Tax and Occupancy of Business Properties: Evidence from UK Business Rate Reliefs*

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Abstract

We study the impact of reliefs on 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 two major reliefs in the UK system: small business rate relief (SBRR) and retail relief (RR). We estimate that RR reduces retail vacancies by 80%, and SBRR increases the small business occupancy rate by up to 51%, and reduces vacancies by up to 31%. We show that a given monetary expenditure on relief per property will lead to a much bigger reduction in vacancies if given via RR, because SBRR is targeted only at small businesses. However, SBRR is equally as effective in increasing the occupancy rate of small businesses as RR is at reducing retail vacancies. SBRR has a bigger effect in clusters of urban properties (the "High St."), and both reliefs are more effective in reducing retail vacancies in less deprived areas. So, while the reliefs are highly effective at achieving their objectives nationally, they may be less effective at reducing regional inequality.

Keywords: Commercial Property, Vacancy, Occupancy, Property Taxation
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1 Introduction

For some time, occupancy rates of commercial 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. 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, while at the same time, real retail rent per square meter has fallen from £155 to £134.[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 commercial property taxes, that might alleviate these problems.

Perhaps as a result of these concerns, some countries have introduced relief schemes to reduce the burden of commercial property taxes. One very common one is exemption from tax for properties occupied by charities, used in both the UK and US.[3] Also in the US, state-level temporary relief from commercial property taxes is widely used to attract inward investment (Dalehite, Mikesell and Zorn, 2005). More generally, a number of countries, including US, UK, and France, have enterprise zones, where exemption is given on a variety of business taxes, including the property tax (Neumark and Simpson, 2015).

However, in spite of the widespread use of reliefs, there is very little empirical evidence on their effectiveness. In this paper, we present evidence on the impact of two important UK reliefs, the small business rate relief (SBRR), and retail relief (RR) on commercial vacancies and rents. These have both been introduced in recent years; RR was explicitly designed to increase the vitality of the UK "High St." via increasing occupancy rates, and SBRR was designed to support small businesses.[4] We use a new hand-collected data-set, and the non-linearity of the property tax schedule, to identify the causal effect of the tax on vacancy rates and rents. Using difference-in-discontinuity and regression kink designs, we show that these reliefs significantly reduce vacancy rates, and also, in the case of the

[1] Figure N1 in the Appendix shows the time series for retail vacancies and rents from 2014 to 2022.

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

[3] Charity relief was introduced in 1988 in the UK. It is a mandatory 80% property tax relief on properties occupied by charities, with an additional discretionary relief of up to 20%.

[4] When retail relief was introduced, the Finance Minister 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).

SBRR, change the mix of businesses occupying properties.[5]

Specifically, defining the effective tax rate (ETR) as the amount of business rate divided by the rateable value of the property (which estimates the open market rental value in April 2015), we find that a one p.p. reduction in the ETR due to RR reduces the vacancy rate by 0.52 p.p., which is a reduction of 5%. As the RR gives a substantial rate reduction of about of one-third (about 16 p.p. of rateable value), our estimates imply that the tax reduction given by RR reduces the vacancy rate of retail properties by around 80%. This is a large decrease, but at the same time, the average cost per property of RR is large, at around £1,640 per property in our sample.

As for SBRR, this policy was designed to reduce 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.[6] This is exactly what we find: a one p.p. reduction in the tax rate from the SBRR increases the probability that a small business occupies the property by 0.37 p.p., which is an increase of 1.06%. The maximum tax reduction due to SBRR is around 48 p.p., this implies an increase in small business occupancy of about 51%.

However, SBRR also decreases the occupancy of eligible properties by large businesses. So, overall, there is a small but significant negative effect of the SBRR on the vacancy rate of qualifying properties: a one p.p. reduction in the ETR due to SBRR reduces the vacancy rate by 0.64% (0.066 p.p.). So, our estimates imply that SBRR reduces the vacancy rate of properties that qualified for full relief by 31% (3.2 p.p.) compared with no relief.

A final observation is that the monetary cost per property of reducing the ETR on a business via RR and SBRR are generally not going to be the same, as the reliefs have different bases. Using our data and estimates, in Section 7, we show that a given monetary increase in the relief per property enables a reduction in the ETR via SBRR that is around 40% larger than the reduction in the ETR achievable via RR.[7] This implies that SBRR and RR are roughly equally effective in achieving their stated objectives i.e. increasing small business occupancy and reducing retail vacancies respectively. Using these results, in Section 7 we also conduct a basic cost-benefit analysis of the effects of increasing reliefs. The net benefits of doing this are uniformly negative, reflecting the fact that although

[5] Other, more minor reliefs include empty property relief; the full list is available at https://www.gov.uk/apply-for-business-rate-relief. We do not study these reliefs in this paper, as they only affect a relatively small number of properties and are not specifically designed to reduce vacancy rates.

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

[7] From Table 8, 3.38/2.44=1.39.

both reliefs are effective, they are also expensive. However, a caveat is that we use market rent to measure the social benefit of filling a vacancy, and thus do not account for any positive external effects of filling vacancies - these might be considerable in retail clusters.

We also study the heterogenous effects of SBRR and RR in a number of ways. First, we split the sample according to whether the property is in a "retail cluster" (known in the UK as a "High Street") or not, by using a recent data-set compiled by the UK's Office of National Statistics.[8] 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 evidence that SBRR is more effective in both boosting small business occupancy rates and reducing vacancy rates on the High St., possibly due to positive spillovers from occupancy for smaller businesses in a cluster e.g. greater footfall. We find that RR, while effective overall, does not seem to have been more effective for High Street properties than others.

We also study whether the reliefs are more effective in deprived areas, where the quality of life arguments are thought to be more important. The results here are mixed. Looking only at retail properties, the reliefs are more likely to achieve their stated objectives (reduction in vacancies and increasing small business occupancy for RR and SBRR respectively) in less deprived areas. Offsetting this, SBRR appears to have a bigger impact on the vacancy rate of all properties in more deprived areas. So, while we find that these reliefs are highly effective at achieving their objectives at the aggregate level, they may be less effective at reducing regional inequality.

Finally, we examine the incidence of the two reliefs on rents. Our estimates suggest that a £1 reduction in the business rates tax from the RR results in £0.7-£1 increase in the rent. For the SBRR, we find that an £1 reduction in the tax for small businesses increases the rent by £0.15-£0.32. This range of the estimates is quite large, but we do not expect them to be the same. Specifically, only the incidence figure for the RR corresponds to arguably the most common concept of incidence, as RR lowers the tax faced by *all* occupiers. The SBRR, in contrast, reduces the tax faced by only *one* type of occupier, namely small business, and we calculate the implied pass-through of tax to rent is about 0.43-0.56.

Related Literature. Our results contribute to a small literature on the effects of commercial property taxes on business activity levels. For the UK, using a spatial identification approach, Duranton, Gobillon and Overman (2011) find that commercial property

[8]The ONS 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).

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 study 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). Finally, Moszkowski and Stackman (2023) use a calibrated model to analyse the effect of a possible tax on vacant commercial property in Manhattan.

Our results also contribute to the literature on the incidence of property taxes on rents. Nearly all the empirical and theoretical work in this area has been done on residential property (England, 2016). There is a very small literature on the incidence of commercial property taxes, and most of this is on property sale prices, not rents. In particular, we are only aware of one earlier study for the UK, Bond et al. (1996), who exploit a harmonization of business tax rates across local authorities in the England in 1990. They find that two years after harmonization, between 45% and 85% of the change in business rates is incident upon rents, depending on geographical area. Our empirical method is quite different to theirs, but we find estimates that also vary considerably, not by geographical area but by type of relief.[10]

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.[11]

In the UK, about 55 percent (in terms of value) of commercial property is rented

[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 commercial property taxes in the UK is via discontinuities and kinks in the national tax schedule, as we do here.

[10]We are also aware of only one study for the US, McDonald (1993), which finds, in the context of Chicago real estate, that 45% of commercial property taxes are passed on to rents.

[11]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).

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 fifteen years (McCluskey et al., 2016).[12]

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.[13] 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 annual open market rental value of the property at a nominal date, currently on 1 April 2021; this rental value is estimated by the Valuation Office Agency (VOA), part of the UK government.[14]

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 N1 in the Appendix.

Businesses, property owners and renters also receive various types of relief, which totalled around £5 billion in 2019/2020 or 16% of gross revenue (UK Ministry of Housing and Governments, 2021).The features of the two reliefs studied in this paper are summarised in Table 1 below. First, there is RR, which is specifically targeted at retail

[12] 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.

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

[14] 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 2023. The VOA uses rental comparison method for most commercial properties - comparing one property with other similar properties to determine a rental value per meter squared on a same specified date for all properties. It contacts a relatively large number of the rate payers (around 1 million) to collect the rent and lease information, e.g. through letter communication. When there is little rental information regarding a property, the VOA uses the receipt and expenditure of a business to compute a "reasonable" rent for the rateable value (e.g. for hotels, cinemas and self-catering accommodation). (VOA, 2023*a*; 2023*b*)

property that has a rateable value below £51,000; for these properties, the amount of business tax payable is reduced by one-third. Granting the relief is at discretion of the local authority but as the costs are born by the national government, local authorities have an incentive to grant the relief, and in fact, all local authorities in our sample do offer this relief. Second, SBRR is targeted at businesses which use only one property with a rateable value of less than £15,000. It is a mandatory relief.[15]

So, to give a numerical example, a property with a rateable value of £30,000 in 2018/19 would have a business rate liability of £30,000 times the small business multiplier, which from Table N1, was 0.48, giving a liability of £14,400. If the property was a retail one, that would be reduced by one-third, down to £9,600. As this example shows, the tax liability as a fraction of rateable value (i.e. the ETR), is high, even with the relief. An offsetting factor is that the rateable value is generally lower than the actual rent that a business will pay, due to infrequent revaluations, so the tax paid as a percentage of the actual rent on the property is therefore less than the ETR.[16]

In Figure 1 below, we show the tax schedules implied by the rules in Table 1 for properties that are occupied by businesses. Panel (a) shows the tax liability as a function of rateable value for firms not eligible for any relief, firms eligible for either RR, SBRR, or both, and Panel (b) shows the ETR.

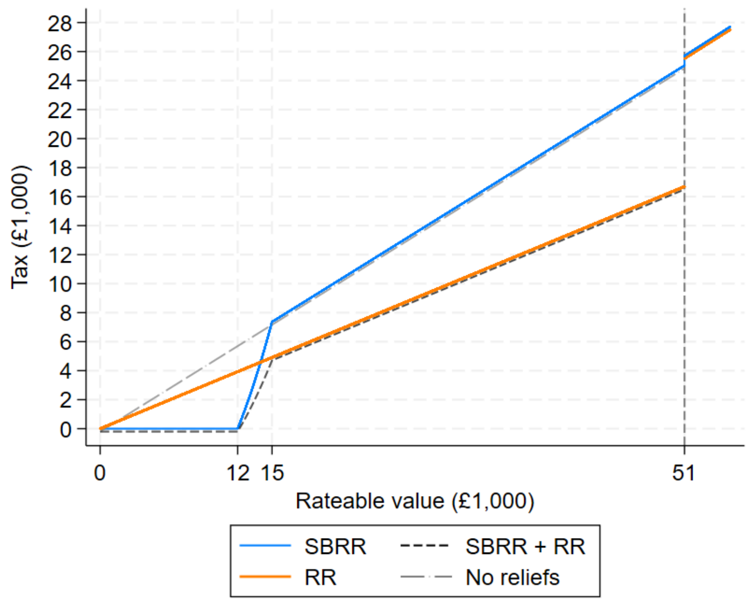
In Figure 1, we can note the following. For a business not eligible for either relief i.e. a large firm not in the retail sector, note that from Table 1, there is a small discontinuity (notch) in the standard business rate at £51K. For a firm eligible for RR only, there is a large notch in the schedule at £51,000; the tax liability jumps by a little over 1/3. For a firm eligible for just SBRR, there are kinks in the tax schedule at £12,000 and £15,000. Finally, the schedule for a business with both SBRR and RR has the same qualitative features as for a firm with just SBRR for rateable values below £51,000, and then additionally there is a large notch in the schedule at £51,000. In what follows, our empirical strategy is to use these notches and kinks to identify the causal effects of reliefs on vacancies.

[15] SBRR accounts for around 40% and RR for around 10% of total relief costs. The third most important relief (accounting also for around 40% of total relief costs) relates to charities. It is a mandatory relief of 80% and an additional voluntary relief of up to 20% for charities as occupier.

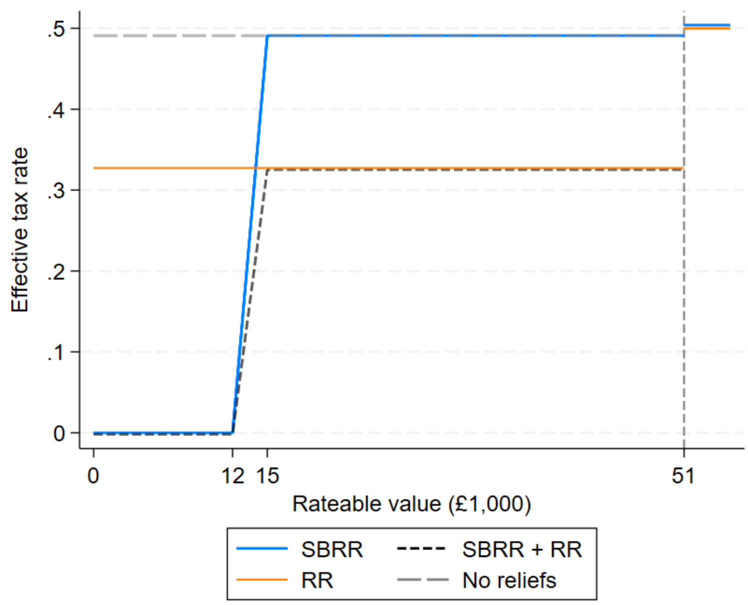
[16] For the sample where we have rent data, the ratio of actual rent paid to rateable value is 1.33. This means that if the business is paying the full standard rate of 49%, on average, the ratio of tax paid to rent actually paid is 0.49/1.33, i.e. 37%.

Figure 1: Tax Schedules for occupied properties, with and without relief

(a) Tax liability



(b) ETR



Note: Panel (a) shows the tax liability as a function of rateable value for firms not eligible for any relief (grey dashed line), firms eligible for either RR (orange line), SBRR (blue line), or both (dark dash line). Note that there is a small discontinuity (notch) in the standard business rates at £51K. Panel (b) shows the ETR, i.e. the tax liability as a fraction of rateable value, for each of these four cases.

Table 1: Description of the business rate reliefs

	Eligibility	Description	Dates Applied
Retail relief	The property is mainly used as shop, restaurant, café, bar or pub, cinema and hospitality.	If the rateable value (RV) is below £51,000, the tax charge is 2/3 of the standard rate.	April 2019 - April 2021 (ii)
Small business rate relief	A business occupier that uses only one property where that property has a rateable value below £15,000. (i)	If $RV < £12,000$, tax charge is zero; if RV is between £12-15,000, the relief is withdrawn linearly with RV; if $RV > £15,000$, the tax charge is the full rate.	April 2017- (First introduced in 2005 with different threshold)

Notes: (i) If a business uses more than one property, provided that (a) the total rateable value of all of their properties is less than £20,000, (b) there is no additional property that has a rateable value above £2,899, a business would still be eligible for the SBRR. (ii) After 2021, the relief was increased to 100%; currently, the relief is at 75%.

3 A Conceptual Framework and Empirical Predictions

3.1 A Conceptual Framework

Perhaps reflecting the lack of empirical work on the topic, there are, to our knowledge, almost no theoretical models of the commercial property market where vacancies and rents are determined endogenously via search frictions.[17] Here, we present a conceptual framework for thinking about the effect of these reliefs on the commercial property market, the purpose of which is to generate our key predictions. This conceptual framework draws on a formal directed search model of commercial landlords and tenants, which is given in detail in the Online Appendix N.2.1.

Key features of the model are as follows. First, it features two-sided heterogeneity i.e. both businesses and properties can differ in size; this feature is required to understand

[17] The exception is Moszkowski and Stackman (2023), which is preceded by an earlier version of this paper, Lockwood, Simmler and Tam (2022). In their model, all landlords are identical and tenants and landlords are paired via random matching. Neither of these assumptions are suitable for the UK context we study; we need two-sided heterogeneity i.e. landlords to own properties of varying rateable value and tenants to be large or small. Also, directed search, rather than random matching is more appropriate to a situation where information on vacant properties is easily available online or via commercial agents, as discussed in Section 2.1 above.

the sorting effects induced by the SBRR.[18] Second, there is a market friction in that it takes time to match businesses to properties. Such a market friction is of course necessary to explain the existence of vacancies. 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. First, all landlords of type simultaneously post and commit to rents. Then, businesses decide which properties to apply to, and landlords choose tenants. Finally, properties are occupied, generate profits, and rents and business rates are paid.[19]

The model allows for an arbitrary number of property types, as measured by their rateable values R. In equilibrium, for a given size of property, we solve for both the probability that the property is vacant, denoted $v(R)$, and the rent set by the landlord as a fraction of rateable value, denoted $r(R)$.

3.2 Empirical Predictions

Sorting. The first feature of the equilibrium (Proposition 1 in the Online Appendix N.2.2) is 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. Here, a small property is one with rateable value R below the £15,000 eligibility cutoff for SBRR, and a small business is one that only rents one property. This result is intuitive; small businesses find small properties more profitable than large business, because they pay lower business rates.[20] Anticipating this, landlords of small properties will set rents to just leave small businesses indifferent between applying and not, thus deterring large businesses.

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

[18]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.

[19]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.

[20]A simplifying assumption of the model that generates this result is that the operating profit from a property with a given property with rateable value R is the same, whether the business is large or small. This could be relaxed at the cost of greater complexity, and the sorting would still hold, even if large businesses are more profitable that small ones, as long as this additional profitability does not completely offset the tax advantage given by SBRR.

for small businesses.[21]

Predictions for reduced form effects of reliefs on vacancies and rents. Recall that the equilibrium probability that a property of type R is vacant is $v(R)$, and the rent, expressed per unit of rateable value, is $r(R)$. Formulae for $v(R), r(R)$ are given in Proposition 2 in Online Appendix N.2.2 and further in equation (N.3). There, it is shown that discontinuities ("jumps") in the amount of business rate paid as R increases due to withdrawal of RR will induce discontinuities in $v(R), r(R)$. Similarly, changes in the slope of the "tax function" (i.e. the function relating business rate paid to rateable value) as R increases due to withdrawal of SBRR will induce changes in the slopes of $v(R), r(R)$ with respect to R. In other words, it is an insight from the theoretical model that the vacancy and rent functions $v(R), r(R)$ reflect the discontinuities and slope changes in RR and SBRR respectively. Our main empirical predictions, given in Table 1 below, are about the signs of these changes.

Table 2: Summary of empirical predictions: rents and vacancy rates

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

Notes: For RR, 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 Section N.2.3.

Some intuition for these results is as follows. First, consider the RR threshold. As is clear from Figure 1, business rates at £51K, as RR is fully withdrawn at this threshold and there are no other reliefs at that threshold. So, at this threshold, there is a discontinuous fall in the total economic surplus from the match. Landlords adjust to this on both margins; they cut rents, but this is not enough to prevent the probability of a vacancy rising.

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. Rents respond in the opposite direction, as landlords respond to rising vacancies by cutting rents. On the other

[21] 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.

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. Again, rents respond in the opposite direction to vacancies.

Causal Effects of Reliefs. Recall the definition in Section 2.2 above of the ETR as the the tax liability as a fraction of rateable value. We are interested in the causal relationship between a change in the ETR, τ, and v, r, all of which depend on R. This will allow us to compare the "bang for the buck" of RR and SBRR in terms of a common metric, τ, as explained further in Section 7. Table 2 above indicates that for RR and SBRR, the marginal effects of an increase in the ETR via withdrawal of these reliefs on vacancies both will be positive. This is because mechanically, when a withdrawal of relief occurs, the ETR increases. For rents, the effect is the reverse; an increase in the ETR via withdrawal of these reliefs on rents will both will be negative.

However, if we are willing to assume that the rate of profit π is independent of scale of operation as measured by R, we can prove a much stronger result (see Appendix N.2.3). A one p.p. decrease in the ETR via RR *always causes a bigger fall in* v than a one p.p. decrease in the ETR via SBRR. This is a testable prediction, and indeed we find strong evidence for this, as described below. The intuition is simply that while RR applies to all tenants, SBRR is targeted only at small tenants, and therefore crowds out large tenants.

4 Data

4.1 Business Rates and Vacancies

Publicly available data on business rates at property level is not available at a national level, but is provided by some local authorities in England. We obtained and harmonized the administrative data from 72 local authorities to create a new data-set.[22] 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. Our sample jurisdictions are somewhat larger than the average or median jurisdiction in England but very similar in terms of population age and firm (size) distribution, and number of commercial properties, floor space, establishments and firms per capita (see Table N15 in the Online Appendix). We plot the area covered in England in Figure D1. In addition, the distribution of our sample properties by rateable

[22]Local councils started publishing this data in 2018 following Freedom of Information requests. However, several jurisdictions also denied access due to public safety concerns or confidentiality reasons, or published only incomplete data (excluding individuals, or the vacancy information). Our sample includes the data for a particular jurisdiction and quarter if it was made available and if it includes information on (almost) all properties in the jurisdiction and the type of properties. For a small number of jurisdictions, one of the key variables in our data set are not directly observed but inferred. For more information, including the source of the data, see Online Appendix N.4.

value (bin) follows closely the full distribution for England, as shown in Figure D2 in the Appendix.[23]

The data set has a quarterly frequency and we collected it for the time period from the second quarter of 2018 to third quarter of 2019 inclusive. Our baseline sample includes the last available quarter for a jurisdiction, which is in most cases the second or third quarter for 2019.[24] It contains 470,932 unique commercial properties.

