias-corrected	0.123***	0.017	0.045*	-0.002	0.011	-0.016
	(0.012)	(0.012)	(0.027)	(0.024)	(0.042)	(0.038)
Observations	3,123	3,293	6,281	6,432	2,207	2,421
Bandwidth	16,371	16,954	16,385	16,657	11,140	12,173

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 ETR of occupied properties (cols. (5) and (6)). Cols. (1) and (2) use the large sample, and all other cols. 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 with standard errors reported in parenthesis. 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 N.6: RDD for retail relief - Rent to rateable value

Dep. Var.	Rent/RV		
Regression	Lin.	Lin.	Quad.
Bandwidth	Optimal	15,000	20,000
	(1)	(2)	(3)
Panel A: Without local authority fixed effects			
D(R≥51k)*Post	-0.091	-0.159**	-0.069
	(0.071)	(0.066)	(0.074)
Observations	247	360	462
Panel B: With local authority fixed effects			
D(R≥51k)*Post	-0.033	-0.155**	-0.098
	(0.112)	(0.066)	(0.102)
Observations	163	360	462

Notes: The table reports reduced form estimates for the retail relief in equation (7). The dependent variable is the rent to rateable value ratio. All specifications include quarter-year fixed effects and use a uniform kernel. In col. (1) we use the optimal bandwidth, in col. (2) a fixed bandwidth of £15,000 and in cols. (3) and (4) of £20,000. In cols. (1) and (2) we allow for a linear relationship between the rateable value and the outcome left and right of the threshold and in col. (3) for a quadratic relationship. Panel A shows the results without local authority fixed effects and panel B with local authority fixed effects. The bandwidths used for estimation are the optimal bandwidths following Calonico, Cattaneo and Titiunik (2014*a*). Robust standard errors are clustered at the local authority and rateable value bin level and are reported in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level. Due to the smaller sample size for rent, we are not able to implement local linear regressions separately for 2018 and 2019 as for vacancy and ETR (in Table N.5).

Table N.7: RDD for retail relief - Rent and ln rent as outcome

Dep. Var.	Without local authority FE		With local authority FE	
Bandwidth	10,000	20,000	10,000	20,000
	(1)	(2)	(3)	(4)
Panel A: Rent				
D(RV≥2.9k)	-4,604	-5,989**	-4,886	-7,120**
	(3,856)	(2,889)	(4,411)	(2,773)
Observations	247	462	247	462
Panel B: ln Rent				
D(RV≥2.9k)	-0.092	-0.094*	-0.085	-0.121**
	(0.080)	(0.054)	(0.084)	(0.051)
Observations	247	462	247	462

Notes: The table reports reduced form estimates for retail relief. The dependent variable is rent (panel A), or ln rent(panel B). In cols. (1) and (3) we use a fixed bandwidth of £10,000, and in cols. (3) and (4) of £20,000. Cols. (1) and (2) include quarter-year and property type fixed effects, cols. (3) and (4) in addition local authority fixed effects. Robust standard errors are clustered at the rateable value bin and local authority-property type level and are reported in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N.8: RDD for retail relief - Sensitivity checks on the sample

Dep. Var.	ETR				D(Vacant)			
Properties	Occupied				All			
W/o jurisd. with not directly observed	RV	Vacancy	Charge	Type	RV	Vacancy	Charge	Type
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D(R≥51k)* Post	0.104*** (0.009)	0.112*** (0.009)	0.104*** (0.009)	0.079*** (0.013)	0.046* (0.024)	0.052** (0.024)	0.052** (0.024)	0.038 (0.029)
Observations	3,149	3,163	3,327	2,008	3,403	3,420	3,598	2,168

Notes: The table reports reduced form estimates for the retail reliefs excluding jurisdictions for which a particular variable was imputed. The dependent variable is the ETR (cols. (1) to (4)) or an indicator of the property being vacant (cols. (5) to (8)). All cols. use the small sample and a fixed bandwidth of £10,000. In cols. (1) and (5), we exclude jurisdictions for which the rateable value is not directly observed, in cols. (2) and (5) we exclude jurisdictions for which the vacancy is not directly observed, in cols. (3) and (7) we exclude jurisdictions for which the charge is not directly observed, and in cols. (4) and (8) we exclude jurisdictions for which the property type is not directly observed. 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.

N.3 Additional results for SBRR

In this appendix section, we report tables and figures for additional empirical results for the SBRR. Figure N.4 shows the number of observations, and estimated density around the first kink and the second kink. The figure shows that the number of observations is smooth around the kinks and that no change in slope is indicated.

Table N.9 reports the results of the reduced form equation (11)-(12) and first stage equation (13)- (14) for specifications without local authority fixed effects. The estimates are almost identical to the ones with local authority fixed effects (reported in Table 7), but less precisely estimated.

Table N.10 reports the results when using a local linear regression for the RKD with optimal bandwidth. The results are in general very similar to our 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.

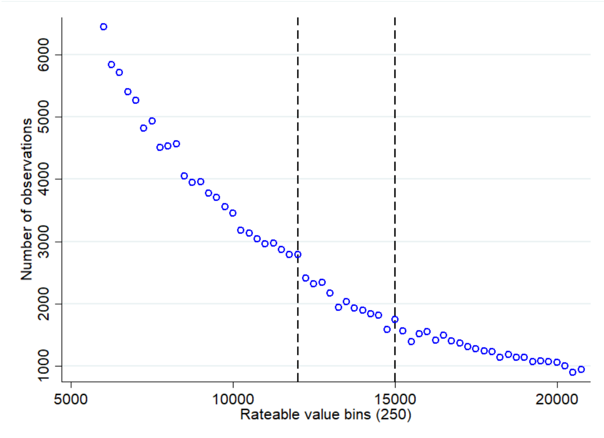
Table N.11 reports results for the reduced form for SBRR when using level of rent or log of rent as dependent variable. The estimates are in line with our baseline results. Panel A shows the results without local authority fixed effects and panel B with local authority fixed effects. Col. (1) reports for the first kink the reduced form estimate using level of rent as outcome. The estimate means that an increase in the rateable value by £1,000 increases rent by £615 (Panel A) or £538 (Panel B) less on the right right compared to on the left of the threshold. In terms of rent to rateable value ratio, this is about 4.5-5%, which is similar to our baseline estimate shown in col. (6) of Table 7. In col. (2) of Table N.11, we report the reduced form estimates using log of rent as outcome. The change in slope at the first kink is estimated at -0.056 (panel B, including local authority fixed effects). This suggests that an increase in the rateable value by £1,000 increases the rent by 5.6% more on the right compared to on the left of the threshold. As the average rent at the first kink is £15,800, this is equivalent to a change in the rent to rateable value of -0.072. In cols. (3) and (4) of Table N.11, we report the reduced form estimates for the upper kink using level or log rents as outcome. Similar to the estimates reported in Section 6.4, we do not find the estimates statistically significant at the upper kink.

