ISSN 2042-2695

CENTRE *for* ECONOMIC PERFORMANCE

CEP Discussion Paper No 1681

March 2020

On the Economic Impacts of Mortgage Credit Expansion Policies: Evidence from Help to Buy

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Abstract

Mortgage credit expansion policies – such as UK's Help to Buy (HtB) – aim to increase access to and affordability of owner-occupied housing and are widespread around the world. We take advantage of spatial discontinuities in the HtB equity loan scheme, introduced in 2013, to explore the causal economic impacts and the effectiveness of this type of policies. Employing a Difference-in-Discontinuities design, we find that HtB increased house prices by more than the expected present value of the implied interest rate subsidy and had no discernible effect on construction volumes in the Greater London Authority (GLA), where housing supply is subject to severe long-run constraints and housing is already extremely unaffordable. HtB did increase construction numbers without affecting prices near the English/Welsh border, an area with less binding supply constraints and comparably affordable housing. HtB also led to bunching of newly built units below the price threshold, building of smaller new units and an improvement in the financial performance of developers. We conclude that credit expansion policies such as HtB may be ineffective in tightly supply constrained and already unaffordable areas.

Key words: help to buy, house prices, construction, housing supply, land use regulation
JEL Codes: G28; H24; H81; R21; R28; R31; R38

This paper was produced as part of the Centre's Urban Programme. The Centre for Economic Performance is financed by the Economic and Social Research Council.

We thank Paul Cheshire, Pierre-Philippe Combes, Gilles Duranton, Steve Gibbons, Ingrid Gould Ellen, Hans Koster, Stanimira Milcheva, Henry Overman, Ruchi Singh, Mark Stephens, Jos Van Ommeren and conference/seminar participants at the Penn-Oxford Symposium on Housing Affordability in the Advanced Economies, the European meeting of the Urban Economics Association in Amsterdam, the ESCP Europe-TAU-UCLA Conference on Low-Income Housing Supply and Housing Affordability in Madrid, the Ministry for Housing, Communities and Local Government, the European Regional Science Congress in Lyon (special session), the "Public Policies, Cities and Regions" Workshop in Lyon, the London School of Economics, University College London and Tinbergen Institute for helpful comments and suggestions. We thank Hans Koster and Ted Pinchbeck who provided code helping us to merge Land Registry and Energy Performance Certificate data. Financial support from Fruition Properties (through LSE Advancement) and STICERD are gratefully acknowledged. This is a slightly revised version of the paper that won the 2019 Nick Tyrrell Research Prize. All errors are the sole responsibility of the authors.
We are grateful to Richard Layard for helpful comments and suggestions.

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Published by
Centre for Economic Performance
London School of Economics and Political Science
Houghton Street
London WC2A 2AE

1. Introduction

Government policies directed at stimulating supply or demand in mortgage markets are common throughout the world. Examples of credit market interventions include mortgage interest deductions in countries as diverse as the United States, India or Sweden, mortgage guarantees in the United States or the Netherlands, and government loans for home purchases in France or the United Kingdom. Most of these interventions have the explicit goal of making homeownership more affordable and thus accessible. In a context in which housing affordability problems are increasingly pervasive, especially in large desirable cities, new policies are discussed – if not implemented – frequently. In this paper, we exploit a unique setting – spatial discontinuities in an equity loan scheme – to shed light on the economic impacts and the effectiveness of publicly-funded credit market expansion policies, and, in particular of government equity loans.

In April 2013, the British government launched a new flagship housing credit policy: Help to Buy (HtB). The program was initially implemented in England, but Welsh and Scottish versions were put in place shortly thereafter. We set out to explore the causal impact of HtB on housing construction, house prices, the size of newly constructed units and the financial performance of residential developers. To do so, we focus on the HtB 'Equity Loan Scheme', which provides an equity loan for up to 20% of the housing unit's value – or 40% within the Greater London Authority (GLA) – to buyers of new build properties. The Equity Loan Scheme is by far the most salient and popular of the four HtB schemes and the one requiring the biggest budget. It is often referred to simply as "Help to Buy" and henceforth, unless we note otherwise, when we refer to HtB we mean the Equity Loan Scheme.[1]

HtB expands housing credit and thus increases demand for housing. To explore how such a positive demand shock in the housing market affects construction and prices, we develop a simple theoretical framework with heterogeneous households and credit constraints. Our model predicts that the impact of the policy depends crucially on the responsiveness of supply to prices. In a setting with responsive supply, HtB can be expected to mainly stimulate construction numbers as intended by the policy. However, when supply is unresponsive (i.e.,

[1] At the time of implementation, HtB consisted of four schemes; the Equity Loan Scheme, Mortgage Guarantees, Shared Ownership, and Individual Savings Accounts (ISA). All four schemes aim to help credit constrained households to buy a property. The Mortgage Guarantees scheme ceased at the end of 2016. The HtB-ISA closes for new entrants in November 2019 and any bonus must be claimed by 2030. In April 2017, the British government introduced a new Lifetime ISA scheme. In contrast to HtB ISA, it is only open to individuals aged 18-39 and the money saved can also be used to fund a pension.

regulatory constraints or physical barriers to residential development impede a supply-response), the effect of the policy may be mainly to increase house prices, with the unintended consequence of making housing less rather than more affordable.

We implement a Difference-in-Discontinuity design to compare changes in house prices and construction activities across jurisdictional boundaries. We separately analyze properties sold on either side of the GLA boundary and on either side of the English/Welsh border. In both cases we only consider housing purchases close to the respective boundaries. As pointed out above, in Wales the scheme was put in place later and it only applied to a subset of the properties that were eligible in England. Likewise, the London scheme that was implemented in 2016 offered larger government equity loans (as a share of house values) for dwellings inside the GLA compared to those available for purchase outside the GLA. Our main estimates exploit these spatial discontinuities to study the effect of HtB on house prices and construction activity. We also use this design to study the impact of the scheme on the size of newly constructed units.

We focus on the GLA boundary and the English/Welsh border for two reasons. First, our research design requires spatial discontinuities in the scheme's conditions, which can be found at these boundaries. Second, the two areas differ starkly in their regulatory land use restrictiveness and in barriers to physical development: While the GLA is the most supply constrained and the least affordable area in the UK – and arguably one of the most supply constrained areas in the world – housing supply is comparably responsive to demand shocks near the English/Welsh border.[2]

Consistent with our theoretical predictions, we find that differences in the intensity of the HtB-treatment have heterogeneous effects depending on local supply conditions. In the GLA, where supply is relatively unresponsive to price changes, the introduction of the more generous London version of the Equity Loan Scheme led to a significant increase in prices for new build units of roughly 6%. However, it had no appreciable effect on construction activity. Conversely, in the areas around the English/Welsh border, where only a small fraction of land is developed and developable land is readily available, we find a significant effect on construction activity and no effect on prices. The introduction of the more generous HtB-price threshold on the English side of the border increased the likelihood of a new build sale by about 8% (compared to the Welsh side of the border). Consistent with this, a bunching analysis reveals that HtB led

[2] We provide supporting evidence for this proposition in Section 3.2.

to significant bunching of properties right below the price threshold, shifting construction away from larger properties above the threshold towards smaller units. We also provide evidence indicating that the scheme caused an improvement of the financial performance of developers; larger revenues as well as higher gross and net profits.

Collectively, these results suggest that the effects of HtB largely depend on local supply conditions. We find that the scheme fails to trigger more construction activity, but instead causes house prices to increase inside the GLA, precisely the region that is most affected by the 'affordability crisis'. This has distributional implications. The main beneficiaries of HtB in already unaffordable areas may be developers and landowners rather than struggling first-time buyers; while access to homeownership is improved in principle (credit constraints are relaxed), the present value of the financial burden associated with the purchase of a home further increases.

Our paper relates to previous studies looking at the effects of credit conditions and credit market policies on housing markets. Previous research in this vast literature has mainly focused on the effect of credit supply on house prices (see Stein 1995, Ortalo-Magné and Rady 2006, Mian *et al.* 2009, Duca *et al.* 2011, Favara and Imbs 2015). These and other studies provide theoretical and empirical credence to the notion that expansions in credit supply lead to higher prices, especially in areas with tight planning conditions. On the policy evaluation front, several studies have explored the impact of demand subsidies on housing market outcomes. Hilber and Turner (2014) examine the impact of the U.S. mortgage interest deduction (MID). They find that the MID boosts homeownership attainment only of higher income households in markets with lax land use regulation. In tightly regulated markets with inelastic long-run supply of housing, the MID lowers homeownership attainment, presumably because higher house prices also raise down-payment constraints of would-be-buyers. Sommer and Sullivan (2018) estimate a dynamic structural model of the housing market to study the effect of removing the MID and predict this would result in a substantial reduction in house prices. Finally, a significant literature has studied the effect of credit expansion policies in the US – such as FHFA guarantees and GSE lending – on homeownership attainment, finding mixed results.[3] Our analysis contributes to this literature by documenting how a credit expansion-policy affects prices, construction activity and developer performance. We interpret our results as the

[3] See for example Bostic and Gabriel (2006), Gabriel and Rosenthal (2010) and Fetter (2013). Olsen and Zabel (2015) review the US literature. A comparison of US policies with policies in the UK and Switzerland can be found in Hilber and Schöni (2016). An evaluation of the French *Pret a Taux Zero* policy – which provides a down-payment subsidy to low and middle-income first-time buyers can be found in Gobillon and le Blanc (2008).

predictable outcome of an exogenous credit expansion shock, which helps link our estimates to the broader literature on mortgage supply and housing markets.

Only a very limited number of studies have shed light on the effects of HtB on housing and mortgage markets. Finlay *et al.* (2016) estimate that since its introduction HtB has generated 43% additional new homes. They conclude that the scheme has been successful in increasing housing supply. While their analysis combines quantitative and qualitative methods, their study lacks proper identification of the effects using a rigorous empirical approach. Szumilo and Vanino (2018) use a spatial discontinuity approach similar to the one employed here but focus their analysis on the effect of HtB on lending volumes only. Benetton *et al.* (2019) explore the effect of HtB on households' house purchase and financing decisions. Applying a Difference-in-Difference strategy, they find that households take advantage of an increase in the HtB maximum equity limit to buy more expensive properties. To date, we have no state-of-the-art evaluation of the impacts of the policy on house prices and construction volumes. Our paper aims to address this.

Finally, this paper links to previous research on housing and land supply, including work on the effects of supply constraints on the responsiveness of housing markets to economic shocks (Hilber and Vermeulen, 2016), the origin of supply restrictions (Saiz 2010, Hilber and Robert-Nicoud, 2013) and their consequences (see Gyourko and Molloy 2015 and the references therein). We contribute to this literature by studying in depth the effect on housing supply of arguably the most important new British housing policy since the implementation of Right to Buy in 1980.

The rest of this paper is structured as follows. Section 2 describes the details of the HtB Equity Loan Scheme and provides a simple theoretical framework to guide the empirical analysis. Section 3 outlines our empirical strategy and discusses the results. Section 4 concludes.

2. Background and Theoretical Framework

2.1. Background: The Help to Buy Equity Loan Scheme

Since the launch of HtB in April 2013 until September 2018, over 195,000 properties were bought with a government equity loan provided by the scheme. The total value of these loans is £10.7 billion, with the value of the properties purchased under the scheme totaling £49.9 billion (Ministry of Housing, Communities and Local Government 2019).[4]

[4] The Ministry of Housing, Communities and Local Government (2019) provides a comprehensive overview and numerous summary statistics relating to the HtB Equity Loan Scheme.

The English version of the HtB Equity Loan Scheme offers government loans of up to 20% of a unit value to households seeking to buy a new residence. It is available to both first-time buyers and home-movers but it is restricted to the purchase of new build units with prices under £600,000. Given that the prevalent maximum Loan-to-Value (LTV) ratios offered by British banks to first-time buyers were around 75% during this period, the scheme offers a substantial reduction in the down-payment needed to buy a property. With the government loan covering part of the down-payment, buyers are only required to raise 5% of the property value as a deposit. The explicit goal of the Equity Loan Scheme is that this reduction in the deposit required to the borrower helps households overcome credit constraints.

The Equity Loan Scheme can also help reduce household borrowing costs by reducing interest payments on the combined loan. This occurs via two channels. The first is that no interest or loan fees on the equity loan have to be paid by the borrower for the first five years after the purchase of the house. Subsequently, there is a charge, which depends on the rate of inflation. We calculate the implied subsidy provided through this channel in Section 3.7. Secondly, by raising the combined deposit to 25%, the equity loan keeps borrowers away from high-LTV, high-interest products available in the commercial mortgage market.[5]

The government equity loan can be repaid at any time without penalty. However, unless they want to sell the property, borrowers do not need to repay the loan at all. When they sell, the government will reclaim its 20% equity stake of the sale price. The government thus participates in capital gains and losses.

In our analysis we exploit differences between the English, Welsh and London versions of the Equity Loan Scheme. The Welsh scheme was introduced in January 2014 and provided support for the purchase of properties with prices under £300,000.[6] The London scheme was introduced in February 2016 and offered an equity loan of up to 40% of the unit's price for properties under £600,000 located within the GLA. The regional differences in the scheme are summarized in Table 1.

One important feature of the different loan schemes is that they are only available for the purchase of newly built properties. This condition is intended to leverage the increase in

[5] This enables households to gain access to more attractive mortgage rates from lenders who participate in the scheme. Eligibility conditions require borrowers to have a suitable credit score and to be able to cover the monthly repayments.

[6] Scotland also introduced a HtB Equity Loan Scheme during 2014; however, we are not able to exploit the discontinuities at the English/Scottish border. This is because the Scottish Land Registry did not identify new build units until 2018.

demand for these properties with the ultimate aim of triggering a supply response. It implies that demand faced by residential developers, construction companies and other actors in the construction sector will increase with the policy. We use information from these companies' accounting data to estimate the effect of the policy on their financial performance.

2.2. Theoretical Framework

In this sub-section we develop a theoretical framework to guide our empirical analysis.[7] Specifically, we develop a simple model of the housing market with heterogeneous households, featuring credit constraints and endogenous housing supply. It is a partial equilibrium model in that we abstract from potential effects of changing credit conditions for new builds on the price of the existing stock.

The framework illustrates how a relaxation of credit conditions affects housing quantities and prices, and how these effects depend on the costs of developing new stock. A relaxation of credit constraints leads to both an increase in prices and an expansion in quantities. Under suitable assumptions – made explicit below – the relative magnitude of the two effects depends on the responsiveness of supply to prices. For low (high) supply responsiveness, the price effect is stronger (weaker) and the quantity effect weaker (stronger). The theoretical insights from this framework can be summarized by the cross-elasticities of quantity and prices taken over the credit conditions parameter and a building cost shifter.[8] We also show how a relaxation of credit conditions can increase developer profits.

Suppose a two-period economy with a unit mass of households with preferences over a numeraire consumption good c and housing h, as given by a period utility $u(c,h)$ which is continuous, strictly increasing and differentiable in both arguments. Assume in addition that $\lim_{h\to\infty} u(c,h) = \infty$ if $c > 0$ and $u(c,h) > 0\ \forall c,h > 0$. Households enjoy utility at the end of periods 1 and 2, and the discount factor is $\beta>0$.

Households can only obtain $h > 0$ if they buy a new unit and obtain housing consumption normalized to 0 otherwise. We can think of these alternatives either as a choice between renting and buying. In this interpretation, this formulation is similar to those used in models featuring warm-glow from ownership (Iacoviello and Pavan 2013, Kiyotaki *et al.* 2011, Carozzi 2019).

[7] The model builds on Hilber and Vermeulen (2016) who consider a similar setting but abstract from the role of credit conditions.

[8] The model presented here introduces credit conditions via a change in required loan-to-value ratios (LTVs), as is customary in the literature. We treat housing as homogeneous, with all built units being identical in the utility they provide to households, but heterogeneous in development costs.

The role of the assumption is to ensure that demand for new build units is determined solely by credit conditions.

Households receive an endowment e in period 1 and a location specific income w in period 2 which can be used for consumption or to buy property. Households are heterogeneous in the initial endowment e, which is continuously distributed over the unit interval [0,1] with cumulative density function F_e. In period 2, income is w.

New build units are homogeneous and can be bought in period 1 for an endogenous price P. Credit is available for the purchase of property, yet a minimum down-payment is required corresponding to a fraction $(1-\gamma)$ of the property value. Credit and savings pay interest r. We assume that $w > \frac{\gamma}{1-\gamma}(1+r)$ which ensures that, for sufficiently large h, demand for new build units is determined solely by the credit constraint.[9] Hence, demand is given by the mass of agents that can afford a down-payment $Q_D = 1 - F_e((1-\gamma)P)$. Note that demand is downward sloping as the function F_e is strictly increasing.

There is a unit mass of developable land which can be used to build – at most – a unit mass of housing units. Development costs for new build units depend on local supply conditions and are heterogeneous across land plots. We assume that the development costs are uniformly distributed in the $[0,\nu]$ interval, with $\nu(1-\gamma) > 1$. We assume land is owned by competitive firms which will develop their plot if the price is smaller than or equal to development costs. As a result, the new build inverse supply curve for competitive developers is given by $P = \nu Q$. High values of ν correspond to higher average development costs and, therefore, to a weaker response of quantities to a change in prices. Conversely, low values of ν are associated with a more responsive supply schedule (i.e. a flatter supply curve). We can substitute this expression in demand to obtain an implicit definition for new build equilibrium quantities:

$$Q^* = \Big(1 - F_e\big((1-\gamma)\nu Q^*\big)\Big) \tag{1}$$

By differentiating this expression, we can obtain the following four statements regarding the responses of equilibrium prices and quantities to changes in credit conditions (γ), and development costs (ν):

$$\frac{dQ^*}{d\nu} < 0 \qquad \frac{dP^*}{d\nu} > 0 \qquad \frac{dQ^*}{d\gamma} > 0 \qquad \frac{dP^*}{d\gamma} > 0 \tag{2}$$

[9] Note that $P \leq \frac{1}{1-\gamma}$. Assumption $w > \frac{\gamma}{1-\gamma}(1+r)$ will therefore ensure that in period 2 all agents are able to pay the remaining part of any loans taken for the purchase of a property, including interest. Large enough h ensures buying property in period 1 is incentive compatible for all households. See theoretical Appendix.

The first two inequalities indicate that an increase in development costs results in a reduction in equilibrium quantities and an increase in equilibrium prices.[10] The third and fourth inequalities mean that both quantities and prices respond positively to an expansion of credit. This follows from the increase in demand associated with a credit expansion. The extent to which a change in credit conditions will translate into a change in quantities or prices depends on both the distribution of the initial endowment F_e and the price responsiveness of supply (through ν).