The key variables in our data are the rateable value of each property and its occupation status, either vacant or occupied.[25] For 63 of the jurisdictions included in the sample, we also observe the relief(s) 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 reliefs businesses may receive) as the "small" sample - it constitutes 52% of the large sample. Table 3 presents summary statistics for both samples (cols. (1) and (2)). While the property type distribution and the rateable value range are similar in both, the vacancy rate is somewhat larger in the large sample (11.1% compared to 10.1%).

We now describe the sub-samples we use to analyze the effect of each of the reliefs.

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). 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.[26]

Retail Relief: The sample for RR includes retail and hospitality properties with a rateable value around £51,000.[27] Since the empirical approach relies on variation over

[23] The property type distribution is also very similar. An exact comparison is not possible as the official classification is based on a code, and ours based on the property description. In the national data, 25% are retail properties, in our data between 23% (this include the most narrow definition) and 29%. The latter number is based on our preferred definition that includes additional properties such as car showrooms and petrol stations which are eligible for RR, although they are not classified as retail in the VOA data.

[24] 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).

[25] The rateable value in the data represents the estimated rental value of the property on April 2015 taking effect from April 2017.

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

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

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 RR.[28]

We report descriptive statistics for each sub-sample in Table 3 columns (3) to (6). The vacancy rate is very similar in both RR and SBRR samples. Note finally that rateable values are reported with varying degree of precision at different range of rateable values. The rateable value is measured at precision of £100 between £5,000 and £10,000, 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 £250 and £500 for the SBRR and RR sub-samples respectively.

Table 3: Descriptive statistics - Vacancy sample

Rateable values (£1,000)	All		Retail relief 41-61		Small business rate relief 9-18	
Sample	Large	Small	Large	Small	Large	Small
# of observations	470,932	245,852	7,384	3,962	82,968	41,547
# of local authorities (LAs)	72	38	35	15	63	31
# of LAs in London	11	7	3	2	9	5
# of LA-quarters	72	38	70	30	63	31
Average rateable value	31,062	32,146	49,814	49,865	12,560	12,547
Median rateable value	8,000	8,000	49,250	49.500	12,000	12,000
Mean vacancy	0.111	0.101	0.076	0.074	0.082	0.074
Share of properties						
Office	0.20	0.18	0	0	0.16	0.15
Shop/Hospitality	0.42	0.43	1	1	0.46	0.45
Warehouse/Factory	0.21	0.21	0	0	0.23	0.22

Notes: The table shows the summary statistics for the full sample (cols. (1) and (2)), the RR sample (cols. (3) and (4)) and the SBRR sample (cols. (5) and (6). For the full sample, the SBRR sample and the RR 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.

4.2 Rent

We use data on all commercial property rental listings on the property letting platform, Rightmove, in 2018 and 2019.[29] For each property rental listing, the data includes address, property type, asking prices and listing date. There are 105,337 (unique) rental listings

[28]If both second and third quarter of 2019 are available, we use the second quarter as the RR 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.

[29]We examine the representativeness of the rental listings data in Section N.4.2 in the Online Appendix, and do not find evidence for over- or under-sampling of properties by jurisdiction or property characteristics.

covering the whole of England.[30] We match the listing data to the business rate data (described in section 4.1) 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 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.[31] 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 RR and SBRR, using the same ranges of rateable value as that for the vacancy analysis. For the SBRR sub-sample, we include listings observed in all quarters during 2018-2019. For the RR sub-sample, we include listings in all quarters except the fourth quarter of 2018, as there could be a partial effect from the announcement of the RR on November 2018, given that rental prices could be forward looking. In addition, and as for the vacancy RR sub-sample, the RR rent sub-sample includes only properties in jurisdictions for which we observe at least one property with a rateable value close to the threshold before and one after the introduction of the RR. We provide the descriptive statistics for the full rent sample, and the two sub-samples in Online Appendix Table N17. The average (median) rent to rateable value is above 1 in both sub-samples and in the full sample is 1.33 (1.28).[32]

5 Empirical Approach

5.1 Retail Relief

As discussed in Section 3.2 above, we expect discontinuities in the reduced form relationship between rateable values, vacancies and rents at the threshold for RR and we use a RDD to estimate these. There is an additional complication that the standard business rate multiplier also changes at the threshold for RR. To deal with this, we use a difference-in-discontinuity approach. Specifically, we estimate the following equation on our sample

[30]We exclude from our sample properties with unspecified or non-commercial 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 N15), 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 3) suggest that the total number of commercial properties available to rent would be approximately 110,000.

[31]We describe in Online Appendix N.4.2 the details of the matching and show that the rent per sq ft does not differ for matched vs unmatched properties.

[32]The number of jurisdictions is slightly larger in the full rent sample compared to the vacancy sample, as we used for the matching also rateable value data for jurisdictions for which vacancy or property information is not available. See Online Appendix N.4.2.

of retail properties:

$$E[y_{it}|R] = \gamma_0 + \gamma_1(R_i - R_r) + \gamma_2(R_i - R_r) \times D_i + \gamma_3 D_i + \gamma_4(R_i - R_r) \times Post_t + \gamma_5(R_i - R_r) \times D_i \times Post_t + \gamma_6 D_i \times Post_t \quad (1)$$

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.[33] R_i is rateable value of property i, R_r is the threshold and $R_i - R_r$ is the rateable value normalized to the threshold. D_i is an indicator for rateable value being above the threshold. $Post_t$ is an indicator for quarters during and after 2019 when the RR applies.[34]

Equation (1) allows the elements of the linear RDD to change after RR is introduced, and thus differences out the discontinuity in outcome at the threshold for 2019 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, coefficient γ_6, identifies the effect of the RR at the threshold on vacancies or rents.

Equation (1) is a linear probability model (LPM) when the outcome is the indicator for vacant property. 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 with indicator variable outcome. 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 3.2 above. If there were no other reliefs affecting the business tax, we could just divide γ_6 by the change in the ETR on a property when the property no longer qualifies for RR as given by the tax rules, which would be just 1/3 of the multiplier ($\frac{1}{3} \times \kappa$), to obtain an estimate of the causal effect. However, there are other reliefs that make τ differ from the statutory level as, for example, the charity relief.

To deal with this, we use a fuzzy difference-in-discontinuity approach. Specifically, we

[33]We use rent to rateable value ratio as the outcome, informed by the theory in section N.2.3. We present the results using level and log of rents in the appendix. All the results are qualitatively and quantitatively similar.

[34]With vacancy as outcome, $Post_t$ is an indicator for time on or after the second quarter of 2019, as the RR start to apply from April 2019. For rents, our data are property listings on the online property letting platform, Rightmove (see Section 4 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 RR was announced on Nov 2018 and would start to apply when the rental for these listings starts.

estimate the following equation:

$$
\begin{aligned}
E[\tau_{it}|R] = \eta_0 + \eta_1(R_i - R_r) + \eta_2(R_i - R_r) \times Post_i + \eta_3 Post_i \\
+ \eta_4(R_i - R_r) \times D_i + \eta_5(R_i - R_r) \times D_i \times Post_t + \eta_6 D_t \times Post_t \quad (2)
\end{aligned}
$$

where τ_{it} is the observed ETR paid at an occupied property i in time t. Here, γ_6 and η_6 in equation (1) and (2) estimate the reduced form effect of the RR and the first stage effect of RR 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. In practice, we use an (numerically) equivalent 2SLS approach to calculate the causal effect for easier implementation.[35]

Both the reduced form and first stage equations are estimated in a bandwidth h of the running variable R i.e. $|R - R_r| \leq h$. In the estimation of equations (1), (2), we use the optimal bandwidth suggested by Calonico, Cattaneo and Titiunik (2014*a*,*b*) and Cattaneo, Idrobo and Titiunik (2019).[36] We weight the observations all equally within the bandwidth, i.e. technically, we use a uniform kernel. Since the standard errors for equation (1) and (2) 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) 1,000 replications.

5.2 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 indicators for occupancy of property i at time t by a small or large business respectively. We study the behaviour of these indicators around the lower threshold for the SBRR only. This is because - as explained in Section 4 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.

[35] To calculate the causal effect, we use an instrumental-variable procedure. As the effective tax rate for the occupied properties by nature is observed only for the occupied properties, from the estimated first stage equation, we impute τ_{it} for the unoccupied properties in which τ_{it} is unobserved. Then, we estimate the effect of τ_{it} on the outcome using using $D_t \times Post_i$ as excluded instrument for τ_{it} controlling for $R - R_r$ and $(R - R_r) \times D_i$ (the ETR for the unoccupied properties are imputed). The procedure is implemented as 2SLS on the sample with partly imputed ETR, and gives exactly the same numerical estimate as the ratio $\frac{\gamma_6}{\eta_6}$ estimated from equation (1) and (2) with the same bandwidth.

[36] Specifically, we use the same (optimal) bandwidth for estimating both the reduced form and first stage equation. The optimal bandwidth is calculated for the outcome variables (i.e. the reduced form equation), and separately for each of the outcome variables of vacancy and rents.

estimate

$$E[o^s_{it}|R] = \alpha_0 + \alpha_1(R_i - \underline{R}_s) + \alpha_2(R_i - \underline{R}_s) \times \underline{D}_i + \alpha_3 \times \underline{D}_i \tag{3}$$

$$E[o^l_{it}|R] = \beta_0 + \beta_1(R_i - \underline{R}_s) + \beta_2(R_i - \underline{R}_s) \times \underline{D}_i + \beta_3 \times \underline{D}_i \tag{4}$$

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 $R_i \geq \underline{R}_s$. Equations (3)-(4) are estimated within a bandwidth of h where $|R - \underline{R}_s| \leq h$ and h is discussed below. Given the discussion in Section 3.2, 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 3.2. Again, we implement a regression kink design. The first step is to estimate

$$E[y_{it}|R] = \gamma_0 + \gamma_1(R_i - \underline{R}_s) + \gamma_2(R_i - \underline{R}_s) \times \underline{D}_i + \gamma_3\underline{D}_i \tag{5}$$

$$E[y_{it}|R] = \delta_0 + \delta_1(R_i - \bar{R}_s) + \delta_2(R_i - \bar{R}_s) \times \bar{D}_i + \delta_3\bar{D}_i \tag{6}$$

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 (5)-(6) are estimated within a bandwidth of h where $|R - \underline{R}_s| \leq h$ and $|R - \bar{R}_s| \leq h$ 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 3.2, 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 RR, we implement a fuzzy RKD. Specifically, we first estimate the following first stage effect of the tax kink on ETR at the two thresholds:

$$E(\tau_{s,it}|R) = \eta_0 + \eta_1(R_i - \underline{R}_s) + \eta_2(R_i - \underline{R}_s) \times \underline{D}_i + \eta_3\underline{D}_i \tag{7}$$

$$E(\tau_{it}|R) = \phi_0 + \phi_1(R_i - \bar{R}_s) + \phi_2(R_i - \bar{R}_s) \times \bar{D}_i + \phi_3\bar{D}_i \tag{8}$$

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 quarter-year fixed effects in the estimations to increase efficiency.

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

$$\frac{\partial o^s}{\partial \tau_s} = \frac{\alpha_2}{\eta_2}, \quad \frac{\partial o^l}{\partial \tau_s} = \frac{\beta_2}{\eta_2} \tag{9}$$

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

$$\frac{\partial y}{\partial \tau_s}|_{\underline{R}_s} = \frac{\gamma_2}{\eta_2}, \quad \frac{\partial y}{\partial \tau_s}|_{\bar{R}_s} = \frac{\delta_2}{\phi_2/\omega}, \qquad y = v, r \tag{10}$$

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.[37] Therefore, for calculation of the causal effect from equation (10), we divide ϕ_2 by the share of small businesses among occupiers at the upper kink (ω).[38]

In the estimation of equations (3)-(8) we use a fixed bandwidth of £3,000 or £2,500 to avoid that the (optimal) bandwidth includes observations around both kinks in estimating one equation.[39] We weight the observations all equally within the bandwidth, i.e. technically, we use a uniform kernel. Since the standard errors for equations (3)-(8) are not directly applicable to the causal effect estimates, we bootstrap the standard errors.

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

[38] To implement equation (9) and (10) for the lower kink, we first use the first stage equation to impute $\tau_{s,it}$ for properties not occupied by small business in which $\tau_{s,it}$ is unobserved. Then, we estimate a 2SLS specification for occupancy, vacancy and rent using $(R_i - \underline{R}_s) \times \underline{D}_i$ as excluded instrument for $\tau_{s,it}$, controlling for $(R_i - \underline{R}_s)$ and $\underline{D}_i$. For the upper kink, we impute τ_{it} for properties that are unoccupied (and therefore τ_{it} is unobserved) using the first stage equation, and uses $(R_i - \bar{R}_s) \times \bar{D}_i$ as instrument for τ_{it} to estimate the causal effect of τ_{it} on the outcomes. The 2SLS procedure gives exactly the same numerical estimate as the ratio of coefficients (in eq. (9)-(10)) estimated from equation (3)-(8) under the same bandwidth.

[39] When using a bandwidth of £3,000, we exclude the data for the other kink, e.g., when studying the first kink we use properties with a rateable value from and including £9,000 to £14,999, and when studying the second kink, we use properties with a rateable value from and including £12,001 to £18,000.

6 Empirical Results

6.1 Retail Relief

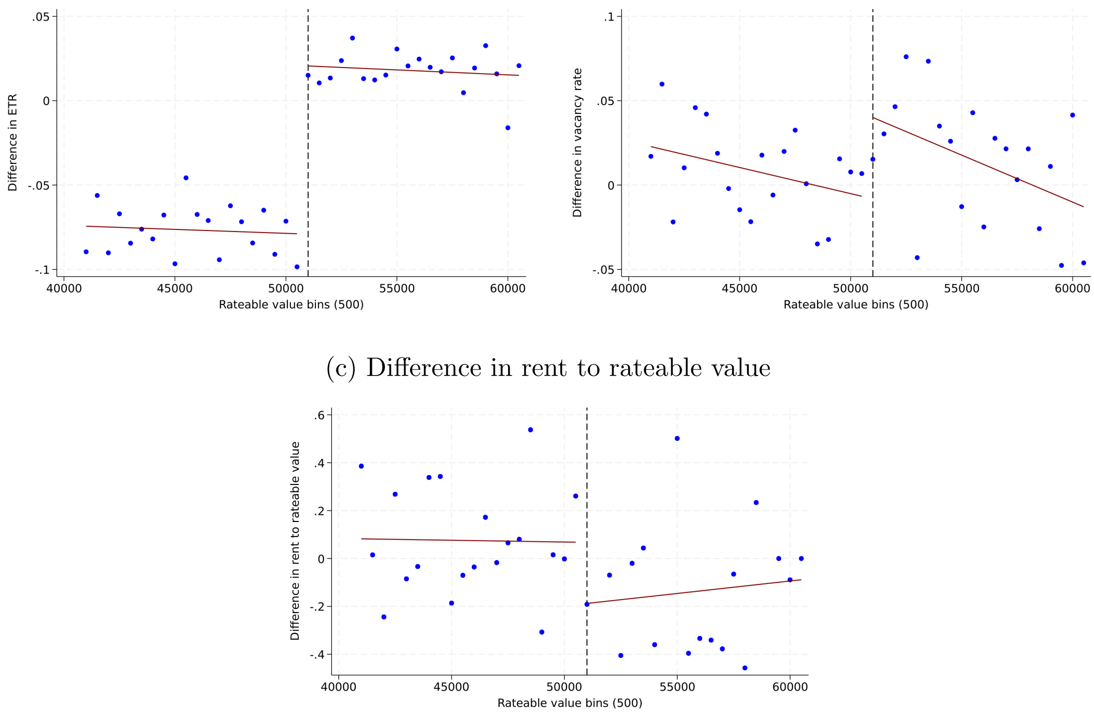
We turn now to our results on the impact of RR on the vacancy rate and rents. We start with the graphical analysis: Figure 2 plots for each rateable value bin between £41,000 and £61,000 (with bin width £500), the difference in the vacancy rate, rent (divided by rateable value), and ETR between 2018 and 2019.[40]

Figure 2: 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 the difference in (a) the average ETR for occupied properties, (b) the average vacancy rate and (c) 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 RR threshold and the solid lines represent linear fits.

The difference in the ETR for occupied properties before and after the introduction of the RR stays largely constant with rateable value up to £51,000, jumps at the threshold by around 10 p.p., and stays almost constant up to £61,000. However, there is some variation around the linear fit (i.e. the empirical ETR as a function of R is not identical to its theoretical counterpart in Figure 1 (b)), which justifies our use of the *fuzzy* difference-

[40]The number of observations in both samples are smooth around the threshold both before and after the introduction of the RR (see Figures N2 and N3 in the Online Appendix). This is also indicated by the results of the McCrary test, which are reported below the relevant Figures. In addition, property characteristics (retail vs. non retail, distance to nearest High Street) are smooth around the threshold (see Table N2).

in-discontinuity estimation strategy. Turning to vacancies and rent, we see from Panels (b) and (c) that there is evidence of an upward jump in vacancies, and a downward jump in rents, at the RR threshold. This is consistent with our theoretical predictions in Table 2.

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

Bandwidth	Opt.	Opt.	Opt.	75% Opt.	125% Opt.	10,000
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A	ETR	Vacant (small sample)				
D(R≥51k)*Post	0.100***	0.042*				
	(0.011)	(0.023)				
Causal effect for ETR			0.416*	0.315	0.394*	0.457*
			(0.252)	(0.280)	(0.219)	(0.234)
Observations	3,349	3,614	3,614	2,718	4,498	4,042
Bandwidth	9,196	9,196	9,196	6,897	11,496	10,000
Panel B	ETR	Vacant (large sample)				
D(R≥51k)*Post	0.099***	0.051**				
	(0.011)	(0.021)				
Causal effect for ETR			0.520**	0.339	0.432**	0.469**
			(0.232)	(0.259)	(0.211)	(0.200)
Observations	3,183	6,383	6,383	4,938	8,001	7,529
Bandwidth	8,697	8,697	8,697	6,523	10,871	10,000
Panel C	ETR	Rent/RV				
D(R≥51k)*Post	0.098***	-0.102**				
	(0.009)	(0.045)				
Causal effect for ETR			-1.041	-1.155	-0.924	-0.716
			(1.771)	(2.308)	(1.556)	(1.925)
Observations	4,105	296	296	229	369	272
Bandwidth	11,119	11,119	11,119	8,339	13,898	10,000

Notes: The table reports the estimates for the RR in equation (2) (col. (1)) and (1) (col. (2)), and the estimates for causal effect for ETR (cols. (3)-(6)). The dependent variable is the ETR of occupied properties (col. (1)), an indicator for property is vacant (Panel A and B, cols. (2)-(6)) or the rent to rateable value ratio (Panel C, cols. (2)-(6)). In cols. (1)-(3) we use the optimal bandwidth, which is the average of the optimal bandwidth for 2018 and 2019, in col. (4) we use 75% of it, and in col. (5) 125%. In col. (6), we use a fixed bandwidth of £10,000. In Panel A, we use the small vacancy sample, in Panel B the large vacancy sample, and in Panel C the rent sample. Panel A and B include quarter-year fixed effects. The optimal bandwidth is estimated following Calonico, Cattaneo and Titiunik (2014*a*) using local-authority-rateable value bin level clustering. Robust standard errors (cols. (1) and (2)) or bootstrapped standard errors (cols. (3) to (6)) are clustered at the local authority-rateable value bin level (Panel A and B) or local authority and rateable value bin level (Panel C) and are reported in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table 4 reports the estimates for the effect of RR using the difference-in-discontinuity approach explained in Section 5.1. Column (1) reports the estimate of η_6 in equation (2) for the ETR using the optimal bandwidth of the reduced form. It suggests a relative increase in the tax rate by 10 p.p.. Column (2) reports the estimate of γ_6 in reduced form equation (1) for vacancies (Panel A - small sample; Panel B - large sample) and rent to rateable value ratio (Panel C). The vacancy rate increases by 4.2 p.p. in the small sample, and 5.1 p.p. in the large sample.[41] The rent to rateable value decreases at the threshold by 10.2 p.p..

The final step in our analysis is to obtain the causal effect of RR on vacancies and rents, which is in each case just the ratio of the two estimates of γ_6, η_6.[42] For vacancies, the causal effect estimate using the optimal bandwidth is 0.42 in the small sample and 0.52 in the large sample. The estimates vary with the bandwidth used (cols. (3)-(6)). This means based on the large sample estimate, a one p.p. decrease in the ETR via RR decreases the vacancy rate by around 0.52 p.p.. Similarly, one p.p. decrease in the ETR via RR decreases rent to rateable value by -1.04 p.p., but due to the small sample, the point estimate is not statistically significant and varies with the bandwidth.

We also check robustness of these results in various ways. First, we use an alternative kernel and use a local polynomial regression of higher order. The results are reported in Table N3 (and illustrated in Figure N4) in the Online Appendix. The estimates are very similar to the estimates in Table 4 but less precise. Second, we use rent and ln rent as dependent variables (Table N4). Third, 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 (Table N5). Overall, the results are very similar to our baseline estimates. Lastly, we check if RR may interact with charity relief if it changes the incentive for charities to choose properties below the RR threshold.[43] We do not find evidence that RR impacts on the likelihood that a property is occupied by a charity (Table N2).

