Supplemental Appendix

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

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B Online Appendix

The Online Appendix consists of four main parts. The first part includes additional tables and figures (B1). 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 (B2). The third part includes additional empirical results for RR and SBRR (B3). In the last part of the Online Appendix (B4), we describe the data used in the empirical analysis in detail.

B1 Additional Tables and Figures

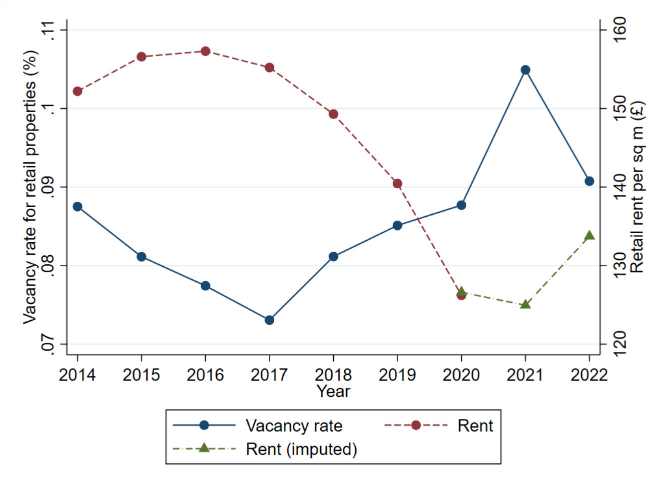
Table B1 reports the small business and the (normal) multiplier for jurisdictions in England outside of London between 2010-2011 and 2020-2021. Figure B1 plots the retail vacancy rate from 2014-2022 and the retail rent per square metre in England.

Table B1: 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 B1: 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 (Local Data Company, 2014-2022), 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) (Investment Property Forum, 2019, 2022); the second series of rents for 2019 to 2022 are calculated from the Savills retail annual change in rental cost (Savills, 2022) using the 2019 rent level from the IPF data. The rents are in real prices in 2015 deflated with CPI from ONS (2023).

B2 Directed Search Model of the Commercial Property Market

In this appendix section, we present model set-up (Appendix B2.1), equilibrium conditions (Appendix B2.2), empirical predictions (Appendix B2.3) and proof of equilibrium conditions (Appendix B2.4) for the directed search model of the commercial property market.

B2.1 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, $i = 1, .., I$ ranked by their rateable value R_i, so $R_1 < R_2 < ...R_I$. 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:

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

Equation (B.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.

B2.2 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 B2.4. 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.[54] 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.[55] 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*

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

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

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

[55] 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 (B.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.[56] These observable implications are discussed in much more detail in Section 3.2. For now, it is important to note by inspection of (B.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 (B.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.

B2.3 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 (B.2) by R and drop the landlord type subscript to get

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

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 (B.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

[56] 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

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

So, the change in v at the threshold is

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

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

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

So, from (B.6) ;

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

Also, from (B.6), (B.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:

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

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 (B.7), (B.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

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

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

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

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

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

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

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

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 (B.6), (B.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 (B.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 (B.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 (B.5) divided by the change in the tax at the notch, which is $\kappa/3$. This gives the effect as

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

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:

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

So, the causal effect is

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

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.

B2.4 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 $(p_{i,j}, p_{i,j})_{i\in\mathcal{I}},\ j = s, l$, where $p_{i,j}$ is the probability that a type j business applies to a particular type i property, and $\mathcal{I} = 1, ..I$ 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

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

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

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

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

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

A business of type j has an expected profit

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

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, (B.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).[57] So, $q_{i,j}$ satisfies:

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

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

$$L_i = (1 - v_i)\tilde{r}_i - v_i T^u(R_i), \tag{B.21}$$

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 (B.21) subject to (B.20) and (B.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 (B.20), the maximum rent that a small landlord can charge a type s business, while still

[57]For suppose $m_i(\Pi(R_i) - r_i - T^o(R_i; j)) > \rho R_i$. 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

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

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

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

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

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

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 (B.21) as:

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

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

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

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

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

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

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

(d) Now note that $o'(q) = e^{-q} = v(q)$. Making this substitution in (B.26), (B.28), we can solve for the vacancy rates for small and large landlords. Both these vacancy rates can be expressed in the form (B.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 (B.22), (B.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. □

B3 Additional Empirical Results for RR and SBRR

In this appendix section, we present additional tables and figures for empirical results for RR (Appendix B3.1) and SBRR (Appendix B3.2). 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 B3.3).

B3.1 Additional Results for Retail Relief

In this appendix subsection, we report tables and figures for additional empirical results for RR. Figures B2 and B3 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 B2 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.