Table N.12 reports sensitivity results where we exclude jurisdictions for which a particular variable is not directly observed. Panel A shows the results when excluding jurisdictions for which the vacancy is not directly observed and panel B shows the results when excluding jurisdictions for which the charge is not directly observed. Overall, the point estimates are very similar to our baseline estimates.

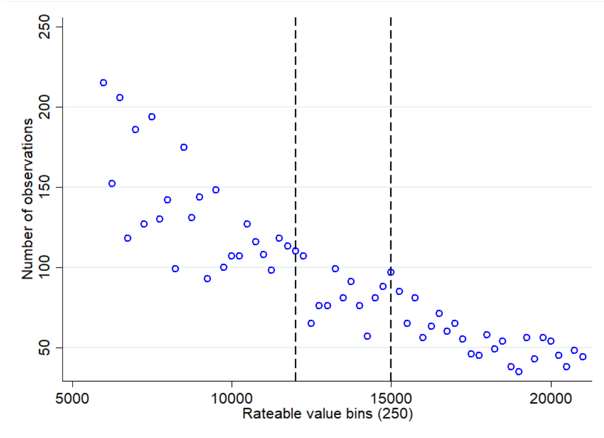
Table N.13 reports heterogeneity results for vacancy and occupancy. Panel A reports the results when including only shops and hospitality properties, and the marginal effect is suggested to be somewhat stronger for these properties. While the first stage estimate using the ETR as dependent variable is similar to our baseline results, the reduced form estimate on vacancy rate is larger. Further, Table N.13 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 - except for the second kink in London for which, however, there is also evidence for a change in the slope of the distribution.

Figure N.4: Validity of RKD for SBRR

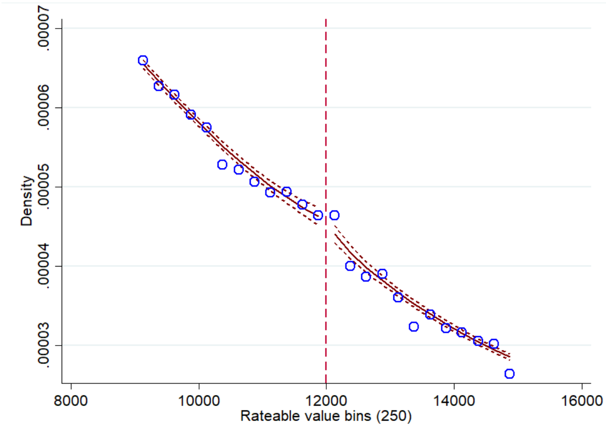
(a) Number of observations - Vacancy sample



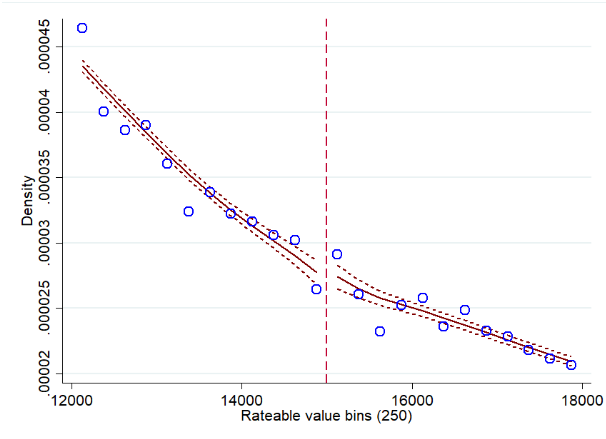
(b) Number of observations - Rent sample



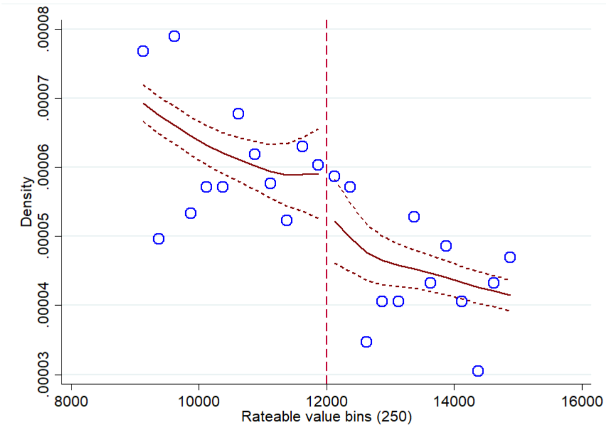
(c) McCrary test first kink - Vacancy sample



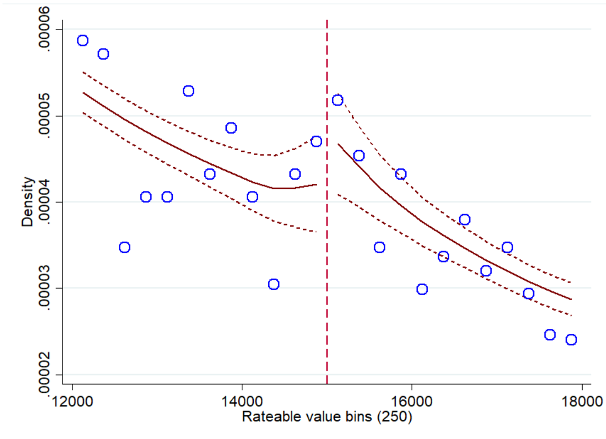
(d) McCrary test second kink - Vacancy sample