6.2 Small Business Rate Relief

We turn now to the results for the small business rate relief (SBRR). We start with graphical evidence. Figure 3 (a) plots the ETR faced by small and large businesses by rateable value from £6,000 to £21,000 (with bin width of £250).[44] The ETR as a function of R is close to the theoretical schedule in Figure 2 for both small and large businesses i.e. for the former, zero up to £12,000 and increasing linearly up to £15,000, due to the phasing out of SBRR. For large businesses, the ETR in contrast, is much higher and

[41]When including in addition local-authority fixed effects, the point estimates (s.e.) are for ETR 0.097 (0.011) and vacancy 0.046 (0.021) using the large sample and for ETR 0.102 (0.011) and vacancy 0.048 (0.024) using the small sample.

[42]We implemented the calculation with an 2SLS/IV procedure as discussed in section 5.

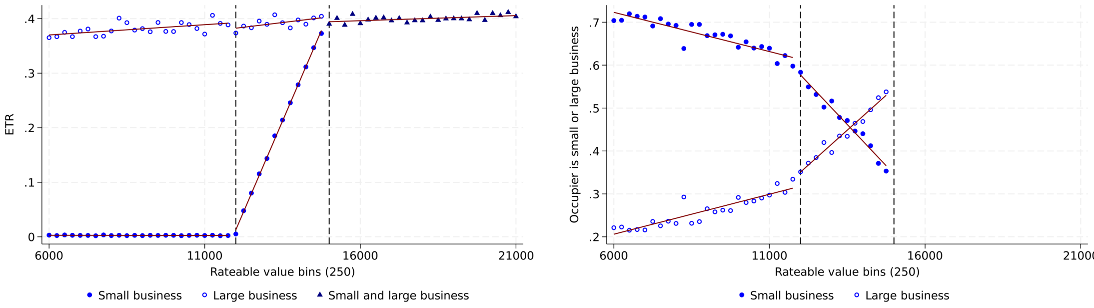
[43]For example, the tax advantage for charity from charity relief could be more important in the absence of RR. There is no statutory change in the charity relief at the RR threshold. If the presence of charities is also smooth across the RR threshold, this suggests any effects from charity relief would be smooth across the threshold, which would not affect our estimates.

[44]Figures N5 and N6 in the Online Appendix show 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. This is also indicated by the results of the McCrary tests, which are reported below the relevant Figures. In addition, property characteristics (retail vs. non retail, distance to nearest High Street) are smooth around the threshold (see Table N6).

nearly constant at about 0.4.

Figure 3: 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.

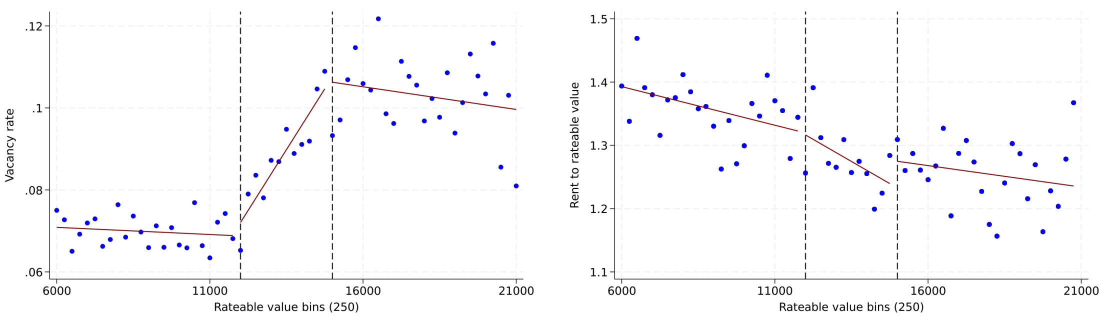
The almost flat ETR schedule faced by large businesses in Figure 3 (a) suggests no other confounding policy changes at rateable value of £12,000-15,000.

Figure 3 (b) plots the share of properties occupied by small business (o_s) and by 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. 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. Overall, Figure 3 provides clear graphical evidence of sorting, as predicted by our theory, subject to the caveat that sorting is incomplete in the data.

In Figure 4 (a), the vacancy rate as a function of rateable value clearly displays

Figure 4: 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 rateable value with the outcomes.

properties consistent with our theoretical predictions in Table 2. specifically, there are two kinks in the function, at £12,000 and 15,000. At the first kink, the slope of the function increases as SBRR stats to be withdrawn. At the second kink, the slope decreases, when SBRR is fully exhausted. Overall, Figure 4 (a) provides strong evidence that SBRR is an important determinant of property vacancies.

Figure 4 (b) plots the rent to rateable value ratio by rateable values. Again, the picture is consistent with our theoretical predictions in Table 2. There are two kinks in the function, at £12,000 and 15,000, and the change in slope is the opposite to vacancies i.e. the slope decreases (becomes more negative) and then increases. This means that the withdrawal of SBRR decreases rents.

Table 5: RKD results for SBRR: Occupancy rate by small and large business

Dep. Var.	ETR	D(Occupied by small business)			D(Occupied by large business)		
Bandwidth	3,000	3,000	3,000	2,500	3,000	3,000	2,500
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Large sample							
R * D(1kink)	0.134***	-0.050***			0.039***		
	(0.002)	(0.008)			(0.008)		
Causal effect for ETR			-0.373***	-0.325***		0.293***	0.254***
			(0.056)	(0.070)		(0.054)	(0.066)
Observations	18,968	64,468	64,468	55,126	64,468	64,468	55,126
Panel B: Small sample							
R * D(1kink)	0.134***	-0.044***			0.027***		
	(0.002)	(0.010)			(0.010)		
Causal effect for ETR			-0.329***	-0.264***		0.199***	0.163*
			(0.076)	(0.101)		(0.072)	(0.089)
Observations	18,968	32,354	32,354	27,664	32,354	32,354	27,664

Notes: The table reports estimates of equation (3) (cols. (2)), equation (4) (cols. (5)), equation (7) (col. (1)) and the causal effect for ETR (col. (3)-(4) and (6)-(7)). The dependent variable is the effective tax rate of small business (col. (1)), an indicator of the property being occupied by a small business (cols. (2) to (4)) or by a large business (cols. (5) to (7)). R*D(1kink) represents the change in relationship between vacancy and rateable value above the threshold at £12,000. Cols. (1), (2), (3), (5) and (6) use a fixed bandwidth of £3,000 and all other columns a fixed bandwidth of £2,500. Panel A uses the large sample, Panel B the small sample. In all cols. we include quarter-year fixed effects. 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 5 col. (1) reports the estimate of η_2 in the first stage equation (7). The estimate shows a positive change in slope as indicated in Figure 3 (a) – the change in slope estimate is 0.134 and statistically significant. Cols. (2) and (5) report the estimates of α_2 and β_2 in the reduced form equations (3) and (4). For occupancy by small business, the estimates of the change in slope coefficient α_2 for o^s is negative and statistically significant, and for occupancy by large businesses, the estimates of the change in slope coefficient β_2 for o^l is positive and statistically significant. In both cases, this is consistent with the graphical evidence shown in Figure 3. Cols. (3), (4), (6) and (7) show the causal effect estimates, calculated using (9). The marginal effect on occupancy by small business with respect to the effective tax rate faced by small business is -0.37 (-0.33) in the large (small) sample, and the marginal effect on occupancy by large business is around 0.29 (0.20).[45] Thus, SBRR raises (lowers) occupancy by small (large) businesses.

Table 6: RKD results for SBRR: Vacancy rate, and rent to rateable value

Dep. Var.	ETR	Vacancy			Rent/RV		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Bandwidth	3,000	3,000	3,000	2,500	3,000	3,000	2,500
Panel A: First Kink							
R*D(kink)	0.134***	0.011***			-0.043*		
	(0.002)	(0.003)			(0.022)		
Causal effect for ETR			0.081***	0.071**		-0.319*	-0.323
			(0.024)	(0.030)		(0.169)	(0.220)
Observations	18,968	64,468	64,468	55,126	2,207	2,207	1,824
Panel B: Second Kink							
R * D(kink)	-0.165***	-0.009**			0.025		
	(0.028)	(0.004)			(0.026)		
Causal effect for ETR			0.050*	0.039		-0.153	-0.084
			(0.030)	(0.033)		(0.161)	(0.138)
Observations	6,714	40,807	40,807	35,920	1,600	1,600	1,347

Notes: The table reports estimates of equation (7) (col. (1)) and eq.(5) (cols. (2) and (5)) in Panel A; and of equation (8) (cols. (1)) and eq. (6) (cols. (2) and (5)) in Panel B. Col. (3), (4), (6) and (7) report the causal effect for ETR in Panel A and B. In col. (1) the dependent variable is the ETR of properties occupied by small businesses (Panel A) or of properties occupied by small and large business (Panel B), an indicator for the property being empty (cols. (2) to (4)) or the rent to rateable value ratio (cols. (5) and (7)). Panel A reports the results for the first kink, and Panel B for the second kink. $R * D(kink)$ represents the change in relationship between vacancy and rateable value above the threshold at £12,000 and £15,000 respectively. Cols. (1), (2), (3), (5), and (6) use a fixed bandwidth of £3,000 and all other columns a fixed bandwidth of £2,500 (except for col. (1) in Panel B which uses a bandwidth of £1,000). Col. (1) uses the small vacancy sample, cols. (2), (3) and (4) the large vacancy sample, and cols. (5), (6) and (7) the rent sample. Panel B col. (1) reports the estimate of ϕ_2 of equation (6) divided by the share of small businesses at the threshold as described in section (5). All specifications include quarter-year fixed effects. Robust (cols. (1), (2) and (5)) or bootstrapped standard errors are clustered at the local authority-rateable value bin (cols. (1) to (5)) or rateable value bin and local authority-level (cols. (6) and (7)) and are in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table 6 first reports the estimates of equations (7) and (8) on ETR for small business. Panel A column (1) reports the first stage estimate of η_2 in (7) for the kink at £12,000. The estimate shows a positive change in slope as indicated in Figure 3 (a) – the change in slope estimate is 0.134 and statistically significant. Panel B reports estimate of ϕ_2 in (8), 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 -0.165 (see col. (1) Panel B).

[45]Including local authority fixed effects in the regressions has little impact on the estimates, the marginal effect (s.e.) for the large sample increases to -0.38 (0.048) for occupancy by small business and to 0.30 (0.048) for occupancy by large business.

Next, Table 6 reports the estimates of the reduced form equations (5) and (6) for the vacancy rate (cols. (2)-(4)) and the rent to rateable value ratio (cols. (5)-(7)). Column (2) of Panel A reports the results for the estimate of γ_2 of equation (5) for the first kink. At bandwidth of £3,000, the change in slope coefficient for vacancy at the £12,000 threshold is positive and statistically significant. Similarly, Panel B reports the results for the estimate of δ_2 of equation (6). It shows that the change in slope coefficient for the vacancy at the £15,000 threshold is negative and statistically significant. Finally, Table 6 also reports the reduced form estimates for rents to rateable value ratio in column (5). There is a statistically negative change in the slope between the outcome and rateable value, at the lower kink £12,000 (Panel A), and a statistically positive change at the upper kink (Panel B), both consistent with the prediction from the model.

Using these estimates, and plugging them into equation (10) above, we can then obtain our estimates of the causal effect of ETR on the vacancy rate. This is 0.081 at the first kink and 0.05 at the second kink.[46] This means that a 1 p.p. decrease in tax rate for small businesses decreases vacancies by about 0.08 p.p. (resp. 0.05) for properties of rateable value around the first kink (resp. second kink). If we compare this to the marginal effect of RR of 0.52, we see that RR has much more "bang for the buck", consistent with our theoretical prediction.

The ratio of the coefficient estimate on rent to rateable value to that on ETR is -0.32 at the first kink and -0.15 at the second kink. Thus, a 1 p.p. decrease in tax rate for small business reduces the rent to rateable value ratio by 32 p.p. (15 p.p.) at the first (second) kink. However, note that at the first (second) kink, the fraction of small businesses is 0.576 (0.352), so the average change in the ETR is only 0.576 (0.352) of the change in tax for small business, implying a pass-through of 0.56= 0.32/0.576 (0.43).

Sensitivity analysis: We report sensitivity results where we use local regressions for the RKD with optimal bandwidth (Table N7 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 ln rent (Table N9) and find consistent results, except for ln rent at the second kink. When using only retail properties, the marginal effects for occupancy are larger in absolute terms but for vacancy and rents almost unchanged (Table N8)). 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 (Table N11). The point estimate changes only very little. Further, to confirm that our findings are driven by the SBRR kinks, and not other unobserved factors

[46]Again, including local authority fixed effects has little impact, the marginal effect for vacancy at the first kink is estimated at 0.080 and at the second kink at 0.050.

around the £12,000 and £15,000 threshold, we conduct a robustness check exploiting that the SBRR kinks are statutorily at £6,000 and £12,000 before the revaluation in 2017 (Figure N7 and Table N12). Again, our findings hold. In addition, we run a placebo test using lagged predetermined values of our outcomes and do not find any effect as expected (Table N13). Moreover, we use an indicator variable for charities as occupier to assess whether SBRR interacts with the charity relief. We do not find evidence for that (Table N6). Lastly, we also assess whether the effect changes with the sample period, and find support for a slight increase in the effect on occupancy over time (Table N14). This seems plausible as there could be adjustment cost, e.g. in the entry of small business.

6.3 Heterogeneity

6.3.1 The High Street

In this section, we focus on the effect of RR and SBRR on High Street vacancies. In the UK, informally, "High Street" typically refers to a spatial cluster of retail properties, grouped on a main street or town centre, To do this, we leverage recent official definitions from ONS and Ordnance Survey of High St. properties, using their mapping of retail clusters in UK.

There are two reasons for investigating effects specifically on this group of properties, relative to non-High St. properties. First, this is of particular policy relevance for the UK, because of the perceived social benefits of having a thriving High Street in UK cities and towns. Second, there are conceptual reasons for thinking the effects of RR and SBRR might be different for High St. properties, due to "crowding in" and "crowding out" effects of spatial agglomeration. Crowding in refers to a scenario where there are positive spillover effects on firm profits in the cluster of an additional occupancy of a property due e.g. to greater footfall or shopping visits to the cluster. Then, a reduction in vacancies in a cluster induced by reliefs would lead to second-round positive effects (further reductions in vacancies) as the location becomes more attractive for business. Crowding out refers to a scenario where the first-round effect leads to negative spillovers, e.g. via more intense competition between retail outlets and thus lower profit when they are co-located.

To proceed, we exploit recent work by ONS and Ordnance Survey that aims to locate the "High Streets" in the 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).[47] 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. We then split the sample into High St. and non-High St. properties.

The results are shown in Table D1 in the Appendix. Panel A reports the estimates of the effect of RR on vacancies for High St. and non-High St. properties, and Panel B and C report the estimates of the effect of SBRR on both vacancies and occupancy by small businesses. Columns (1) and (2) present the results using the ONS's preferred definition of the High Street. In columns (3) and (4) we use our definition of properties in postcodes that have above the median number of retail units.

We can see that for either definition of High St., the effect of the SBRR on both vacancies and occupancy by small business is larger for High St. than non-High St. properties, which is consistent with a crowding in effect. On the other hand, there is no difference in the estimates for RR. One interpretation of this is crowding in benefits smaller retail outlets more than larger ones as our estimates on the effect of the RR are for larger properties than that for the SBRR.

6.3.2 Regional Heterogeneity

Here, we examine if RR and SBRR have different effects in regions with a tighter or less tight rental commercial property markets. Using the Rightmove listing data, we calculate the duration a property is listed using the first and last listing date, and for each local authority, the share of properties with short listing duration (less than 60 days). In a tight rental market, empty properties would be rented faster and therefore with a shorter empty duration (proxied with their listing duration).[48] At the local authority level, we define a property-type specific rental market as tight if it has an above median share of properties that have short listing duration.

Table D2 presents the estimates of the effect of RR and SBRR in regions with tight and less tight rental markets. Panel A report the effects for RR. The effect on rents is suggested to be larger in tight rental markets although the estimates are not precisely estimated due to the small sample size (see cols. (1) and (2)). There is, however, little difference in

[47] On the ONS definition of a high residential density area is one formed from more than 15 contiguous 100m grid squares with residential use, and that the ratio of residential address count in the area to the grid count is equal to 10 or more. Residential use for each grid is defined by the presence of at least one residential address, by address and residential property tax (council tax) record from VOA. All other areas are considered as low density. (Ordnance Survey and ONS, 2021)

[48] Carrillo, de Wit and Larson (2015) and Halket and di Custoza (2015) measures the tightness of residential property market similarly based on duration of listings. For more details see Section N.4.2.

the impact on vacancies, although again the estimates are imprecisely estimated. Panel B reports the effects for SBRR on retail properties and Panel C for all properties. The estimates are similar, so we refer only to the ones for retail properties. As for RR, the effect of SBRR on rents is larger in tight rental markets but there is little difference in the impact on vacancies. This suggests that landlords are more able to capture the benefits of reliefs in the form of higher rent in tight property markets, which is in line with intuition, as tenants have fewer outside options.

Then, we assess regional heterogeneity with regard to properties being in or outside of London, in less or more deprived areas, and in areas with low or high unemployment rate (Table D3).[49] The RR seems to be more effective in reducing vacancies in less deprived areas and areas with low unemployment rates (Panel A). Although quantitatively less sharp, we find similarly that the SBRR increases the occupancy rate of small business more strongly in these regions for retail properties (Panel B). However, the impact of SBRR on the vacancy rate differs little between less and more deprived areas, and areas with low and high unemployment rate (Panel C). This implies that the crowding out effect of the SBRR, i.e. the impact on occupancy by larger business, is stronger in less deprived regions or regions with low unemployment rate for retail properties.

The effect of SBRR, for all properties including retail and non-retail, on the occupancy by small business differs little between less and more deprived regions, and regions with low and high unemployment rate (Panel D). This could be because local demand matters most for retail, and less so for offices or industrial units which produce tradeable goods. The impact of SBRR on vacancies for all property types is larger in more deprived/high unemployment regions (Panel E), implying again smaller crowding out effects in these regions (similar to the effect for retail properties).

Finally, there is a stronger impact of the SBRR on the occupancy by small business, both for retail and all properties in London than outside London. This could be because a property with a rateable value of £12,000 might be physically smaller in size in London than outside, given the higher rents in London.[50] A second factor could be that the share of retail properties, which are more strongly affected by the SBRR, is much higher in London. This stronger effect within London also leads to a stronger impact of SBRR in London on the overall vacancy rate.

[49]We use the official 2015 Index of Multiple Deprivation (IMD) calculated by the Ministry of Housing, Communities and Local Government. It measures the relative deprivation of different areas in England. Deprived areas are defined at the local authority level and have a IMD score above the median. Unemployment rate is provided by the ONS and refers to the year 2018. Areas with high unemployment are defined at the local authority level and have an unemployment rate above the median.

[50]The fraction of properties occupied by small business inside of London is 14% p.p. higher than outside of London.

7 Policy Implications

For policy purposes, and to explain the results in the Introduction, it is helpful to summarise our estimates of the causal effects of reductions in the ETR via RR and SBRR on our outcomes. These estimates are given in Table 7. Note that for both RR and SBRR, the values tell us how much vacancies fall (rise) when the relief is introduced (removed).

Table 7: Causal Estimates - All Main Results

	$\partial v/\partial \tau$	$\partial o_s/\partial \tau$	$\partial o_l/\partial \tau$	$\partial r/\partial \tau$
SBRR: estimate at £12,000				
All properties	0.081	-0.373	0.293	-0.319
Retail properties	0.160	-0.497	0.337	-0.357
SBRR: estimate at £15,000				
All properties	0.050			-0.153
Retail properties	0.141			-0.135
Retail relief				
Retail properties	0.520			-1.041

Notes: The table reports estimates on the effect of one p.p. increase in the effective tax rate from RR or SBRR on the outcomes in p.p.. r in the table refers to rent to rateable value ratio. Estimates in cols. (1)-(4) are from Table 4 col. (3), Table 6 cols. (3) and (6), Table 5 Panel A cols. (3) and (6), and Table N8.

Using these results, we can now derive our estimates referred to in the Introduction. For RR, a one p.p. increase in the ETR increases the vacancy rate v by 0.52 p.p. or 5%, using the fact that $v = 0.103$ at rateable value £51,000. For SBRR, a one p.p. increase in the ETR faced by small businesses increases v by 0.066 p.p. (average of 0.081 p.p. at the first kink and 0.05 p.p. at the second kink) or 0.64%, as $v = 0.103$ at rateable value £15,000, and we use this value as baseline as SBRR phases out completely at the second kink; at the first kink, it decreases occupancy by small business by -0.373 p.p. or 1.06% (the small business occupancy rate at rateable value £15,000 is 0.352).

What can these results tell us about the effectiveness of both forms of relief in achieving their policy objectives? From Table 7, it appears that RR is more effective than SBRR in the sense that a given reduction in the ETR reduces the vacancy rate for eligible properties by approximately six to ten times more if it is delivered via RR. However, there is an important caveat here; delivering a given percentage decrease in the ETR via RR will *not* in general cost the government the same in money terms as doing the same via SBRR.

To see this, note that the average cost per property of either relief is given by[51];

$$\textit{cost per property} = \textit{rate of relief} \times \textit{average RV of properties} \times \textit{occupancy rate}$$

[51]This is an approximate formula as it assumes; (i) the rate of relief does not depend on rateable value; (ii) the occupancy rate does not vary as rateable value changes. Assumption (i) holds for RR, and in our formulae in the online Appendix, we allow for the fact that with SBRR, the rate of relief is decreasing with rateable value.

Call the product of the last two elements the *base* of the relief (per property), analogously to the base of a tax. These bases will clearly differ between RR and SBRR. For example, the relevant occupancy rate for SBRR is the occupancy rate of small properties by small businesses, where for RR it is just one minus the vacancy rate. Second, increasing either relief will have a positive feedback effect on the relevant occupancy rate and thus the base of the relief, making the increase more costly in money terms.