Proposition 1 – The effect of a credit expansion on prices and quantities depends on the distribution of development costs, as measured by ν. Specifically, if e is uniformly distributed and $\nu(1-\gamma) > 1$, then $\frac{dQ}{d\gamma d\nu} < 0 < \frac{\partial P}{d\gamma d\nu}$.

Proof: See theoretical Appendix

Proposition 1 states that, under the specified parameter conditions, the effect of credit on quantities will be smaller, and the effect on prices larger, in high ν markets (i.e., in markets with tighter supply constraints and thus more inelastic long-run supply of housing). This intuition will help us account for regional differences in our estimates of the impact of Help to Buy reported in the next sections.

The assumption of uniform endowments is a sufficient condition, but it is not necessary. Intuitively, this assumption results in linear demand curves. In the theoretical Appendix we show that without linear demand curves either the first or the second inequality is not satisfied. Hence, the conclusions derived from the uniform case may or may not follow with more general assumptions on the distribution of endowments. This *ex-ante* ambiguity partly motivates the empirical analysis below.

The statements in the derivatives in (2), as well as Proposition 1, are derived for the case of competitive land and housing markets. Proposition 2 states that an expansion of credit will result in an increase in total developer profits.

Proposition 2 – A credit expansion will result in an increase in total developer profits. That is, the sum of equilibrium profits across developers $\Pi(\mathrm{P})$ is increasing in γ.

Proof: See theoretical Appendix

This result hinges on the assumption that developers own all land, preventing entry from other firms from eroding profits. The notion that developers have some degree of market power is

[10] See proofs in theoretical Appendix.

reasonable in our case, as the residential construction market is characterized by substantial concentration and high returns. We test empirically whether Proposition 2 is satisfied in Section 3.

3. Empirical Analysis

3.1. Data and Descriptive Statistics

Our empirical analysis employs geo-located data on housing sales in England and Wales, including information on unit characteristics and transaction prices. Our main data source is the Land Registry Price Paid Dataset (or short 'Land Registry'), which covers most residential and all new build residential transactions in England and Wales. The dataset includes property sales from 1995 to 2018, recording the transaction price, postcode, address, the date the sale was registered (which proxies for the transaction date), and categorical data on dwelling type (detached, semi-detached, flat or terrace), tenure (freehold or leasehold) and whether the home is a new build property. We use the National Statistics Postcode Lookup Directory to match properties in the dataset to coordinates and wards.

Over the period between 2012 and 2018, the Land Registry recorded 700,338 sales of new housing units. We use the sale of these units as a proxy for construction activity. All sales are geo-coded using address postcodes. In our spatial discontinuity analysis, we select all the new build transactions near the GLA boundary and the English/Welsh border. Specifically, we select all new build transactions within 5km from the GLA boundary and within 10km from the English/Welsh border.[11] We use a 10km bandwidth for the latter exercise because transactions near the English/Welsh border are sparser. We also use areas near the Greater Manchester boundary in a placebo test.[12]

In addition, we use Energy Performance Certificate (EPC) data that contains information on the floor area and other physical characteristics of newly built units. We match this data to the Land Registry in order to augment the latter dataset with additional information on the transacted newly built units.[13] Demographic neighborhood characteristics at ward level are collected from

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[11] The number of transactions for the resulting samples are reported in Appendix Table B1. This table also reports sample sizes for smaller bands around the respective boundaries.

[12] Greater Manchester is the second largest travel to work area in the United Kingdom and arguably the one most comparable to London.

[13] EPCs provide information on buildings that consumers plan to purchase or rent. Since 2007 an EPC has been required whenever a home is constructed or marketed for social rent, private rent or sale. We use a dataset that contains all EPCs issued between 2008 and 2019. The dataset includes the type of transaction that triggered the EPC, the energy performance of properties and their physical characteristics. Following Koster and Pinchbeck (2017), we merge the EPC data into the Land Registry using a sequential match strategy. First, we match a Land Registry sale to certificates using the primary address object name (PAON; typically, the house number or name),

the 2011 Census and used as controls. We include the fraction of married residents, and the fraction of residents with level-4 and above educational qualifications.

In Panel A of Table 2, we present summary statistics for the sample of new build sales located within 5 kilometers of the GLA boundary taking place between January 2012 to December 2018. There are 32,127 newly built property transactions in this area. The average house price is £394,703, and the average size of these properties is 87.3 square meters. Panel B of Table 2 shows the descriptive statistics for the baseline sample of new build transactions within 10 kilometers of the English/Welsh border from 2012 to 2018. The average house price in this region is £234,202, and the average size of these properties is 102.2 square meters.

When estimating the effect of the policy on housing construction, we assemble a ward by month panel using data from January 2012 to December 2018. We obtain ward-level observations by aggregating from individual new build sales. Panels C and D of Table 2 document the descriptive statistics of our estimation sample for the construction effect. The datasets for the GLA boundary-area and the English/Welsh border-area consist of 401 wards and 195 wards respectively. The propensity to have at least one new build transaction in any month and ward is 0.22 for the GLA sample and 0.18 for the English/Welsh sample. On average, 0.95 new units are built each month in a ward near the GLA boundary and 0.52 near the English/Welsh border.

To conduct our analysis of developer performance, we construct a developer/construction company panel that covers 84 companies during the period 2010 to 2018. The panel includes financial information of these companies from Orbis. It also includes information on whether or not the companies are registered with a HtB agency. A builder must be registered with one of the regional government offices managing the scheme for its properties to be eligible for a HtB equity loan. The full sample of 84 developers is our *Difference-in-Differences* sample. In addition, we include hand-coded data on the fraction of properties sold through the scheme from annual reports in a selected sample of 30 residential developers. This is our *intensity* sample. The large sample of 84 companies is obtained after combining a list of the main builders in the United Kingdom from Zoopla – one of the main property websites in the country – and

secondary address object name (SAON; typically, the identification of separate unit/flat), street name, and full postcode. We then retain the certificate that is closest in days to the sale or take the median value of characteristics where there is more than one EPC in the same year as the sale. We repeat this exercise for unmatched properties but allow one of the PAONs or SAONs to be different. Our final round of matching is on the full postcode. The matched dataset provides us total floor area; whether the property has a fireplace or not; total energy consumption and total CO_2 emission of the property.

financial data from Orbis. This list includes residential developers, commercial developers and construction companies.

3.2. The Role of Local Supply Conditions

Below, we report separate estimates of the impact of the generosity of HtB schemes obtained from a sample of properties near the GLA boundary, and a sample of properties near the English/Welsh. We choose these two areas because they both provide an ideal quasi-natural setting to identify the economic effects of HtB. We also report estimates using the area near the Greater Manchester boundary for our placebo tests, as the same generosity of the English HtB scheme does not change at that boundary.

One crucial difference between our two focal areas – the area near the GLA boundary and the area near the English/Welsh border – is that the former has overall vastly less responsive supply, driven by both, tighter local planning regulations and a relative scarcity of undeveloped developable land. As shown above, theory suggests that the positive impact of HtB on house prices should be much larger – and the positive impact on new construction much smaller – in the area near the GLA boundary.

In order to illustrate the differences in supply conditions between the areas, we employ a number of measures that capture long-term housing supply constraints. These measures are the share of land designated as green belt (provided by the Ministry of Housing, Communities and Local Government), the average planning application refusal rate taken over the period from 1979 to 2008, the average share of developed developable land, and the average elevation range (all derived from Hilber and Vermeulen, 2016). We calculate these measures for the three areas employed in our analysis using Local Planning Authority (LPA)-level data and LPA surface areas as weights.[14]

Table 3 (rows 1 to 4) illustrates the differences in supply conditions between the three areas. The most striking difference between the two focal areas lies in the share of 'green belt' land. Land in green belts is typically off limits for any development (residential or commercial) and thus represents a 'horizontal' supply constraint. This share is 66.5% for boroughs along the boundary of the GLA but only 3.8% for English boroughs along the English/Welsh border. Another measure to capture physical supply constraints is the share of developable land already

[14] We do not currently have data for LPAs on the Welsh side of the English/Welsh border. We expect that the differences between the GLA and the English/Welsh border area will be even more striking when taking account of the data from the Welsh LPAs.

developed. This share is 27.6% for boroughs along the GLA boundary but only 6.3% for English boroughs along the English/Welsh border.

The arguably quantitatively most important long-term supply constraint are restrictions imposed by the British planning system (Hilber and Vermeulen 2016). The weighted average of this refusal rate is 35.6% for boroughs along the GLA boundary and 27.2% for English boroughs along the English/Welsh border.

While the area near the English/Welsh border is subject to greater topographical (slope related) supply constraints, Hilber and Vermeulen (2016) demonstrate that these constraints, while statistically significant, are quantitatively unimportant in explaining local price-earnings elasticities.

Lastly, it is important to point out that the area near the GLA boundary is not only characterized by vastly more restrictive supply conditions, but these constraints are also significantly more binding in practice, simply because aggregate housing demand there is much stronger. To illustrate this point, consider a ten-story height restriction in the heart of a superstar city such as London and compare it to the same constraint in the desert. The restriction is extremely binding in the former location, while completely irrelevant in the latter.

To explore the differences in supply responsiveness across the three areas further, we employ the estimated coefficients from Hilber and Vermeulen (2016) to compute an implied house price-earnings elasticity. Table 3 (rows 5 and 6) reports our estimated elasticities based on these coefficients. Using the OLS estimates, we find that the price-earnings elasticity along the GLA boundary (0.40) is higher than that of the area along the Greater Manchester boundary (0.28), which in turn is higher than the elasticity near the English/Welsh border (0.25). As two of the three supply constraints measures employed in their estimation, refusal rate and share developed land, are likely endogenous, we employ the instrumental variable strategy proposed in Hilber and Vermeulen (2016). This provides exogenous variation in our supply constraint measures, which we use to re-compute the unbiased price-earnings elasticities. The rank order remains unchanged. The GLA has again the highest elasticity (0.21) followed by Greater Manchester (0.16) and the English/Welsh border area (0.13).

The higher price-earnings elasticity along GLA boundary suggests that, due to local supply constraints, housing prices respond more strongly to a given change in local housing demand. This also suggests a lower supply price elasticity in the GLA boundary area. In the next section, we outline our identification strategy and discuss how we measure the impact of HtB on house prices and construction activity.

3.3. Identification Strategy and Empirical Specifications

Our empirical strategy is designed to test the impact of HtB on housing construction and house prices. We exploit spatial differences in the intensity of the HtB policy. As mentioned above, HtB Wales was rolled out nine months later than in England and offered a government-backed loan for the purchase of new build properties under £300,000 (£600,000 in England). There were also differences in the intensity of the HtB policy between the GLA and its surroundings, starting in 2016. In this case, the difference lies in the size of the government-backed loan available to households. London-HtB offers loans of up to 40% of a new build's value, while this figure is 20% elsewhere (i.e., outside the GLA boundary). We exploit these regional policy differences in a Difference-in-Discontinuities design combining time variation in prices and new build construction with local variation in policy intensity around the regional boundaries.

The samples of new build properties used in the analyses of prices and construction effects near the GLA boundary and the English/Welsh border are illustrated in Figures 1 and 2, respectively.[15] Our boundary approach is meant to ensure that we are comparing properties affected by similar economic and amenity shocks, as compared to a standard Difference-in-Differences strategy that simply takes whole regions as control groups. The identifying assumption in both cases can be likened to the typical assumption of parallel trends: in the absence of the policy, prices and construction on either side of the boundary would have followed a parallel evolution over time. Figures 3 and 4 depict the evolution of house prices at both sides of the GLA boundary and English/Welsh border, respectively, and indicate that prices moved in parallel prior to the implementation of the policy.[16] Figures 5 and 6 depict the average number of units built by ward at the GLA boundary and English/Welsh border, respectively. Again, we see that the evolution of building activity followed reasonably parallel trends prior to the implementation of the policy.

In addition to studying the effect of the policy on prices and construction activity, we also estimate the impact on HtB on developers' profits, and document evidence of substantial

[15] Appendix Figure A1 depicts the corresponding map for our placebo sample of new build sales near the Greater Manchester boundary.

[16] The price index is constructed by estimating a linear regression of log prices on property characteristics (property type dummies for detached, semidetached and terraced properties, property size, a leasehold dummy, measures of energy efficiency) and postcode fixed effects. The lines in Figures 3 and 4 correspond to time dummies included in that specification.

bunching of new build property prices around the eligibility thresholds for England (£600,000) and Wales. These specific analyses further clarify developers' responses to the policy.

3.3.1. Specification: Impact of Help to Buy on House Prices

The HtB policy is meant to operate as a relaxation of households' credit constraints. Hence, it can lead to an increase in demand for new builds, and as a result, to an increase in the price of new builds. To test this, we use observed transactions of new build units located near the boundary of the GLA and the English/Welsh border in two Difference-in-Discontinuities analyses. We conduct both exercises separately. To estimate the magnitude of these differences in our Difference-in-Discontinuities framework we estimate:

$$\ln\left(P_{ipjt}\right) = \phi_p + \beta HtB_i \times Post_t + \delta_t + \gamma' X_i + \tau' Z_j \times d_y + \gamma_y Distance_i \times d_y + \varepsilon_{ipjt} \qquad (3)$$

where i indexes individual properties, j indexes the (ward-level) neighborhood, p indexes the postcode (within a ward), t indexes the month, and y indexes the year. The variable HtB_i is a dummy that takes value 1 in the region with a more generous HtB policy (i.e. inside the GLA or on the English side of the English/Welsh border), and the variable $Post_t$ represents a dummy taking value 1 if individual transaction i occurs after the difference in policy takes place. A vector of postcode fixed effects is represented by ϕ_p, δ_t is a set of (year-month) time dummies, X_i is a set of individual housing characteristics, and Z_j are neighborhood characteristics at the ward level (from the 2011 Census) interacted with year dummies d_y.

After we control for postcode fixed effects, we include the distance to the boundary interacted with year dummies d_y to account for potential time varying shocks that differ spatially.[17] We estimate this equation by OLS, clustering standard errors at the postcode-level to account for potential spatial correlation in local price shocks. This is estimated on properties within a bandwidth around the corresponding boundary. In the case of the London HtB, we use a 5km bandwidth around the GLA boundary. We use a 10km bandwidth around the English/Welsh border. In the robustness checks section, we show that our results are robust to alternative bandwidth choices.

Our parameter of interest is β. It measures the effect of differences in the intensity of the HtB policy on the price of new build properties.

3.3.2. Specification: Impact of Help to Buy on Housing Construction

[17] In an alternative specification, we omit the postcode fixed effects and control flexibly for distance to the boundary by estimating different linear terms in the distance, specified separately on either side.

The government's equity loan is available only for the purchase of new build units. In this way, the government attempts to ensure the policy triggers additional residential construction. In order to test whether this is the case, we estimate the effect of differences in the intensity of the policy on construction activity. We again use a Difference-in-Discontinuities specification. This exercise is conducted by aggregating new build counts at the ward level for every month. We estimate:

$$New\ builds_{jt} = \omega_j + \beta HtB_j \times Post_{t-12} + \delta_t + \tau' Z_j \times d_y + \gamma_y Distance_j \times d_y + \varepsilon_{jt} \quad (4)$$

where j indexes wards, t indexes months, and y indexes years. The dependent variable is now $New\ builds_{jt}$, which can represent either the number of new build transactions in ward j and period t, or a dummy taking value 1 if there are any new build sales in ward j and period t. The variable HtB_j is a dummy taking value 1 in the area with a more generous HtB policy (i.e., inside the GLA boundary or on the English side of the English/Welsh border), and the variable $Post_{t-12}$ represents a dummy that takes value 1 if transactions in ward j occur after the difference in policy arises. The variable is lagged by twelve months to account for the likely delayed response of construction to the policy shock.[18] We include a set of ward fixed effects, represented by ω_j and time fixed effects δ_t.[19] Z_j are neighborhood characteristics (from the 2011 Census) interacted with year dummies d_y. In addition to controlling for ward fixed effects, we include the distance to the boundary interacted with year dummies to account for potential time varying shocks that differ spatially. In all specifications we cluster standard errors at the ward level to account for potential spatial correlation. We estimate our specification using observations within 5km of the boundary in the case of the London GLA, and 10km in the case of the English/Welsh border.

Our parameter of interest is β, which measures the effect of differences in the intensity of HtB on new construction. The differences in intensity are not the same across the English/Welsh border and across the GLA boundary. Therefore, we obtain separate estimates for these two exercises.

3.3.3 Help to buy and Developers' Financial Performance

As indicated in Proposition 2, the increase in demand for newly built housing induced by HtB should positively impact the financial performance of firms participating in the scheme. The

[18] As a robustness check, we estimate a contemporaneous specification. Construction lags in the UK tend to be long by international standards, often in excess of 12 months.
[19] We also provide estimates that are obtained by controlling flexibly for distance to the boundary, omitting ward fixed effects.

policy should induce an increase in revenue of existing developers.[20] Moreover, barriers to entry and imperfect competition in the housing production and land markets imply that the policy should translate into increased profits. This, however, depends on whether the increase in revenues is neutralized by an increase in the costs of land after the implementation of the policy.[21] Uncovering how HtB affected the performance of developers can therefore identify some of the beneficiaries of this policy.

To study this empirically, we use our developer dataset, covering 84 large British developers and construction companies. The dataset includes information on developers' financial performance and, crucially, on the participation of these firms in HtB. We use our dataset to compare how the change in the performance of firms before and after 2012 varied with their participation in the scheme. For this purpose, we estimate a fixed effect model specified as:

$$Fin\,performance_{kt} = \beta HtB_k \times Post_t + \alpha_k + \delta_t + \varepsilon_{kt} \qquad (5)$$

$Fin\,performance_{kt}$ is an indicator of various measures of financial performance for developer k in year t. We look at turnover (i.e. total revenues), gross profits, net profits before taxes, the difference between gross and net profits, and the salary cost of employees. The latter two variables are crude proxy measures for the pay packages of the senior management. The measure HtB_k captures whether a developer participates in the program. We use two different definitions of this variable depending on the information available and therefore conduct the analysis on two separate samples. Our intensity sample consists of the 30 developers, for which we know the fraction of the units produced that were sold under the HtB scheme. We average this figure over time to obtain a time-invariant average fraction of units per developer. Our second definition of HtB_k is based on the registry of developers in regional HtB offices across the country. In this case, the variable is a dummy taking value 1 if the developer is included in the registry. The information on registrations is available across a larger group of firms, so we can estimate this specification for our larger Difference-in-Differences sample of 84 developers. Variable $Post_t$ is a variable taking value 1 after 2012. Finally, α_k is a developer fixed-effect and δ_t represents a set of year dummies.

Estimates of β will measure the impact of the policy of firms and revenues under the assumption that unobservables ε_{kt} are uncorrelated with $HtB_k \times Post_t$ conditional on individual and year effects. Because firms actively self-select into the program, the identifying

[20] The increased supply could in principle be taken up exclusively by new entrants. Yet the presence of economies of scale in housing production and the learning curve required to navigate the British planning system mean the volume of new entrants will probably be very small.