(e) McCrary test first kink - Rent sample



(f) McCrary test second kink - Rent sample



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

Table N.9: RKD results for SBRR - Specification without controls

Dep. Var.	ETR		D(Vacant)			Rent/RV	
Properties	Occupied by small business		All				
Sample	Small		Large		Small		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Bandwidth	3,000	2,500	3,000	2,500	2,500	3,000	2,500
Panel A: First Kink (£12,000)							
R*D(1kink)	0.134***	0.135***	0.011***	0.010***	0.014***	-0.046***	-0.043***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.011)	(0.012)
Observations	18,968	16,080	64,468	55,126	27,664	2,383	2,059
Panel B: Second Kink (£15,000)							
R * D(2Kink)	-0.158***		-0.009**	-0.007	-0.014**	0.035	0.017
	(0.005)		(0.004)	(0.004)	(0.006)	(0.021)	(0.019)
Observations	6,714		40,807	35,920	17,926	1,681	1,530

Notes: The table reports estimates of equation (13) (cols. (1) and (2)) and of equation (11) (cols. (3) to (7)) in panel A and of equation (14) (cols. (1)) and (12) (cols. (3) to (7)) in panel B. The dependent variable is the ETR of properties occupied by small businesses (cols. (1) and (2) for panel A) or of properties occupied by small and large business (cols. (1) for panel B), an indicator for the property being empty (cols. (3) to (5)) or the rent to rateable value ratio (cols. (6) and (7)). 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 (6) use a fixed bandwidth of £3,000 and all other columns a fixed bandwidth of £2,500 (except for column (1) in panel B which uses a bandwidth of £1,000). Cols. (1), (2) and (5) use the small sample, all other columns the large sample. Panel B col. (1) reports the estimate of ϕ_2 of equation (12) divided by the share of small businesses at the threshold (0.38) as described in section (4). Cols. (1) to (5) include no controls, and col. (6) and (7) include quarter-year and property type fixed effects. Robust standard errors are clustered at the local authority-rateable value bin (cols. (1) to (5)) or rateable value bin (cols. (6) and (7)) and local authority-property type level and are in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N.10: RKD for SBBR - Local regressions

	First Kink (£12,000			Second Kink (£15,000)		
Dep. Var.	ETR	D(Vacant)		ETR	D(Vacant)	
Properties	Occupied by small business	All		Occupied by small business	All	
Sample	Small	Large	Small	Small	Large	Small
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A1: Uniform kernel & Without local authority fixed effects						
Conventional	0.147***	0.007***	0.016*	-0.163***	-0.011***	-0.012
	(0.004)	(0.001)	(0.008)	(0.039)	(0.003)	(0.016)
Bias-corrected	0.152***	0.009***	0.013	-0.132***	-0.016***	-0.015
	(0.005)	(0.002)	(0.014)	(0.042)	(0.005)	(0.024)
Observations	5,374	122,349	16,951	5,147	43,588	9,090
Bandwidth	862	5,365	1,520	897	3,077	1,387
Panel A2: Uniform kernel & With local authority fixed effects						
Conventional	0.149***	0.012**	0.014**	-0.161***	-0.007	-0.005
	(0.007)	(0.005)	(0.007)	(0.037)	(0.016)	(0.022)
Bias-corrected	0.152***	0.014*	0.018*	-0.129***	0.001	-0.004
	(0.009)	(0.008)	(0.010)	(0.042)	(0.023)	(0.033)
Observations	3,878	38,888	19,494	5,148	14,920	7,433
Bandwidth	622	1,816	1,845	979	1,176	1,155
Panel B1: Triangular kernel & Without local authority fixed effects						
Conventional	0.154***	0.013***	0.016**	-0.168***	-0.007	-0.013
	(0.007)	(0.005)	(0.007)	(0.029)	(0.016)	(0.017)
Bias-corrected	0.161***	0.015*	0.020*	-0.155***	-0.005	-0.015
	(0.010)	(0.008)	(0.011)	(0.050)	(0.026)	(0.028)
Observation	3,880	45,626	22,913	6,718	18,265	10,883
Bandwidth	684	2,160	2,111	1,144	1,306	1,544
Panel B2: Triangular kernel & With local authority fixed effects						
Conventional	0.152***	0.014**	0.016**	-0.168***	-0.003	-0.009
	(0.007)	(0.005)	(0.007)	(0.029)	(0.015)	(0.016)
Bias-corrected	0.157***	0.016*	0.019*	-0.147***	0.003	-0.008
	(0.009)	(0.009)	(0.011)	(0.044)	(0.024)	(0.026)
Observation	5,373	44,215	22,235	6,731	18,266	10,884
Bandwidth	752	2,027	2,067	1,206	1,343	1,586

Notes: The table reports reduced form estimates using local linear regressions. The dependent variable is the ETR of properties occupied by small business (cols. (1) and (3)) or an indicator of the property being vacant (cols. (2), (3), (5) and (6)). Col. (3) reports the estimate of ϕ_2 of (12) divided by the share of small businesses at the threshold (0.38) as described in section (4). Each cell shows an RKD estimate with standard errors in parenthesis. The sample is in cols. (2) and (4) the large and in cols. 12), (3), (5) and (6) the small sample. Panel A1 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*). We do not report results for occupancy by type of business as we only observe the occupier type for properties with a rateable value up to £15,000. Thus, we would need to constrain the sample for the optimal bandwidth estimations resulting certainly in a non-optimal bandwidth estimation. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N.11: RKD for SBRR - Rent and ln rent as outcome