In Appendix B, we show how to calculate the increase in the rate of relief that is attainable for a given increase in the government expenditure on the relief per property, taking into account these two factors.[52] The first two rows of Table 8 show these calculations. For example, the first cell in the table shows that if the government spends £250 more per property by increasing the rate of RR, the rate would rise by 2.44 p.p. For comparison, the baseline rate of RR is $\kappa/3$ which is 16 p.p. and baseline average expenditure of RR per property is £1646, taking a typical value of $\kappa = 0.48$ from Table N1.

Comparing the first two rows, we see that £1 spent on SBRR is about 50% more effective in increasing the rate of relief than £1 spent on RR. This can be explained by the facts; (i) the base of the relief, and thus its cost, is lower for SBBR as only small businesses are eligible; (ii) the occupancy rate of small properties by small businesses (o_s in Table 7) is less responsive to changes in the relief than is the occupancy rate of retail properties ($1 - v$ in Table 7).

These figures in rows 1 and 2 can then be combined with the causal estimates $\partial v/\partial \tau$ in Table 7 above to compute the p.p. decreases in the vacancy rates for properties eligible for the reliefs in the two different cases, as explained in Appendix B. These are shown in rows 3 and 4 of Table 8. We see that RR is nearly six times times more effective (5.71=1.27/0.22) in reducing vacancies for eligible retail properties than SBRR is in reducing vacancies for eligible small properties.

However, one could argue that this is not a fair comparison, because (as noted in the Introduction), the primary policy objective of SBRR when introduced in 2005 was to support small businesses, not reduce vacancies of properties with a low rateable value. So, an alternative way of assessing SBRR is to ask; for a given increase in the money value of SBRR per property, what is the p.p. increase in the occupancy rate by small businesses? This is shown in row 5 of Table 8. If we compare rows 3 and 5, we see that RR and SBRR are approximately equally effective in achieving their specific policy objectives.

[52]In these calculations, we assume that in the case of SBRR, the rate of relief is only increased for properties with rateable value between £12K and £15K where small businesses are paying positive business rates. Increasing the rate of relief for properties with rateable value below £12K would involve *subsidising* them, which is not realistic.

Table 8: Effectiveness of RR and SBRR

Form of relief	*increase in relief expenditure per property,£*	250	500	1000
RR	p.p. increase in relief rate	2.44	4.89	9.78
SBRR	p.p. increase in relief rate	3.38	6.75	13.50
RR	p.p. reduction in vacancy rate	1.27	2.54	5.08
SBRR	p.p. reduction in vacancy rate	0.22	0.45	0.89
SBRR	p.p. increase in occupancy by small businesses	1.25	2.50	5.00

Notes: Rows (1)-(2) are the implied change in relief rate (in p.p.) when the relief expenditure per property is £250, £500, or £1000, for retail relief (RR) and small business rate relief (SBRR) respectively. Row (3)-(5) are the effect of RR or SBRR on vacancy or occupancy by small business (in p.p.) for the respective relief expenditure per property. Details of the calculation are in Appendix B.

Finally, we can use the results in Table 8 to conduct a basic cost-benefit analysis. To measure the social benefit of filling an additional vacancy, we can use the market rent from our Rightmove data. So, for RR, the gross benefit of (for example) a £250 increase in relief expenditure per property is the average market rent of eligible properties times the p.p. reduction in the vacancy rate, which is 1.27, from Table 8. The cost is £250 times the marginal cost of public funds. These calculations are in Table D5 in the Appendix. We see there that the net benefit of further expenditure on reliefs is always negative, even if we assume no deadweight loss of taxation (marginal cost of public funds equal to one). However, the caveat here is that we are not including any external benefits of fewer vacancies. These benefits are likely to be higher for retail clusters where vacant shops arguably lower the quality of life for residents.

8 Conclusion

In this paper, we have studied 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 two major reliefs in the UK system. We found that both reliefs have significant impacts on vacancies and in the case of SBRR, occupancy rates of small businesses, in line with their policy objectives. There is some evidence that SBRR is more effective in reducing the vacancy rate in retail clusters. Both reliefs are more effective in less deprived areas, so, while reliefs are are highly effective at achieving their objectives nationally, they may be less effective at reducing regional inequality. We showed that a given monetary expenditure on relief per property will lead to a much bigger reduction in vacancies if given via RR, because SBRR is targeted only at small businesses. However, SBRR is equally as effective in reducing the occupancy rate of small businesses as RR is at reducing retail vacancies.

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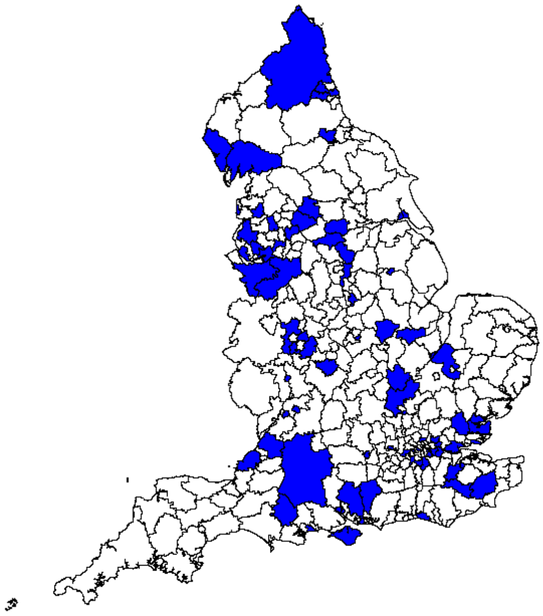
Appendices

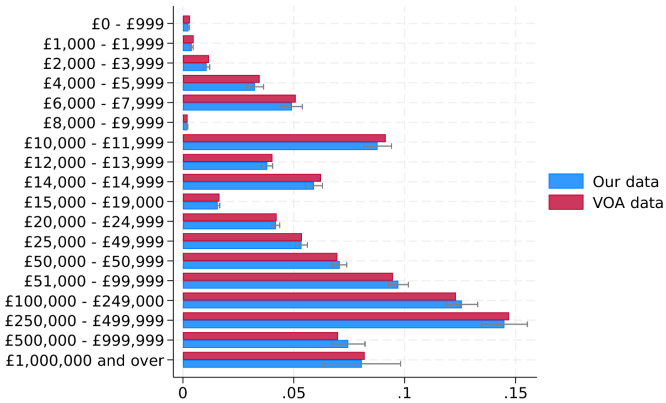
A Additional Tables and Figures

Figure D1: 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.

Figure D2: Distribution of properties by rateable value



Note: The graph shows the distribution of properties by rateable value bin (as defined by the VOA) for the properties in our sample as well as for all properties in England as published by the VOA. It plots the 95% confidence interval for the fraction in each of the rateable value bin in our data, calculated with a regression using an indicator variable of a property i belonging to a rateable value bin k as outcome variable using our data sample, clustering the standard error at local authority level.

Table D1: High Street vs Non-High Street Properties

	ONS Definition		Our Definition	
	High St.	Non-High St.	High St.	Non-High St.
	(1)	(2)	(3)	(4)
Panel A: Retail Relief - Vacancy Rate				
Causal effect for ETR	0.453*	0.381	0.428	0.429
	(0.238)	(0.405)	(0.328)	(0.280)
Observations	4,368	2,282	3,851	2,878
Bandwidth	9,382	9,432	10,345	8,448
Panel B: SBRR - Vacancy Rate - Retail properties				
Causal effect for ETR	0.132***	0.050	0.117**	0.081*
	(0.044)	(0.050)	(0.049)	(0.044)
Observations	17,506	11,417	14,692	14,231
Bandwidth	3,000	3,000	3,000	3,000
Panel C: SBRR - Occupancy by small business - Retail properties				
Causal effect for ETR	-0.583***	-0.506***	-0.578***	-0.526***
	(0.118)	(0.100)	(0.122)	(0.088)
Observations	17,506	11,417	14,692	14,231
Bandwidth	3,000	3,000	3,000	3,000

Notes: The table reports estimates of the causal effect for ETR of RR (Panel A) and SBRR at the first kink (Panel B and C). Cols. (1) and (3) include properties in the High Street, cols. (2) and (4) include properties in non-High Street. Cols. (1)-(2) use the ONS definition for High Street, and cols. (3)-(4) use the number of retail properties in a postcode, if it is above median, for definition of High Street. Panel A (B and C) use the optimal (fixed) bandwidth. Bootstrapped standard errors clustered at local authority-rateable value bin are in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table D2: Tight vs less tight rental markets

	Rent/RV		Vacancy	
	Tight (1)	Less tight (2)	Tight (3)	Less tight (4)
Panel A: Retail Relief				
Causal effect for ETR	-2.708	-1.044	0.387	0.416
	(3.511)	(1.889)	(0.319)	(0.306)
Observations	155	149	3,139	3,780
Bandwidth	11,620	11,907	9,750	9,137
Panel B: SBRR - Retail properties				
Causal effect for ETR	-0.508	-0.286	0.096**	0.092**
	(0.349)	(0.269)	(0.046)	(0.046)
Observations	605	630	14,655	14,514
Bandwidth	3,000	3,000	3,000	3,000
Panel C: SBRR- All properties				
Causal effect for ETR	-0.583**	-0.087	0.085**	0.071**
	(0.238)	(0.217)	(0.038)	(0.032)
Observations	1,088	1,117	28,017	30,001
Bandwidth	3,000	3,000	3,000	3,000

Notes: The table reports estimates of the causal effect for ETR of RR (Panel A) and SBRR at the first kink (Panel B and C). The outcomes are the rent/rateable value ratio (cols. (1)-(2)) and the vacant indicator (cols. (3)-(4)). Tight or less tight rental market is defined at local authority level by its share of properties with empty duration less than 60 days - a local authority area has a property-type specific tight rental market if its share is below median, otherwise it has a less tight rental market. Cols. (1), (3) include local authorities with tight rental market, cols. (2), (4) include jurisdictions with less tight rental market. Panel A (B and C) use the optimal (fixed) bandwidth. Bootstrapped standard errors clustered at the rateable value bin and local authority level (cols. (1)-(2)) or local authority-rateable value bin (cols. (3)-(4)) are in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table D3: Regional Heterogeneity

	London		Deprived Area		High Unemployment	
	Yes (1)	No (2)	Yes (3)	No (4)	Yes (5)	No (6)
Panel A: Retail Relief - Vacancy Rate						
Causal effect for ETR	0.110 (0.303)	0.596** (0.284)	0.088 (0.229)	1.138*** (0.405)	0.241 (0.271)	0.894** (0.424)
Observations	1,280	5,716	3,864	3,079	3,080	3,164
Bandwidth	8,361	9,774	9,541	9,112	8,873	8,082
Panel B: SBRR - Occpuancy by small business - Retail properties						
Causal effect for ETR	-0.632*** (0.241)	-0.536*** (0.077)	-0.418*** (0.108)	-0.688*** (0.124)	-0.542*** (0.128)	-0.568*** (0.104)
Observations	6,741	23,164	14,540	15,365	14,973	14,932
Bandwidth	3,000	3,000	3,000	3,000	3,000	3,000
Panel C: SBRR - Vacancy Rate - Retail properties						
Causal effect for ETR	0.078 (0.056)	0.103*** (0.038)	0.093** (0.042)	0.098** (0.045)	0.083** (0.039)	0.109** (0.048)
Observations	6,741	23,164	14,540	15,365	13,781	16,124
Bandwidth	3,000	3,000	3,000	3,000	3,000	3,000
Panel D: SBRR - Occpuancy by small business - All properties						
Causal effect for ETR	-0.578*** (0.177)	-0.333*** (0.061)	-0.348*** (0.091)	-0.397*** (0.075)	-0.408*** (0.089)	-0.337*** (0.073)
Observations	10,326	54,142	31,749	32,719	31,602	32,866
Bandwidth	3,000	3,000	3,000	3,000	3,000	3,000
Panel E: SBRR - Vacancy Rate - All properties						
Causal effect for ETR	0.119** (0.058)	0.073*** (0.026)	0.107*** (0.030)	0.052 (0.040)	0.103*** (0.029)	0.056 (0.038)
Observations	10,326	54,142	31,749	32,719	31,602	32,866
Bandwidth	3,000	3,000	3,000	3,000	3,000	3,000

Notes: The table reports causal estimates for ETR of RR (Panel A) and of SBRR at the first kink (Panel B to E) for different subsamples. The outcomes are the vacant indicator (Panel A, C and E) and the indicator for occupied by small business (Panel B and D). In Panel A, B and C only retail properties are included, and in Panel D and E all properties are included. The sample includes in col. (1) properties inside and in col. (2) outside of London, in col. (3) in deprived areas and in col. (4) in less deprived areas, in col. (5) in high unemployment rate jurisdictions and in col. (6) in low unemployment jurisdictions. Deprived area is defined at the local authority level - a local authority area is more deprived if its average IMD score is above median, otherwise it is not. Area with low or high unemployment are defined with unemployment rate below or above the median at the local authority level. All specifications include quarter-year fixed effects. Bootstrapped standard errors are clustered at the local authority-rateable value bin in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

B Formulae and Calculations for Table 8

Assume that there are $i = 1,..n$ properties, $N = \{1,..n\}$ with rateable values R_i. Suppose the government allocates a fixed budget C which can be allocated to either increasing RR or SBRR. We measure all monetary units in £1000. We consider policy reforms that increase RR or SBRR by a uniform amount θ per unit of rateable value for all eligible properties. In the case of RR, the set of eligible retail properties $E_R \subset N$ are those with ratable value below 51. In the case of SBRR, eligible properties with rateable value below 12 do not pay any business rate, so we consider only a reduction for properties with rateable values $R_i \in [12, 15]$; this set is denoted E_{SB}. Also, define the numbers of eligible properties as: $n_R = \#E_R$, $n_{SB} = \#E_{SB}$. Finally, to simplify calculations, we assume that the vacancy rate is constant at v_R, v_{SB} respectively across the properties eligible for RR and SBRR.

Retail Relief. With a relief rate of $\frac{\kappa}{3}+\theta$, the revenue cost of RR per eligible property, C/n_R, is the relief rate times average rateable value times the occupancy rate, as in the formula in Section 6 of the paper. This is:

$$C/n_R = \left(\frac{\kappa}{3} + \theta\right) \overline{R}_R(1 - v_R(\theta)) \tag{A.1}$$

where $\overline{R}_R = \frac{1}{n_R}\sum_{i \in E_R} R_i$ is the average rateable value of eligible retail properties and where we note that the vacancy rate v_R will respond to θ. Now, suppose that the government increases the amount spent on RR by $dC > 0$, starting at $\theta = 0$. This finances an increase in θ on all eligible properties, where

$$dC/n_R = d\theta\ \overline{R}_R(1 - v_R) - \frac{\kappa}{3}\overline{R}_R\frac{dv_R}{d\theta}d\theta \tag{A.2}$$

Also, we have estimated from Table 7 that

$$\frac{dv_R}{d\theta} = -\frac{dv_R}{d\tau} = -0.52 \tag{A.3}$$

Combining (A.3) with (A.2) and rearranging gives:

$$d\theta = \frac{dC/n_R}{\overline{R}_R(1 - v_R) + \frac{\kappa}{3}0.52\overline{R}_R} \tag{A.4}$$

Note that the feedback effect (higher θ implies v_R down, implies a lower increase in θ for a given change in C) dampens the effect of dC on $d\theta$, as captured by the term $\frac{\kappa}{3}0.52\overline{R}_R$ in the denominator. Then, given the data in Table D4 below, we compute $d\theta$ for $dC/n_R = 0.25, 0.5, 1.0$ from (A.4). This gives the values in the first row of Table 8. To get the values on row 3, we note that from (A.3) that $dv_R = -0.52d\theta$, so we multiply all values in row 1 through by 0.52.

SBRR. Consider an additional relief θ to all properties with rateable value $R_i \in E_{SB}$. Over this range, the rate of SBRR is decreasing in R i.e. $\kappa\left(\frac{60}{R} - 4\right)+\theta$ where $\kappa\left(\frac{60}{R} - 4\right)$ is the baseline level of SBRR and θ is a common increment to SBRR independent of R. Then, the total revenue cost of the SBRR is

$$C = \sum_{i \in E_{SB}} R_i \left(\kappa\left(\frac{60}{R_i} - 4\right) + \theta\right) o_S(\theta)$$

where $o_S(\theta)$ is the probability that the property is occupied by a small property and thus eligible for SBRR.

Now, suppose that the government increases the amount spent on SBRR by $dC > 0$, starting at $\theta = 0$. This finances an increase in θ on all eligible properties, where;

$$dC = d\theta \sum_{i \in E_{SB}} R_i o_S(0) + \sum_{i \in E_{SB}} \kappa\left(60 - 4R_i\right)\frac{do_S}{d\theta}d\theta$$

Note that from Table 7, we have estimated

$$\frac{do_S}{d\theta} = -\frac{do_s}{d\tau} = 0.37 \quad \text{(A.5)}$$

Also, let $\overline{R}_{SB} = \frac{1}{n_{EB}} \sum_{i \in E_{SB}} R_i$. So

$$\begin{aligned} d\theta &= \frac{dC}{\sum_{i \in E_{SB}} R_i o_S(0) + 0.37 \sum_{i \in E_{SB}} \kappa \left(60 - 4R_i\right)} \\ &= \frac{dC/n_{SB}}{\frac{1}{n_{SB}} \sum_{i \in E_{SB}} R_i o_S(0) + 0.37.4\kappa \left(15 - \frac{1}{n_{EB}} \sum_{i \in E_{SB}} R_i\right)} \\ &= \frac{dC/n_{SB}}{\overline{R}_{SB} o_s(0) + 0.37.4\kappa \left(15 - \overline{R}_{SB}\right)} \end{aligned} \quad \text{(A.6)}$$

Again, note that the feedback effect (higher θ implies o_S up, implies a lower increase in θ for a given change in C) dampens the effect of dC on $d\theta$ via the second term in the denominator.

Then, given the data in Table D4 below, we compute $d\theta$ for $dC/n_{SB} = 0.25, 0.5, 1.0$ from (A.6). Thus gives the values in row 2 of Table 8. To get the values on row 5, we note that from (A.3) that $do_S = 0.37d\theta$, so we multiply all values in row 2 through by 0.37. Finally, to get row 4, Note from table 7 that we have estimated an average value $\frac{\partial v_{SB}}{\partial \theta} = -0.066$,where 0.066=(0.05+0.081)/2 is the average of the estimates at the two kinks. So, $dv_{SB} = -0.066d\theta$, so we multiply all values in row 2 through by 0.066 to get row 4.

Table D4: Data Values

	Average rateable value	Vacancy rate	Occupancy rate by small businesses
RR	10.286	0.0889	n.a.
SBRR	13.409	0.0894	0.468

The net benefit of increasing expenditure by £X on either RR or SBRR can now be calculated via the formula: net benefit equals average market rent of an eligible property times p.p. reduction in the vacancy rate from £X, minus £X times the marginal cost of public funds (MCPF). The net benefits are shown in Table D5 below for

Table D5: Net Benefits

MCPF	increase in expenditure per property, £1000	0.25	0.5	1
1	RR	-0.07	-0.15	-0.30
1	SBRR	-0.21	-0.42	-0.83
1.3	RR	-0.15	-0.30	-0.60
1.3	SBRR	-0.28	-0.57	-1.13

N Online Appendix

The Online Appendix consists of four main parts. The first part includes additional tables and figures (N.1). The second parts presents a directed search model of the commercial property market, and derives the empirical predictions reported in Table 2 of the paper (N.2). The third part includes additional empirical results for RR and SBRR (N.3). In the last part of the Online Appendix (N.4), we describe the data used in the empirical analysis in detail.

N.1 Additional Tables and Figures

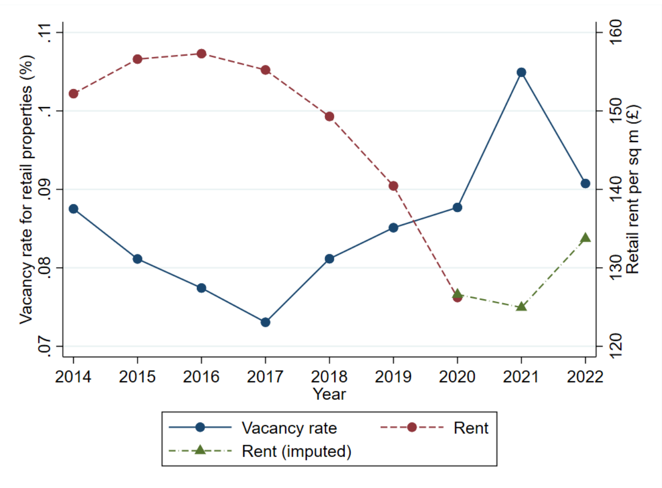
Table N1 reports the small business and the (normal) multiplier for jurisdictions in England outside of London between 2010-2011 and 2020-2021. Figure N1 plots the retail vacancy rate from 2014-2022 and the retail rent per square metre in England.

Table N1: 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 N1: Long term trend in vacancy and rents



Notes: The figure plots the retail vacancy rate and retail rents per square metre from 2014 to 2022 in England. The retail vacancy rate uses data for retail and vacant units of the Local Data Company, aggregated at local authority level, and is computed as ratio of vacant unit to total units for each year. Retail rents per square metre for 2014 to 2020 are annual aggregate estimates from Investment Property Forum (indicated by circles marker); the second series of rents for 2019 to 2022 are calculated from the Savills retail annual change in rental cost (from Statista) using the 2019 rent level from the IPF data. The rents are in real prices in 2015 deflated with CPI from ONS.

N.2 Directed Search Model of the Commercial Property Market

In this appendix section, we present model set-up (Appendix N.2.1), equilibrium conditions (Appendix N.2.2), empirical predictions (Appendix N.2.3) and proof of equilibrium conditions (Appendix N.2.4) for the directed search model of the commercial property market.