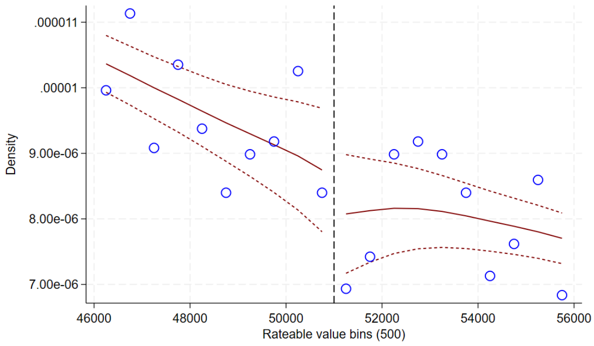
As a robustness check, we employ regression discontinuity design using data for 2018 and using data for 2019 separately to estimate the discontinuity at the threshold for each of the two years. Figure B4 shows the graphical analysis for all outcome variables, and Table B3 reports the results for vacancy and ETR. The difference in the estimates for 2018 and 2019 are very similar to that in Table 4 but less precisely estimated.

Table B4 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.

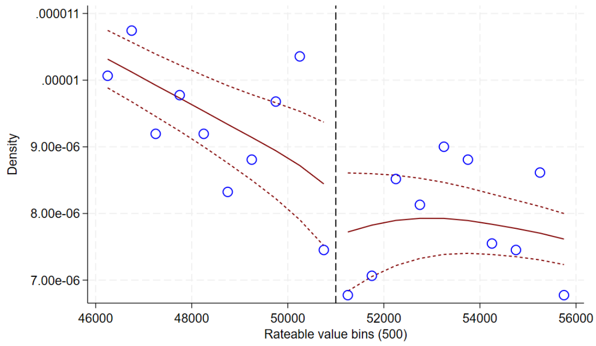
Table B5 reports sensitivity results where we exclude jurisdictions for which either vacancy, tax charge, rateable value or the property type is not directly observed but inferred or imputed. We described how we infer/impute the variables in data appendix B4. Panel A shows the results when excluding 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 B2: Validity of RDD for retail relief - Vacancy sample

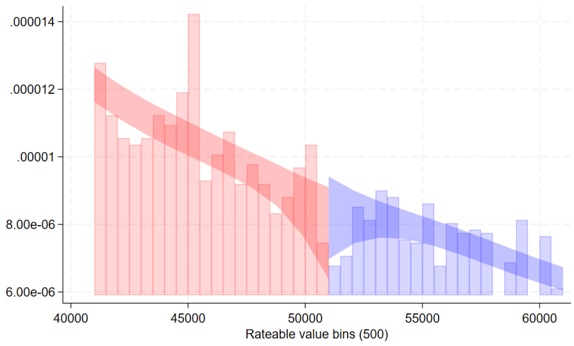
(a) McCrary test 2018 - Vacancy sample



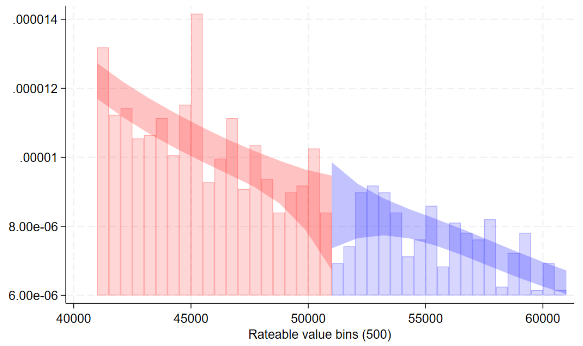
(b) McCrary test 2019 - Vacancy sample



(c) RD density test 2018 - Vacancy sample



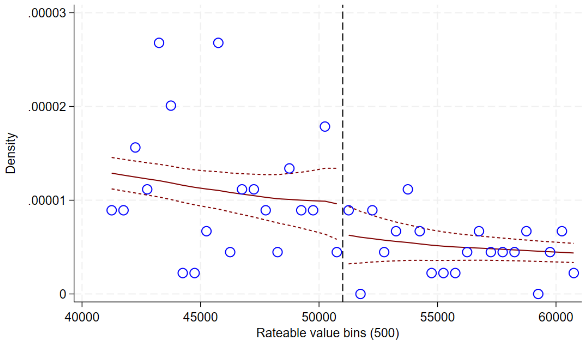
(d) RD density test 2019 - Vacancy sample



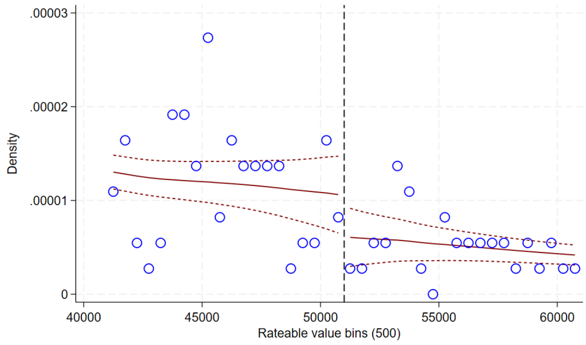
Notes: The graph plots the estimated density function for the McCrary test (a) for 2018 and (b) for 2019, and for the RD density test (c) for 2018 and (d) for 2019 for the vacancy sample. The rateable value range is £41,000 to £61,000, and the bin width £500. The dashed line indicates the rateable value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