	First Kink (£12,000		Second Kink (£15,000)	
Dep. var.	Rent	ln Rent	Rent	ln Rent
	(1)	(2)	(3)	(4)
Panel A: Without local authority fixed effects				
R*D(1kink)	-615***	-0.060***		
	(109)	(0.007)		
R*D(2kink)			436	0.015
			(269)	(0.019)
Observations	2,383	2,383	1,681	1,681
Panel B: With local authority fixed effects				
R*D(1kink)	-538***	-0.056***		
	(165)	(0.011)		
R*D(2kink)			213	0.005
			(274)	(0.018)
Observations	2,382	2,382	1,676	1,676

Notes: The table reports reduced form estimates for SBRR. The dependent variable is in cols. (1) and (3) rent and in cols. (2) and (4) ln rent. All cols. use a fixed bandwidth of £2,500. Panel A reports the results when including only quarter-year fixed effects and panel B when including in addition 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 N.12: RKD for SBRR - Sensitivity checks on the sample

	First kink				Second kink	
Dep. Var.	ETR	D(Vacant)	D(Occ.) by small business	D(Occ.) by large business	ETR	D(Vacant)
Properties	Occ. by small business	All	All	All	Occ. by small business	All
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Without jurisdictions with not directly observed charge						
R*D(1kink)	0.137***	0.011***	-0.032***	0.021	-0.166***	-0.013*
	(0.003)	(0.003)	(0.009)	(0.011)	(0.003)	(0.006)
Observations	13,661	23,617	23,617	23,617	5,743	15,343
Panel B: Without jurisdictions with not directly observed vacancy						
R * D(2Kink)	0.135***	0.013***	-0.030***	0.016	-0.153***	-0.015**
	(0.003)	(0.003)	(0.009)	(0.010)	(0.003)	(0.006)
Observations	13,512	23,286	23,286	23,286	5,726	15,206

Notes: The table reports reduced form estimates for SBRR excluding jurisdictions for which a particular variable is not directly observed. The dependent variable is the ETR of properties occupied by small business (cols. (1) and (4)), an indicator of the property being vacant (cols. (2) and (5)), or an indicator variable for the property being occupied by a small business (col. (3)) or large business col. ((4)) or Col. (4) reports the estimate of ϕ_2 of (12) divided by the share of small businesses at the threshold (0.38) as described in section (4). All cols. use a fixed bandwidth of £2,500 and the small sample. Panel A reports the results when excluding jurisdictions for which the vacancy is not directly observed and panel B reports the results when excluding jurisdictions for which the charge is not directly observed. 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 N.13: RKD results for SBRR - Heterogeneity analysis

	First kink				Second kink	
Dep. Var.	ETR	D(Vacant)	D(Occ.) by small business	D(Occ.) by large business	ETR	D(Vacant)
Properties	Occ. by small business	All	All	All	Occ. by small business	All
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Retail/hospitality properties						
R * D(Kink)	0.121*** (0.005)	0.017*** (0.005)	-0.057*** (0.013)	0.040*** (0.013)	-0.166*** (0.034)	-0.019** (0.008)
Observations	8,105	12,516	12,516	12,516	3,291	7,933
Panel B: Jurisdictions inside London						
R * D(Kink)	0.131*** (0.010)	0.012 (0.009)	-0.038*** (0.013)	0.026** (0.011)	-0.209*** (0.059)	-0.046*** (0.013)
Observations	2,865	4,334	4,334	4,334	994	2,772
Panel C: Jurisdictions outside London						
R * D(Kink)	0.136*** (0.002)	0.014*** (0.003)	-0.034*** (0.009)	0.020* (0.011)	-0.164*** (0.003)	-0.008 (0.005)
Observations	13,215	23,330	23,330	23,330	5,720	15,154

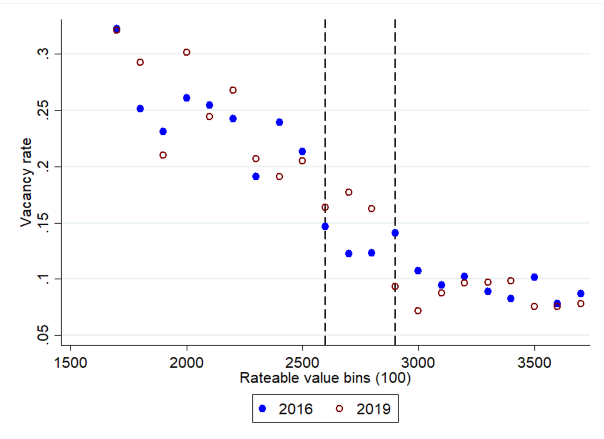
Notes: The table reports reduced form results for impact heterogeneity of SBRR. Panel A shows the results for retail/hospitality properties and panel B (C) for jurisdictions in (outside of) London. The dependent variable is the ETR of properties occupied by small business (cols. (1) and (5)), an indicator of the property being vacant (cols. (2) and (6)) or occupied by a small (col. (3)) or large (col. (4)) business. 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, use the small sample and include local authority fixed effects. 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 0.091 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 (except for the second kink inside of London) based on a bandwidth of £2,000. The vacancy rate in (outside of) London is 0.112 (0.097). 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.

N.4 Additional empirical results - comparison before and after the revaluation

In this appendix section, we present tables and figures for comparing the empirical results using data before the 2017 revaluation and after the 2017 revaluation, for empty relief and SBRR. The sample available before the revaluation in 2017 is much smaller and includes only 10 jurisdictions. We start with the additional results for the empty relief and then turn to the additional results for SBRR.

Before the revaluation in 2017, the threshold that applied for the empty property exemption was £2,600. After the revaluation it increased to £2,900. The threshold increase implies that properties with rateable values between £2,600-£2,900 become eligible for the empty property exemption after revaluation in 2017. Figure N.5 plots the vacancy rate by rateable values in 2016/2017 and 2018/2019 for the sample of jurisdictions included, and we find a discontinuous drop in vacancy rate at the £2,600 threshold using the 2016 data. We also present the estimates on the same sub-sample in the figure, and the discontinuity is similar to that at the £2,900 threshold in 2019.