N.2.1 The Formal Model of Vacancy and Rent Determination

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, $i = 1,..,m$ ranked by their rateable value R_i, so $R_1 < R_2 < ...R_m$. 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 existing properties of large businesses are taken as fixed and exogenous to the model. The number of small businesses is determined by free entry. 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 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 as follows.

First, consider an unoccupied property. As we are ignoring empty property relief, any property will pay the standard business rate i.e. $T^u(R) = \kappa(R)R$ 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 RR applies, so $T^o(R;j) = \frac{2}{3}\kappa(R)R$. If $R \leq 15$, both RR and SBRR apply. In this case, $T^o(R;l) = \frac{2}{3}\kappa(R)R$, as large businesses are not eligible for RR. However, if the property is let to a small business, both RR 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:

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

Equation (N.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 1 (a) above.

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. 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. The assumption being made here is that businesses first make the decision either (a) to participate in the property market or (b) to pursue an outside option worth ρR_i. If they choose (a), they then are locked into the property market and if they cannot find a property to rent, they do not operate and make zero profit, as already stated.

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.

N.2.2 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 N.2.4. Here, we just discuss the equilibrium vacancy rates, rents, 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.[53] Note first that if the landlord is small, the maximum rent that can be extracted from a type s business is higher than a type l business, because the former tenant will be eligible for SBRR. In any equilibrium, it can be shown that small landlords will always set this higher rent, and as a consequence, large businesses will apply only to large landlords. So, the equilibrium must be *fully* or *semi-segmented*; large businesses will rent only from large landlords, and small businesses are indifferent between large and small landlords and may rent from both. Moreover, all these equilibria are payoff-equivalent for all agents, because (i) small businesses are indifferent between applying to small or large properties; (ii) large landlords are indifferent between letting to large and small businesses. 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.[54] 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.

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

$$v_i = \frac{\rho R_i}{\Pi(R_i) + T^u(R_i) - T^o(R_i)}, \quad \tilde{r}_i = \Pi(R_i) - T^o(R_i) - \frac{\rho R_i}{m(v_i)} \tag{N.2}$$

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

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

[54]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 $T^o(R; s) = T^o(R; l) \equiv T^o(R)$.

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. $T^u(R) - T^o(R)$.

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 (intuitively) increases the probability of a match for a particular tenant, which then *increases* the rent from (N.2). 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.[55] These observable implications are discussed in much more detail in Section 3.2. For now, it is important to note by inspection of (N.2) that *both* vacancies 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 (N.3) is completely general in that the tax functions $T^u(R), T^o(R)$ capture any interactions between reliefs - for example, RR may also apply at the SBRR thresholds.

N.2.3 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. 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 (N.2) by R and drop the landlord type subscript to get

$$v(R) \equiv \frac{\rho}{\pi(R) + \tau^u(R) - \tau^o(R)}, \quad r(R) \equiv \pi(R) - \tau^o(R) - \frac{\rho}{m(v(R))} \tag{N.3}$$

Here, $v(R)$ is the vacancy rate for properties with a rateable value of R, $r \equiv \tilde{r}/R$ 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 (N.3), this amounts to assuming that $\pi(R)$ is continuous.

We are now in a position to derive the results in Table 2. To lighten notation, we introduce the following shorthand for right-hand and left-hand limits of v, r at thresholds:

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

where r, s refer to RR and SBRR respectively.

Retail Relief. Here, at this threshold, SBRR does not apply, so we can write the vacancy rate

[55] For example, at $R = 51$, RR 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.

as a function of R as

$$v(R)=\frac{\rho}{\pi(R)+\kappa-\tau(R)},\quad \tau(R)=\begin{cases}\frac{2\kappa}{3}, & R\leq R_r\\ \kappa & R>R_r\end{cases} \tag{N.4}$$

So, the change in v at the threshold is

$$\overline{v}(R_r)-\underline{v}(R_r)=\frac{\rho}{\pi(R_r)}-\frac{\rho}{\pi(R_r)+\frac{\kappa}{3}}>0 \tag{N.5}$$

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

$$r(\tau;R)\equiv\pi(R)-\tau+f(v(\tau)),\ v(\tau)=\frac{\rho}{\pi(R)+\kappa-\tau},\qquad f(v)=\rho\frac{\ln(v)}{1-v} \tag{N.6}$$

So, from (N.6) ;

$$\overline{r}(R_R)-\underline{r}(R_R)=r(\kappa;R_R)-r\left(\frac{2\kappa}{3};R_R\right)=\int\limits_{2\kappa/3}^{\kappa}\big(-1+f'(v)v'(z)\big)\,dz \tag{N.7}$$

Also, from (N.6), (N.4):

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

So, after some simplification:

$$-1+f'(v)v'(z)=-1+\frac{1}{(1-v)^2}\left(1-v+v^2\ln(v)\right)\equiv g(v) \tag{N.8}$$

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 (N.7), (N.8), $\overline{r}(R_R)<\underline{r}(R_R)$ 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 RR as well. As the property is not entitled to EPR, at the SBRR threshold, the vacancy function is

$$v(R)=\frac{\rho}{\pi(R)+\kappa-\tau(R)},\quad \tau(R)=\begin{cases}0, & R\leq\underline{R}_s\\ \kappa-\kappa(\frac{60}{R}-4) & \underline{R}_s<R\leq\overline{R}_s\\ \kappa & R>\overline{R}_s\end{cases} \tag{N.9}$$

So, from (N.9), the left- and right-hand derivatives of $v(R)$ at $\underline{R}_s$ are

$$\left.\frac{\partial v^-}{\partial R}\right|_{\underline{R}_s}=\frac{-\pi'(\underline{R}_s)\rho}{(\pi(\underline{R}_s)+\kappa)^2},\quad \left.\frac{\partial v^+}{\partial R}\right|_{\underline{R}_s}=\frac{-(\pi'(\underline{R}_s)-60\kappa\underline{R}_s^{-2})\rho}{(\pi(\underline{R}_s)+\kappa)^2} \tag{N.10}$$

respectively. So, from (N.10), the change in the slope of v at the lower threshold is

$$\left.\frac{\partial v^+}{\partial R}\right|_{\underline{R}_s}-\left.\frac{\partial v^-}{\partial R}\right|_{\underline{R}_s}=\frac{60\kappa}{\underline{R}_s^2}\frac{\rho}{(\pi(\underline{R}_s)+\kappa)^2}=\frac{60\kappa}{\underline{R}_s^2}\frac{(v(\underline{R}_s))^2}{\rho}>0 \tag{N.11}$$

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

$$\left.\frac{\partial v^+}{\partial R}\right|_{\overline{R}_s}-\left.\frac{\partial v^-}{\partial R}\right|_{\overline{R}_s}=-\frac{60\kappa}{\overline{R}_s^2}\frac{\rho}{(\pi(\overline{R}_s))^2}=-\frac{60\kappa}{\rho\overline{R}_s^2}\frac{(v(\overline{R}_s))^2}{\rho}<0 \tag{N.12}$$

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 (N.6), (N.9) 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

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

where in the second line, we use (N.11). 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 (N.12).

Predictions on Causal Effects. As RR induces a notch in the tax schedule, the effect of a one p.p. decrease in the ETR via withdrawal of RR is (N.5) divided by the change in the tax at the notch, which is $\kappa/3$. This gives the effect as

$$\frac{\rho}{\pi(\pi + \frac{\kappa}{3})} \tag{N.13}$$

To get the effect of the effect of a one p.p. increase in the ETR via withdrawal of SBRR, note that as π is assumed independent of R, at any point where $\tau(R)$ is differentiable:

$$\frac{dv}{dR} = \frac{\rho}{(\pi + \kappa - \tau)^2}\frac{d\tau}{dR} \tag{N.14}$$

So, the causal effect is

$$\frac{dv/dR}{d\tau/dR} = -\frac{\rho}{(\pi + \kappa - \tau)^2} \leq \frac{\rho}{(\pi + \kappa)^2} \tag{N.15}$$

But, by inspection, $(\pi + \kappa)^2 > \pi(\pi + \frac{\kappa}{3})$. But, by inspection, $(\pi + \kappa)^2 > \pi(\pi + \frac{\kappa}{3})$. So, one p.p. decrease in the ETR via RR causes a bigger fall in v than a one p.p. decrease in the ETR via SBRR.

N.2.4 Proofs of Propositions 1 and 2

Proof of Proposition 1. 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, and $P = 1, ..p$ is the set of property types. 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

$$v_i = (1 - p_{i,s})^{N_s}(1 - p_{i,l})^{N_l} = \left(1 - \frac{q_{i,s}}{N_s}\right)^{N_s}\left(1 - \frac{q_{i,l}}{N_l}\right)^{N_l} \tag{N.16}$$

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

$$v_i = e^{-(q_{i,s}+q_{i,l})} \equiv v(q_{i,s} + q_{i,l}) \tag{N.17}$$

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

$$m_i = \frac{1 - v_i}{q_{l,s} + q_{i,l}} \equiv m(q_{i,s} + q_{i,l}) \tag{N.18}$$

A business of type j has an expected profit

$$m_i(\Pi(R_i) - \tilde{r}_i - T^o(R_i; j)) \tag{N.19}$$

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, (N.19) 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).[56] So, $q_{i,j}$ satisfies:

$$q_{i,j} = \begin{cases} \in (0, \infty), & m_i(\Pi(R_i) - \tilde{r}_i - T^o(R_i; j)) = \rho R_i \\ 0, & m_i(\Pi(R_i) - \tilde{r}_i - T^o(R_i; j)) < \rho R_i \end{cases} \tag{N.20}$$

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

$$(1 - v_i)\tilde{r}_i - v_i T^u(R_i), \quad i \in P \tag{N.21}$$

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 (N.21) subject to (N.20) and (N.17). 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.

Now consider the problem facing the small landlord i.e. one whose property is eligible for SBRR. From (N.20), the maximum rent that a small landlord can charge a type s business, while still

[56]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.

attracting applications, is

$$\overline{r}_{i,s} = \Pi(R_i) - T^o(R_i; s) - \frac{\rho R_i}{m_i}. \tag{N.22}$$

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

$$\overline{r}_{i,l} = \Pi(R_i) - T^o(R_i; l) - \frac{\rho R_i}{m_i}. \tag{N.23}$$

So, as $T^o(R_i; s) < T^o(R_i; l)$, it follows from (N.22), (N.23) 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

$$\tilde{r}_i = \overline{r}_i \equiv \Pi(R_i) - T^o(R_i) - \frac{\rho R_i}{m_i} \tag{N.24}$$

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. □

Proof of Proposition 2. 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 (N.21) as:

$$\begin{aligned} R_s &= o(q_{i,s})(\overline{r}_{i,s} + T^u(R_i)) - T^u(R_i) \\ &= o(q_{i,s})\left(\Pi(R_i) + T^u(R_i) - T^o(R_i; s) - \frac{\rho R_i}{m_i}\right) - T^u(R_i) \\ &= o(q_{i,s})\left(\Pi(R_i) + T^u(R_i) - T^o(R_i; s)\right) - q_{i,s}\rho R_i - T^u(R_i) \end{aligned} \tag{N.25}$$

where in the second line we substitute out $\overline{r}_{s,s}$ using (N.22), 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 (N.25). The first-order condition is

$$o'(q_{i,s})(\Pi(R_i) + T^u(R_i) - T^o(R_i; s)) = \rho R_i \tag{N.26}$$

(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 (N.24) above. So, for such a landlord, we can rewrite (N.21) as

$$\begin{aligned} R_l &= o_l(q_{i,s} + q_{i,l})(\overline{r}_i + T^u(R_i)) - T^u(R_i) \\ &= o(q_{i,s} + q_{i,l})\left(\Pi(R_i) + T^u(R_i) - T^o(R_i; j) - \frac{\rho R_i}{m(q_{i,s} + q_{i,l})}\right) - T^u(R_i),\ j = s, l \\ &= o(q_{i,s} + q_{i,l})\left(\Pi(R_i) + T^u(R_i) - T^o(R_i; j)\right) - (q_{i,s} + q_{i,l}), \rho R_i - T^u(R_i),\ j = s, l \end{aligned} \tag{N.27}$$

where the second line we substitute out $\overline{r}_i$ using (N.24), 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 (N.25) and (N.27); 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 (N.27). The FOC for this choice is

$$o'(q_{i,s} + q_{i,l})(\Pi(R_i) + T^u(R_i) - T^o(R_i; j)) = \rho R_i, j = s, l \tag{N.28}$$

(d) Now note that $o'(q) = e^{-q} = v(q)$. Making this substitution in (N.26), (N.28), we can solve for the vacancy rates for small and large landlords. Both these vacancy rates can be expressed in the form (N.2). The final step is to check that that small businesses are indifferent between applying to small and large properties. It is easy to check from (N.22), (N.24), 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. □

N.3 Additional Empirical Results for RR and SBRR

In this appendix section, we present additional tables and figures for empirical results for RR (Appendix N.3.1) and SBRR (Appendix N.3.2). The additional empirical results in both parts are based on the same sample as used for the results reported in the paper. In the third part of this section, we presents tables and figures for comparing the empirical results for SBRR using data before the 2017 revaluation and after the 2017 revaluation (Appendix N.3.3).

N.3.1 Additional Results for Retail Relief

In this appendix subsection, we report tables and figures for additional empirical results for RR. Figures N2 and N3 plot the estimated density of the McCrary and the RD density test 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 RR.

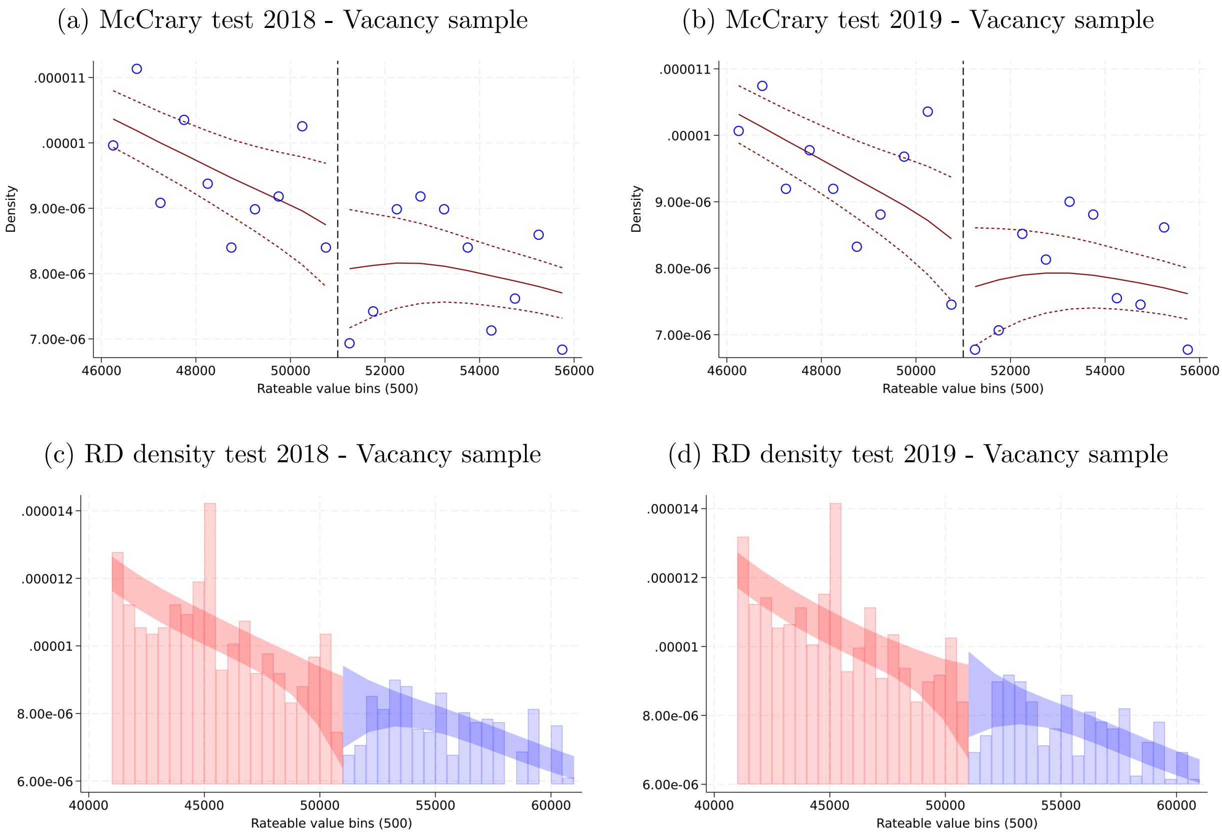
Table N2 assesses in addition whether other property and tenant characteristics change at the threshold, in 2018 and 2019, or 2018 vs 2019. Panel A shows the results for the vacancy data and Panel B for the rent data. In the vacancy data, there is no evidence for a change in the distance to the nearest High Street of properties at the threshold in 2018, 2019 or from 2018 to 2019. In the rent data, the distance to the High Street seems to be shorter below the threshold in 2018 but not in 2019, and the difference is statistically significant at the 10% level when comparing below and above the threshold in 2018 and 2019. However, the difference is very small with only 140m, and including the distance to the High St. interacted with the reform dummy in the estimation of the effects for RR has little impact on the results (results are available upon request). To assess whether the RR interacts with the charity relief (that reduces the tax for charities as occupier by 80% or more), we use an indicator variable for charities as occupier. We assume a charity is the occupier, if the ETR is less than 80% of the statutory rate (and for properties that SBRR may be applicable, no SBRR is claimed). We do not find evidence that the RR affects the likelihood of properties being occupied by a charity. Thus, the RR does not interact with the charity 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 N4 shows the graphical analysis for all outcome variables, and Table N3 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.

Table N4 reports results when using rent (cols. (1)-(3)) or ln rent (cols. (4)- (6)) as dependent variable. We estimate an absolute reduction in rents at the threshold of around £4,200. This is equivalent to a reduction in rents to rateable value at the threshold of 8.2% (col. (1)). The estimated reduction in rents varies substantially with the bandwidth, the average over the three specifications is around 6%. Given an average rent of £52,250 left to the threshold, this translates into an absolute reduction of around £3,100 in rent or 6.1% of rent to rateable value.

Table N5 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.4. Panel A shows the results when excluding jurisdictions for which the rateable value is not directly observed, Panel B when excluding jurisdictions for which the vacancy is not directly observed, Panel C when excluding jurisdictions for which the charge is not directly observed, and Panel D 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 with around 0.3 somewhat lower than our baseline estimate. This results, however, less from excluding certain jurisdictions but rather from the higher optimal bandwidth due to the smaller sample. Col. (4) shows the results when using the same optimal bandwidth as in our baseline specification, and the results center around our baseline estimate.

Figure N2: Validity of RDD for retail relief - Vacancy sample



(a) McCrary test 2018 - Vacancy sample

(b) McCrary test 2019 - Vacancy sample

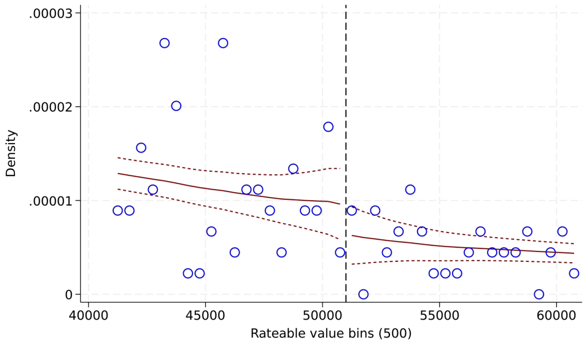
(c) RD density test 2018 - Vacancy sample

(d) RD density test 2019 - Vacancy sample

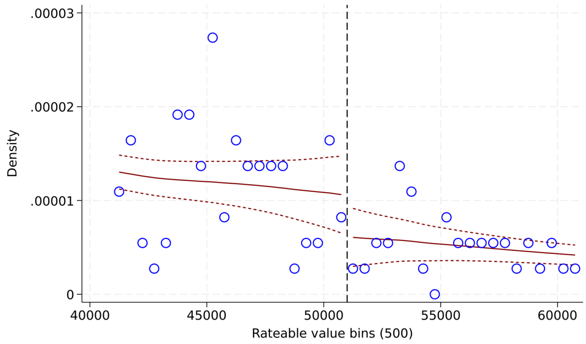
Notes: The graph plots the estimated density function for the McCrary test (a) for 2018 and (b) for 2019, and for the RD density test (c) for 2018 and (d) for 2019 for the vacancy sample. The rateable value range is £41,000 to £61,000, and the bin width £500. The dashed line indicates the rateable value threshold for the RR and the solid lines represent polynomial fits.