[21] In our model, this is ruled out because land is owned by developers, so land rents are included in profits.

assumption requires that the difference in performance between firms that self-select into the scheme and those that do not is fixed over time. That is, we assume other shocks to performance during the 2010-2018 period are uncorrelated with program participation.

3.3.4. Bunching Analysis

The English HtB policy is only available for properties purchased under 600,000 GBP. We can use this threshold to study bunching of property sales close to this price level. In doing so, we apply some of the methods recently developed in Chetty *et al.* (2011), Kleven (2016) and Best and Kleven (2017). The purpose of this analysis is two-fold. First, it allows us to test whether HtB induced a change in the *type* of properties supplied by developers. In addition, a bunching analysis provides an alternative method to study the effect of the policy on building volumes.

We first document that indeed there is substantial bunching at the £600,000 price threshold. Next, we construct a counterfactual price distribution for new builds using information on sales excluding the region around the bunching thresholds. Following Kleven (2016), we estimate this counterfactual distribution by calculating the number of new build transactions in 5000 GBP bins and use these to estimate:

$$S_{lt} = \sum_{q=0}^{3} p_{lt}^{q} + \sum_{r \in R} \rho_r 1\left\{\frac{p_j}{r} \in \mathbb{N}\right\} + \varepsilon_{lt} \tag{6}$$

where l indexes price bins and t indexes time. The dependent variable S_{lt} measures the number of new build transactions in bin l at time t. The first two sums provide an estimate of the counterfactual price distribution. The first sum is a third-degree polynomial on the distance between price bin l and the cutoff of £600,000. The second sum estimates fixed-effects for round numbers, with $\mathbb{N}$ representing the set of natural numbers and $R = \{5000, 10000, 25000, 50000\}$ representing a set of round numbers. We estimate this equation with data for new build transactions in England taking place after April of 2013 (the introduction of HtB in England). We then obtain differences between this estimated counterfactual distribution and the observed distribution of prices to estimate bunching effects induced by HtB.

The difference between the size of the spike just under the threshold and the gap just after the threshold can be used to estimate the size of the local effect of HtB on new building activity. This can be driven by changes in the types of properties sold after accounting for local shifting in prices induced by the policy.

3.4. Main Results

3.4. 1. Visual Evidence of Boundary Discontinuity

We first provide a series of graphs that illustrate our main results. Figure 7 represents the prices for newly built units at different distances from the GLA boundary. Positive distances correspond to locations inside the GLA, while negative distances refer to locations outside of this area. Circles depict the mean value of new build house prices for 500-meter-wide distance bins with the size of each circle being proportional to the number of observations in that bin. Lines in both panels represent fitted values from 2nd order polynomials estimated separately on each side of the boundary. Gray bands around them represent 95% confidence intervals.[22] Panels A and B illustrate results before and after the introduction of London HtB, respectively. Comparing both panels, we find that a discontinuity in prices at the boundary emerges after the implementation of London's HtB. We interpret this as evidence that differences in the size of available equity loans at the boundary led to a significant and positive effect on the price of newly built properties within London. We test this formally in Section 3.4.2.

Figure 8 illustrates our results for the new build price effect at the English/Welsh border. Circles depict the mean value of house prices for 1000-meter-wide distance bins. As above, solid lines represent 2nd degree polynomials estimated on both sides of the boundary.[23] In this case, however, we do not observe a spatial discontinuity of house prices in either Panel A or B. Hence, the difference in the scheme at the border – the eligibility price threshold is twice as large in England as in Wales – did not generate an appreciable difference in new build prices.

We conduct a similar exercise looking at changes in construction volumes at these boundaries before and after the corresponding changes in HtB. Results are illustrated in Figures 9 and 10. The former shows construction as measured by new build sales near the GLA boundary with Panels A and B corresponding to the periods prior and post implementation of London HtB, respectively. We do not find a spatial discontinuity in homebuilding at the London boundary in either period. Figure 10 shows results for the English/Welsh border before and after the English HtB policy was implemented. In this case, we find a clear discontinuity emerging in Panel B, indicating more building took place on the English side of the boundary after the policy was introduced.

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[22] We report 2nd degree polynomials in these figures because they yield a lower Akaike Information Criterion statistic than 1st degree polynomials. Appendix Figure A2 reports results when using linear equations on either side of the boundary.

[23] Appendix Figure A3 reports results when using a linear polynomial.

Finally, we conduct a placebo experiment using properties sold around the Greater Manchester boundary to test whether any spatial discontinuities in prices emerge after the introduction of London HtB in 2016. Note that the intensity of the policy is identical inside and outside the Manchester boundary. Results are provided in Figure A4 in the Appendix. As expected, we observe no discontinuity in prices at the boundary before or after the London HtB policy was put in place.

Overall, these graphs indicate that more generous versions of the policy triggered a price response in the supply inelastic areas around London. Conversely, the policy generated a quantity response in the relatively supply elastic areas around the English/Welsh border. This is in line with the intuition that price or quantity responses to shifts in demand depend on the shape of the supply curve, as illustrated in the theoretical framework provided in Section 2.2. In the following two sections, we present reduced-form estimates for the magnitudes of these effects.

3.4.2. Effect of HtB on House Prices

Table 4 summarizes the results from estimating equation (3) using the sample of transactions of new build properties within 5 kilometers from the GLA boundary. Different sets of covariates are included sequentially from columns 1 to 5. Column 1 controls for time effects and independent linear terms in distance of each property to the GLA boundary. Column 2 adds a vector of housing characteristics such as total floor area, type of the property, and tenure of the property. Column 3 adds postcode fixed effects. In column 4 we include neighborhood characteristics from the census interacted with year effects. Finally, in column 5, we allow for heterogeneous spatial price trends by controlling for interactions between distance from the GLA boundary and year dummies. Our preferred specifications are controlling for property characteristics. The standard errors in all specifications are clustered at the postcode level to allow for a degree of spatial correlation in the error term.

The resulting estimates show that London's HtB policy increased the price of newly built houses inside the GLA by between 4.5% and 6.4% depending on the specification, with 4 out of 5 estimates being significant at the 1% level. The average property price in this sample is £394,703, so this finding suggests that homebuyers are paying £24,393 more to buy newly built properties inside the GLA because of London's HtB (compared to the less generous English-version of the scheme). In Section 3.7, we compare this effect to that which would result from the implicit interest subsidy provided by the equity loan granted by the scheme.

Table 5 summarizes the results from estimating equation (3) for the sample of properties around the English/Welsh border. Again, we successively include additional controls from columns 1 to 5. Once we control for postcode fixed effects, we observe no significant effect of the policy on the price of new build sales. The point estimates in columns 3 to 5 are positive but small, ranging between 1.7 and 2.5%, and not statistically significant, with p-values above 0.37 in all specifications.

These estimates confirm the results reported in the graphical analysis provided in Section 3.4.1 and are also in line with the predictions highlighted in our theoretical framework. As land supply is relatively inelastic near the GLA boundary, the shift in demand induced by HtB is capitalized into prices. Near the English/Welsh border, where developable land is available, the response is more likely to happen in quantities rather than prices. Naturally, this hypothesis is testable; we estimate the effect of HtB on housing supply in the next section.

3.4.3. Effect of HtB on Housing Construction

Table 6 summarizes the results from estimating equation (4) for the sample including all wards within 5 kilometers of the GLA boundary. We define the post-HtB period as extending from February 2017 to December 2018, – starting one year after the implementation of London's HtB – to allow for a one-year construction lag. From Table 6, we observe that London's HtB did neither have a significant effect on construction volumes nor on the probability that any newly built property was sold in a ward. Coefficients are insignificant and small in all specifications, indicating that the increase in the size of available equity loans at the boundary did not lead to an increase in housing supply.

In Table 7, we provide estimates of equation (4) for wards around the English/Welsh border. As above, the post-treatment period is defined as starting one year after the introduction of the English HtB-scheme. We find a significant and positive effect of HtB on housing construction in all specifications. Our estimates suggest that the higher eligibility threshold on the English side of the boundary increased the number of new build transactions at each ward by 0.42 on average, and the propensity for any new build construction at each ward by 7.8%. These results are consistent with the predictions from our theoretical framework that indicate that HtB has differential effects in London and the areas around Wales as a consequence of differences in supply conditions in the two areas.

3.4.4. Effect of HtB on Financial Performance of Developers

Our findings in previous sections indicate that HtB increased demand, translating into higher house prices or building outputs. How did this affect the financial performance of residential developers? Table 8 presents our estimates for the effect of the scheme on revenues, gross profits and net profits before taxes, obtained from a developer panel as detailed in Section 3.3.3. Panel A presents estimates of the effects for our continuous measure of HtB participation using our intensity sample. The first column shows that a 1 percentage-point increase in the fraction of HtB properties supplied by a developer, leads to a 1.1% increase in revenue. The effect is large and significant. The estimates for gross profits and net profits, displayed in columns 2 and 3 are even larger, indicating that changes in costs – e.g. costs of acquiring land – did not neutralize the changes in revenue. Hence, these estimates suggest that the policy improved the performance of residential developers. The estimate in column 4 measures the effect of the policy on operating and interest expenses, obtained by taking the difference between gross and net profits. The effect is positive and significant for both samples.

Panel B of Table 8 shows estimates using our larger Difference-in-Differences sample, where participation in HtB is measured using a dummy variable taking value 1 if the developer is registered with one of the regional HtB offices in the country. Participation in the program appears to increase revenues substantially, with program participants obtaining over 60% higher revenues than non-participants.[24] Again, the coefficients for gross and net profits are even larger. The estimate in column 4 of Panel B tells us that operating plus interest expenses of companies registered with the program increased by 36% relative to the control group. The policy is unlikely to have had an impact on firm's financing costs, so we interpret this as suggestive evidence that the scheme affected the operating costs of the developers, possibly including management costs.

In Figure 11, we display yearly average profits adjusted for individual company fixed-effects for the HtB and non-HtB groups of developers before and after the policy. The pre-trends are reasonably parallel, and we observe a divergence after 2013, with substantial growth for developers registered for HtB. These results reinforce the notion that developers improved their financial performance as a result of HtB. An additional implication is that, on the supply side of the residential market, the benefits of the scheme did not go exclusively to land owners.

Some caution is warranted when interpreting these findings. Both the intensity and Difference-in-Differences samples used to produce the estimates in Table 8 cover a small number of

[24] The coefficient β is 0.49, so we can write the proportional difference in revenues is $\Delta r = e^{0.49} - 1$.

relatively large developers and are only partially representative of the entire industry. In addition, there are substantial observable differences in characteristics between the developers self-selecting into the scheme and other developers in the sample. For example, luxury developers typically are in the control group, as they will not normally be registered with HtB. Our estimates can be interpreted causally only if we consider that these differences have a time-invariant influence on performance. Unfortunately, lack of detailed information on the location of developers' assets prevents us from deploying the spatial techniques used in our analysis of price and construction effects.

3.5. Additional Results

3.5.1. Bunching Effect

The English HtB program led to significant bunching of sales right below the price threshold. Figure 12 shows two histograms of new build frequencies for prices between £550,000 and £650,000. The left-panel represents properties sold in the period from January 2012 to March 2013, before the implementation of HtB in England. The right-panel corresponds to a histogram for properties sold between April 2013 and December 2018, after HtB was introduced. We observe a substantial increase in the amount of bunching in the price distribution of new builds just below £600,000 between the two periods.

One issue to take into account when identifying the degree of bunching at that price level is given by round-number bunching. As shown in Figure 12, there was already some bunching at the £600,000 thresholds before the policy was in place. To deal with this initial level of bunching we first use the total number of sales to normalize for a baseline level of round-number bunching. In Appendix Figure A5 we first group sales into £10,000 price bins and then plot the evolution of the fraction of new builds over total sales for each bin from 2012 to 2018. The black line represents the price bin of interest, £590,000 to £600,000. Grey lines correspond to the other bins between £510,000 and £700,000. We can see that a gap between black line and the grey lines appears in 2013 and widens substantially from 2015, implying a significant amount of bunching of new builds at £600,000 after this year, after accounting for round-number bunching in the price distribution of all sales. Figure A6 shows the fraction of new builds over total sales for £5000 price bins averaged over the period between April 2013 and December 2018. Horizontal dashed lines represent averages above and below the £600,000 threshold. We also observe significant bunching at £600,000.

Figure A7 illustrates the difference between the observed density of property transactions and our estimated counterfactual density around the £600k notch.[25] The counterfactual distribution is obtained by estimating equation (6). We observe substantial bunching below the cut-off of £600,000 and a large hole in the distribution above the cut-off. Using our counterfactual price distribution, we estimate there are 2,033 more transactions for properties valued from £590,000 to £600,000 and 982 *less* transactions for properties valued from £600,000 to £630,000.[26] These estimates suggest that HtB leads to a significant shift in housing construction away from properties above the price threshold, towards properties below the threshold. We relate this to changes in the size of built units in the next section.

Figures A8 and A9 indicate that the Welsh HtB program also led to significant bunching of sales right below the price corresponding to the £300,000 threshold. Figure A8 plots histograms of the Welsh new build price distribution between £250,000 and £350,000 before and after the introduction of the Welsh version of the scheme. Figure A9 shows the fraction of new builds over total sales for different prices levels. Horizontal dashed lines represent averages above and below the £300,000 threshold. We also observe significant bunching at £300,000.

The fact that bunching is also observed in Wales is important because it shows that the £300,000 threshold induces a change in market outcomes, and a local increase in demand. It therefore motivates the strategy used to measure price and quantity effects at the English/Welsh border.

3.5.2. Size Effect

We can also apply a Difference-in-Discontinuities design to estimate the effect of HtB on the size of newly built housing units. Appendix Tables B2 to B5 summarize the results. We use data on the size of new build transactions close to the GLA boundary and the English/Welsh border respectively, using the estimation samples discussed in Section 3.3.1. We allow for a delayed response of one year so that the post-HtB period starts from April 2014 at the English/Welsh border and from February 2017 at the GLA boundary. We include additional variables sequentially from columns 1 to 5. Only the coefficients and standard errors for the key treatment estimates of HtB are reported.

Table B2 estimates negative but insignificant effects of the London HtB scheme on new build size. When we restrict the sample to properties under £600,000, we do find a negative, marginally significant and non-negligible effect on size. According to Table B3 the size of

[25] See Section 3.3.4 for details on the estimation of this counterfactual density.

[26] These numbers amount, respectively, to 10.4% and 5% of all sales in the £550000-£650000 range.

newly built housing units inside GLA is 3.1% smaller post implementation, than new builds just outside. Together with the results for bunching for England, this suggests that developers adjusted the characteristics of properties to meet the HtB conditions. Tables B4 and B5 report estimates of the size effect at the English/Welsh border; we observe overwhelmingly negative but statistically insignificant results.

3.6. Robustness Checks

3.6.1 Displacement of Homebuyer Demand Across Boundaries

The potential displacement of demand across either the English/Welsh or GLA boundaries is an important threat to our identification strategy. Displacement could occur if the policy induces short-distance sorting of prospective buyers so that, for example, demand for housing falls outside the GLA boundary as a result of the policy. This would violate the stable unit treatment vale assumption required to interpret our quantitative estimates of the price or construction effects as the outcome of the policy. Fortunately, if we assume demand displacement is relatively local – i.e. occurring mostly over short distances – we can use our samples to evaluate whether this is indeed a problem and what is its impact on each set of estimates. We do so with two different strategies.

In our first strategy, we reproduce our Difference-in-Discontinuities baseline estimates, sequentially dropping the transactions closest to the boundary. If the displacement of demand across the boundary of interest is important and happens over relatively short distances, then excluding observations next to the boundary should partially correct our estimates for demand sorting.[27] Estimates for the price effect of London's HtB obtained after excluding different bands around the GLA boundary are reported in Panel A of Appendix Figure A10. We observe that we can exclude transactions taking place within up to at least 2.5km of the GLA boundary without a significant effect on our estimates. In Panel B, we report an analogous figure for the area around the English/Welsh border. Again, excluding observations around the border does not affect the conclusion that differences in the HtB scheme's generosity did not lead to a significant price effect.

It is also possible that our housing supply estimates of the effects of the different schemes are biased by demand sorting. To explore this, we obtain estimates after iteratively excluding wards

[27] To prevent this sample restriction from compromising the precision of our estimates, we expand the bandwidth around the boundary, so that the width of the regions used in our analysis remains unchanged.

around the boundary.[28] Results for the construction effect on the Welsh boundary under different sample restrictions are provided in Panel A of Appendix Figure A11. We observe that coefficients are fairly stable between 3% and 6%. We also report the coefficients on the supply effect at the GLA boundary across subsamples in Panel B. All coefficients are statistically indistinguishable from zero, and point estimates are smaller in absolute value than the coefficients for the Welsh boundary.

In our second strategy to deal with the problem of demand displacement, we seek to directly test whether there is any evidence of displacement across our boundaries of interest. To do so, we follow the intuition in Turner *et al.* (2014) and compare transaction prices close to and far away from the boundary *within* each side.[29]

When looking at the role of demand displacement around the GLA, we split the London sample into two sub-samples corresponding to property sales on each side of the boundary. The displacement hypothesis has specific predictions regarding how demand changes *within* each spatial band around the border. In the case of the sub-sample of properties *inside* of the GLA, a local displacement of demand would result in an increase in new build prices close to the boundary relative to prices further inside the region. Conversely, for sales *outside* of the London region, displacement of demand would reduce prices close to the boundary relative to prices further out into the periphery. These predictions are easily testable using a modified version of equation (3) in which we replace $HTB_i \times Post_t$ with $close_i \times Post_t$, where $close_i$ is a dummy taking value 1 for properties within 2.5 or 5km of the boundary in the London and Welsh samples, respectively. Estimates for London, split by sub-sample are reported in Appendix Table B6. We find little evidence of displacement. The point estimates are negative or very small for both sub-samples, and generally not statistically significant. The largest negative point estimates are observed inside of London. Taken at face value, these are not consistent with the displacement hypothesis, as they suggest a *reduction* in demand close to the boundary in the London sub-sample.

Statistical power is quite low in these sub-samples, partly because we are using a binary to capture distance. To avoid this, we can use another modified version of equation (3) but now replacing $HtB_i \times Post_t$ with $dist_i \times Post_t$ where $dist_i$ is a linear term in distance to the GLA boundary. Estimates for the coefficient on $dist_i \times Post_t$ for each sub-sample are provided in

[28] As above, we expand the bandwidth accordingly to ensure that we have sufficient observations to obtain reliable estimates.
[29] Specifically, we follow the approach in the external effect regressions in Section 2.5 of Turner *et al.* (2014).

Appendix Table B7. Coefficients are generally insignificant, and small. Importantly, none of the coefficients for the GLA subsample are negative, as displacement would predict in this case. We conclude from these analyses that local displacement of demand across the London boundary is not present or is negligible.