Figure N.5: Graphical evidence for empty property exemption: Comparison before (2016/2017, threshold of £2,600) and after revaluation (2018/2019, threshold of £2,900)



Note: The graph plots the aveage vacancy rate before the revaluation (2016/2017) and after the revaluation (2018/2019) using the same set of jurisdictions. These include Barking and Dagenham, Barnsley, Bedford, Bexley, Blackburn with Darwen, Darlington, Isle of Wight, Rochdale, 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 -0.06 (0.04) and after the revaluation -0.00 (0.04).

Table N.14 presents the estimates of equation (4) and (5) with 2016/2017 data (using £2,600 as the threshold), and separately with the 2018/2019 data for the same set of jurisdictions (using £2,900 as the threshold). We find very similar effects for before and after the revaluation and with respect to our baseline results.

Table N.14: RDD results for empty property exemption - before and after the revaluation

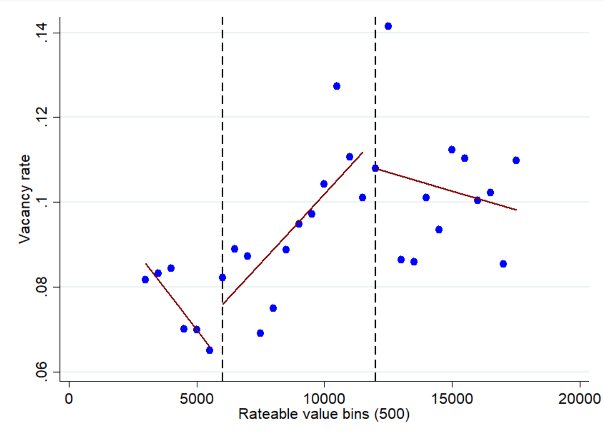
Dep. Var.	D(Vacant)					
Properties	All					
Sample	Before revaluation			After revaluation		
Threshold	£2,600			£2,900		
Bandwidth	Optimal	500	1.75-3.75	Optimal	500	1.75-3.75
	(1)	(2)	(3)	(4)	(5)	(6)
D(RV≥2.6k)	-0.059*	-0.058*	-0.068***			-0.017
	(0.033)	(0.033)	(0.023)			(0.026)
D(RV≥2.9k)			0.013	-0.072***	-0.066***	-0.069**
			(0.028)	(0.022)	(0.021)	(0.027)
Observations	4,485	4,816	9,370	4,101	4,837	9,295

Notes: The table reports reduced form estimates for empty property exemption for before and after revaluation using the same set of jurisdictions. These include Barking and Dagenham, Barnsley, Bedford, Bexley, Blackburn with Darwen, Darlington, Isle of Wight, Rochdale, 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. 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.

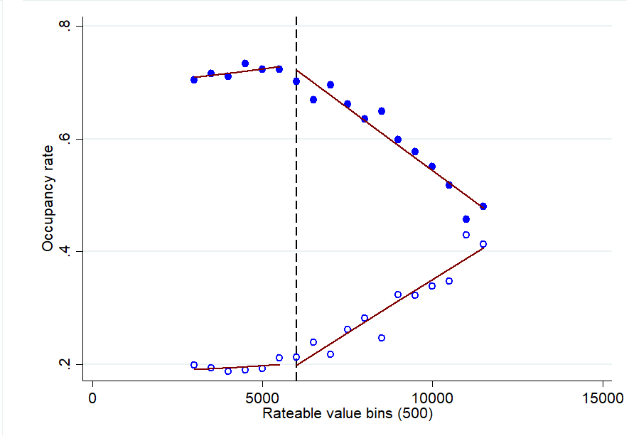
We turn now to the comparison before and after the revaluation for the SBRR results. Before the revaluation in 2017, the SBRR kinks are statutorily at £6,000 (when SBRR start to apply) and £12,000 (above which SBRR do not apply). Figure N.6 plots the vacancy rate by rateable value with data from 2016/2017 for jurisdictions for which the data is available. We find graphical evidence that the vacancy rate exhibit kinks at £6,000 and £12,000 (while the set of jurisdictions with the data available is small), similar to our baseline results. In addition, for this sub-sample of jurisdiction in 2018/2019, we obtain results very similar to our baseline results.

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

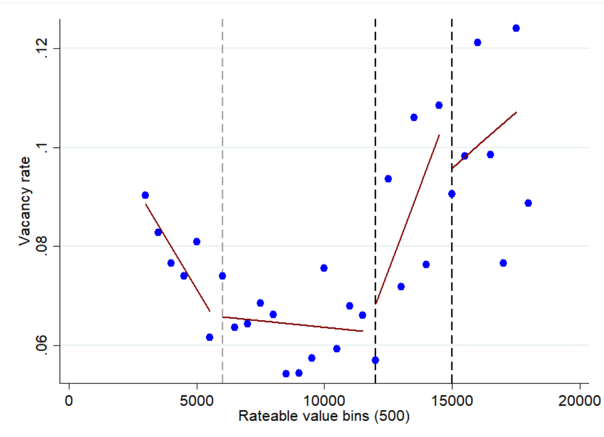
(a) Vacancy rate before revaluation, kinks at £6,000 and £12,000



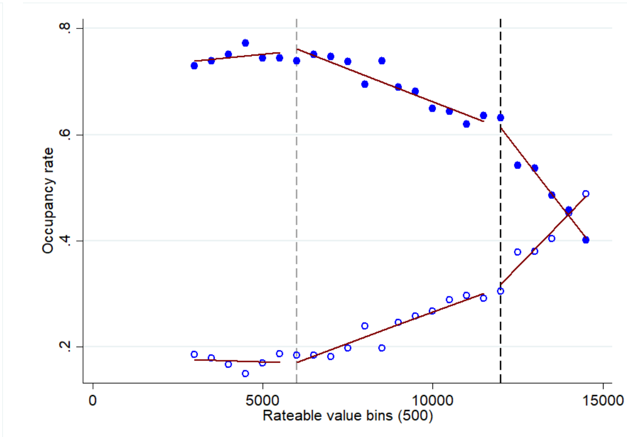
(b) Occupancy by type of business before revaluation, kinks at £12,000 and £15,000



(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, Barking and Dagenham, Darlington, Isle of Wight, 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 -0.04 (0.04) and 0.03 (0.06) and after the revaluation -0.06 (0.06) and 0.11 (0.08). No change in the slope of the rateable value distribution is indicated for the first kink before the revaluation and for the second kink after the revaluation. The test for change in the slope of the rateable value distribution for the second kink before the revaluation and for the first kink after the revaluation are marginally significant.