Figure B3: Validity of RDD for retail relief - Rent sample

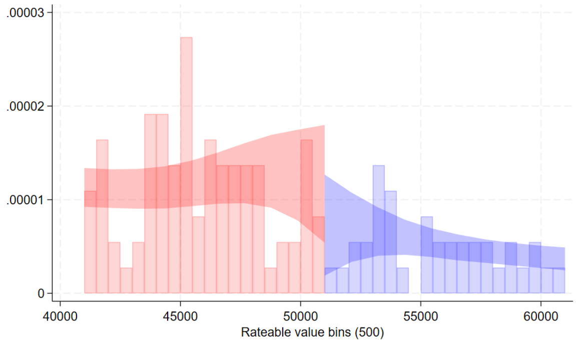
(a) McCrary test 2018 - Rent sample



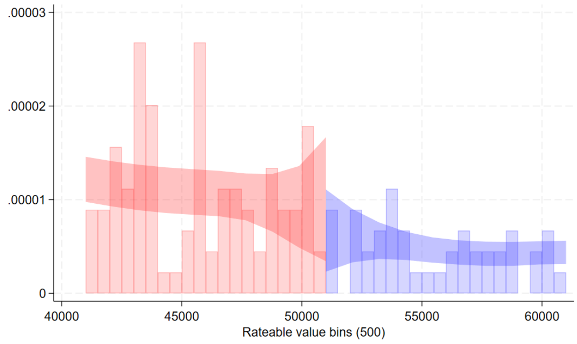
(b) McCrary test 2019 - Rent sample



(c) RD density test 2018 - Rent sample



(d) RD density test 2019 - Rent sample

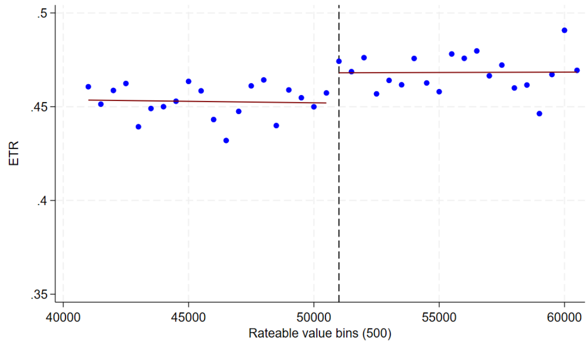


Notes: The graph plots the estimated density function for the McCrary test (a) for 2018 and (b) for 2019, and for the RD density test (c) for 2018 and (d) for 2019 for the rent sample. The rateable value range is £41,000 to £61,000, and the bin width £500. The dashed line indicates the rateable value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

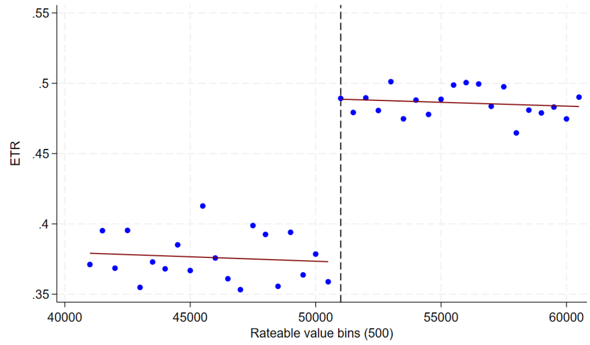
The McCrary test results (point estimate (s.e.)) using a bandwidth of £500 and a rateable value range from £16,000 to £86,000 are: Large vacancy sample for 2018 -0.07 (0.09) and for 2019 -0.08 (0.09), small vacancy sample for 2018 -0.03 (0.11) and for 2019 0.00 (0.12) and for the rent sample for 2018 -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 B4: Graphical evidence for retail relief: 2018 vs 2019