We also test directly for evidence of displacement across the English/Welsh border by estimating a version of equation (4) in which $HtB_j \times Post_{t-12}$ is replaced with $close_j \times Post_{t-12}$ where $close_j$ is a dummy taking value 1 for wards with centroids within 5km of the boundary. We estimate this separately for the English and Welsh sub-samples around the border. Results are reported in Appendix Table B8 and are not consistent with the pattern that would emerge if displacement of demand across the boundary was significant. A similar analysis using a linear term for distance in the interaction is reported for completeness in Appendix Table B9.

Collectively, these set of estimates indicate local demand displacement is either not taking place or is rather negligible. As a result, we believe this is unlikely to induce a substantial bias in our baseline estimates of the effects of HtB.

3.6.2. Robustness of Price Effects

We conduct a battery of checks to evaluate the robustness of the estimated effects of the scheme on prices. Our first set of checks reproduces results using different bandwidths around the London boundary and the English/Welsh border. Results with alternative bandwidths for each exercise are reported in tables B10 and B11, respectively, and indicate no substantial difference in estimated effects.

We also conduct a placebo check using the boundary of Greater Manchester. No specific scheme was put in place in this area, so the eligibility conditions and the maximum size of the loan are continuous at this boundary. Estimates for this placebo test are reported in Table B12 and indicate no statistically significant price effect, as expected.

3.6.3. Robustness of Construction Effects

Our construction estimates allow for a one-year construction lag. In Tables B13 and B14 we replicate the results reported in Tables 6 and 7 using contemporaneous construction effects (i.e., the post-treatment-period is defined as the implementation date of the policy). Again, we find that HtB does not have a significant impact on housing construction at the GLA boundary but increases construction significantly at the English/Welsh border. We also find no significant contemporaneous construction effect for Greater Manchester, our placebo area (Table B15).

3.6.4. Difference in Timing of Implementation at the English/Welsh Border

The English version of HtB was implemented 9 months before the Welsh version was introduced. Thus, the estimated effects obtained for the Welsh border have to be interpreted as weighted averages of the impact of the difference eligibility conditions of HtB at the boundary (i.e., the fact that the price threshold on the English side of the border is twice that as in Wales) and differences arising from the timing of implementation in both locations. To cleanly identify the effect of the different eligibility conditions, we drop observations between April and December 2013 (i.e., the time period with only English HtB) for our price estimates. The pre-period goes from January 2012 to March 2013 and the post period is January 2014 to December 2018. The estimates for the effect on prices are reported in Appendix Table B16 and continue to be statistically insignificant at all conventional levels. Results for construction are reported in Appendix Table B17 and indicate a positive and significant effect of the difference in eligibility conditions on transaction volumes, similar to the one reported in Table 7.

3.7. Back-of-the-Envelope Calculation of Price Effect

Our empirical results indicate that the introduction of London's HtB led to a 6% increase in house prices inside the GLA. The policy effect can operate via two main channels. First, as discussed in the theoretical section, the reduction in required down-payments can increase demand, leading to higher prices. Second, the government equity loan has a lower interest rate than that typically paid for mortgage loans and during the first five years the equity loan carries no interest. This interest rate subsidy could also result in higher demand, and an increase in prices. Because both effects are bundled together with the policy, it is not easy to disentangle them empirically. However, we do know the size of the interest rate subsidy in each period. We can combine this with prevailing interest rates on mortgages, discount rates and reasonable assumptions for the expected appreciation of house prices to obtain the present discounted value of that subsidy. Using these numbers, we can decompose the 6% total price effect into an interest-rate subsidy and a credit relaxation effect.

We compare discounted cash flows for two hypothetical households buying a property using different forms of financing. Household A buys a property using a London HtB equity loan for 40% of the property's value, a 55% LTV mortgage and a 5% down-payment. Household B buys a property of the same price using an English HtB equity loan for 20% of the property's value, a 75% LTV mortgage and a 5% down-payment. For the sake of simplicity, we consider a 10-

year time window.[30] We also assume that both mortgages are 10 year fixed-rate with equal rates. Under these assumptions, the value of the interest-rate subsidy accruing to household A can be obtained by comparing two figures: i) the discounted value of payments for a 20% reduced-interest HtB-equity loan after subtracting the proceeds from saving the 20% cash excess in a standard household portfolio, and ii) the stream of payments arising from a 20% non-HtB 10-year fixed rate mortgage.

HtB equity mortgages require no interest paid in the first 5 years since the purchase. After that, the interest rate is 1.75% × (1 + (1%+Retail Price Inflation)). Assuming the RPI stays constant at 2.9% (the average rate between 2016 and 2018), we can trace out future payments on all HtB loans. We assume a 10-year fixed-rate mortgage pays a nominal interest of 3.27% based on the Bank of England data of rates for January 2016. This pins down the path of interest payments for mortgages. The interest on savings is assumed to be equal to 1.4%, which is also taken as the discount rate in our present value calculations.[31] Finally, the expected yearly growth rate for house prices – necessary to value foregone capital gains on the 20% equity stake of the government – is assumed to be 2.4%, which was the average rate of growth between 2008 and 2018.

Based on these assumptions, we find that the net present value of the interest rate subsidy is 2.31% of the value of the purchased property. This figure is slightly under 40% of our total estimated price effect, indicating that most of the effect of London HtB on prices operates via a relaxation of household credit conditions.

The calculated present discounted value of the interest rate subsidy depends on our assumptions regarding mortgage rates, inflation expectations, etc. A sensitivity analysis reveals this figure is particularly responsive to the expected appreciation rate of house prices and the return on savings. A high appreciation rate of prices reduces the value of the subsidy. A high return on savings has the opposite effect. Yet, given the other parameters of the exercise, either the expected capital gains should be unreasonably small (i.e. lower than 0.5%), or the returns on

[30] Specifically, we assume household A pays off half of the equity loan in a single installment in year 10 and household B pays off an equivalent amount of the mortgage in the same way. After these payments, both agents are left with a HtB loan amounting to 20% of the property's initial price and a mortgage amounting to 55% of the initial price (minus any amortization paid in the intervening years).

[31] The interest on savings is computed after observing assets held by recent buyers – buyers purchasing property in the previous two years - as recorded in the 2016 Wealth and Assets Survey. Most households in this group have their wealth in a combination of traditional savings accounts and ISAs (Individual Savings Accounts). One-year limited access ISAs are particularly popular, and they pay an interest of roughly 1.4%. Only about 1 in 10 recent buyers hold stock or other risky assets. The average portfolio of a recent buyer by size – which is not quite representative of the most common portfolio – includes a 10% invested in stock. This increases total return on savings to roughly 2.6%.

investment unreasonably large (i.e. as large as mortgage rates), for the interest subsidy to explain away our price effect. Hence, we conclude that there is indeed overcapitalization of interest rate subsidies and interpret this overcapitalization as a result of reduced down-payment requirements.

4. Discussion and Conclusions

In 2013 the UK government announced the HtB scheme, which provides different forms of assistance to households aiming to buy a property as owner-occupiers. We exploit differences in the intensity of implementation of the policy's Equity Loan Scheme across two regional boundaries to estimate the effect of the policy on the price of newly built homes and on construction volumes. We estimate different effects depending on the boundary under consideration. In the case of the GLA, we find that the more generous London HtB program led to higher new build prices but had no discernible effect on construction volumes. Both of these effects are arguably contrary to the policy's objectives which are to improve affordability and promote new construction.

The estimated effects of the policy are more encouraging in the relatively supply-elastic markets around the English/Welsh border, with no significant effect on prices and a substantial and statistically significant effect on construction activity. Yet, the housing affordability crisis in the UK tends to be most severe in the supply inelastic markets of the South East and especially in the GLA.

Our findings suggest that HtB has stimulated housing construction in the 'wrong areas'; that is, it has stimulated construction in areas where planning constraints are less rigid and it is therefore comparably easy to build, not in areas where productivity and employment concentration are highest and new housing is most needed. This is consistent with observed patterns in the intensity of HtB-construction across England and Wales (see Appendix Figure A12): The policy has led to the construction of housing outside of the green belt areas of the most productive agglomerations in the UK (London, Oxford and Cambridge). This is in line with other stylized facts that suggest that workers increasingly commute excessively long distances through green belts to get from their place of residence to their work place.

Contrary to the policy's title, HtB may not have 'helped' the population of credit constrained households in the most unaffordable areas of the country. There are two reasons for this. First, the policy pushed up house prices, increasing housing costs rather than housing consumption in square meters. Only developers or land owners, not new buyers, benefited from the policy-induced price increases. The price effect limits substantially the impact of the policy on the affordability conditions faced by credit constrained households. Second, the design of the HtB Equity Loan Scheme is such that those borrowers who took advantage of the scheme to gain access to the owner-occupied housing ladder, unlike existing homeowners, do not participate in the same way in future capital gains. This is because, at the time of sale, they have to pay back the equity loan at market value. If the price increases, so does the amount that the borrower owes the government. Ultimately, HtB arguably did little to 'help' young credit constrained households in unaffordable areas.

So who benefited from HtB, if not the credit constrained households in the most unaffordable areas? Landowners in supply constrained areas (including developers who held land in those areas prior to the policy's implementation) are likely beneficiaries. Moreover, our analysis of the financial performance of developers indicates that the developers benefited too. Our findings reveal that HtB increased revenues, profits and operating expenses of those developers intensively engaged in the HtB business. This suggests that HtB not only had limited effects on affordability but may have also led to unwanted regressive distributional effects.

TABLES

Table 1:
Equity Loan Scheme in Different Regions in UK (applies to new build only)

Region	Introduction date	House value up to	Loan from government
England	April 2013	£600,000	Up to 20%
London	February 2016	£600,000	Up to 40%
Wales	January 2014	£300,000	Up to 20%

Table 2:
Descriptive Statistics: Regression Sample

	Observations	Mean	SD	Max	Min
Panel A: London, price effect					
House price	32127	394703.1	290817.7	7850000	27720
HtB treatment	32127	0.26	0.44	1	0
Inside GLA	32127	0.6	0.49	1	0
Post London HtB	32127	0.45	0.5	1	0
Total floor area	32127	87.27	49.77	797.5	0
Terrace	32127	0.18	0.38	1	0
Flat	32127	0.65	0.48	1	0
Detached	32127	0.08	0.27	1	0
Semi-detached	32127	0.09	0.29	1	0
Leasehold	32127	0.67	0.47	1	0
Energy consumption	32127	98.47	67.49	1038	-124
Fireplace	32127	0.12	0.33	1	0
CO2 emissions	32127	1.4	1.08	36.9	-1.8
Distance to boundary	32127	2492.09	1392.62	4999.27	4.75
Panel B: English/Welsh border, price effect					
House price	8471	234201.7	111031.9	1550000	16260
HtB treatment	8471	0.48	0.5	1	0
Inside GLA	8471	0.47	0.5	1	0
Post English HtB	8471	0.88	0.33	1	0
Total floor area	8471	102.21	41.63	575	0
Terrace	8471	0.18	0.39	1	0
Flat	8471	0.13	0.34	1	0
Detached	8471	0.49	0.5	1	0
Semi-detached	8471	0.2	0.4	1	0
Leasehold	8471	0.27	0.44	1	0
Energy consumption	8471	102.33	42.7	1076	-19
Fireplace	8471	0.11	0.31	1	0
CO2 emissions	8471	1.84	1.23	61	-0.2
Distance to boundary	8471	4899.43	2765.6	9980.05	11.18
Panel C: London, construction effect (ward-level sample)					
Number of units constructed	33684	0.95	3.68	87	0
Any new build in ward, by month	33684	0.22	0.41	1	0
HtB Treatment	33684	0.13	0.33	1	0
Inside GLA	33684	0.54	0.5	1	0
Post London HtB	33684	0.27	0.45	1	0
Distance to boundary	33684	2775.04	1630.83	9214.02	186.7
Panel D: English/Welsh border, construction effect (ward-level sample)					
Number of units constructed	16380	0.52	1.81	73	0
Any new build in ward, by month	16380	0.18	0.39	1	0
HtB treatment	16380	0.27	0.44	1	0
In Wales	16380	0.6	0.49	1	0
Post HtB in England	16380	0.68	0.47	1	0
Distance to boundary	16380	5420.1	3139.91	14592.72	324.18

Table 3:
Supply Constraints Measures and Implied Price-Earnings Elasticities

Region	English/Welsh border	GLA boundary	Greater Manchester boundary
Share of land in green belts	3.77%	66.5%	52.6%
Average refusal rate 1979-2008	27.2%	35.6%	25.1%
Average share of developed land	6.3%	27.6%	18.2%
Average elevation range	476.0	143.9	382.3
Implied price-earning elasticity (OLS)	0.252	0.403	0.284
Implied price-earning elasticity (IV)	0.127	0.205	0.164

Notes: The refusal rate, share developed land and elevation range are weighted by the surface area of the Local Planning Authority. Data on refusal rates, share developed land and elevation range come from Hilber and Vermeulen (2016). The green belt shape file comes from the Ministry of Housing, Communities and Local Government.

Table 4:
Price Effect at GLA Boundary

Specifications	(1)	(2)	(3)	(4)	(5)
HtB [1)]	0.1613***	0.0712***	0.0446*	0.0644***	0.0618***
	(0.0423)	(0.0261)	(0.0245)	(0.0211)	(0.0211)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	Yes	No	No	No
Housing controls [2)]	No	Yes	Yes	Yes	Yes
Postcode FEs	No	No	Yes	Yes	Yes
Census variables by year [3)]	No	No	No	Yes	Yes
Distance by year	No	No	No	No	Yes
N	32127	32127	32127	32127	32127
R^2	0.0906	0.6232	0.9187	0.9194	0.9194

Notes: [1)] HtB captures the difference between the 40% and the 20% equity loan threshold (inside vs. outside GLA). [2)] Housing controls include total floor area, dwelling type, the tenure of properties, whether the property has a fireplace, energy consumption and CO_2 emissions. [3)] Neighborhood controls (from the 2011 Census) are the percentage of (1) married residents and (2) residents with level-4 and above educational qualifications at ward level. Standard errors are clustered at the postcode level.

Table 5:
Price Effect at English/Welsh Border

Specifications	(1)	(2)	(3)	(4)	(5)
HtB [1)]	0.1483*	0.0867	0.0166	0.0237	0.0246
	(0.0863)	(0.0532)	(0.0266)	(0.0293)	(0.0277)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	Yes	No	No	No
Housing controls [2)]	No	Yes	Yes	Yes	Yes
Postcode FEs	No	No	Yes	Yes	Yes
Census variables by year [3)]	No	No	No	Yes	Yes
Distance by year	No	No	No	No	Yes
N	8471	8471	8471	8471	8471
R^2	0.1013	0.6746	0.9224	0.9228	0.9230

Notes: [1)] HtB is a dummy taking value 1 for England after the introduction of the Help-to-Buy scheme. [2)] Housing controls include total floor area, dwelling type, the tenure of properties, whether the property has a fireplace, energy consumption and CO_2 emissions. [3)] Neighborhood controls (from the 2011 Census) are the percentage of (1) married residents and (2) residents with level-4 and above educational qualifications at ward level. Standard errors are clustered at the postcode level.

Table 6:
Construction Effect at GLA Boundary

Dependent Variable:	#New builds				Dummy			
Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HtB [1)]	0.1683	0.1683	0.2759	0.2528	0.0203	0.0203	0.0219	0.0225
	(0.2071)	(0.2083)	(0.2509)	(0.2444)	(0.0251)	(0.0252)	(0.0261)	(0.0260)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	No	No	No	Yes	No	No	No
Ward fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Census variables by year [2)]	No	No	Yes	Yes	No	No	Yes	Yes
Distance by year	No	No	No	Yes	No	No	No	Yes
N	33684	33684	33684	33684	33684	33684	33684	33684
R^2	0.0109	0.1736	0.1746	0.1751	0.0137	0.1893	0.1905	0.1909

Note: The dependent variable in columns 1 to 4 corresponds to the number of new builds in a ward. The dependent variable in columns 5 to 8 corresponds to a dummy taking value 1 if there was any sale of new build property in that ward-month pair. [1)] HtB captures the difference between the 40% and the 20% equity loan threshold (inside vs. outside GLA). [2)] Neighborhood controls (from the 2011 Census) are the percentage of (1) married residents and (2) residents with level-4 and above educational qualifications at ward level. Standard errors are clustered at the ward level.

Table 7:
Construction Effect at English/Welsh Border

Dependent Variable:	#New builds				Dummy			
Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HtB [1)]	0.4136***	0.4136***	0.3932***	0.4187***	0.0832**	0.0832**	0.0761**	0.0783**
	(0.1387)	(0.1395)	(0.1291)	(0.1266)	(0.0335)	(0.0336)	(0.0328)	(0.0325)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	No	No	No	Yes	No	No	No
Ward fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Census variables by year [2)]	No	No	Yes	Yes	No	No	Yes	Yes
Distance by year	No	No	No	Yes	No	No	No	Yes
N	16380	16380	16380	16380	16380	16380	16380	16380
R^2	0.0243	0.2544	0.2625	0.2638	0.0243	0.2502	0.2534	0.2546

Note: The dependent variable in columns 1 to 4 corresponds to the number of new builds in a ward. The dependent variable in columns 5 to 8 corresponds to a dummy taking value 1 if there was any sale of new build property in that ward-month pair. [1)] HtB captures the difference between the £600k and the £300k price-threshold (English vs. Welsh side of border). [2)] Neighborhood controls (from the 2011 Census) are the percentage of (1) married residents and (2) residents with level-4 and above educational qualifications at ward level. Standard errors are clustered at the ward level.