Table N.15 reports the RKD estimates for the change in slope at £6,000 and £12,000 in 2016, and we find similar evidence as our baseline results. In addition, the table shows that this sub-sample of jurisdiction, in 2019, give similar results to our baseline estimates. 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. Before the revaluation in 2016/2017, the relief phases out over £6,000 (from £6,000 to £12,000) instead of over £3,000 (from £12,000 to £15,000), we expect the slope change for the ETR at both the lower and upper kink to be half the size of our baseline estimates after the revaluation. The point estimates for 2019 (panel B) are twice as large as for 2016 (panel A) - except for the second kink. Thus the results are largely in line with our baseline results.

Table N.15: 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)	0.006	-0.030***	0.024***	
	(0.004)	(0.004)	(0.003)	
R * D(2Kink)				-0.013
				(0.009)
Observations	14,724	14,724	14,724	5,845
Panel B: After the revaluation, Kinks at £12,000 and £15,000				
R * D(1Kink)	0.011*	-0.062***	0.051***	
	(0.006)	(0.006)	(0.005)	
R * D(2Kink)				-0.013*
				(0.007)
Observations	6,271	6,271	6,271	4,064

Notes: The table reports reduced form results for the SBRR for before and after the revaluation using the same set of jurisdictions. These include These are Barnsley, Bedford, Bexley, Darlington, Isle of Wight, Rochdale, 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 £3,000. 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.

N.5 Data appendix

N.5.1 Business rates data and sample description

We construct our data sample from business rates data published by councils on their websites. In addition, we supplement it with publicly available data from the online archive of Freedom-of-Information requests previously made by the public (www.whatdotheyknow.com).[54]

While a large number of councils publish information on business rates, the information in the data could be slightly different by each council, for example, data for some councils do not include information on occupation status, property type, or on sole proprietors. To avoid a selection bias, we first compare the number of properties in the dataset provided by the local authority, with the number of properties that are subject to business rates in the local jurisdiction from ONS statistics (Non-domestic rating: stock of properties, ONS). We include only jurisdiction-quarters in our data for which at least 90% of the properties are observed in a jurisdiction *and* the property type is observed for at least 90% of the properties.[55]

Overall, there are 72 jurisdictions and 118 jurisdiction-quarters in our sample. While the included jurisdictions are somewhat larger in terms of population compared to the average jurisdiction in England, little differences exists in terms of the level of local economic activity (see Table N.16).

Due to different data requirements for the analysis of empty exemption, retail relief, and SBRR, the jurisdiction-quarters included in the subsamples differ. For the empty property exemption, we use the latest available quarter of a jurisdiction that includes the tax charge information. For the retail relief, we use - if possible - the same (either the second or third) quarter for 2018 and 2019. If both quarters are available, we use the second quarter since the retail relief was introduced at the end of the first quarter in 2019 - unless only the third quarter includes the tax charge information or this would mean comparing different quarters. We exclude the fourth quarter of 2018 and the first quarter of 2019 as the retail relief was announced at the beginning of the fourth quarter of 2018. For the SBRR, we use the latest available quarter of a jurisdiction that includes relief information. Table N.17 shows the list of the jurisdiction-quarters included in the different subsamples.

For some jurisdiction-quarters, one or more key variables are not directly observed but inferred or imputed. For 9 jurisdiction-quarters (7 jurisdictions), the tax charge is not directly observed - we calculate the tax charge using the gross charge and relief and exemption information (i.e. net tax charge = gross charge - relief and exemption). For 23 jurisdiction-quarters (13 jurisdictions), the occupation status is not directly observed but inferred from the relief and exemption information.[56] For 13 jurisdiction-quarters (9 jurisdictions), the property type is not directly observed, and we impute it with data of the same property in previous or later quarters. Lastly, for 9 jurisdiction-quarters (6 jurisdictions) the rateable value is not directly observed, we either i) infer it from the gross charge and the multiplier (for 3 jurisdictions), or ii) impute it using the rateable value of the same property in previous or later quarters (for 3 jurisdictions).

N.5.2 Matching of the rent data with the business rates data

We match the commercial property listing data from Rightmove with the business rates data from local authorities described in Section 5 and Appendix N.5, by address and property type. In the overall matched sample, 75% are exact matches by address and 24% are uniquely matched based on postcode and property type. In addition, we manually matched retail and hospitality properties with a rateable value between £40,000-£60,000 for the retail relief sample, constituting

[54] Savage and Hyde (2014) provide in-depth discussion on the usefulness of data available from Freedom-of-Information in social science research.

[55] 67 of the 72 included jurisdictions have a coverage above 95%.

[56] The tax rate for empty properties, when not exempted under one of the empty property exemptions, is the standard multiplier that usually applied above £51,000. Thus, for jurisdictions that include the rate information and the exemptions, empty properties can be identified.

Table N.16: Descriptive statistics for jurisdictions included in the vacancy sample

Sample (# jurisdictions)	All jurisdictions (326)		Empty exemptions (38)		Retail relief (35)		SBRR (63)	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Residents								
Population in thsd	163	125	204	195	216	159	214	190
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	7,989	6,440	7,508	6,440
Number per 1,000 pop	46	35	36	34	36	35	35	34
Floor space	1,705	1,303	2,095	1,598	2,263	1,603	2,225	1,771
Floor space per 1,000 pop	13	10	10	9	11	10	10	11
Labor market								
Employment in thsd	83	62	98	88	107	88	100	86
Jobseeker per 1,000 pop	5	4	6	4	6	4	6	5
Wages (gross)	29,505	28,757	29,363	28,456	28,927	28,789	29,528	28,929
Firms								
# local units	8,401	6,523	9,863	9,540	10,357	8,805	9,869	8,770
# local units per 1,000 pop	64	51	50	48	50	48	48	46
# enterprises	7,242	5,468	8,391	8,205	8,809	7,045	8,391	7,045
# enterprises per 1,000 pop	55	44	43	42	42	42	41	40
Share of local units with ... in %								
0-4 employees	72	72	71	73	70	70	71	71
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	78	78	78
5-9 employees	11	11	11	11	12	11	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	7	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 vacancy sample, cols. (5) and (6) the jurisdictions included in the retail relief vacancy sample and cols. (7) and (8) the jurisdictions included in the SBRR vacancy sample. Data on residents, labor market and firms are from ONS local authority level data.

about 1% of the final sample.