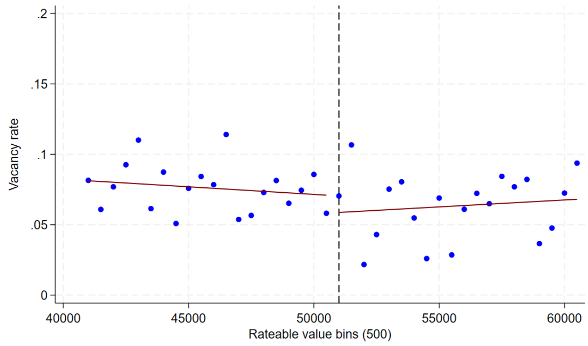
(a) ETR of occupied properties 2018



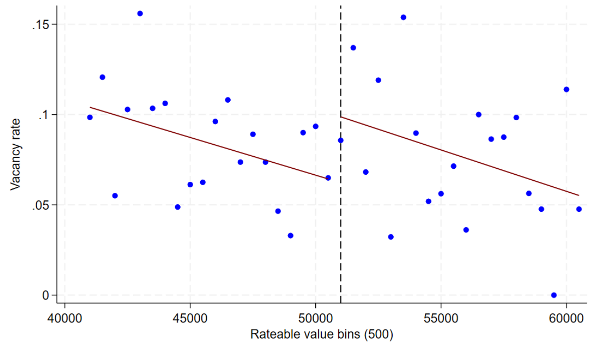
(b) ETR of occupied properties 2019



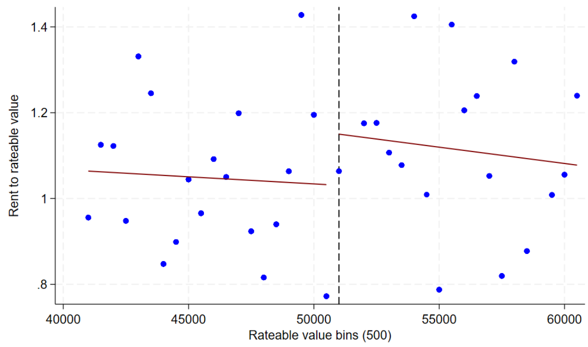
(c) Vacancy rate 2018



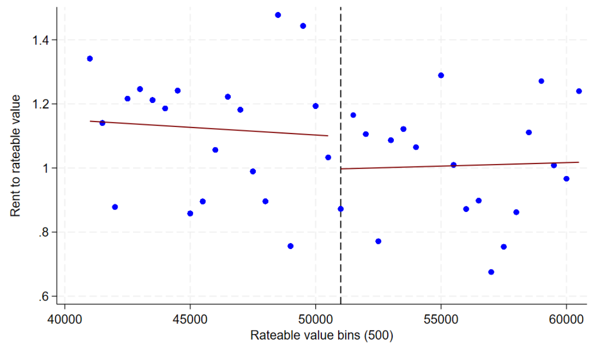
(d) Vacancy rate 2019



(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 B2: 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	-47.184		-0.016	-0.006	
	(68.735)	(70.814)		(0.014)	(0.014)	
D(R≥51k)*Post			25.239			-0.007
			(19.005)			(0.009)
Observations	3,828	3,729	7,557	1,945	2,021	4,042
Bandwidth	10,506	10,638	10,572	9,968	10,097	10,033
Panel B: Rent data						
D(R≥51k)	140.557	-8.358				
	(132.974)	(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 B3: 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 B4: 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 B5: 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.

B3.2 Additional Results for SBRR

In this appendix subsection, we report tables and figures for additional empirical results for the SBRR. Figures B5 and B6 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 B6 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 B7 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 B8 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.

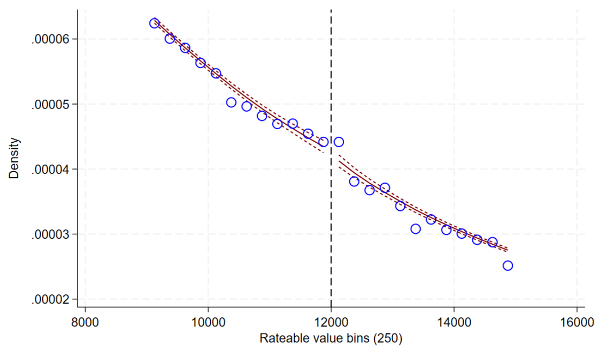
Table B9 reports results for the reduced form for SBRR when using level of rent (Panel A) or log of rent (Panel B) as dependent variable. The estimates are in line with our baseline results. Cols. (1) and (2) report for the first kink the reduced form estimate, and cols. (3) and (4) for the second kink. 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 B9, 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 B10 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).

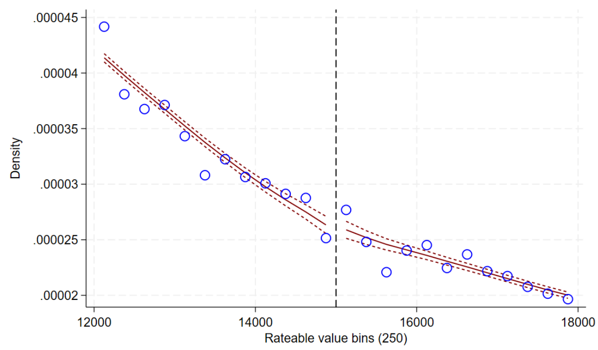
Table B11 reports sensitivity results where we exclude jurisdictions for which a particular variable is not directly observed. Panel A shows the results when excluding jurisdictions for which the vacancy is not directly observed and Panel B shows the results when excluding jurisdictions for which the charge is not directly observed. Overall, the point estimates are very similar to our baseline estimates.