Figure N3: Validity of RDD for retail relief - Rent sample

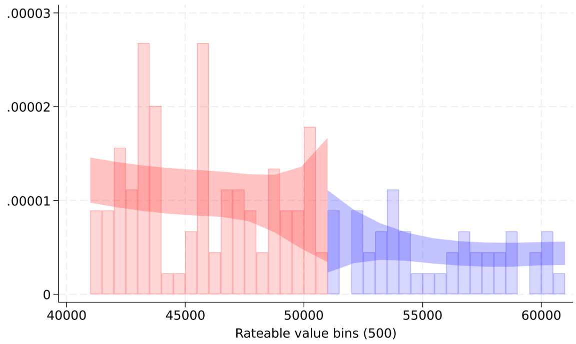
(a) McCrary test 2018 - Rent sample



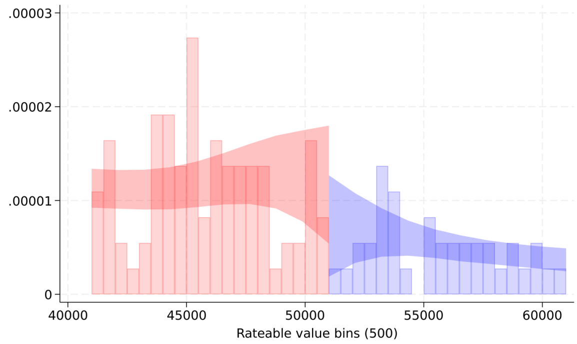
(b) McCrary test 2019 - Rent sample



(c) RD density test 2018 - Rent sample



(d) RD density test 2019 - Rent sample

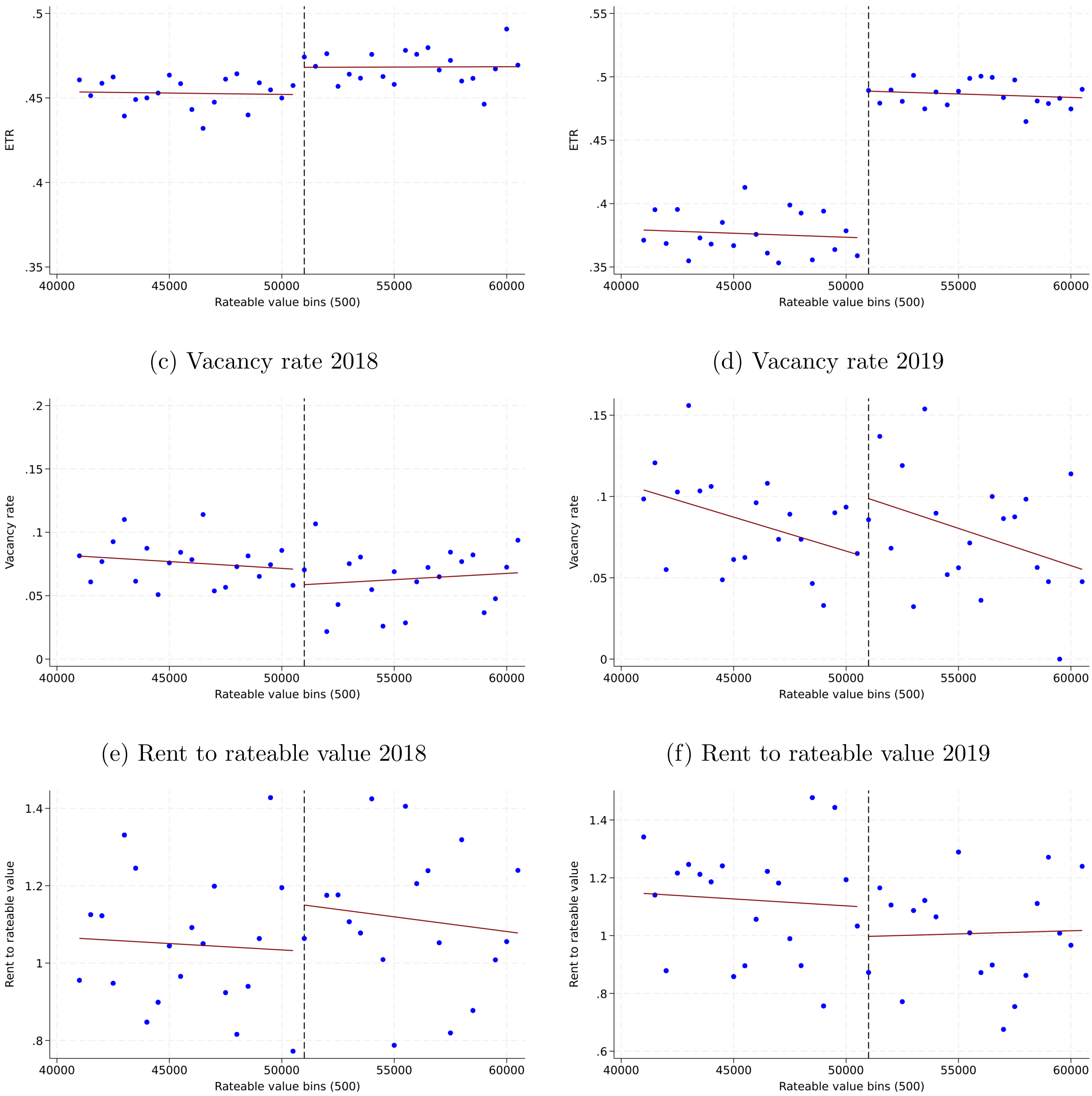


Notes: The graph plots the estimated density function for the McCrary test (a) for 2018 and (b) for 2019, and for the RD density test (c) for 2018 and (d) for 2019 for the rent sample. The rateable value range is £41,000 to £61,000, and the bin width £500. The dashed line indicates the rateable value threshold for the RR and the solid lines represent polynomial fits.

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 (0.09) and for 2019 -0.08 (0.09), small vacancy sample for 2018 -0.03 (0.12) and for 2019 0.00 (0.12) and for the rent sample for 2018 -0.40 (0.33) and for 2019 -0.54 (0.34). The results of the RD density test (p-value) are 0.63 (2018) and 0.66 (2019) for the large vacancy sample, and 0.47 (2018) and 0.29 (2019) for the rent sample.

Figure N4: 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



Notes: 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 RR and the solid lines represent linear fits.

Table N2: RDD for retail relief - property or tenant characteristics

Dep. Var.	Distance to High Street			Charity		
	2018 (1)	2019 (2)	2018 vs 2019 (3)	2018 (4)	2019 (5)	2018 vs 2019 (6)
Panel A: Vacancy data						
D(R≥51k)	-21.945 (68.735)	-47.184 (70.814)		-0.013 (0.013)	-0.006 (0.014)	
D(R≥51k)*Post			16.947 (29.611)			-0.007 (0.009)
Observations	14,491	14,026	4,022	7,814	7,777	4,043
Bandwidth	10,506	10,638	10,572	10,209	10,097	10,153
Panel B: Rent data						
D(R≥51k)	140.557 (132.974)	-8.358 (113.609)				
D(R≥51k)*Post			-140.214* (79.724)			
Observations	155	143	298			
Bandwidth	10,969	12,009	11,489			

Notes: The table reports reduced form estimates for RR using property or tenant characteristics. The dependent variable is distance to the nearest High Street (cols. (1)-(3)) and an indicator for charities (cols. (4)-(6)), Cols. (1) and (4) show the 2018, cols. (2) and (5) the 2019, and cols. (3) and (6) the 2018 vs 2019 results. Panel A shows the results for the vacancy data and Panel B for the rent data. We assume a charity as occupier if the ETR is 80% or more lower than the statutory rate. Charities as occupier can only be identified in the vacancy data. All cols. use the optimal bandwidth. The optimal bandwidth is estimated following Calonico, Cattaneo and Titiunik (2014*a*) using local authority-rateable value bin level clustering. Robust standard errors are clustered at the rateable value bin and local authority level and are reported in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N3: RDD for retail relief - Local regressions for ETR and Vacancy

	Without local authority FE				With local authority FE	
Local regression Kernel	Linear Triangular		Quadratic Triangular		Linear Triangular	
Year	2019	2018	2019	2018	2019	2018
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ETR of occupied properties						
Conventional	0.114***	0.015*	0.116***	0.016*	0.119***	0.016**
	(0.011)	(0.008)	(0.012)	(0.009)	(0.010)	(0.008)
Bias-corrected	0.116***	0.016	0.118***	0.017*	0.121***	0.018*
	(0.013)	(0.010)	(0.013)	(0.010)	(0.011)	(0.010)
Observations	2,040	2,100	4,242	4,421	1,894	2,100
Bandwidth	11,181	11,299	21,171	21,523	10,471	11,272
Panel B: Vacant (large sample)						
Conventional	0.032	-0.010	0.029	-0.008	0.032*	-0.011
	(0.020)	(0.018)	(0.019)	(0.018)	(0.019)	(0.017)
Bias-corrected	0.039*	-0.006	0.033	-0.005	0.039*	-0.008
	(0.023)	(0.021)	(0.021)	(0.021)	(0.021)	(0.020)
Observations	3,431	4,002	8,884	9,155	3,430	3,939
Bandwidth	9,400	10,838	21,639	22,024	9,358	10,528
Panel C: Vacant (small sample)						
Conventional	0.040	-0.003	0.045*	0.002	0.043*	-0.002
	(0.025)	(0.022)	(0.025)	(0.023)	(0.024)	(0.021)
Bias-corrected	0.045	-0.002	0.049*	0.004	0.048*	-0.002
	(0.029)	(0.026)	(0.029)	(0.026)	(0.028)	(0.025)
Observations	2,146	2,318	4,796	4,957	2,113	2,215
Bandwidth	10,785	11,650	21,988	22,454	10,749	11,132
Panel D: Rent to rateable value						
Conventional	-0.035	0.055	-0.041	0.054	-0.125	0.115
	(0.143)	(0.112)	(0.154)	(0.112)	(0.095)	(0.076)
Bias-corrected	-0.036	0.035	-0.044	0.039	-0.149	0.133
	(0.179)	(0.128)	(0.181)	(0.125)	(0.109)	(0.089)
Observations	183	175	407	436	95	113
Bandwidth	15,190	12,648	27,238	25,439	7,155	7,933

Notes: The table reports reduced form estimates for RR 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 occupied properties (Panel A), an indicator of the property being vacant (Panel B - large sample - and C - small sample) or the rent to rateable value ratio (Panel D). 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 all cols. we use a Triangular Kernel and include quarter-year fixed effects. In cols. (1), (2), (5) and (6) we use a local linear regression, and in cols. (3) and (4) a local quadratic regression. Cols. (1) to (4) show the results of specifications without local authority fixed effects and cols. (5) and (6) 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. Standard errors are clustered at the local authority-rateable value bin level. The bandwidths used for estimation are the optimal bandwidths following Calonico, Cattaneo and Titiunik (2014*a*) using local authority-rateable value bin level clustering. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N4: RDD for retail relief - Rent and ln rent as outcome

Dep. Var.	Rent			ln Rent		
Bandwidth	Optimal	75% Optimal	125% optimal	Optimal	75% Optimal	125% optimal
	(1)	(2)	(3)	(4)	(5)	(6)
D(R≥51k)*Post	-4,248	-6,461**	-5,444	-0.031	-0.066	-0.089
	(2,842)	(2,621)	(3,381)	(0.054)	(0.051)	(0.076)
Observations	275	218	334	286	225	341
Bandwidth	10,402	7,802	13,003	10,793	8,095	13,492

Notes: The table reports reduced form estimates for RR. The dependent variable is rent (cols. (1) to (3)), or ln rent (cols. (4) to (6)). In cols. (1) and (4) we use the optimal bandwidth, in cols. (2) and (5) 75% of it, and in cols. (3) and (6) and 125% of it. The optimal bandwidth is estimated following Calonico, Cattaneo and Titiunik (2014*a*) using local authority-rateable value bin level clustering. Robust standard errors are clustered at the rateable value bin and local authority level and are reported in parentheses. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N5: RDD for retail relief - Sensitivity checks on the sample

Dep. Var.	ETR	Vacant		
Properties	Occupied	All		
Bandwidth	Optimal			Optimal (Full sample)
	(1)	(2)	(3)	(4)
Panel A: Without jurisdictions with not directly observed rateable value				
D(R≥51k)*Post	0.105***	0.036*		
	(0.011)	(0.021)		
Causal effect for ETR			0.351	0.389*
			(0.217)	(0.228)
Observations	2,864	6,070	6,070	5,654
Bandwidth	9,367	9,367	9,367	8,697
Panel B: Without jurisdictions with not directly observed vacancy				
D(R≥51k)*Post	0.107***	0.035		
	(0.012)	(0.024)		
Causal effect for ETR			0.333	0.449**
			(0.225)	(0.226)
Observations	2,501	4,321	4,321	4,587
Bandwidth	8,153	8,153	8,153	8,697
Panel C:Without jurisdictions with not directly observed tax charge				
D(R≥51k)*Post	0.102***	0.042*		
	(0.011)	(0.023)		
Causal effect for ETR			0.423*	0.423*
			(0.245)	(0.245)
Observations	2,825	5,472	5,472	5,472
Bandwidth	8,722	8,722	8,722	8,697
Panel D: Without jurisdictions with not directly observed property type				
D(R≥51k)*Post	0.076***	0.041*		
	(0.015)	(0.025)		
Causal effect for ETR			0.535	0.552
			(0.382)	(0.382)
Observations	1,733	4,538	4,538	4,456
Bandwidth	8,916	8,916	8,916	8,697

Notes: The table reports reduced form estimates for the RR excluding jurisdictions for which a particular variable was imputed. In Panel A we exclude jurisdictions for which the rateable value is not directly observed, in Panel B jurisdictions for which the vacancy is not directly observed, in Panel C jurisdictions for which the charge is not directly observed, and in Panel D we exclude jurisdictions for which the property type is not directly observed. The dependent variable is the ETR (col. (1)) or an indicator of the property being vacant (cols. (2), (3) and (4))). All cols. use the optimal bandwidth, except col. (4) which uses the optimal bandwidth when using the full sample. The optimal bandwidth is estimated following Calonico, Cattaneo and Titiunik (2014*a*) using local authority-rateable value bin level clustering. Robust (cols. (1)-(2)) or bootstrapped (cols. (3)-(4)) 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.3.2 Additional Results for SBRR

In this appendix subsection, we report tables and figures for additional empirical results for the SBRR. Figures N5 and N6 plot the estimated density of the McCrary and the RD density test around the first kink and the second kink for the vacancy sample and the rent sample. The figure shows that the number of observations is smooth around the kinks and that no change in slope is indicated.

Table N6 assesses in addition whether other property and tenant characteristics are smooth around the kinks. Panel A shows the results for the vacancy data, and Panel B for the rent data. It suggests that the likelihood of being a retail property (cols. (1) and (4)) and the distance to the nearest High Street of properties (cols. (2) and (5)) are smooth around the threshold. In addition, the likelihood that a charity occupies the property does not change at the kinks (cols. (3) and (6)). This suggests that the charity relief and the SBRR do not interact.

Table N7 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, except for the rent to rateable value when including local authority fixed effects due to the small sample size.

Table N8 reports heterogeneity results for occupancy, vacancy and rent using only retail properties. The marginal effects are suggested to be stronger for occupancy but less different for vacancy and rents.

Table N9 reports results for the reduced form for SBRR when using level of rent (Panel A) or log of rent (Panel B) as dependent variable. The estimates are in line with our baseline results. Cols. (1) and (2) report for the first kink the reduced form estimate, and cols. (3) and (4) for the second kink. The estimate in col. (1) of Panel A for the first kink means that an increase in the rateable value by £1,000 increases rent by £568 less on the right right compared to on the left of the threshold. In terms of rent to rateable value ratio, this is about 4.7%, which is similar to our baseline estimate shown in col. (4) of Table 6. In col. (1) of Panel B, 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. 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 £15,100, this is equivalent to a change in the rent to rateable value of -0.070. In cols. (3) and (4) of Table N9, we report the reduced form estimates for the upper kink using level or log rents as outcome. Similar to the estimates reported in Section 6.2, we do not find the estimates statistically significant at the upper kink.

Table N10 reports the rent results when excluding properties that are longer on the market than typical for the jurisdiction and property type. There could be potential selection in the rent offer data in the form that properties with a high offer rent given the property characteristics/quality are over-represented, since these properties are more likely to be empty for longer. We exclude properties from the estimations that are longer than typical on the market. In cols. (1) and (4) we exclude properties that are 175% longer than the median duration on the market, and in cols. (2) and (5) 200% and in cols. (3) and (6) 225%. Cols. (1)-(3) report the results for all properties, and cols. (4)-(6) for retail properties. Panel A shows the results for the first kink and Panel B for the second kink. The estimates are very similar when excluding properties with long empty duration. We conclude that within a jurisdiction, the empty duration varies by property but it is not related systematically to the offer rent (to rateable value ratio).

Table N11 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.

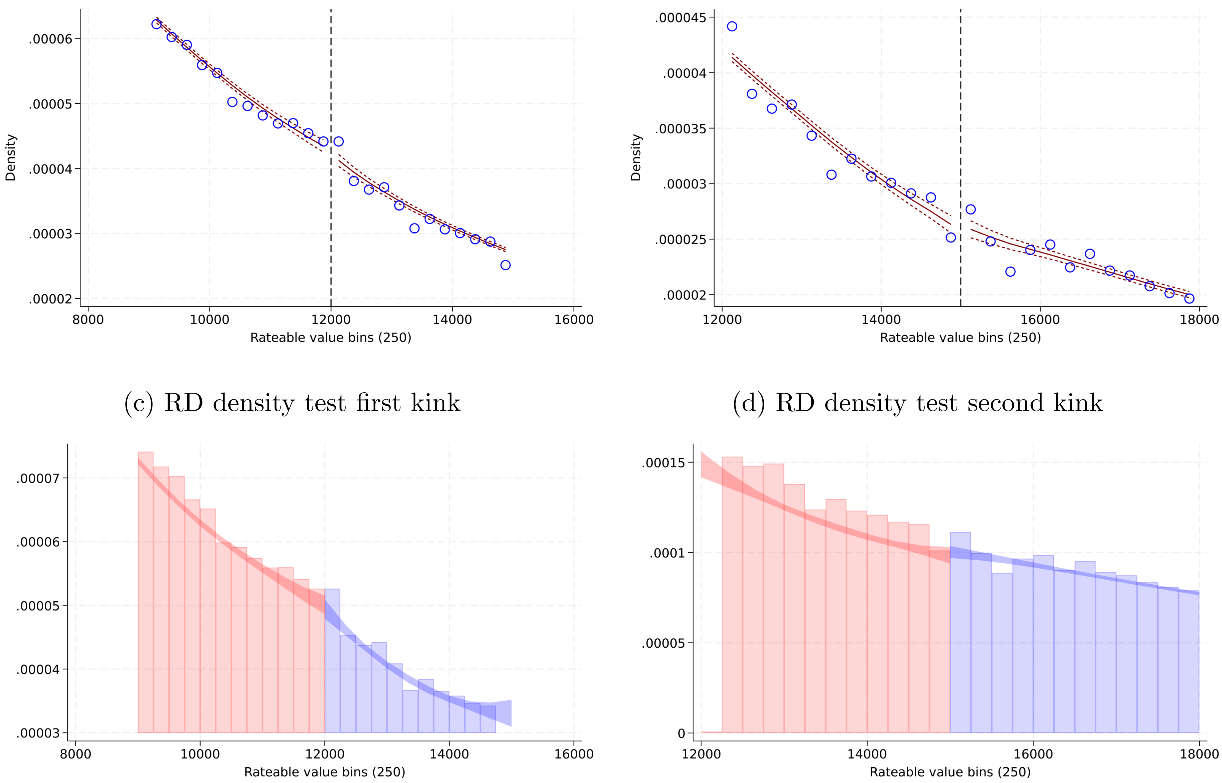
Figure N5: Validity of RKD for SBRR - Vacancy sample

(a) McCrary test first kink

(b) McCrary test second kink

(c) RD density test first kink

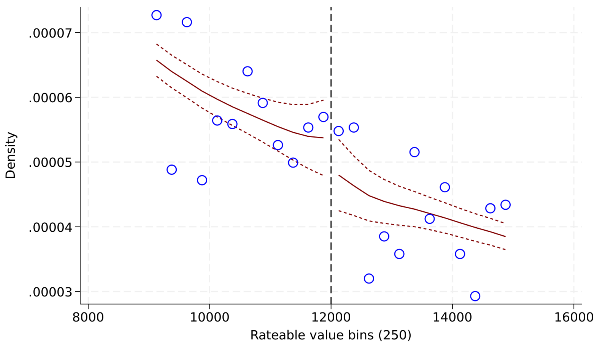
(d) RD density test second kink



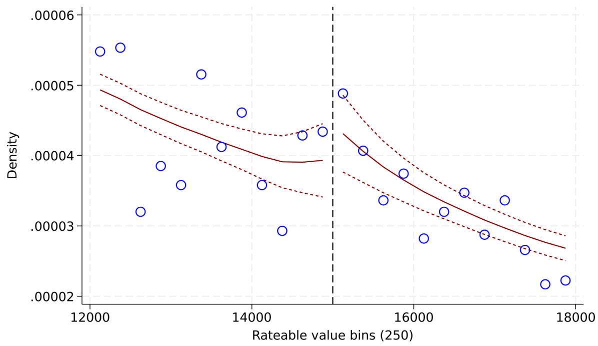
Note: The graphs plot the the estimated density function for the McCrary test for the first kink (a) and second kink (b) and for the RD density test for the first kink (c) and second kink (d) for the large vacancy sample. The rateable value range is from £9,000 to £15,000 (a,c) or £12,0000 to £18,000 (b,d) with bin width £250. The dashed lines indicate the two kinks for the small business rate relief and the solid lines represent polynomial fits.

Figure N6: Validity of RKD for SBRR - Rent sample

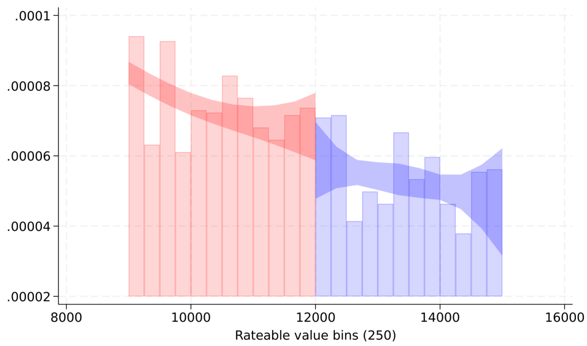
(a) McCrary test first kink



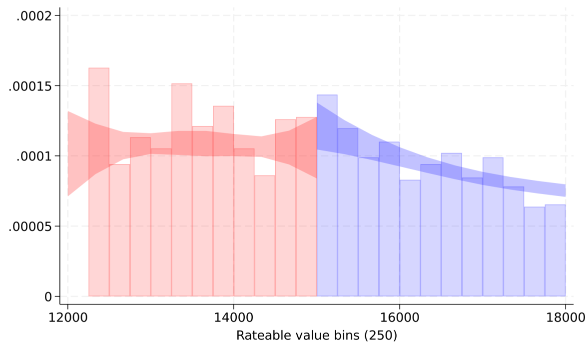
(b) McCrary test second kink



(c) RD Density test first kink



(d) RD Density test second kink



Note: The graphs plot the the estimated density function for the McCrary test for the first kink (a) and second kink (b) and for the RD density test for the first kink (c) and second kink (d) for the rent sample. The rateable value range is from £9,000 to £15,000 (a,c) or £12,0000 to £18,000 (b,d) with bin width £250. The dashed lines indicate the two kinks for the small business rate relief and the solid lines represent polynomial fits.