The Rightmove data contains information on the period each listing was active on the platform. We assume that rateable values do not change between 2018-2019 (as rateable values normally do not change outside of re-valuation periods), and use the latest quarter-year for each jurisdiction available in the business rate data for the matching, regardless of the active period for the listing.

Our date variable, for the definition of variables described in Section 4 with subscript t, is based on the first listing date. For the rent variable, we use the first listing price, unless i) only the last listing price is observed, or ii) using the first listing prices gives an unreasonable rent to rateable value ratio. Typically the rent is given per month on Rightmove, and in some cases, it is given per week or per year on the Rightmove website. Since we do not observe in the data whether the rent is per month, week or year, we assume a monthly rent unless this leads to an unreasonable rent to rateable value ratio. In these cases, we assumed either the rent is per week or per year. Since the rateable value is the tax base for a whole year, we convert the rent for each property into an annual rent. Thus, rent to rateable value measures the annual rent to the annual business rate tax base.

To increase the number of properties in the retail relief sample, for the matching of retail properties with a rateable value above £31,000, we use also business rate data from jurisdictions that do not publish the data for individual rate payers.[57] While individual rate payers are important for properties with a rateable value in the range of the empty exemption (around £2,900) and the SBRR (around £12,000 and £15,000), this is not the case for properties with a rateable value in the range of the retail relief (around £51,000). Based on data from jurisdictions that redact only the names of individual ratepayers, we find that only around 6% of retail properties with a rateable value between £41,000 and £61,000 belong to individual ratepayers. In addition, there is no difference in the share of individual rate payers below and above the threshold for the retail relief.

Despite the exact address and/or postcode and property type matching, we observe measurement error in the rent to rateable value ratio. Upon careful examination of some examples, the measurement error arises either (i) as the listing rent includes components of secondary properties in addition to that for the primary address of the listing or ii) as the listing rent is covering only part of the property that was used to estimate the rateable value by the VOA. As both of these cases result in outliers in terms of rent to rateable value ratio, we drop observations with rent to rateable value ratio in the top and bottom 5% of the distribution.

The jurisdictions included in the rent sub-samples are shown in Table N.17. Descriptive statistics for the rent-subsamples are reported in Table N.18. As in the vacancy sub-samples, there are more industrial, retail and hospitality properties and fewer offices in the SBRR sample compared to the empty exemption sample. The average rent in the listings is above the average rateable value. This is plausible as the rateable value proxies the rent in 2015, while the listing data covers 2018-2019, reflecting the general trend in rent.

[57]Due to this, the final retail relief rent sub-sample includes also properties in the following (8) jurisdictions: Barnet, Lambeth, Leeds, Plymouth, Stockport, Tameside, Tower Hamlets, and Waltham Forest.

Table N.17: Data source by council

Council	Source	ER		RR			SBRR	
		Vacancy	Rent	Vacancy		Rent	Vacancy	Rent
Ashford	2		X	18Q2	19Q3			X
Barking and Dagenham	1		X			X	19Q3	X
Barnsley	1		X	18Q3[c]	19Q3		19Q3	X
Bath and North East Somerset	2		X					X
Bedford	1		X	18Q2	19Q2		19Q3	X
Bexley	1	19Q2	X	18Q2	19Q2		19Q2	X
Birmingham	2		X	18Q2[b]	19Q2[b]	X	19Q2[b]	X
Blackburn with Darwen	2	18Q4[b]	X	18Q3[b]	19Q3[b,c]		19Q3[b,c]	X
Blackpool	2	19Q3[a]	X				19Q3[a]	X
Bolsover	1	19Q3	X					X
Bolton	2		X			X		X
Bournemouth	1		X			X	19Q3	X
Bracknell Forest	2							X
Bradford	1	19Q3	X				19Q3	X
Brent	2							X
Brighton and Hove	1	19Q3	X	18Q3	19Q3	X	19Q3	X
Bury			X					X
Calderdale	1		X	18Q2	19Q2		19Q2	X
Cambridge	1							X
Camden	1		X			X		X
Canterbury	1		X			X		X
Central Bedfordshire	1	19Q3	X	18Q3	19Q3		19Q3	X
Chelmsford	1	19Q3	X	18Q2	19Q2	X	19Q3	X
Cheltenham	1		X				19Q3	X
Cheshire East	1		X			X	19Q3	X
Cheshire West and Chester	1	19Q3	X	18Q3	19Q3	X	19Q3	X
Copeland	1	19Q1	X				19Q1	X

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Table N.17 – *Continued from previous page*