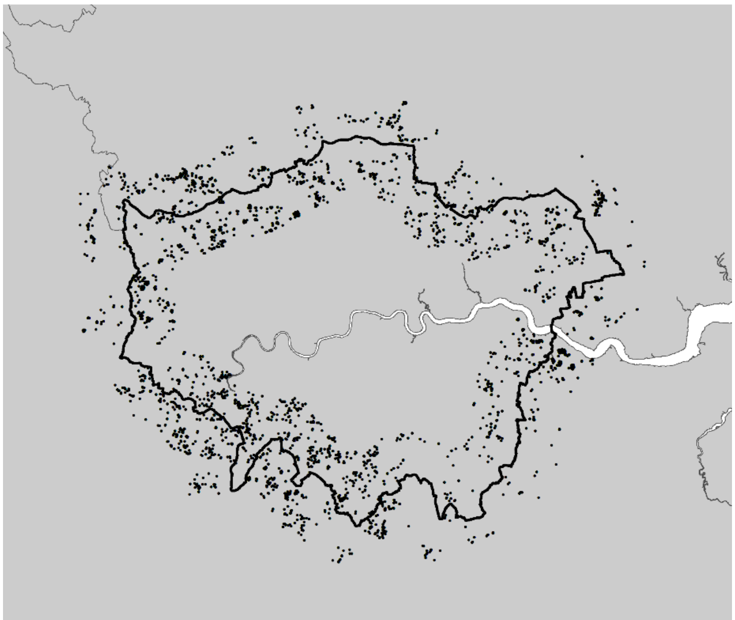
Table 8:
Effects on Financial Performance of Developers

Specifications	(1)	(2)	(3)	(4)	(5)
Dependent Variable	Ln(turnover)	Ln(gross profit)	Ln(net profit before tax)	Ln(△(2)-(3))	Ln(cost of employees)
			Panel A: HtB intensity sample		
HtB intensity	1.1200**	1.4607**	2.4509*	0.8786**	0.9383***
× Post [1)]	(0.4168)	(0.6219)	(1.4252)	(0.3222)	(0.2875)
N	193	193	193	193	193
R^2	0.9732	0.9651	0.8625	0.9059	0.9875
			Panel B: DID sample		
HtB dummy	0.4863***	0.6781***	1.5559***	0.3045***	0.4143***
× Post [2)]	(0.1510)	(0.1900)	(0.5577)	(0.0889)	(0.1346)
N	499	499	499	499	499
R^2	0.9755	0.9733	0.8942	0.9458	0.9872
Year FEs	Yes	Yes	Yes	Yes	Yes
Developer FEs	Yes	Yes	Yes	Yes	Yes

Note: [1)] HtB intensity is defined as the 5-year average ratio of HtB-completions relative to all property completions by the developer. [2)] HtB dummy equals to on if a developer is recorded with one of the HtB regional offices. Standard errors are clustered at developer level.

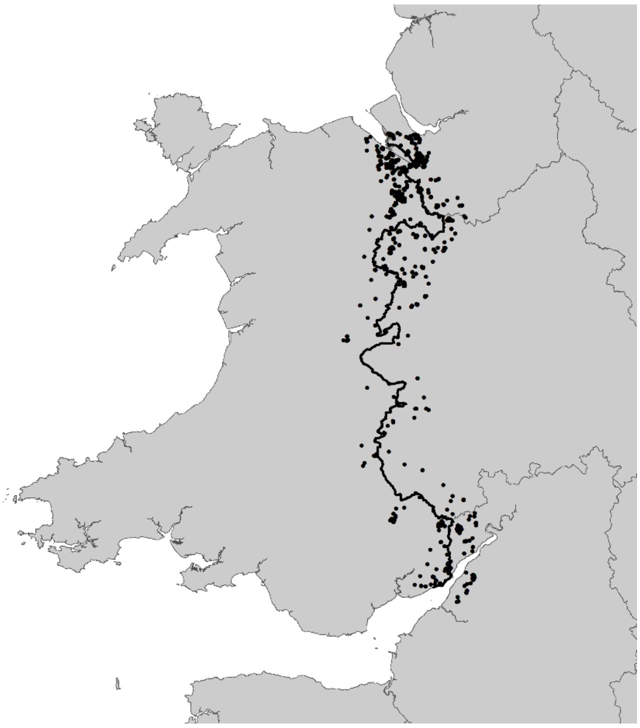
FIGURES

Fig. 1
New Builds near the Greater London Authority Boundary



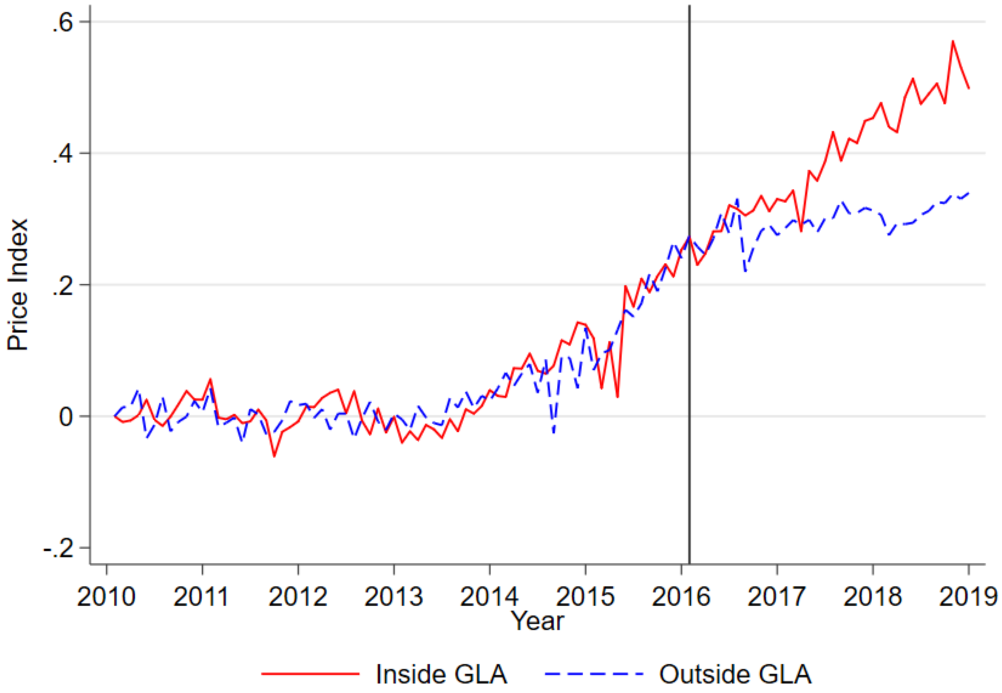
Note: Solid black line represents the boundary of the Greater London Authority (GLA). Each of the black dots represents a new build sale taking place during our sample period within 5km of the boundary.

Fig. 2
New Builds near English/Welsh Border



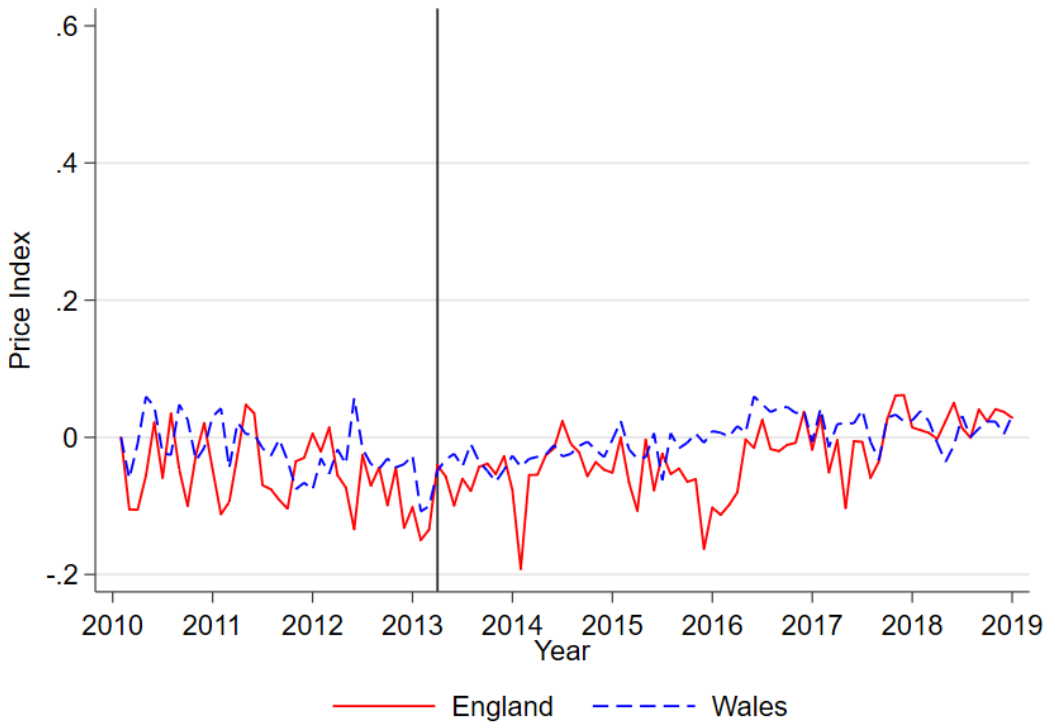
Note: Solid black line represents the boundary of the English-Welsh border. Each of the black dots represents a new build sale taking place during our sample period within 10km of the boundary.

Fig. 3:
House Price Index at GLA boundary



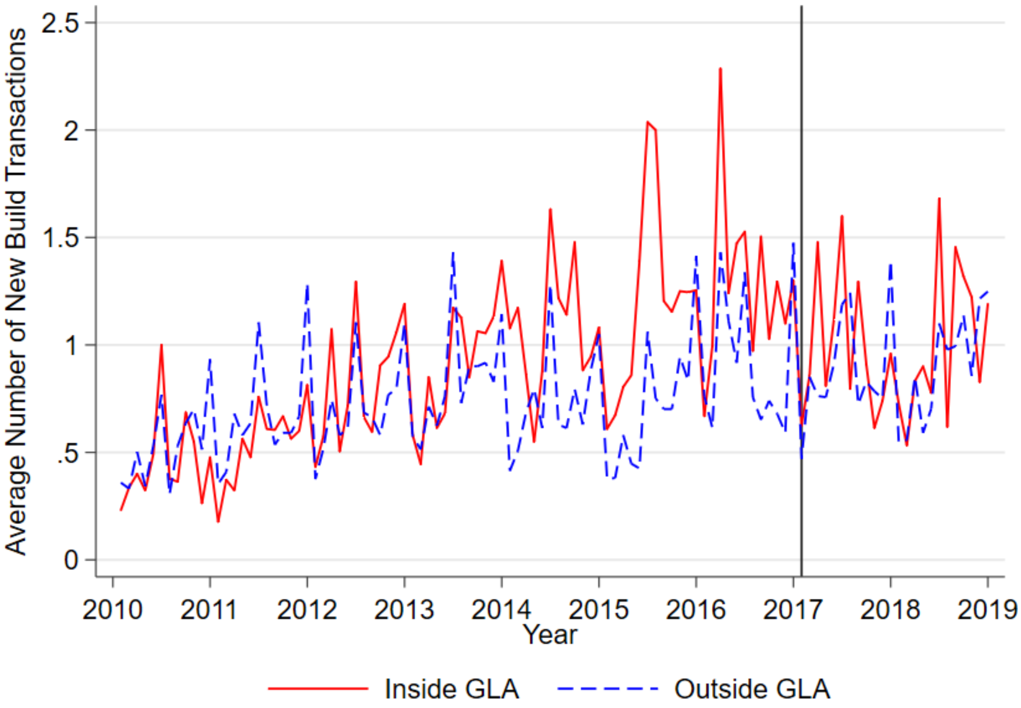
Note: The vertical line represents January 2016. In February 2016, GLA Help to Buy scheme was implemented.

Fig. 4:
House Price Index at English/Welsh Border



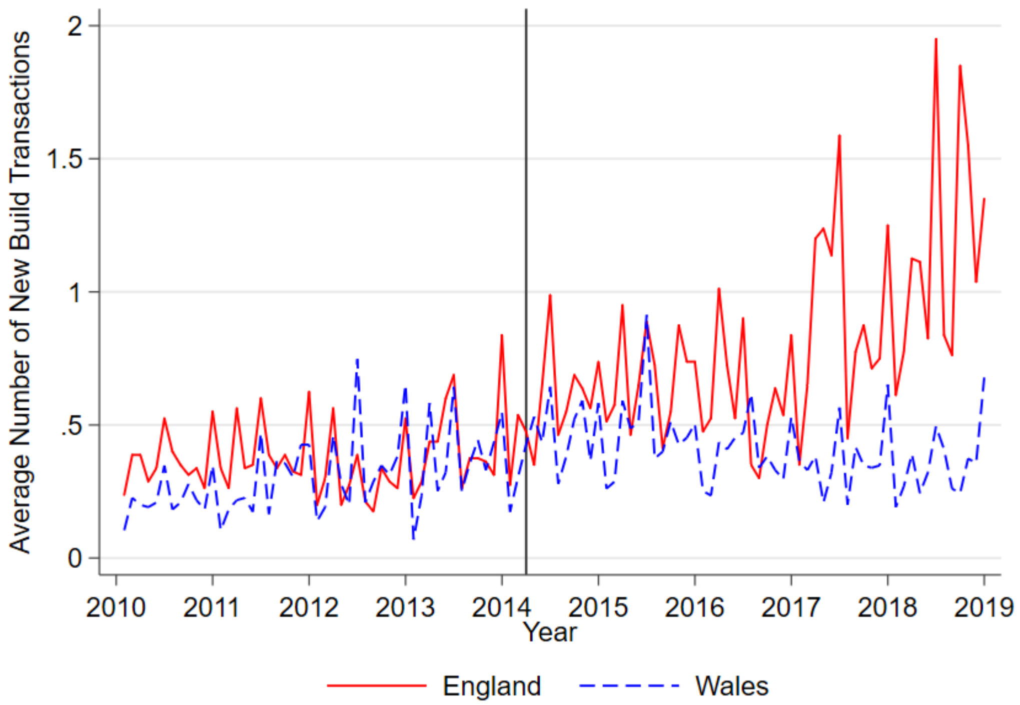
Note: The vertical line represents March 2013. In April 2013, Help to Buy was implemented in England.

Fig. 5:
New Building at GLA Boundary



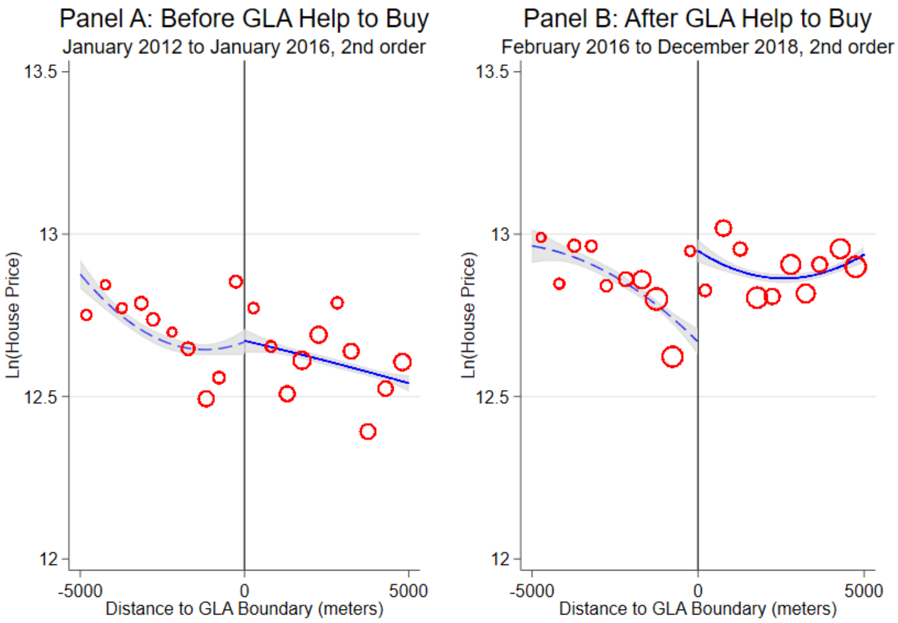
Note: The vertical line represents January 2017. In February 2016, GLA Help to Buy scheme was implemented.

Fig. 6:
New Building at English/Welsh Border



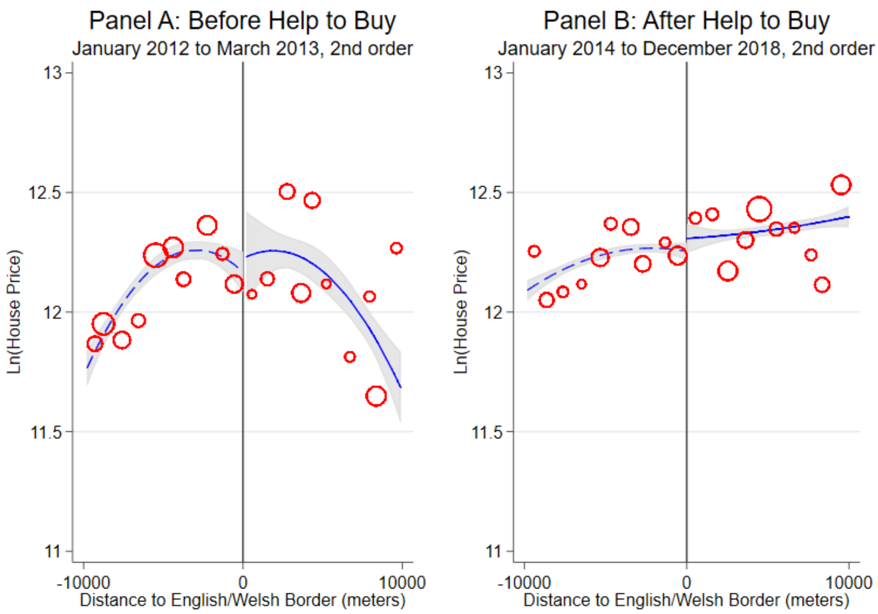
Note: The vertical line represents March 2014. In April 2013, Help to Buy was implemented in England.

Fig. 7:
Boundary Discontinuity Design: Price Effect at GLA Boundary



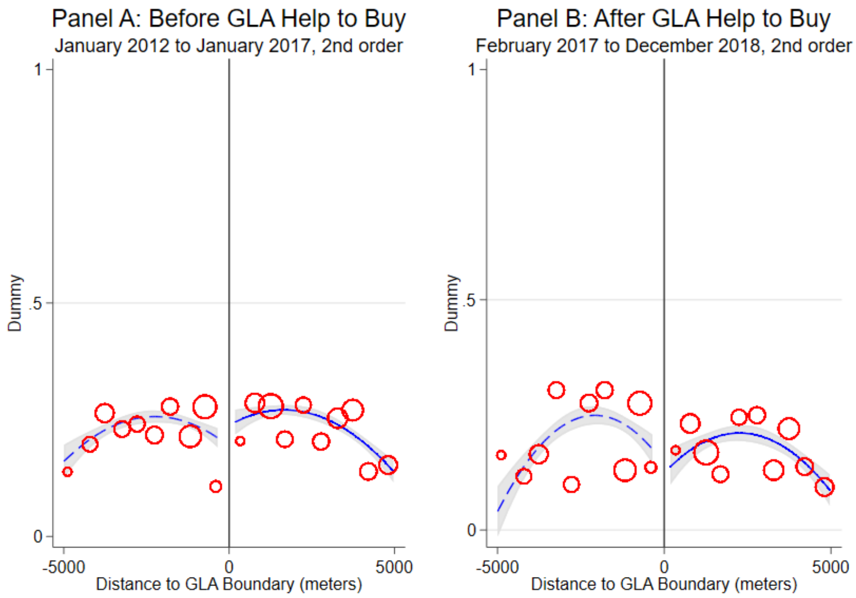
Note: New build prices close to the London boundary. Positive distance: transactions inside GLA; Negative distance: transactions outside GLA. Circles represent averages taken within 0.5km bins, with the diameter of each circle corresponding to the number of sales in that bin. Lines correspond to second degree polynomials estimates separately on each side of the boundary. Shaded areas correspond to 95% confidence intervals around those lines.