Figure B5: Validity of RKD for SBRR - Vacancy sample

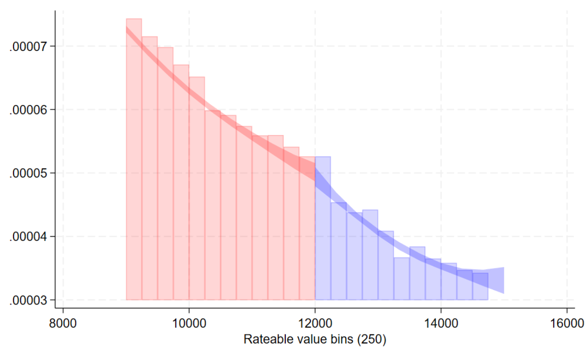
(a) McCrary test first kink



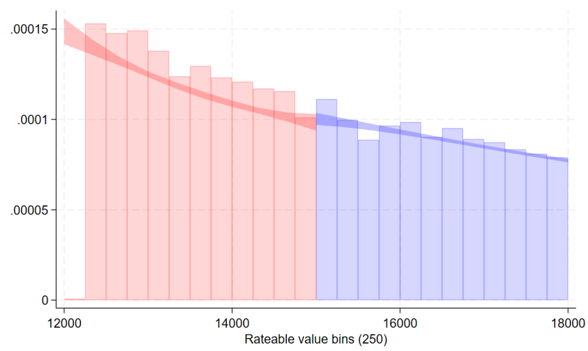
(b) McCrary test second kink



(c) RD density test first kink



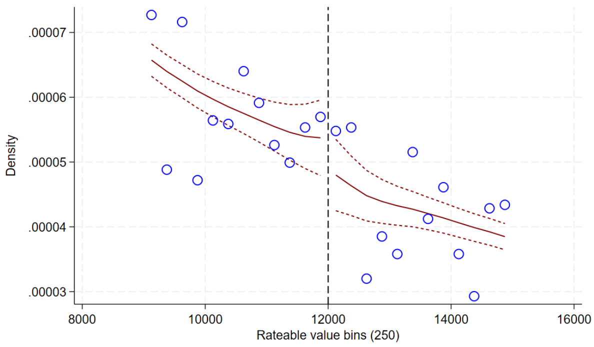
(d) RD density test second kink



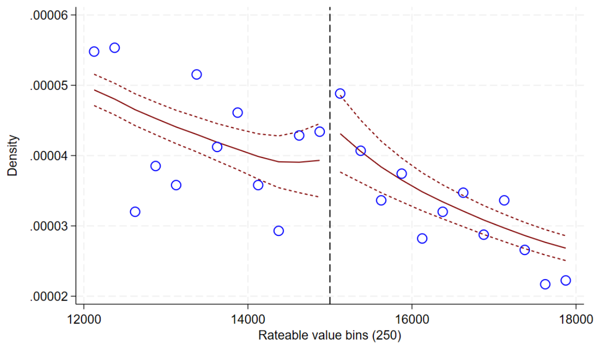
Note: The graphs plot the the estimated density function for the McCrary test for the first kink (a) and second kink (b) and for the RD density test for the first kink (c) and second kink (d) for the large vacancy sample. The rateable value range is from £9,000 to £15,000 (a,c) or £12,0000 to £18,000 (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 B6: Validity of RKD for SBRR - Rent sample

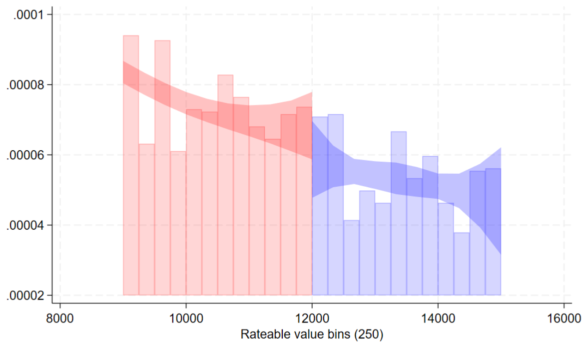
(a) McCrary test first kink



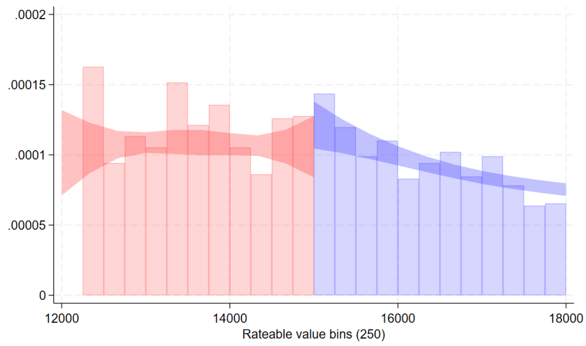
(b) McCrary test second kink



(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 -0.017 (0.018) and second kink: 0.02 (0.02), small vacancy sample first kink -0.035 (0.023) and second kink: 0.04 (0.03), rent sample first kink -0.10 (0.09) and second kink 0.12 (0.10)). The RD density p-values are for the large vacancy sample first kink 0.51 and second kink 0.23, and for the rent sample first kink 0.25 and 0.15. 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 127 (72), small vacancy sample first kink -43 (66) and second kink 80 (44), rent sample first kink -5 (10) and second kink -9 (9).