	Source	ER		RR			SBRR	
		Vacancy	Rent	Vacancy		Rent	Vacancy	Rent
Cornwall	2		X			X		X
Croydon	1						19Q3	X
Dacorum	2							X
Darlington	2		X	18Q2[b]	19Q2[b]		19Q2[b]	X
Dudley	1		X				19Q2	X
East Cambridgeshire	2	19Q2	X				19Q2	X
East Hampshire	1	19Q3[a]	X	18Q2	19Q2[a]		19Q3[a]	X
East Riding of Yorkshire	1		X					X
Erewash	1		X					X
Gateshead	1	19Q3[a]	X				19Q3[a]	X
Gloucester	1		X	18Q3	19Q3		19Q3	X
Greenwich	1	19Q3	X				19Q3	X
Haringey	1	19Q3[b]	X			X	19Q3[b]	X
Harrow	1		X			X		X
Hastings	2		X					X
Herefordshire	1		X					X
Hounslow	2	19Q3[c]		18Q2[c]	19Q3[c]		19Q3[c]	X
Isle of Wight	1	19Q3[a,b]	X	18Q3[a,b]	19Q3[a,b]		19Q3[a,b]	X
Kensington and Chelsea	2	19Q2[c]		18Q2	19Q2[c]	X		X
Kingston upon Hull, City of	1	19Q2[b]	X	18Q2[a,b,d]	19Q2[b]		19Q2[b]	X
Kingston upon Thames	1	19Q1[c]	X					X
Kirkless	2		X			X		X
Leicester	1		X			X		X
Lewisham	2		X				19Q3	X
Lincoln	1		X	18Q2[c,d]	19Q2[c]		19Q2[c]	X
Liverpool	2		X	18Q2	19Q2			X
Luton	2		X					X
Maldon	1		X	18Q2[d]	19Q2[d]		19Q3[c]	X
Newcastle upon Tyne	1	19Q3	X				19Q3	X

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Table N.17 – *Continued from previous page*

	Source	ER		RR			SBRR	
		Vacancy	Rent	Vacancy		Rent	Vacancy	Rent
North Dorset	1		X				18Q2	X
North Kesteven	2		X					X
North Somerset	1	19Q3	X	18Q2	19Q2		19Q3	X
North Tyneside	1		X			X		X
Northumberland	1	19Q3[b]	X	18Q3[b]	19Q3[b]		19Q3[b]	X
Nottingham	1	19Q1	X			X	19Q1	X
Oadby and Wigston	2	19Q3	X	18Q2	19Q2		19Q3	X
Oldham	1		X					X
Oxford	1							X
Peterborough	1						19Q3	X
Portsmouth	1		X				19Q3	X
Preston	1		X				19Q3	X
Reading	1		X			X	19Q3	X
Redbridge	1						19Q3[b]	X
Redcare and Cleveland	2		X			X		X
Rochdale	2		X			X	18Q2	X
Rotherham	1	19Q3	X				19Q3	X
Rutland	1	19Q3	X				19Q3	X
Salford	1		X				19Q2[b]	X
Sandwell	1		X					X
Slough	1						19Q3	X
Solihull	2		X					X
South Gloucestershire	1	19Q3[b]	X					X
South Lakeland	3	19Q2	X				19Q2	X
South Staffordshire	2	19Q3	X	18Q2	19Q2[c,d]			X
South Tyneside	2		X	18Q2[c,d]	19Q2[c,d]			X
Southampton	1		X	18Q2	19Q2	X	19Q2	X
Southend-on-Sea	1	18Q2	X			X		X
Southwark	2		X			X		X

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Table N.17 – *Continued from previous page*

	Source	ER		RR			SBRR	
		Vacancy	Rent	Vacancy		Rent	Vacancy	Rent
St. Helens	1		X				19Q2	X
Sutton	1	19Q3^a	X				19Q3^a	X
Swale	2		X					X
Swindon	2		X					X
Telford and Wrekin	1		X					X
Thurrock	1	19Q3					19Q3	X
Tonbridge and Malling	2		X	18Q3	19Q3		19Q3	X
Torridge	1		X					X
Tunbridge Wells	1						19Q3	X
Wakefield	1	18Q2	X				18Q2	X
Walsall	1		X	18Q3^b	19Q3^b	X	19Q3^b	X
Warrington	1	19Q3	X	18Q2	19Q2		19Q3	X
Warwick	2	19Q2^a	X	18Q2	19Q2		19Q2^a	X
West Berkshire	2							X
West Lancashire	2		X	18Q2^b	19Q2^b		18Q2^b	X
Wiltshire	1	19Q3	X	18Q2^{c,d}	19Q2^{c,d}	X	19Q3	X
Winchester	1		X	18Q2^b	19Q2^b	X	19Q2^b	X
Wokingham	1							X
Wolverhampton	1		X					X
Worcester	1		X	18Q2	19Q2	X	19Q3	X

Notes: The table reports the jurisdictions and jurisdiction-quarters included in the vacancy and rent analysis of empty property exemption (ER), retail relief (RR) and SBRR and the source of the data for the local authority. Source of data: 1 represents data published on council websites, 2 represent data available from the online archive of Freedom-of-Information previously made by public on/through the archive. 19Q2 stands for 2019 second quarter. Subscript a denotes jurisdiction-quarters for which the tax charge is not directly observed but calculated using the gross charge and relief and exemption information. Subscript b denotes jurisdiction-quarters for which the vacancy is not directly observed but inferred from relief and exemption information. Subscript c denotes jurisdiction-quarters for which the property type is not directly observed but imputed using previous or following quarters, and subscript d denotes jurisdiction-quarters for which the rateable value is not directly observed but either calculated using the gross charge and the multiplier or the imputed using previous or following quarters.

Table N.18: Descriptive statistics - Rent sample

Rateable values (£1,000)	All	Empty exemption 1.9-3.9	Retail relief 41-61	Small business rate relief 9-18
# of observations	11,030	818	249	3,232
# of counties	104	89	36	104
# of counties in London	15	10	10	15
Average rateable value	27,352	3,001	48,947	12,850
Median rateable value	11,750	3,153	47,500	12,500
Mean rent	32,720	4,944	53,161	16,580
Median rent	15,000	4,968	50,004	15,600
Mean rent to rateable value	1.33	1.61	1.09	1.30
Median rent to rateable value	1.28	1.60	1.04	1.25
Share of properties				
Office	0.27	0.31	0	0.24
Shop/Hospitality	0.51	0.52	1	0.55
Warehouse/Factory	0.22	0.17	0	0.20

Notes: The table shows the summary statistics for the full rent sample (col. (1)), the empty property exemption rent sample (col. (2)), the retail relief rent sample (cols. (3)) and the small business retail relief rent sample (cols. (4)).