Fig. 8:
Boundary Discontinuity Design: Price Effect at English/Welsh Border



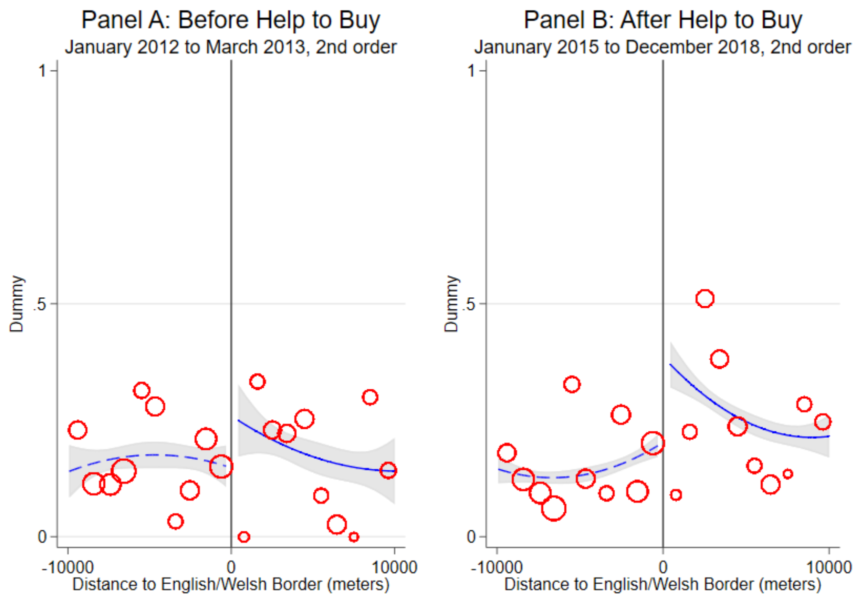
Note: New build prices close to the Welsh boundary. Positive distance: transactions in England; Negative distance: transactions in Wales. Circles represent averages taken within 1km bins, with the diameter of each circle corresponding to the number of sales in that bin. Lines correspond to second degree polynomials estimates separately on each side of the boundary. Shaded areas correspond to 95% confidence intervals around those lines.

Fig. 9:
Boundary Discontinuity Design: Construction Effect at GLA Boundary



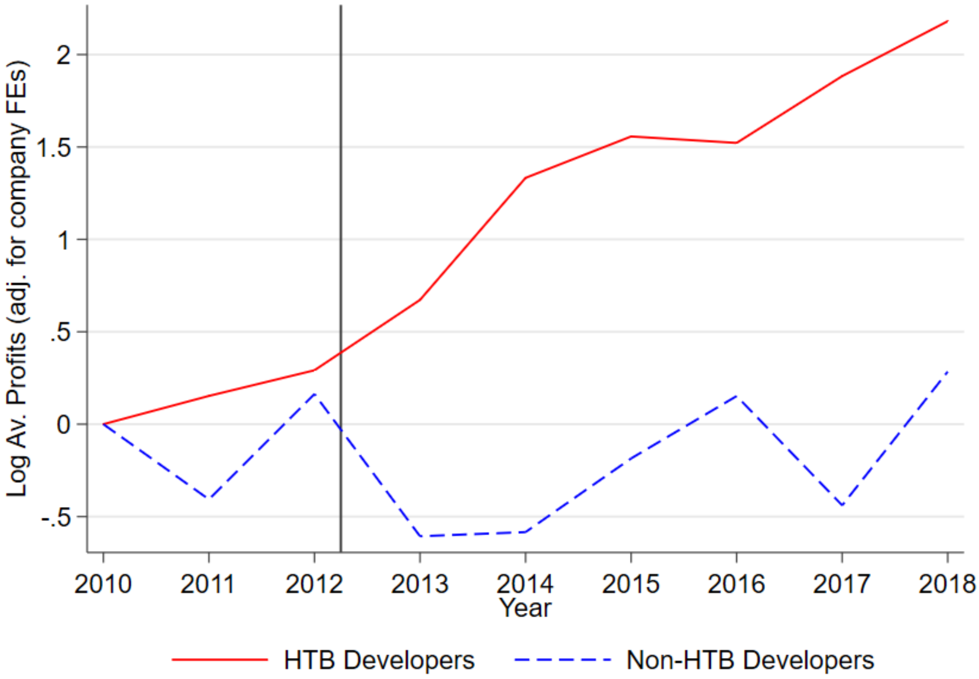
Note: Vertical axis corresponds to the average of a dummy taking value 1 for wards with at least one new build sales, 0 otherwise. Circles represent averages taken within 1km bins, with the diameter of each circle corresponding to the number of sales in that bin. Lines correspond to second degree polynomials estimates separately on each side of the boundary. Shaded areas correspond to 95% confidence intervals around those lines. Positive distance: transactions inside GLA; Negative distance: transactions outside GLA.

Fig. 10:
Boundary Discontinuity Design: Construction Effect at English/Welsh Border



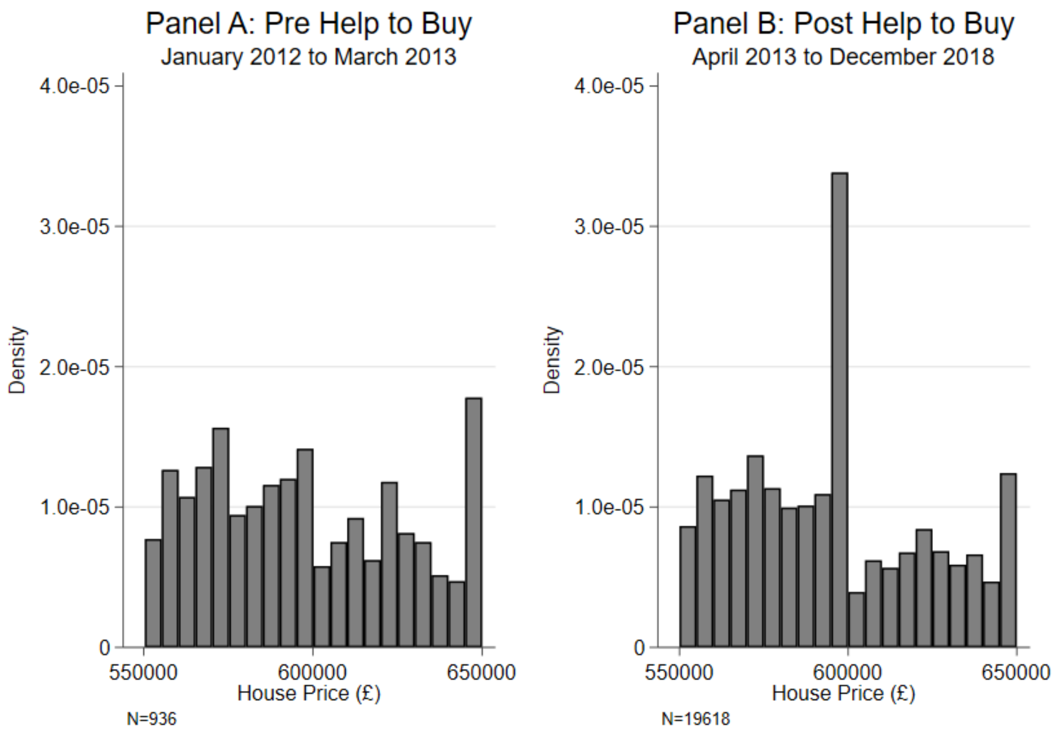
Note: Vertical axis corresponds to the average of a dummy taking value 1 for wards with at least one new build sales, 0 otherwise. Circles represent averages taken within 1km bins, with the diameter of each circle corresponding to the number of sales in that bin. Lines correspond to second degree polynomials estimates separately on each side of the boundary. Shaded areas correspond to 95% confidence intervals around those lines. Positive distance: transactions in England; Negative distance: transactions in Wales.

Fig. 11:
Developers' Profits over Time



Note: Vertical axis represents the log of average profits computed after removing company fixed effects (normalized to 0 in 2010). The vertical line represents March 2012. In April 2013, Help to Buy was implemented in England.

Fig. 12:
Histogram of House Prices in England

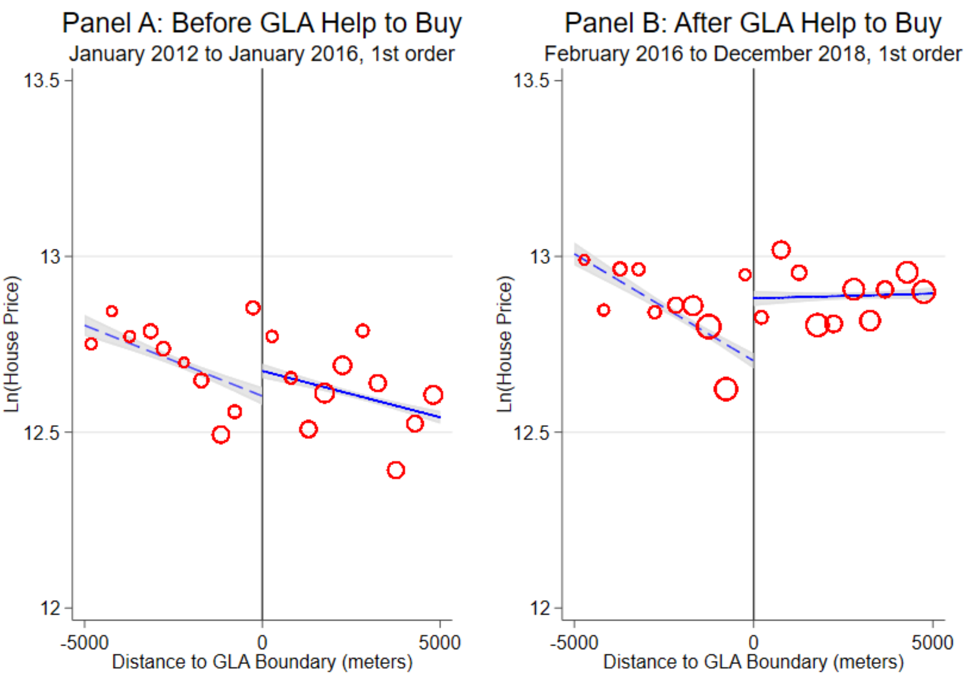


APPENDICES
Appendix A: Appendix Figures

Fig. A1:
New Builds near Greater Manchester Boundary

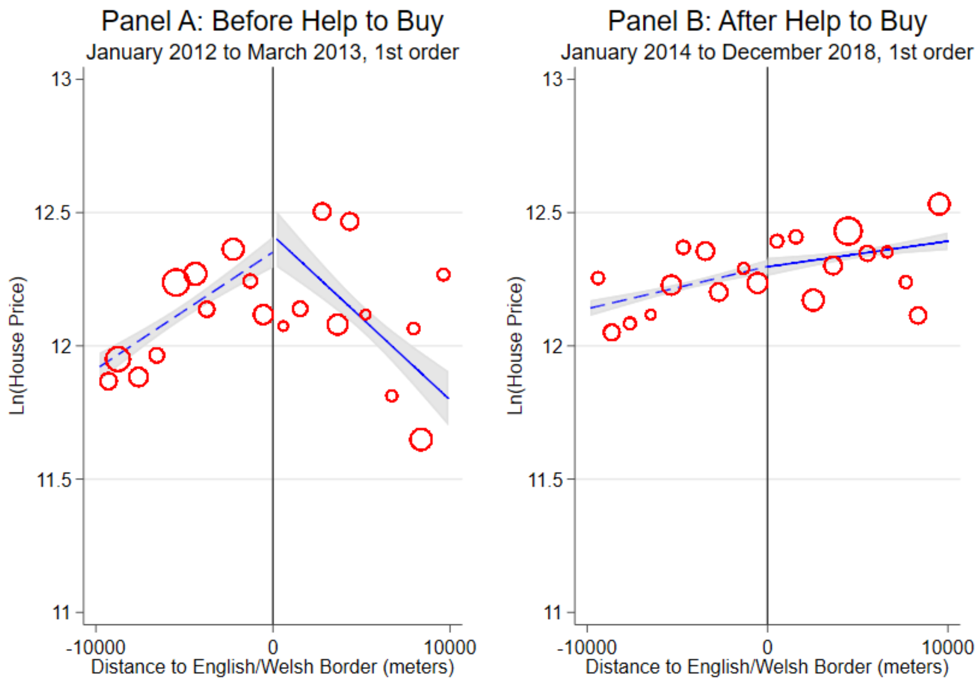
Note: Solid black line represents the Greater Manchester boundary. Each of the black dots represents a new build sale taking place during our sample period within 5km of the boundary.

Fig. A2:
BDD Robustness – GLA Boundary HtB Price Effect, Linear Polynomial



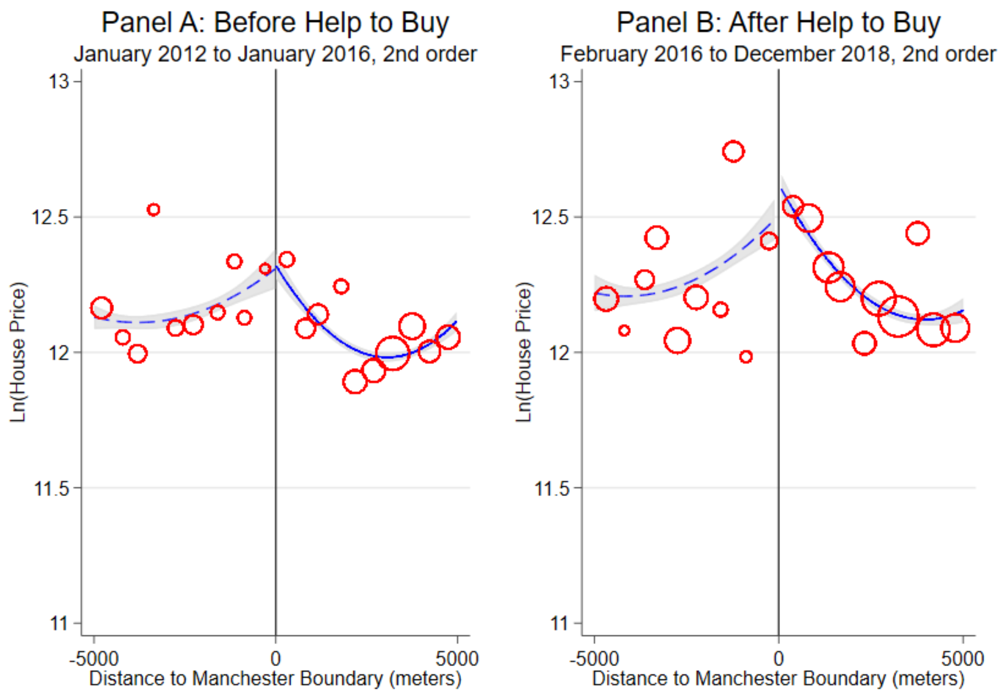
Note: Positive distance: transactions inside GLA; Negative distance: transactions outside GLA.

Fig. A3:
BDD Robustness – English/Welsh Border Price Effect, Linear Polynomial



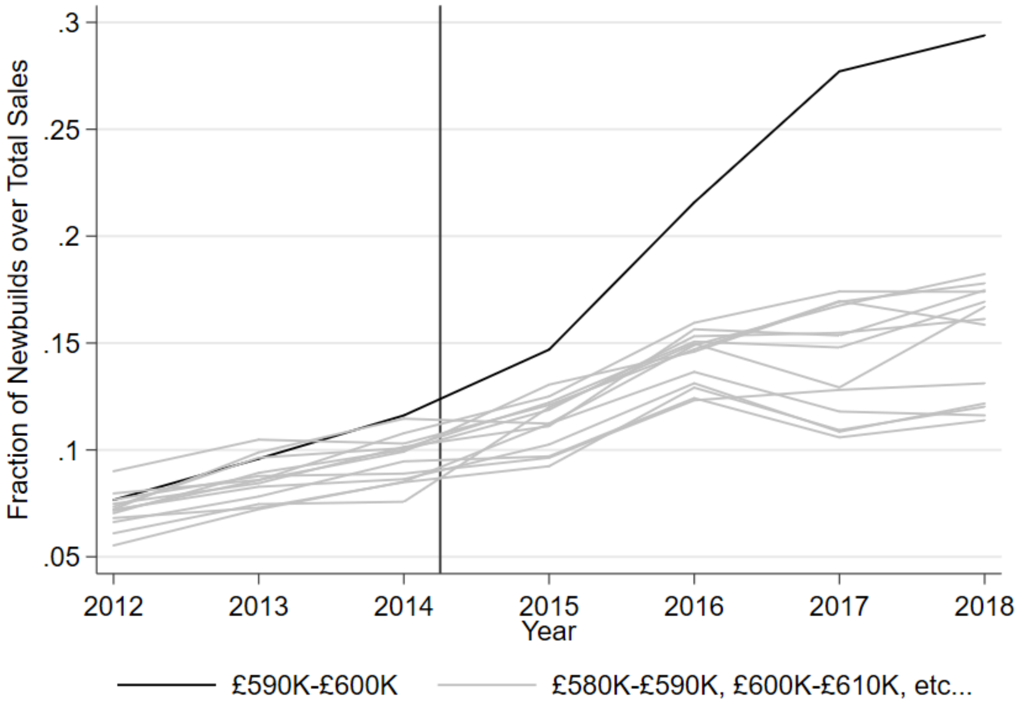
Note: Positive distance: transactions in England; Negative distance: transactions in Wales.