Table B6: 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)	(48.341)	(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 B7: 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	48,877	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 B8: RKD for SBRR - Retail properties

	Occupied by		Vacant	Rent/RV
	small business	large business		
	(1)	(2)	(3)	(4)
Panel A: First kink				
Causal effect for ETR	-0.560***	0.464***	0.097***	-0.357
	(0.084)	(0.081)	(0.032)	(0.222)
Observations	29,905	29,905	29,905	1,235
Panel B: Second kink				
Causal effect for ETR			0.073	-0.135
			(0.195)	(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 B9: 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*	249	298
	(265)	(325)	(406)	(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 B10: 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	-0.341*	-0.369**	-0.395**	-0.369	-0.425	-0.473*
	(0.187)	(0.174)	(0.167)	(0.284)	(0.265)	(0.257)
Observations	1,589	1,727	1,828	852	928	988
Bandwidth	3,000	3,000	3,000	3,000	3,000	3,000
Panel B: Second kink (£15,000)						
Causal Effect	-0.170	-0.223	-0.132	-0.133	-0.155	-0.065
	(0.182)	(0.175)	(0.175)	(0.189)	(0.176)	(0.176)
Observations	1,060	1,188	1,290	543	623	683
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 B11: 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)		(0.061)		(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.

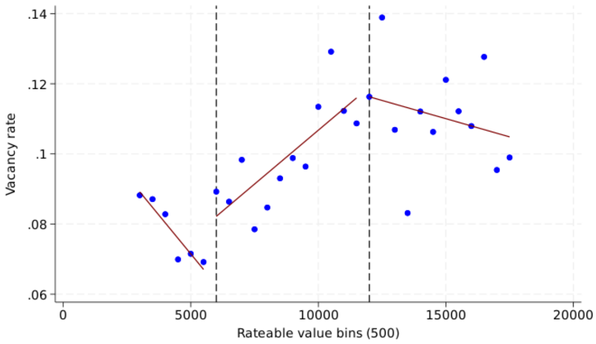
B3.3 Additional Results for SBRR - Variation over time

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.

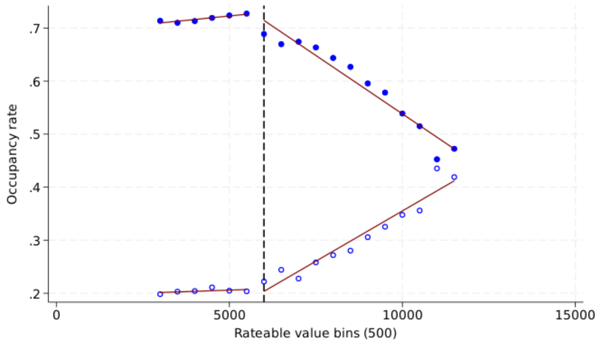
We turn now to the comparison before and after the revaluation for the SBRR results. The sample of jurisdictions used in the analysis includes Barnsley, Bedford, Bexley, Cheshire West and Chester, Darlington, Isle of Wight, Walsall and Worcester, as we require information on the relief type. Before the 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 B7 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 B7: Graphical evidence for SBRR: Comparison before (kinks at £6,000 and £12,000) and after revaluation (kinks at £12,000 and £15,000)

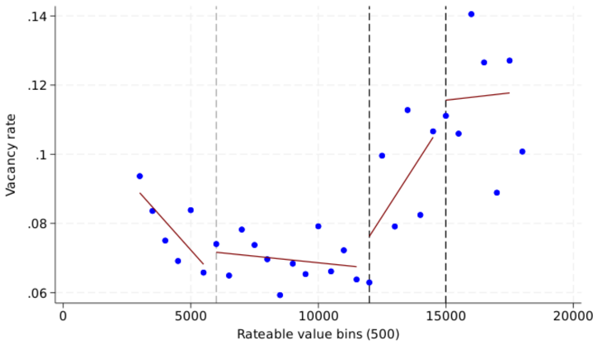
(a) Vacancy rate before revaluation, kinks at £6,000 and £12,000



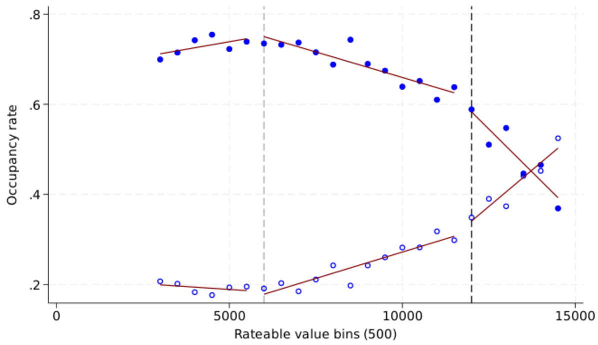
(b) Occupancy by type of business before kink at £6,000



(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 first and the second kink before and after the revaluation.