The results of the McCrary tests (point estimate (s.e.)) using a bandwidth of £250 and a rateable value range from £3,000 to £24,00 are : Large vacancy sample first kink -0.02 (0.02) and second kink: 0.02 (0.02)), small vacancy sample first kink -0.03 (0.02) and second kink: 0.04 (0.03)), rent sample first kink -0.10 (0.09) and second kink 0.11 (0.10)). The RD density p-values are for the large vacancy sample first kink 0.54 and second kink 0.23, and for the rent sample first kink 0.24 and 0.14. 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 -74 (88) and second kink 126 (72), small vacancy sample first kink -43 (66) and second kink 79 (44), rent sample first kink -4 (10) and second kink -9 (9).

Table N6: RKD for SBRR - Property or tenant characteristics

	First Kink (£12,000)			Second Kink (£15,000)		
	Retail property	Distance to High St.	Charity	Retail property	Distance to High St.	Charity
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Vacancy data						
R*D(kink)	0.000	40.423	-0.004	-0.003	-42.563	0.001
	(0.013)	(47.838)	(0.004)	(0.013)	(47.524)	(0.005)
Observations	32,354	31,031	32,354	20,341	19,529	20,341
Bandwidth	3,000	3,000	3,000	3,000	3,000	3,000
Panel B: Rent data						
R*D(kink)	0.019	-17.572		0.001	-20.002	
	(0.031)	(50.456)		(0.034)	(49.292)	
Observations	2,207	2,207		1,600	1,600	
Bandwidth	3,000	3,000		3,000	3,000	

Notes: The table reports reduced form estimates for SBRR using property/tenant characteristics. The dependent variable is an indicator variable for retail property (cols. (1) and (4)), distance to the nearest High Street (cols. (2) and (5)) and an indicator variable for charities (cols. (3) and (6)). Panel A shows the results for the vacancy data and Panel B for the rent data. We assume a charity as occupier if no SBRR is claimed and the ETR is 80% or more lower than the statutory rate. Charities as occupier can only be identified in the vacancy data. All cols. use a fixed bandwidth of £3,000. Robust standard errors are clustered at the local authority-rateable value bin level and are in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N7: RKD for SBRR - Local regressions

	First Kink (£12,000)			Second Kink (£15,000)		
LA FE			x			x
Kernel	Uniform	Triangular	Uniform	Uniform	Triangular	Uniform
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ETR of properties occupied by small business						
Conventional	0.147***	0.154***	0.153***	-0.174***	-0.162***	-0.173***
	(0.013)	(0.018)	(0.021)	(0.021)	(0.016)	(0.016)
Bias-corrected	0.152***	0.161***	0.159***	-0.197***	-0.151***	-0.161***
	(0.017)	(0.027)	(0.032)	(0.025)	(0.024)	(0.020)
Observations	5,377	3,880	3,886	8,227	11,392	8,234
Bandwidth	946	682	710	1,365	1,915	1,401
Panel B: Vacancy						
Conventional	0.009**	0.011***	0.012**	-0.008	-0.006	-0.008
	(0.005)	(0.004)	(0.005)	(0.007)	(0.006)	(0.006)
Bias-corrected	0.013**	0.014**	0.014**	-0.012	-0.007	-0.011
	(0.006)	(0.006)	(0.006)	(0.009)	(0.009)	(0.008)
Observations	48,879	66,202	38,909	28,698	39,569	28,669
Bandwidth	2,280	3,011	1,981	2,219	2,796	2,043
Panel C: Rent/RV						
Conventional	-0.046	-0.028	0.037	0.024	0.014	0.001
	(0.031)	(0.030)	(0.040)	(0.031)	(0.029)	(0.029)
Bias-corrected	-0.077*	-0.051	0.008	0.041	0.018	0.007
	(0.042)	(0.045)	(0.048)	(0.045)	(0.047)	(0.042)
Observations	1,776	2,120	1,195	1,409	1,701	1,307
Bandwidth	2,489	2,898	1,748	2,706	3,095	2,354

Notes: The table reports reduced form estimates for SBRR using local linear regressions. The dependent variable is the ETR of properties occupied by small business (Panel A), an indicator of the property being vacant (Panel B) or the rent to rateable value (Panel C). Cols. (4) to (6) of Panel A report the estimate of ϕ_2 of (6) divided by the share of small businesses at the threshold as described in section (4). Each cell shows an RKD estimate with standard errors in parenthesis. The sample is in Panel A the small vacancy sample, in Panel B the large vacancy sample and in Panel C the rent sample. Cols. (1) to (3) show the results for the first kink and cols. (4) to (6) for the second kink. Cols. (1), (3), (4) and (6) show the results when using a uniform kernel, cols. (2) and (4) when using triangular kernel. All cols. in Panel A and B include quarter-year fixed effects. Cols. (3) and (6) include in addition local authority fixed effects. Standard errors are clustered at the local authority-rateable value bin level. The bandwidths used for estimation are the optimal bandwidths following Calonico, Cattaneo and Titiunik (2014*a*) using local authority-rateable value bin level clustering. 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, which constrains the sample for the optimal bandwidth estimations (that may results in a non-optimal bandwidth). *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N8: RKD for SBRR - Retail properties

	Occupied by		Vacant	Rent/RV
	small business	large business		
	(1)	(2)	(3)	(4)
First kink				
Causal effect for ETR	-0.560***	0.464***	0.097***	-0.357
	(0.083)	(0.082)	(0.031)	(0.222)
Observations	29,905	29,905	29,905	1,235
Second kink				
Causal effect for ETR			0.073	-0.135
			(0.270)	(0.191)
Observations			18,482	882

Notes: The table reports causal estimates for SBRR and retail properties. The dependent variable is an indicator variable for the property being occupied by a small business (col. (1)) or large business (col. (2)), an indicator of the property being vacant (col. (3)) and the rent to rateable value ratio. All cols. use a fixed bandwidth of £3,000 and include quarter-year fixed effects. In cols. (1)-(3) we use the large vacancy sample and in col. (4) the rent sample. Panel A reports the results for the first kink and Panel B for the second kink. Bootstrapped standard errors are clustered at the local authority-rateable value bin level and are in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.

Table N9: RKD for SBRR - Rent and ln rent as outcome

	First Kink (£12,000		Second Kink (£15,000)	
Bandwidth	3,000	2,500	3,000	2,500
	(1)	(2)	(3)	(4)
Panel A: Rent				
R*D(kink)	-568**	-631*	248	297
	(265)	(325)	(405)	(471)
Observations	2,207	1,903	1,600	1,406
Panel B: ln Rent				
R*D(kink)	-0.056***	-0.058***	0.006	0.005
	(0.017)	(0.021)	(0.021)	(0.024)
Observations	2,207	1,903	1,600	1,406

Notes: The table reports reduced form estimates for SBRR. The dependent variable is rent (Panel A) or ln rent (Panel B). Cols. (1) and (3) use a fixed bandwidth of £3,000, cols. (2) and (4) a fixed bandwidth of £2,500. Robust standard errors are clustered at the local authority-rateable value bin level and are in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N10: RKD for SBRR - Rent results for excluding properties with long empty duration

	All properties			Retail properties		
Excluding properties with empty duration of median	> 175%	> 200%	> 225%	> 175%	> 200%	> 225%
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: First kink (£12,000)						
Causal Effect	-0.346*	-0.300*	-0.292*	-0.372	-0.350	-0.360
	(0.186)	(0.177)	(0.171)	(0.263)	(0.237)	(0.244)
Observations	1,689	1,962	2,069	932	1,092	1,161
Bandwidth	3,000	3,000	3,000	3,000	3,000	3,000
Panel B: Second kink (£15,000)						
Causal Effect	-0.188	-0.149	-0.201	-0.120	-0.102	-0.140
	(0.178)	(0.170)	(0.166)	(0.186)	(0.184)	(0.178)
Observations	1,177	1,412	1,491	631	775	825
Bandwidth	3,000	3,000	3,000	3,000	3,000	3,000

Notes: The table reports causal effect estimates for SBRR that account for a potential selection of properties in the rent data. The dependent variable is rent to rateable value. Panel A shows the results for the first kink, and Panel B for the second kink. Cols. (1)-(3) show the results for all properties and cols. (4)-(6) for retail properties. In cols. (1) and (4) we exclude properties with an empty duration above 175% of the median duration, in cols. (2) and (5) above 200% , and in cols. (3) and (6) above 225% All cols. use a fixed bandwidth of £3,000. Robust standard errors are clustered at the local authority-rateable value bin level and are in parenthesis. *, **, *** indicate statistical significance at the 10, 5 and 1% level.

Table N11: RKD for SBRR - Sensitivity checks on the sample

	First kink							Second kink		
	ETR	Occupied by				Vacant		ETR	Vacant	
		small business		large business						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Without jurisdictions with not directly observed vacancy										
R*D(kink)	0.132***	-0.043***		0.034***		0.009**		-0.156***	-0.007	
	(0.002)	(0.009)		(0.009)		(0.004)		(0.028)	(0.005)	
Causal effect for ETR			-0.324***		0.257***		0.067**			0.040
			(0.067)		(0.067)		(0.029)			(0.031)
Observations	15,967	48,179	48,179	48,179	48,179	48,179	48,179	5,726	30,710	30,710
Panel B: Without jurisdictions with not directly observed tax charge										
R*D(kink)	0.136***	-0.049***		0.039***		0.009***		-0.175***	-0.007	
	(0.002)	(0.009)		(0.008)		(0.004)		(0.031)	(0.005)	
Causal effect for ETR			-0.357***		0.289***		0.068***			0.042
			(0.064)		(0.060)		(0.026)			(0.035)
Observations	16,133	55,688	55,688	55,688	55,688	55,688	55,688	5,743	35,297	35,297

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 (8)), an indicator variable for the property being occupied by a small business (cols. (2) and (3))) or large business (cols. (4) and (5)), and an indicator of the property being vacant (cols. (6), (7), (9) and (10)). Cols. (1)-(7) report the results for the first kink and cols. (8)-(10) for the second kink. Col. (8) reports the estimate of ϕ_2 of (6) divided by the share of small businesses at the threshold as described in section (4). All cols. use a fixed bandwidth of £3,000 and include quarter-year fixed effects. In cols. (1) and (8) we use the small sample, and in all other cols. the large sample. Panel A report 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 tax charge is not directly observed. Robust standard errors are clustered at the local authority-rateable value bin level and are in parenthesis. *, **, *** indicate statistical significance at the 10,5 and 1% level.

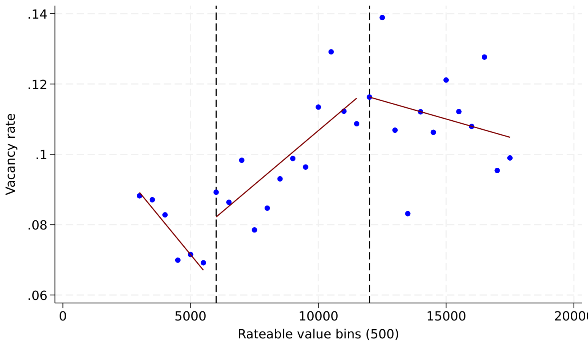
N.3.3 Additional Results for SBRR - Variation over time

In this appendix subsection, we present additional results for SBRR that exploit variation over time. First, we present tables and figures for comparing the empirical results using data before the 2017 revaluation and after the 2017 revaluation. Second, we show the results of placebo tests, e.g. specifications that use the pre-detremined values (from before the revaluation) of our outcome variables as dependent variable. Both set of results are based on samples of jurisdictions which we observe before and after the revaluation. Third, we inspect effect dynamics using all available data for after the revaluation.

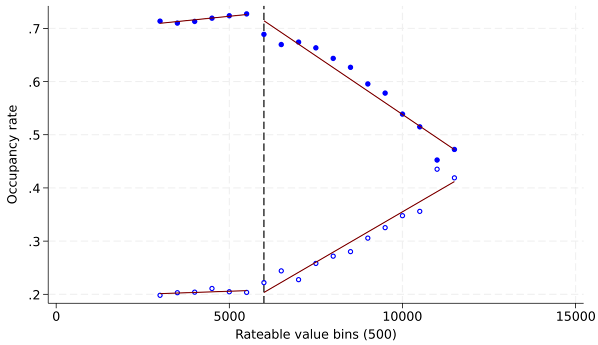
We turn now to the comparison before and after the revaluation for the SBRR results. The sample of jurisdictions used in the analysis includes Barnsley, Bedford, Bexley, Cheshire West and Chester, Darlington, Isle of Wight, Walsall and Worcester, as we require information on the relief type. Before the revaluation in 2017, the SBRR kinks are statutorily at £6,000 (when SBRR starts to apply) and £12,000 (above which SBRR does not apply). Figure N7 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 N7: Graphical evidence for SBRR: Comparison before (kinks at £6,000 and £12,000) and after revaluation (kinks at £12,000 and £15,000)

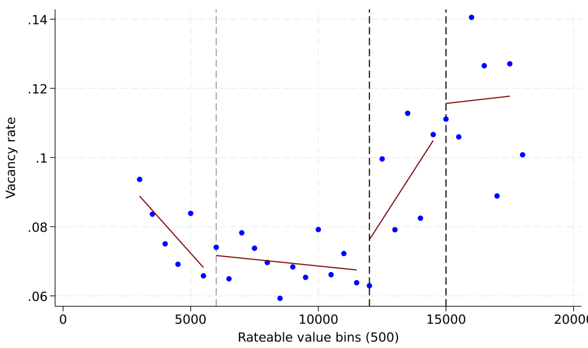
(a) Vacancy rate before revaluation, kinks at £6,000 and £12,000



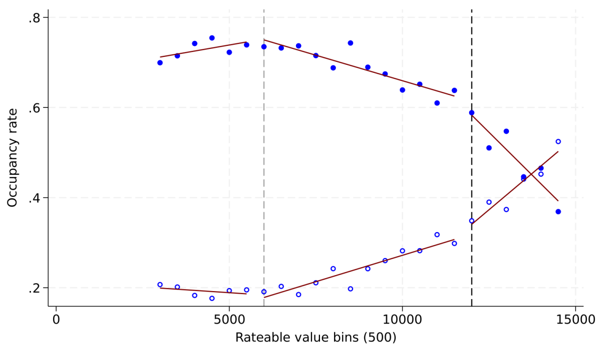
(b) Occupancy by type of business before kink at £6,000



(c) Vacancy rate after revaluation, revaluation, kinks at £12,000 and £15,000



(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 -0.06 (0.05) and 0.11 (0.07) and after the revaluation 0.08 (0.07) and -0.06 (0.09). No change in the slope of the rateable value distribution is indicated for the second kink before the revaluation and both kinds after the revaluation. The test for change in the slope of the rateable value distribution for the first kink before the revaluation is significant.

Table N12 reports the RKD estimates for the change in slope at £6,000 and £12,000 in 2016. We find similar evidence as our baseline results when estimating the effect of the 2019 threshold. 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 around 75% larger as for 2016 (Panel A) - except for the second kink. Thus the results are largely in line with our baseline results.

Table N12: 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(Kink)	0.008	-0.027***	0.020**	-0.014*
	(0.005)	(0.009)	(0.009)	(0.008)
Observations	16,818	16,818	16,818	6,526
Panel B: After the revaluation, Kinks at £12,000 and £15,000				
R * D(Kink)	0.014*	-0.050***	0.036**	-0.009
	(0.008)	(0.016)	(0.015)	(0.010)
Observations	6,910	6,910	6,910	4,290

Notes: The table reports reduced form results for the SBRR for before and after the revaluation using the same set of jurisdictions. These include Barnsley, Bedford, Bexley, 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. Panel A shows the results for before the revaluation and Panel B for after the revaluation. All specifications use a bandwidth of £3,000 and include quarter-year fixed effects. 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 N13 reports RKD estimates for placebo tests using lagged dependent variable. We focus on a sub-sample of properties which we can link over time, starting with the data measured at time t after the revaluation. Panel A shows the results when using rateable value, vacancy and occupancy outcomes measured at time t after the revaluation. The effects are in line with our baseline results in this sub-sample.

In Panel B we use lagged dependent variable as our outcome variables, i.e. the vacancy and occupancy before the revaluation, measured at $\tilde{t}$ while the rateable value is measured at time t, with $\tilde{t} < t$. As one may expect, none of the point estimate is statistically different from zero, and are all are close to zero.

Table N13: RKD results for SBRR - Placebo

	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: Baseline results for sub-sample for the placebo test				
R * D(Kink)	0.018*	-0.047**	0.030*	-0.025**
	(0.009)	(0.019)	(0.017)	(0.010)
Observations	5,822	5,291	5,291	5,822
Panel B: Placebo - Lagged outcomes (before the revaluation)				
R * D(Kink)	-0.007	-0.010	0.022	0.001
	(0.010)	(0.022)	(0.022)	(0.012)
Observations	5,822	5,291	5,291	5,822

Notes: The table reports reduced form placebo results for the SBRR for after the revaluation using only properties that we observe and could link before and after the revaluation. 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)). Panel A shows the baseline results, with rateable value and the outcomes measured at the same time t, Panel B shows the placebo results using the outcome from before the revaluation. All specifications include quarter-year fixed effects. All specifications use a bandwidth of £3,000. 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.

Lastly, we inspect whether the effect varies over time. We run two different specifications to test this. The first specification includes interaction effects of the interaction of rateable value with the kink indicator variables and year dummies. Specifically, we estimate the following equation extending from equation (5) and (6),

$$E[y_{it}|R] = \sum_t \left[\gamma_{0t} + \gamma_{1t}(R_i - \underline{R}_s) \times Y_t + \gamma_{2t}(R_i - \underline{R}_s) \times D_i \times Y_t + \gamma_{3t} D_i \times Y_t\right] \tag{N.29}$$

where Y_t is an indicator for year t for year 2017, 2018 and 2019.

The second specification include, instead of the year dummy interaction, the interaction with how many quarters last since the revaluation and the introduction of the relief (or the new thresholds), NQ_t. For example, in the second quarter of 2018, the quarter from revaluation that took place in the second quarter 2017 would be 4, i.e. $NQ_t = 4$. We then similarly estimate the following extension from equation (5) and (6),

$$\begin{aligned} E[y_{it}|R] =& \gamma_0 + \gamma_1(R_i - \underline{R}_s) + \gamma_{1NQ}(R_i - \underline{R}_s) \times NQ_t \\ &+ \gamma_2(R_i - \underline{R}_s) \times D_i + \gamma_{2NQ}(R_i - \underline{R}_s) \times D_i \times NQ_t \\ &+ \gamma_3 D_i + \gamma_{3NQ} D_i \times NQ_t \end{aligned} \tag{N.30}$$

The results are depicted in Table N14. It suggests that the effect of the relief on the vacancy is increasing over time. In Panel A the slope change at the threshold increases in broad terms from 2017 to 2018 and to 2019 for the vacancy and occupancy outcomes, while remain constant across years for the ETR. Similarly, in Panel B the effect increases with the number of quarters that the new SBRR thresholds are in effect for the vacancy and occupancy outcomes, while remain constant over time for the ETR.

Table N14: RKD results for SBRR - Effect heterogeneity over time

	First kink				Second kink	
Dep. Var.	ETR	D(Vacant)	D(Occupied by) small business	D(Occupied by) large business	ETR	D(Vacant)
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Interaction with year dummies						
R * D(Kink) * D(2017)	0.136***	0.001	-0.025**	0.024**	-0.141***	-0.004
	(0.002)	(0.006)	(0.011)	(0.011)	(0.011)	(0.018)
R * D(Kink) * D(2018)	0.140***	-0.000	-0.032***	0.032***	-0.171***	0.000
	(0.002)	(0.004)	(0.010)	(0.010)	(0.011)	(0.012)
R * D(Kink) * D(2019)	0.133***	0.008**	-0.050***	0.040***	-0.0164***	-0.011***
	(0.002)	(0.003)	(0.008)	(0.008)	(0.008)	(0.010)
Observations	42,391	175,745	171,091	171,091	24,076	117,417
Panel B: Interaction with number of quarters since introduction						
R * D(Kink)	0.139***	-0.003	-0.020	0.023*		0.003
	(0.003)	(0.007)	(0.013)	(0.013)		(0.008)
R * D(Kink) * # quarters	-0.001	0.001	-0.003*	0.002		-0.001
	(0.000)	(0.001)	(0.002)	(0.001)		(0.001)
Observations	42,391	175,745	171,091	171,091		117,417

Notes: The table reports reduced form results for time-varying effects of the SBRR. 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)). Panel A shows the results when allowing the effect to differ between years. Panel B shows the results when allowing it to differ with the number of quarter since introduction of the new thresholds (second quarter of 2017). All specifications use a bandwidth of £3,000, except col. (5) which uses a bandwidth of £1,500. We cannot estimate col. (5) of Panel B as the point estimate has to be divided by the share of small business at the second kink (discussed in section 5.2). All specifications include quarter-year fixed effects. 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.4 Data appendix

N.4.1 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).[57]

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.[58]

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 N15).

Due to different data requirements for the analysis of RR, and SBRR, the jurisdiction-quarters included in the subsamples differ. For the RR, 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 RR 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 RR 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 N18 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.[59] 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).