Fig. A4:
Boundary Discontinuity Design: Placebo Manchester



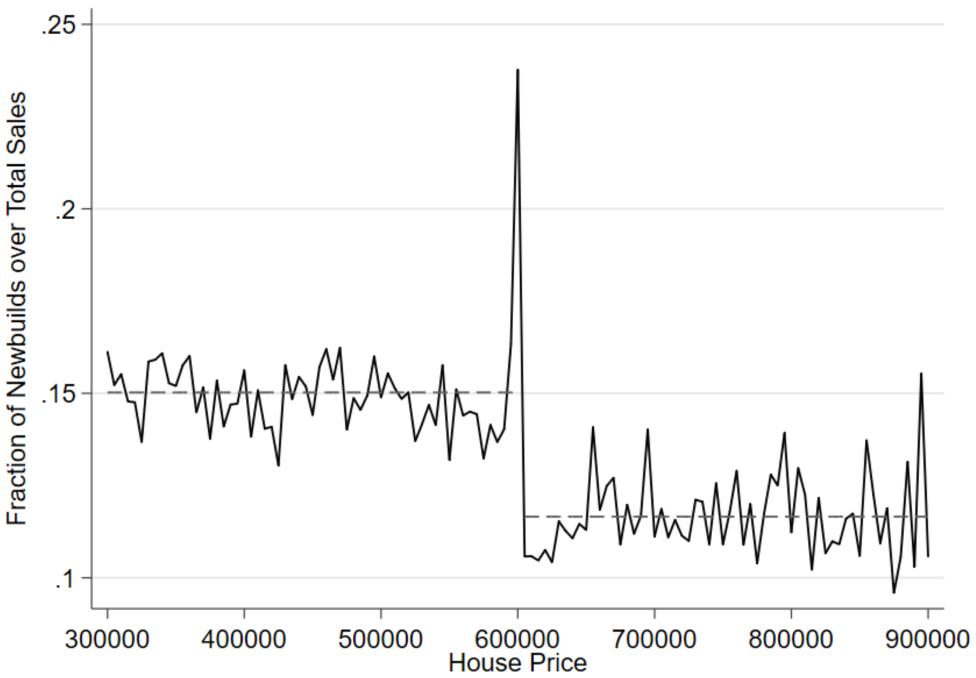
Note: Positive distance: transactions inside Greater Manchester; Negative distance: transactions outside Greater Manchester.

Fig. A5:
Fraction of New Builds over Total Sales in England



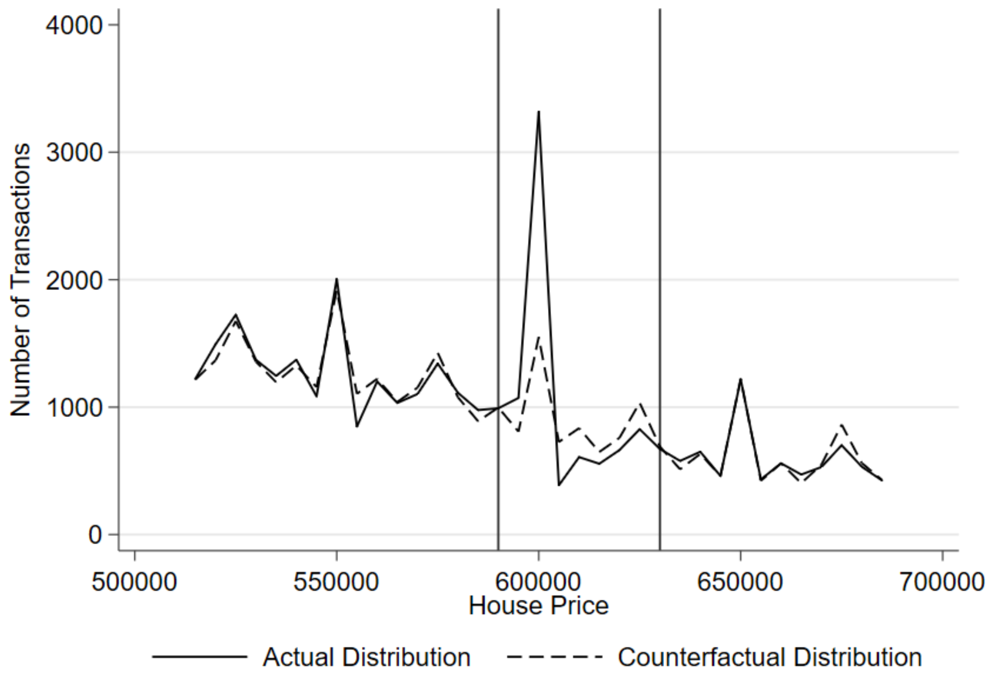
Note: The vertical line represents March 2014. In April 2013, Help to Buy was implemented in England.

Fig. A6:
The Fraction of New Builds over Total Sales in England (April 2013 to December 2018)



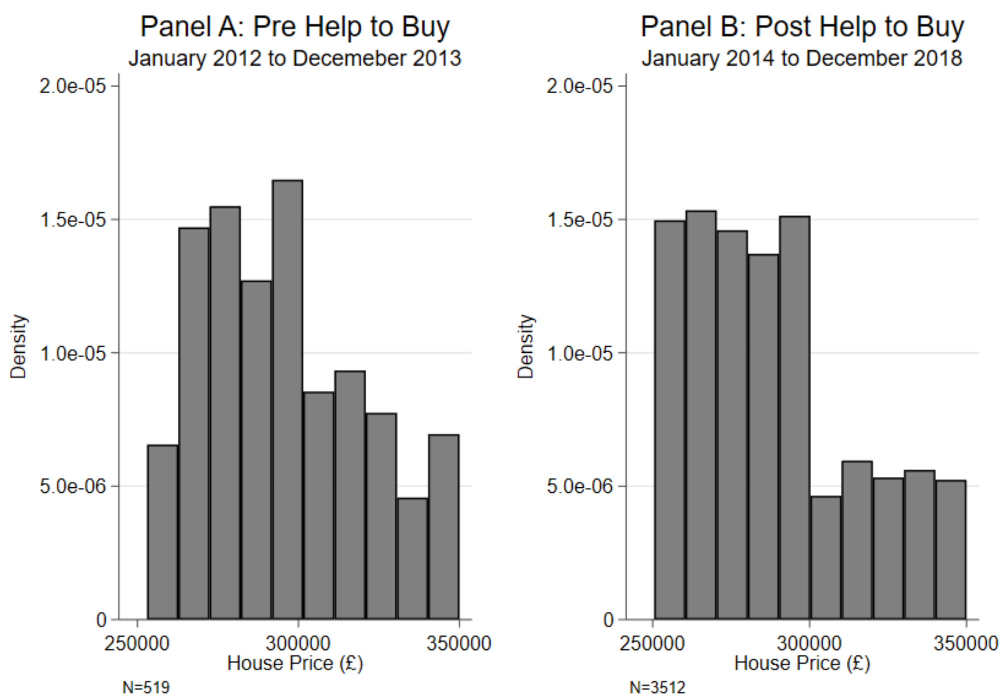
Note: Vertical axis measures fraction of new build sales over total sales for £5000 width price bins. Sales counted in the period between April 2013 and December 2018. England only.

Fig. A7:
Estimated Bunching Effect



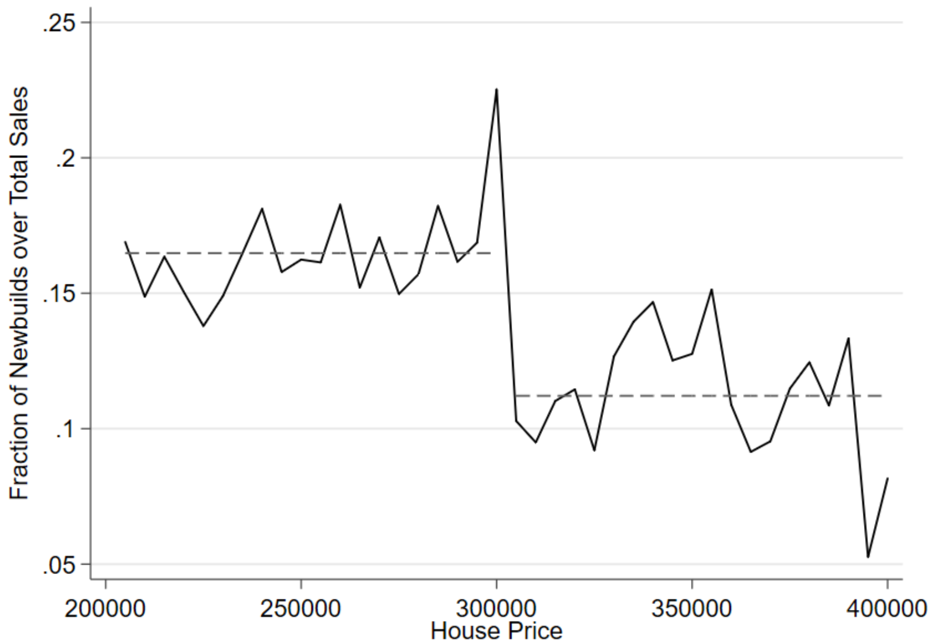
Note: Counter-factual distribution of prices estimated after excluding transactions between £590k and £630k, and represented using a dashed line. Other details on estimation discussed in the text.

Fig. A8:
Histogram of House Prices in Wales



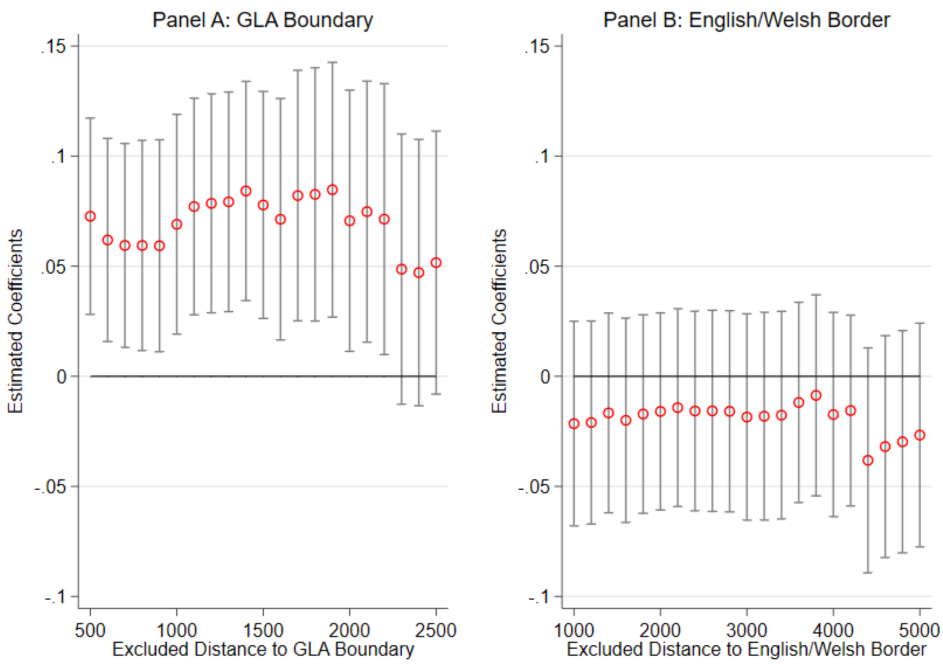
Note: Histogram of price distribution of new build sales in Wales.

Fig. A9:
The Fraction of New Builds over Total Sales in Wales (January 2014 to December 2018)



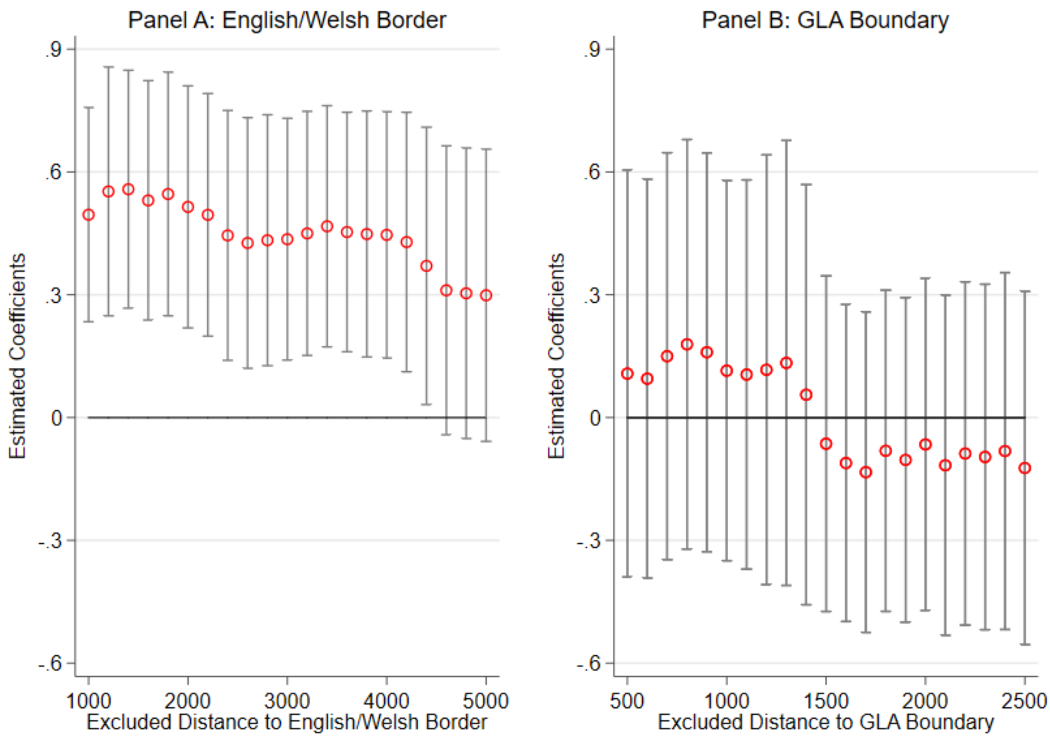
Note: Vertical axis measures fraction of new build sales over total sales for £5000 width price bins. Sales counted in the period between April 2013 and December 2018. Wales only.

Fig. A10:
Price Effect Excluding Properties near the Boundary



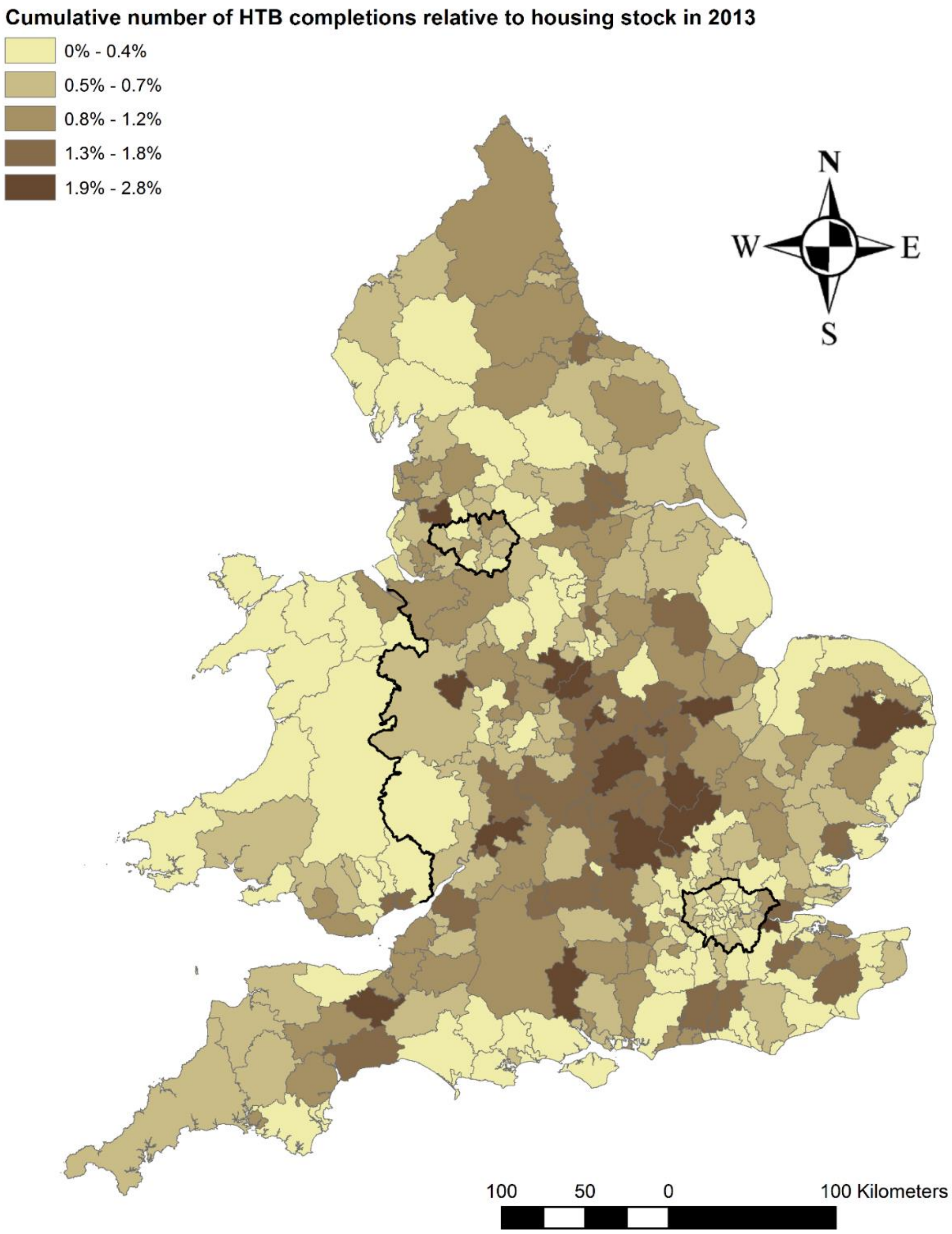
Note: Properties near the GLA boundary and the English/Welsh border are dropped respectively for the re-estimation of HtB's price effect. The horizontal axis represents the excluded distance. Red points correspond to the estimates of price effect. Vertical lines correspond to 95% confidence intervals around those estimates.

Fig. A11:
Construction Effects Excluding Wards near the Boundary



Note: Properties near the GLA boundary and the English/Welsh border are dropped respectively for the re-estimation of HtB's construction effect. The horizontal axis represents the excluded distance. Red points correspond to the estimates of construction effect. Vertical lines correspond to 95% confidence intervals around those estimates.

Fig. A12:
Accumulated Help to Buy Completions (2013-2017)



Appendix B: Appendix Tables

Table B1:
Number of Transactions

London					
	5km	4 km	3 km	2 km	1 km
Total number of sales	32127	25845	19850	14006	5149
Postcodes	2980	2391	1824	1258	505
Sales in treatment group	8495	6196	4596	2860	1108
Postcodes in treatment group	604	437	338	233	94
Wales					
	10km	9km	8km	7km	6km
Total number of sales	8471	7612	6689	6204	5827
Postcodes	886	786	703	641	583
Sales in treatment group	4106	3527	3155	2960	2797
Postcodes in treatment group	428	361	324	304	278

Notes: Number of new build property sales for bands around the GLA (top panel) or Welsh (bottom panel) boundaries. Bandwidths in each case indicated in the top row of the bottom and top panels.