Table B12 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 B12: 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 B13 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 B13: 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	5,685	5,291	5,291	3,423
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	5,685	5,291	5,291	3,423

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),

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

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),

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

The results are depicted in Table B14. 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 B14: 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)	(0.029)	(0.007)
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)	(0.027)	(0.005)
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)	(0.019)	(0.004)
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.

B4 Data appendix

B4.1 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).[58]

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 VOA statistics (UK Valuation Office Agency, 2019-2020). 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.[59] 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 B15).

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 B18 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.[60] 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).

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

[59]67 of the 72 included jurisdictions have a coverage above 95%.

[60]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 B15: 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	33	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 Office for National Statistics (2013, 2019*b*, 2020*a*, 2021*a*, 2022) and UK Valuation Office Agency (2019-2020).

B4.2 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 B4, by address and property type [61]. 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.[62] 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 B17.

Table B16 reports the results. The dependent variable in columns (1) and (2) is rent and in

[61] Address data are harmonised using information from Office for National Statistics (2019*a*, 2020*c*) and property information is harmonised using UK Valuation Office Agency (2019).

[62] 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.

columns (3) and (4) ln rent. Panel A reports the results for retail properties with the proxied 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 B8).

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 B18. Descriptive statistics for the rent-subsamples are reported in Table B17. 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.[63]

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 B8a plots the number of properties in the rent listings data of a local authority (scaled by total number

[63]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.

of commercial properties in the local authority) by the vacancy rate. While the number of 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 B8b 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.[64]

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 B8c 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.

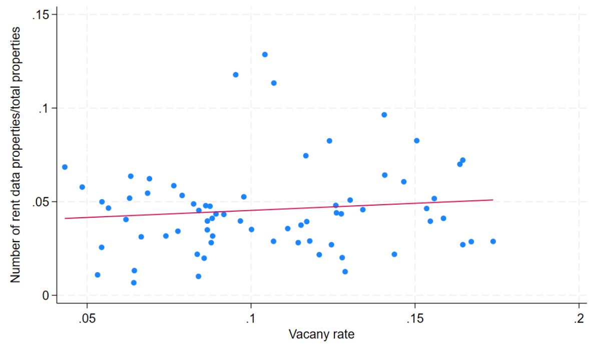
Our second robustness test to assess the relevance of selection of properties by unobserved characteristics into the rent data (within a jurisdiction) is to exclude properties that are on the market for a particular long time. Since the typical duration of properties on the market may differ by jurisdiction 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 B10. 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 B8c 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 B9, 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.

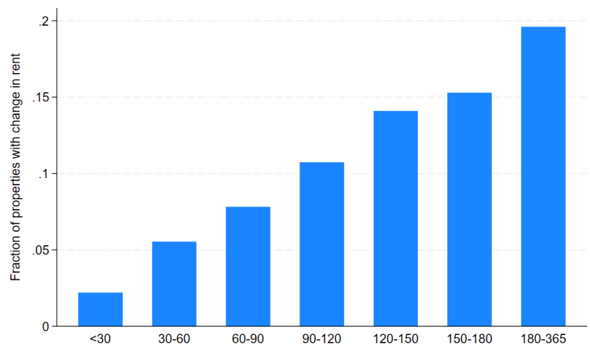
[64]While it could be informative to also use the empty duration from the admin data, it is not directly comparable with that calculated from the rent data, as the former data is quarterly data.

Figure B8: Property composition in the rent listing data

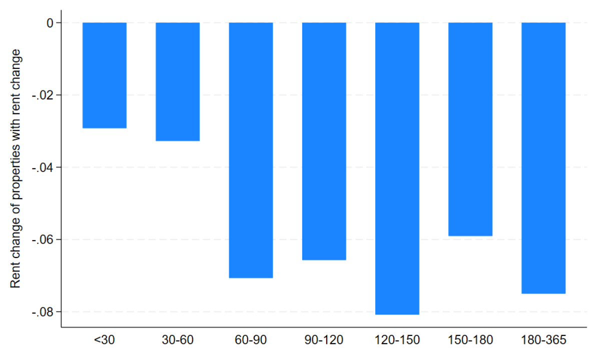
(a) Number of properties in the rent data to total number of properties and vacancy rate by local authority



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

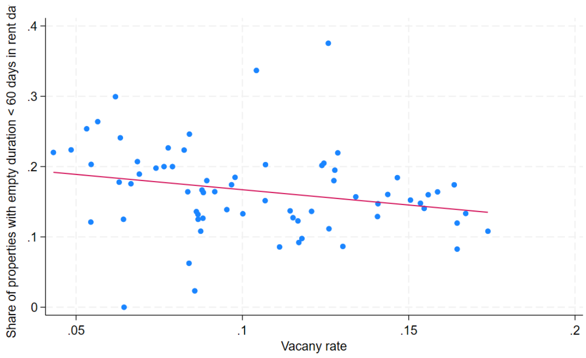


(c) Average rent change of properties with rent changes by duration on the market