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

[58] 67 of the 72 included jurisdictions have a coverage above 95%.

[59] The tax rate for empty properties, when not exempted, 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 N15: Descriptive statistics for jurisdictions included in the vacancy sample

Sample (# jurisdictions)	All jurisdictions (325)		Retail relief (35)		SBRR (63)	
	Mean	Median	Mean	Median	Mean	Median
Residents						
Population in thsd	163	126	216	159	214	190
Share pop. > 65 yrs	17	17	17	17	16	16
Share pop. < 16 yrs	19	19	19	19	19	19
Commercial properties						
Number	5,944	4,570	7,989	6,440	7,508	6,440
Number per 1,000 pop	37	35	36	35	35	34
Floor space	1,691	1,300	2,263	1,603	2,225	1,771
Floor space per 1,000 pop	10	10	11	10	10	11
Labor market						
Employment in thsd	82	61	107	88	100	86
Unemployment rate	4	4	4	4	4	4
Wages (gross)	29,397	28,742	28,927	28,789	29,528	28,929
Firms						
# local units	8,342	6,520	10,357	8,805	9,869	8,770
# local units per 1,000 pop	53	50	50	48	48	46
# enterprises	7,191	5,465	8,809	7,045	8,391	7,045
# enterprises per 1,000 pop	46	44	42	42	41	40
Share of local units with ... in %						
0-4 employees	72	72	70	70	71	71
5-9 employees	13	13	14	14	13	13
10-19 employees	8	8	8	8	8	8
20-49 employees	5	5	5	5	5	5
50-99 employees	2	2	2	2	2	2
100 or more employees	1	1	1	1	1	1
Share of enterprises with ... in %						
0-4 employees	78	78	77	78	78	78
5-9 employees	11	11	12	11	11	11
10-19 employees	6	6	6	6	6	6
20-49 employees	3	3	3	3	3	3
50-99 employees	1	1	1	1	1	1
100 or more employees	1	1	1	1	1	1
Share of enterprises with ... in %						
0-49k turnover	15	15	14	14	15	14
50-99k turnover	23	23	24	23	24	23
100-199k turnover	32	32	32	32	33	33
200-499k turnover	13	13	13	13	13	13
500-999k turnover	7	7	7	7	7	7
1,000k-1,999k turnover	4	4	4	4	4	4
2,000k-4,999k turnover	3	3	3	3	3	3
5,000k and more turnover	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 except for the City of London, cols. (3) and (4) the jurisdictions included in the RR vacancy sample and cols. (5) and (6) the jurisdictions included in the SBRR vacancy sample. Data on residents, labor market and firms are from ONS local authority level data.

N.4.2 Rent data

Matching of the rent listing 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 4 and Appendix N.4, 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 RR sample, constituting about 1% of the final rent 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 current listing price, unless i) only the first listing price is observed, or ii) using the current 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 SBRR sample, we use all available business rate data available to us for jurisdictions which publish information on the rateable value of all properties, even if these jurisdictions are not included in the vacancy sample as, for example, the data does not include information on vacancy or property type. In addition, to increase the number of properties in the RR sample further, 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.[60] 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 RR (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 RR.

To check if the rent listings matched with the business rates data with rateable value is similar to those that we cannot match between the two data, we compare rent and ln rent between the matched and unmatched listings. To test for differences, we regress rent or ln rent on an indicator variable that is one if the property listing was matched. In addition to testing for any difference unconditional on property characteristics, we also conduct the test conditional on physical size of the properties using property information from the listing data (for some properties, we do not observe the size, we set the size for these properties to zero, and include an indicator that is one for properties with no size information in the regression.).

We focus on properties with rateable values in the rateable value ranges of RR and SBRR sample. Given that we have the exact rateable value only for matched properties, we proxy the rateable value using the rent and the median rent-to-RV ratio (for both the matched and unmatched properties) as reported in Table N17.

Table N16 reports the results. The dependent variable in columns (1) and (2) is rent and in columns (3) and (4) ln rent. Panel A reports the results for retail properties with the proxied

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

RV in the relevant range of the RR, Panel B the results for all properties and Panel C for retail properties with a proxied RV relevant for the SBRR. Col. (1) shows the unconditional difference in rent, and col. (2) the difference in rent conditional on property size. Cols. (3) and (4) show the same specifications for ln rent. Lastly, col. (5) shows the unconditional difference in rent per square foot. The sample is reduced as this variable can only be constructed for properties with non-missing size information. In all specifications, the indicator variable for matched properties is not statistically significant from zero. This suggests no differences in the analyzed characteristics of matched and unmatched properties.

The matching rate is somewhat larger for retail properties with a rateable value in the range of the SBRR sample. This is most likely related to the fact that (smaller) retail stores are usually situated along streets, while for offices and industrial properties this is not necessarily the case. Since the additional details needed to match the latter properties (e.g., floor and unit information) are less likely to be included in the listing data, the matching rate is lower for these properties. The share of retail properties in rent and vacancy sample are similar (see below). In addition, any impact of this on the implications of our findings is relatively small. First, for the analysis of the RR we use only retail properties. Second, the estimates for the impact of SBRR on rent to rateable value are very similar for all properties or with only retail properties (see col. (6) of Table 6 and col. (4) of Table N.8).

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 N18. Descriptive statistics for the rent-subsamples are reported in Table N17. 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.

The property type classifications in the rent and vacancy sample are based on information from the respective source data: in the vacancy sample, it is based on the property description in the business rates data, and in the rent data, it is based on the classification by Rightmove, the data provider. We use the classification from Rightmove in the rent data for two reasons. First, there is a non-negligible number of properties with mixed usage in the vacancy sample, which we classify as other properties. Second, for the matched properties in both the business rates and rent data, the property description from the business rates data may not be available for some properties (as we only use address and rateable value information for matching rateable values to the properties in the rent data). To increase the sample size for rent, we use the property type classification included in the rent listings data for the rent sample. Conditional on the three main property types (office, retail, warehouse/factory), the share of retail properties is very similar.[61]

Representativeness of rental listing data The rent sample is constructed from rental listing data on the online platform Rightmove with offer price information. It includes only properties that are listed for rent during the sample period (i.e. vacant or expected to be vacant soon). In this section we examine if the listing data is representative for all rental properties before matching with the business rates data and sample refinements.

First, because of the nature of the data, jurisdictions with high vacancy rates could be over-represented because there are more vacant properties to be listed. Figure N8a plots the number of properties in the rent listings data of a local authority (scaled by total number of commercial properties in the local authority) by the vacancy rate. While the number of

[61] The retail share in the SBRR vacancy sample using only office, retail, and warehouse/factory properties is 0.55 = 0.45/(0.15+0.45+0.22), see Table 3.

properties observed in the rent listings data for a jurisdiction (relative to the number of all properties) increases slightly with the vacancy rate, the correlation is not significantly different from zero at conventional levels (results are available upon request). This suggests the listing data does not over-represent jurisdictions with high vacancy rate. One potential explanation is that when there are multiple similar properties at a particular location, e.g. nearby retail units in a shopping centre or High Street, industrial units in a business park or offices in the same building, landlords or estate agents may advertise only one or two typical properties but not all the available properties.

Second, property listings with offer price at the top of the price distribution given the property characteristics (i.e. adjusted for quality), could be more likely to be vacant and listed for longer, and thus be present in the rental listing data. We assess its relevance in our setting using two different strategies. First, Figure N8b plots the share of properties with changes in the offer rent between the first and last (current) listing price - the likelihood of an offer rent reduction increases with the duration a property being on the market/advertised online.[62]

This is consistent with the possibility that some properties that are on the market for longer could be overpriced (quality-adjusted) early on. However, it could also simply reflect the duration-to-find-a-tenant heterogeneity between properties, and that in some cases, landlords prefer to rent out at a reduced price sooner than waiting for longer. Figure N8c shows that the average magnitude of the reduction in rent offer, for properties that had a rent offer change during the listing time, does not increase with the duration on the market if it has been on the market for more than 60 days. This suggests that properties that are longer on the market were not overpriced (adjusted for quality) than properties that are less long on the market given that it is on the market for more than 60 days. In addition, the magnitude of price changes is relatively small (e.g. for properties on the market between 5-6 month, the average rent reduction is only -1%, with 15% of the listed properties see their rent decrease by on average by 7% during the listing time). Therefore, the selection by quality-adjusted price into the rent data is unlikely to be quantitatively important.

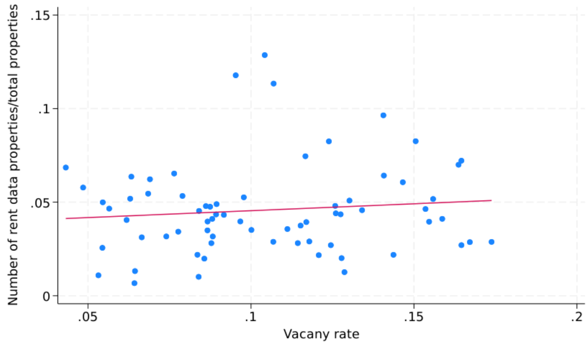
Our second robustness test to assess the relevance of selection of properties by unobserved characteristics into the rent data (within a jurisdiction) is to exclude properties that are on the market for a particular long time. Since the typical duration of properties on the market may differ by jurisdiction and by property type, we exclude properties from the estimation sample if they are on the market for 175%, 200% or 225% of the local authority-property type specific median duration. The results are reported in Table N10. They do not suggest that properties that are on the market for a long time drive the results.

Construction of rental market tightness indicator To construct an indicator at the local authority level to measure the tightness of the local rental market, we use the empty duration of properties in a jurisdiction (by property type), calculated from the listing data. Our preferred indicator is the share of property listings on the market for less than 60 days. This is based on the observation in Figure N8c that the magnitude of the rent reduction were constant within the first 60 days on the market, and increases if properties are on the market for more than 60 days. This would be consistent with an expectation from landlords that a tenant could be found within 2 months if the listing price accurately reflects the market price. Rental market tightness is likely to be related to the overall vacancy rate - in Figure N9, we plot the share of properties on the markets for less than 60 days at the local authority level by the vacancy rate, and there is a clear negative correlation between the measure with vacancy rate.

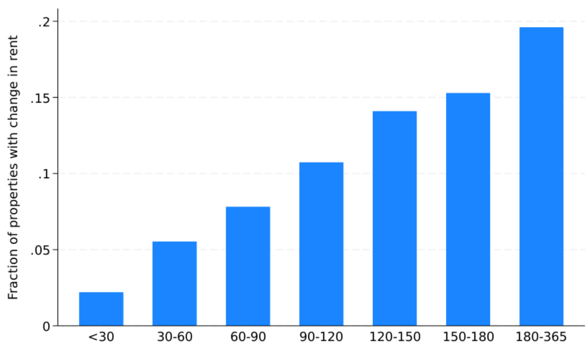
[62]While it could be informative to also use the empty duration from the admin data, it is not directly comparable with that calculated from the rent data, as the former data is quarterly data.

Figure N8: Property composition in the rent listing data

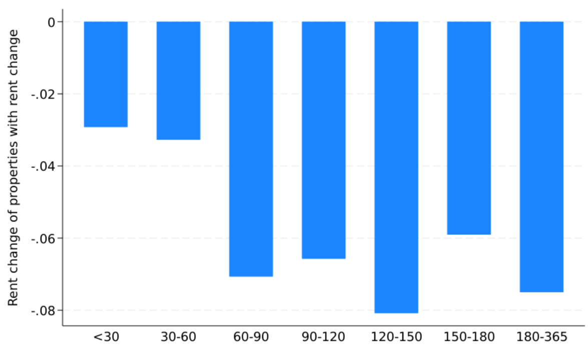
(a) Number of properties in the rent data to total number of properties and vacancy rate by local authority



(b) Share of properties by duration on the market with adjustment in posted rent

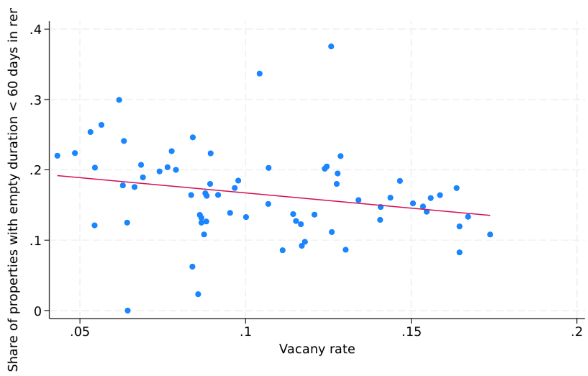


(c) Average rent change of properties with rent changes by duration on the market



Note: The graphs plot (a) the number of properties in the rent data relative to the total number of commercial properties of a local authority and the vacancy rate (and a linear fit), (b) the share of properties with rent changes between first and last (current) listing price by empty duration bins and (c) the average rent change of properties with rent changes by empty duration bins.

Figure N9: Share of properties with empty duration less than 60 days



Note: The graph plots the relationship between vacancy rate and share of properties with empty duration of less than 60 days in the rent listing data.

Table N16: Descriptive statistics - Property listing with and without matched rateable value

Dependent Variable	Rent (1)	Rent (2)	ln(Rent) (3)	ln(Rent) (4)	Rent/Sqft (5)
Panel A: RR: Retail properties - Proxied RV ≈ 41-61 (Matching Rate 0.31)					
D(Matched)	5	-30	-0.00	-0.00	-3.73
	(423)	(420)	(0.01)	(0.01)	(2.67)
Sqft/ln(Sqft)		0.30***		0.01**	
		(0.11)		(0.01)	
D(Missing Sqft)		175		0.10**	
		(551)		(0.05)	
Observations	993	993	993	993	774
Panel B: SBRR: All properties - Proxied RV ≈ 9-18 (Matching Rate 0.32)					
D(Matched)	-38	29	-0.00	-0.00	-1.06
	(89)	(95)	(0.01)	(0.01)	(0.81)
Sqft/ln(Sqft)		0.18***		0.05**	
		(0.08)		(0.01)	
D(Missing Sqft)		-129		0.32***	
		(115)		(0.05)	
Observations	9,783	9,783	9,783	9,783	7,573
Panel C: SBRR: Retail properties - Proxied RV ≈ 9-18 (Matching Rate 0.41)					
D(Matched)	-57	-33	-0.00	-0.00	-0.58
	(134)	(139)	(0.01)	(0.01)	(0.75)
Sqft/ln(Sqft)		0.31***		0.07**	
		(0.08)		(0.01)	
D(Missing Sqft)		6		0.42***	
		(134)		(0.06)	
Observations	4,329	4,329	4,329	4,329	2,998

Notes: The table shows the results for testing for differences of rent (cols. (1)-(2)), ln rent (cols. (3)-(4)) and rent per square feet (col. (5)) of property listing for which a rateable value can be matched and property listing for which no rateable value can be matched. Panel A shows the results for retail properties with proxied rateable value between £41,000 and £61,000 (RR rateable value range). Panel B shows the results for all properties and Panel C for retail properties for properties with proxied rateable value between £9,000 and £18,000 (SBRR rateable value range). The proxied rateable value (RV) is based on the rent from the listing data (for both matched and unmatched properties) and using RV ≈ rent/1.03 for Panel A (the median rent to rateable value ratio in Table N17) and RV ≈ rent/1.26 for Panel B and C. Col. (2) controls for the size of properties and col. (4) for ln size of properties. The size is set to zero if the size is not observed, and we include an indicator variable that is one if the size of the property is not observed. The number of observations in col. (5) is smaller than in col. (1)-(4) as rent per square feet can only be calculated when the size of the property is observed. Standard errors, shown in parenthesis, are clustered at the local authority level.

Table N17: Descriptive statistics - Rent sample

Rateable values (£1,000)	All	Retail relief 41-61	Small business rate relief 9-18
# of observations	11,030	268	2,923
# of counties	104	62	104
# of counties in London	15	15	15
Average rateable value	27,352	48,547	12,741
Median rateable value	11,750	47,500	12,250
Mean rent	32,720	52,877	16,516
Median rent	15,000	50,004	15,504
Mean rent to rateable value	1.33	1.09	1.30
Median rent to rateable value	1.28	1.03	1.26
Share of properties			
Office	0.27	0	0.24
Shop/Hospitality	0.51	1	0.56
Warehouse/Factory	0.22	0	0.20

Notes: The table shows the summary statistics for the full rent sample (col. (1)), the RR rent sample (cols. (2)) and the small business RR rent sample (cols. (3)).

Table N18: Data source by council

Council	Source	RR			SBRR	
		Vacancy		Rent	Vacancy	Rent
Ashford	2	18Q2	19Q3			X
Barking and Dagenham	1			X	19Q3	X
Barnsley	1	18Q3[c]	19Q3		19Q3	X
Bath and North East Somerset	2					X
Bedford	1	18Q2	19Q2		19Q3	X
Bexley	1	18Q2	19Q2		19Q2	X
Birmingham	2	18Q2[b]	19Q2[b]	X	19Q2[b]	X
Blackburn with Darwen	2	18Q3[b]	19Q3[b,c]		19Q3[b,c]	X
Blackpool	2				19Q3[a]	X
Bolsover	1					X
Bolton	2			X		X
Bournemouth	1			X	19Q3	X
Bracknell Forest	2					X
Bradford	1				19Q3	X
Brent	2					X
Brighton and Hove	1	18Q3	19Q3	X	19Q3	X
Bury						X
Calderdale	1	18Q2	19Q2		19Q2	X
Cambridge	1					X
Camden	1			X		X
Canterbury	1			X		X
Central Bedfordshire	1	18Q3	19Q3		19Q3	X
Chelmsford	1	18Q2	19Q2	X	19Q3	X
Cheltenham	1				19Q3	X
Cheshire East	1			X	19Q3	X
Cheshire West and Chester	1	18Q3	19Q3	X	19Q3	X
Copeland	1				19Q1	X
Cornwall	2			X		X
Croydon	1				19Q3	X
Dacorum	2					X
Darlington	2	18Q2[b]	19Q2[b]		19Q2[b]	X
Dudley	1				19Q2	X
East Cambridgeshire	2				19Q2	X
East Hampshire	1	18Q2	19Q2[a]		19Q3[a]	X
East Riding of Yorkshire	1					X
Erewash	1					X
Gateshead	1				19Q3[a]	X
Gloucester	1	18Q3	19Q3		19Q3	X
Greenwich	1				19Q3	X
Haringey	1			X	19Q3[b]	X
Harrow	1			X		X
Hastings	2					X
Herefordshire	1					X
Hounslow	2	18Q2[c]	19Q3[c]		19Q3[c]	X
Isle of Wight	1	18Q3[a,b]	19Q3[a,b]		19Q3[a,b]	X
Kensington and Chelsea	2	18Q2	19Q2[c]	X		X
Kingston upon Hull, City of	1	18Q2[a,b,d]	19Q2[b]		19Q2[b]	X
Kingston upon Thames	1					X

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Table N18 – *Continued from previous page*

	Source	RR			SBRR	
		Vacancy		Rent	Vacancy	Rent
Kirkless	2			X		X
Leicester	1			X		X
Lewisham	2				19Q3	X
Lincoln	1	18Q2[c,d]	19Q2[c]		19Q2[c]	X
Liverpool	2	18Q2	19Q2			X
Luton	2					X
Maldon	1	18Q2[d]	19Q2[d]		19Q3[c]	X
Newcastle upon Tyne	1				19Q3	X
North Dorset	1				18Q2	X
North Kesteven	2					X
North Somerset	1	18Q2	19Q2		19Q3	X
North Tyneside	1			X		X
Northumberland	1	18Q3[b]	19Q3[b]		19Q3[b]	X
Nottingham	1			X	19Q1	X
Oadby and Wigston	2	18Q2	19Q2		19Q3	X
Oldham	1					X
Oxford	1					X
Peterborough	1				19Q3	X
Portsmouth	1				19Q3	X
Preston	1				19Q3	X
Reading	1			X	19Q3	X
Redbridge	1				19Q3[b]	X
Redcare and Cleveland	2			X		X
Rochdale	2			X	18Q2	X
Rotherham	1				19Q3	X
Rutland	1				19Q3	X
Salford	1				19Q2[b]	X
Sandwell	1					X
Slough	1				19Q3	X
Solihull	2					X
South Gloucestershire	1					X
South Lakeland	3				19Q2	X
South Staffordshire	2	18Q2	19Q2[c,d]			X
South Tyneside	2	18Q2[c,d]	19Q2[c,d]			X
Southampton	1	18Q2	19Q2	X	19Q2	X
Southend-on-Sea	1			X		X
Southwark	2			X		X
St. Helens	1				19Q2	X
Sutton	1				19Q3[a]	X
Swale	2					X
Swindon	2					X
Telford and Wrekin	1					X
Thurrock	1				19Q3	X
Tonbridge and Malling	2	18Q3	19Q3		19Q3	X
Torridge	1					X
Tunbridge Wells	1				19Q3	X
Wakefield	1				18Q2	X
Walsall	1	18Q3[b]	19Q3[b]	X	19Q3[b]	X
Warrington	1	18Q2	19Q2		19Q3	X

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Table N18 – *Continued from previous page*

	Source	RR			SBRR	
		Vacancy		Rent	Vacancy	Rent
Warwick	2	18Q2	19Q2		19Q2[a]	X
West Berkshire	2					X
West Lancashire	2	18Q2[b]	19Q2[b]		18Q2[b]	X
Wiltshire	1	18Q2[c,d]	19Q2[c,d]	X	19Q3	X
Winchester	1	18Q2[b]	19Q2[b]	X	19Q2[b]	X
Wokingham	1					X
Wolverhampton	1					X
Worcester	1	18Q2	19Q2	X	19Q3	X

Notes: The table reports the jurisdictions and jurisdiction-quarters included in the vacancy and rent analysis of 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.