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 B9: 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 B16: 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
	(424)	(420)	(0.01)	(0.01)	(3.30)
Sqft/ln(Sqft)		0.33***		0.01**	
		(0.09)		(0.01)	
D(Missing Sqft)		279		0.08*	
		(527)		(0.05)	
Observations	993	993	993	993	774
Panel B: SBRR: All properties - Proxied RV ≈ 9-18 (Matching Rate 0.31)					
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***	
		(0.03)		(0.01)	
D(Missing Sqft)		-129		0.32***	
		(116)		(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***	
		(135)		(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 B17) 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 B17: 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	27,353	48,548	12,741
Median rateable value	11,750	47,500	12,250
Mean rent	32,721	52,877	16,517
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 B18: Data source by council

Council	Source	RR			SBRR	
		Vacancy		Rent	Vacancy	Rent
Ashford	2	18Q2	19Q3[a]			X
Barking and Dagenham	1,2			X	19Q3	X
Barnsley	1	18Q3[c]	19Q3		19Q3	X
Bath and North East Somerset	1					X
Bedford	1	18Q2[a]	19Q2[a]	X	19Q3[a]	X
Bexley	1,2	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	1			X	19Q3[a]	X
Bolsover	1					X
Bolton	2			X		X
Bournemouth	1			X	19Q3	X
Bracknell Forest	1					X
Bradford	1				19Q3	X
Brent	1			X		X
Brighton and Hove	1,2	18Q3	19Q3	X	19Q3	X
Bury	2					X
Calderdale	1	18Q2	19Q2		19Q2	X
Cambridge	2					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	2				19Q1	X
Cornwall	2			X		X
Croydon	1				19Q3	X
Dacorum	2			X		X
Darlington	2	18Q2[b]	19Q2[b]		19Q2[b]	X
Dudley	1			X	19Q2	X
East Cambridgeshire	1				19Q2	X
East Hampshire	1	18Q2	19Q2[a]		19Q3[a]	X
East Riding of Yorkshire	1					X
Erewash	1					X
Gateshead	1,2				19Q3[a]	X
Gloucester	1	18Q3	19Q3		19Q3	X
Greenwich	1				19Q3	X
Haringey	1			X	19Q3[b]	X
Harrow	1			X		X
Hastings	1					X
Herefordshire	1					X
Hounslow	1,2	18Q2[c]	19Q3[c]	X	19Q3[c]	X
Isle of Wight	1,2	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	1,2					X

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Table B18 – *Continued from previous page*

	Source	RR			SBRR	
		Vacancy		Rent	Vacancy	Rent
Kirklees	1			X		X
Leicester	1			X		X
Lewisham	1				19Q3[a]	X
Lincoln	1	18Q2[a,c,d]	19Q2[a,c]	X	19Q2[a,c]	X
Liverpool	2	18Q2	19Q2	X		X
Luton	1			X		X
Maldon	1	18Q2[a,d]	19Q2[a,d]		19Q3[c]	
Newcastle upon Tyne	1			X	19Q3	X
North Dorset	2				18Q2	X
North Kesteven	2					X
North Somerset	1	18Q2	19Q2	X	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	1,2			X	19Q3	X
Portsmouth	1				19Q3	X
Preston	1				19Q3	X
Reading	1			X	19Q3	X
Redbridge	1			X	19Q3[b]	X
Redcar and Cleveland	2			X		X
Rochdale	1			X	18Q2[a]	X
Rotherham	1				19Q3	X
Rutland	1				19Q3	X
Salford	1				19Q2[b]	X
Sandwell	1			X		X
Slough	1,2				19Q3	X
Solihull	1					X
South Gloucestershire	1					X
South Lakeland	1				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	1,2			X		X
Southwark	1			X		X
St. Helens	1				19Q2	X
Sutton	1			X	19Q3[a]	X
Swale	1					X
Swindon	1,2					X
Telford and Wrekin	1					X
Thurrock	1,2				19Q3	X
Tonbridge and Malling	2	18Q3[a]	19Q3[a]		19Q3[a]	X
Torridge	1			X		X
Tunbridge Wells	1				19Q3	X
Wakefield	1			X	18Q2	X
Walsall	1	18Q3[b]	19Q3[b]	X	19Q3[b]	X
Warrington	1	18Q2	19Q2		19Q3	X

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Table B18 – *Continued from previous page*

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

Notes: The table reports the jurisdictions and jurisdiction-quarters for which rateable value data covers almost the entire local property market and that are included in the vacancy and rent analysis of RR and SBRR and the source of the data for the local authority. The jurisdictions with incomplete coverage included in the rent analysis of RR are Barnet, Coventry, Durham, Hillingdon, Lambeth, Leeds, Manchester, Middlesborough, Plymouth, Shropshire, Stockport, Stockton-On-Tees, Tameside, Tower Hamlets, Waltham Forest. 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.