Table B2:
Size Effect at GLA Boundary

Specifications	(1)	(2)	(3)	(4)	(5)
HtB [1)]	0.0836**	0.0040	-0.0092	-0.0162	-0.0129
	(0.0420)	(0.0160)	(0.0181)	(0.0177)	(0.0201)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	Yes	No	No	No
Housing controls [2)]	No	Yes	Yes	Yes	Yes
Postcode FEs	No	No	Yes	Yes	Yes
Census variables by year [3)]	No	No	No	Yes	Yes
Distance by year	No	No	No	No	Yes
N	32051	32051	32051	32051	32051
R^2	0.0460	0.8151	0.9473	0.9475	0.9475

Notes: Sample corresponds to new build property sales within 5km of the GLA boundary for the period between 2012 and 2018. Dependent variable is the logarithm of the property size in square meters. [1)] HtB corresponds to a dummy taking value 1 for properties sold inside of London after February 2017 – which is one year after the implementation of London HtB. [2)] Housing controls include transaction price, dwelling type, the tenure of properties, whether the property has a fireplace, energy consumption and CO_2 emissions. [3)] Neighborhood controls (from the 2011 Census) are the percentage of (1) married residents and (2) residents with level-4 and above educational qualifications at ward level. Standard errors are clustered at the postcode level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B3:
Size Effect at GLA Boundary (Units valued less than £600k)

Specifications	(1)	(2)	(3)	(4)	(5)
HtB [1)]	0.0602	-0.0176	-0.0293*	-0.0317*	-0.0310*
	(0.0375)	(0.0157)	(0.0168)	(0.0166)	(0.0188)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	Yes	No	No	No
Housing controls [2)]	No	Yes	Yes	Yes	Yes
Postcode FEs	No	No	Yes	Yes	Yes
Census variables by year [3)]	No	No	No	Yes	Yes
Distance by year	No	No	No	No	Yes
N	28500	28500	28500	28500	28500
R^2	0.0534	0.7819	0.9437	0.9439	0.9439

Notes: Sample corresponds to new build transactions valued less than £600,000 within 5km of the GLA boundary sold between 2012 and 2018. Dependent variable is the natural logarithm of the floor area of the property in squared meters. [1)] HtB corresponds to a dummy taking value 1 for properties sold inside of London after February 2017 – which is one year after the implementation of London HtB. [2) - 3)] see Table B2. Standard errors are clustered at the postcode level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B4:
Size Effect at English/Welsh Border

Specifications	(1)	(2)	(3)	(4)	(5)
HtB [1)]	0.0119	-0.0524**	0.0016	-0.0108	-0.0111
	(0.0557)	(0.0208)	(0.0221)	(0.0210)	(0.0197)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	Yes	No	No	No
Housing controls [2)]	No	Yes	Yes	Yes	Yes
Postcode FEs	No	No	Yes	Yes	Yes
Census variables by year [3)]	No	No	No	Yes	Yes
Distance by year	No	No	No	No	Yes
N	8467	8467	8467	8467	8467
R^2	0.1031	0.8151	0.9366	0.9371	0.9372

Notes: Sample corresponds to new build transactions within 10km of the English/Welsh border from 2012 to 2018. Dependent variable is the natural logarithm of the floor area of the property in squared meters. [1)] HtB is a dummy taking value 1 in the English side of the boundary after April 2014, which is one year after the implementation of the English HtB. [2) - 3)] see Table B2. Standard errors are clustered at the postcode level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B5:
Size Effect at English/Welsh Border (Units valued less than £600k)

Specifications	(1)	(2)	(3)	(4)	(5)
HtB [1)]	0.0017	-0.0534**	-0.0011	-0.0140	-0.0142
	(0.0552)	(0.0208)	(0.0220)	(0.0208)	(0.0195)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	Yes	No	No	No
Housing controls [2)]	No	Yes	Yes	Yes	Yes
Postcode FEs	No	No	Yes	Yes	Yes
Census variables by year [3)]	No	No	No	Yes	Yes
Distance by year	No	No	No	No	Yes
N	8408	8408	8408	8408	8408
R^2	0.1080	0.8147	0.9362	0.9367	0.9368

Notes: Sample corresponds to new build transactions within 10km of the English/Welsh border from 2012 to 2018 valued at less than £600,000. Dependent variable is the natural logarithm of the floor area of the property in squared meters. [1)] HtB is a dummy taking value 1 in the English side of the boundary after April 2014, which is one year after the implementation of the English HtB. [2) - 3)] see Table B2. Standard errors are clustered at the postcode level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B6:
Testing for Displacement Effect around GLA (Dummy)

Sample:	Inside London			Outside London		
Specifications	(1)	(2)	(3)	(4)	(5)	(6)
D. Close x Post [1)]	-0.0689	-0.0425	-0.0118	-0.0011	-0.0478	0.0024
	(0.0553)	(0.0364)	(0.0330)	(0.0664)	(0.0379)	(0.0368)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Housing Controls [2)]	No	Yes	Yes	No	Yes	Yes
Postcode FEs	No	No	Yes	No	No	Yes
Census variables by year [3)]	No	No	Yes	No	No	Yes
N	19272	19272	19272	12855	12855	12855
R^2	0.1410	0.6108	0.9016	0.0613	0.6802	0.9470

Notes: Sample in columns 1 through 3 corresponds to properties sold in the GLA within 5km of the GLA boundary. Sample in columns 4 to 6 corresponds to properties sold outside of the GLA within 5km of the GLA boundary. Dependent variable is the natural logarithm of sale price in all columns. [1)] Close is a dummy taking value 1 for properties within 2.5km of the GLA boundary. Post is a dummy that takes value 1 if individual transaction occurs after the implementation of London HtB. [2) - 3)] see Table B2. Standard errors clustered at the postcode level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B7:
Testing for Displacement Effect around GLA (Linear)

Sample:	Inside London			Outside London		
Specifications	(1)	(2)	(3)	(4)	(5)	(6)
Distance x Post [1)]	0.0245	0.0125	0.0122	0.0251	0.0320**	-0.0106
	(0.0198)	(0.0122)	(0.0100)	(0.0262)	(0.0150)	(0.0128)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Housing Controls [2)]	No	Yes	Yes	No	Yes	Yes
Postcode FEs	No	No	Yes	No	No	Yes
Census variables by year [3)]	No	No	Yes	No	No	Yes
N	19272	19272	19272	12855	12855	12855
R^2	0.1413	0.6105	0.9020	0.0595	0.6779	0.9471

Notes: Sample in columns 1 through 3 corresponds to properties sold in the GLA within 5km of the GLA boundary. Sample in columns 4 to 6 corresponds to properties sold outside of the GLA within 5km of the GLA boundary. Dependent variable is the log of property sale price in all columns. [1)] Distance represents the distance from a property to the GLA boundary. Post is a dummy taking value 1 if an individual transaction occurs after the implementation of London HtB. [2) - 3)] See Table B2. Standard errors are clustered at the postcode level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B8:
Displacement Effect around English/Welsh Border (Dummy)

Sample:	Wales			England		
Specifications	(1)	(2)	(3)	(4)	(5)	(6)
D. Close x Post [1)]	0.2471	0.2471	0.2915*	0.2762	0.2762	0.2072
	(0.1611)	(0.1621)	(0.1739)	(0.2338)	(0.2352)	(0.2246)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Ward FEs	No	Yes	Yes	No	Yes	Yes
Census variables by year [2)]	No	No	Yes	No	No	Yes
N	9828	9828	9828	6552	6552	6552
R^2	0.0157	0.2997	0.3079	0.0376	0.2355	0.2513

Notes: Sample in columns 1 to 3 corresponds to wards in Wales within 10km of the English/Welsh border. Sample in columns 4 to 6 corresponds to wards in English within 10km of the English/Welsh border. Distance between ward and border calculated from the ward's centroid. Dependent variable is the number of new build sales in a ward in a given month. [1)] Close is a dummy taking value 1 for wards with centroids within 5km of the English/Welsh border. Post is a dummy that takes value 1 for year-month fixed effects post March 2014 (one year after the implementation of English HtB). [2)] see Table 6. Standard errors clustered at the ward level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B9:
Displacement Effect around English/Welsh Border (Linear)

Sample:	Wales			England		
Specifications	(1)	(2)	(4)	(5)	(6)	(8)
Distance x Post [1)]	-0.0427	-0.0427	-0.0511	-0.0379	-0.0379	-0.0309
	(0.0291)	(0.0292)	(0.0317)	(0.0348)	(0.0350)	(0.0335)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Ward FEs	No	Yes	Yes	No	Yes	Yes
Census variables by year [2)]	No	No	Yes	No	No	Yes
N	9828	9828	9828	6552	6552	6552
R^2	0.0161	0.2998	0.3081	0.0335	0.2354	0.2512

Notes: Sample in columns 1 to 3 corresponds to wards in Wales within 10km of the English/Welsh border. Sample in columns 4 to 6 corresponds to wards in English within 10km of the English/Welsh border. Distance between ward and border calculated from the ward's centroid. Dependent variable is the number of new build sales in a ward in a given month. [1)] Distance represent the straight-line distance between the ward centroid and the English/Welsh border. Post is a dummy that takes value 1 for year-month fixed effects post March 2014 (one year after the implementation of English HtB). [2)] see Table 6. Standard errors clustered at the ward level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B10:
Robustness – Bandwidth Selection & Price Effect at GLA Boundary

Specifications	(1)	(2)	(3)	(4)	(5)
			Panel A: 2.5km Bandwidth		
HtB [1)]	0.1044*	0.0414	0.0437*	0.0655***	0.0479**
	(0.0548)	(0.0330)	(0.0262)	(0.0226)	(0.0215)
N	17005	17005	17005	17005	17005
			Panel B: 7.5km Bandwidth		
HtB [1)]	0.1243***	0.0746***	0.0457**	0.0619***	0.0594***
	(0.0352)	(0.0218)	(0.0219)	(0.0215)	(0.0213)
N	51079	51079	51079	51079	51079
Year-month FEs	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	Yes	No	No	No
Housing controls [2)]	No	Yes	Yes	Yes	Yes
Postcode FEs	No	No	Yes	Yes	Yes
Census variables by year [3)]	No	No	No	Yes	Yes
Distance by year	No	No	No	No	Yes

Notes: Estimates obtained on the sample of new build properties sold within 2.5km and 7.5km of the GLA boundary in panels A and B, respectively. Dependent variable is the natural logarithm of the sale price in all columns. [1)] HtB corresponds to a dummy taking value 1 for properties sold inside of the GLA after February 2016. [2- 3)] see Table B2. Standard errors clustered at the postcode level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B11:
Robustness – Bandwidth Selection & Price Effect at English/Welsh Border

Specifications	(1)	(2)	(3)	(4)	(5)
		Panel A: 5km Bandwidth			
HtB [1)]	0.0207	-0.0377	0.0179	0.0223	0.0190
	(0.0879)	(0.0447)	(0.0280)	(0.0309)	(0.0312)
N	4864	4864	4864	4864	4864
		Panel B: 15km Bandwidth			
HtB [1)]	0.1496**	0.0809**	-0.0064	-0.0038	-0.0045
	(0.0635)	(0.0387)	(0.0195)	(0.0200)	(0.0203)
N	14496	14496	14496	14496	14496
Year-month FEs	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	Yes	No	No	No
Housing controls [2)]	No	Yes	Yes	Yes	Yes
Postcode FEs	No	No	Yes	Yes	Yes
Census variables by year [3)]	No	No	No	Yes	Yes
Distance by year	No	No	No	No	Yes

Notes: Estimates obtained on the sample of new build properties sold within 5km and 15km of the English/Welsh boundary in panels A and B, respectively. Dependent variable is the natural logarithm of the sale price in all columns. [1)] HtB corresponds to a dummy taking value 1 for properties sold in England after April 2013. [2) - 3)] see Table B2. Standard errors clustered at the postcode level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B12:
Placebo - Price Effect at Greater Manchester Boundary

Specifications	(1)	(2)	(3)	(4)	(5)
HtB (placebo) [1)]	0.0313	0.0006	-0.0035	0.0083	0.0068
	(0.0550)	(0.0323)	(0.0182)	(0.0219)	(0.0210)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	Yes	No	No	No
Housing controls [2)]	No	Yes	Yes	Yes	Yes
Postcode fixed effects	No	No	Yes	Yes	Yes
Census variables by year [3)]	No	No	No	Yes	Yes
Distance by year	No	No	No	No	Yes
N	13318	13318	13318	13318	13318
R^2	0.0872	0.6764	0.9221	0.9223	0.9224

Notes: Estimates obtained on the sample of new build properties within 5km of the Greater Manchester boundary. [1)] HtB variable takes value 1 for properties sold in Greater Manchester after February 2016. [2) - 3)] see Table B2. Standard errors clustered at the postcode level. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B13:
Robustness – GLA Boundary Contemporaneous Construction Effects

Dependent Variable:	#New builds				Dummy			
Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HtB [1)]	0.0499	0.0499	0.1237	0.0957	0.0142	0.0142	0.0145	0.0141
	(0.1782)	(0.1792)	(0.2067)	(0.2022)	(0.0246)	(0.0248)	(0.0255)	(0.0256)
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	No	No	No	Yes	No	No	No
Ward FEs	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Census variables by year [2)]	No	No	Yes	Yes	No	No	Yes	Yes
Distance by year	No	No	No	Yes	No	No	No	Yes
N	33684	33684	33684	33684	33684	33684	33684	33684
R^2	0.0108	0.1735	0.1744	0.1750	0.0136	0.1893	0.1904	0.1908

Note: Estimated with the sample of wards within 5km of the GLA boundary between 2012 and 2018. The dependent variable in columns 1 to 4 corresponds to the number of new builds in a ward. The dependent variable in columns 5 to 8 corresponds to a dummy taking value 1 if there was any sale of new build property in that ward-year pair. [1)] HtB is a dummy taking value 1 for wards inside the GLA after February 2016. [2)] See Table 6. Standard errors clustered at the ward level in parentheses. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B14:
Robustness - English/Welsh Border Contemporaneous Construction Effects

Dependent Variable:	#New builds				Dummy			
Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HtB [1)]	0.3977***	0.3977***	0.3727***	0.3978***	0.0797**	0.0797**	0.0712**	0.0729**
	(0.1390)	(0.1398)	(0.1284)	(0.1280)	(0.0311)	(0.0313)	(0.0302)	(0.0302)
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	No	No	No	Yes	No	No	No
Ward Fes	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Census variables by year [2)]	No	No	Yes	Yes	No	No	Yes	Yes
Distance by year	No	No	No	Yes	No	No	No	Yes
N	16380	16380	16380	16380	16380	16380	16380	16380
R^2	0.0233	0.2533	0.2615	0.2627	0.0234	0.2493	0.2526	0.2537

Note: Estimated over the sample of wards within 10km of the English/Welsh boundary between 2012 and 2018. The dependent variable in columns 1 to 4 corresponds to the number of new builds in a ward. The dependent variable in columns 5 to 8 corresponds to a dummy taking value 1 if there was any sale of new build property in that ward-year pair. [1)] HtB corresponds to a variable taking value 1 for wards in England after April 2013 (the exact time of introduction of English HtB). [2)] See Table 6. Standard errors clustered at the ward level in parentheses. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Table B15:
Placebo - Construction Effect at Greater Manchester Boundary

Dependent Variable:	#New builds				Dummy			
Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HtB [1]	-0.2320	-0.2320	-0.3628	-0.3653	0.0111	0.0111	-0.0103	-0.0159
	(0.2549)	(0.2565)	(0.2838)	(0.2861)	(0.0469)	(0.0472)	(0.0480)	(0.0480)
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	No	No	No	Yes	No	No	No
Ward FEs	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Census variables by year [2]	No	No	Yes	Yes	No	No	Yes	Yes
Distance by year	No	No	No	Yes	No	No	No	Yes
N	14784	14784	14784	14784	14784	14784	14784	14784
R^2	0.0349	0.2361	0.2415	0.2419	0.0309	0.3012	0.3065	0.3074

Note: Estimated over the sample of wards within 5km of the Greater Manchester boundary between 2012 and 2018. The dependent variable in columns 1 to 4 corresponds to the number of new builds in a ward. The dependent variable in columns 5 to 8 corresponds to a dummy taking value 1 if there was any sale of new build property in that ward-year pair. [1] HtB corresponds to a variable taking value 1 for wards inside of Greater Manchester after February 2017 (1 year after the introduction of London HtB). [2] See Table 6. Standard errors clustered at the ward level in parentheses.

Table B16:
Price Effect at English/Welsh Border
(Pre-period: Jan 2012 to Mar 2013; Post period: Jan 2014 to Dec 2018)

Specifications	(1)	(2)	(3)	(4)	(5)
HtB [1]	0.1405	0.0838	0.0270	0.0374	0.0408
	(0.0909)	(0.0566)	(0.0372)	(0.0407)	(0.0399)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	Yes	Yes	No	No	No
Housing controls [2]	No	Yes	Yes	Yes	Yes
Postcode FEs	No	No	Yes	Yes	Yes
Census variables by year [3]	No	No	No	Yes	Yes
Distance by year	No	No	No	No	Yes
N	7660	7660	7660	7660	7660
R^2	0.0983	0.6788	0.9225	0.9230	0.9232

Notes: Estimated with the sample of new build properties sold within 10km of the English/Welsh boundary sold between 2012 and 2018 excluding properties sold between April 2013 and December 2013. [1] HtB corresponds to a dummy taking value 1 for properties sold in England after 2013. [2) - 3)] see Table B2. Standard errors clustered at the postcode level in parentheses.

Table B17:
Construction Effect at English/Welsh Border
(Pre-period: Jan 2012 to Mar 2013; Post period: Jan 2015 to Dec 2018)

Dependent Variable:	#New builds				Dummy			
Specifications	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HtB [1)]	0.5076***	0.5076***	0.4777***	0.5098***	0.1***	0.1***	0.0902**	0.0929**
	(0.1705)	(0.1718)	(0.1576)	(0.1569)	(0.0378)	(0.0381)	(0.0372)	(0.0374)
Year-month FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance to boundary on each side	No	No	No	No	No	No	No	No
Ward FEs	No	No	Yes	Yes	No	No	Yes	Yes
Census variables by year [2)]	No	No	Yes	Yes	No	No	Yes	Yes
Distance by year	No	No	No	Yes	No	No	No	Yes
N	12285	12285	12285	12285	12285	12285	12285	12285
R^2	0.0268	0.2546	0.2635	0.2648	0.0287	0.2607	0.2640	0.2655

Note: [1] Estimated with the sample of new build properties sold within 10km of the English/Welsh boundary sold between 2012 and 2018 excluding properties sold between April 2013 and December 2013. Dependent variable in columns 1 through 4 is the number of new builds sold in a ward in a given month. Dependent variable in columns 5 through 8 corresponds to a dummy taking value 1 if a ward-month pair has experienced any new build sales. [1)] HtB corresponds to a dummy taking value 1 for properties sold in England after 2013. [2)] see Table 6. Standard errors clustered at the ward level in parentheses. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively.

Appendix C: Theoretical Appendix

Demand for New Build Housing

Households buy a new build unit if:

$$u(c_{1h}, h) + \beta u(c_{2h}, h) \geq u(c_{1\emptyset}, 0) + \beta u(c_{2\emptyset}, 0)$$
$$w \geq (P - e)(1 + r)$$
$$e \geq P(1 - \gamma)$$

The first condition simply states that buying a new build is incentive compatible. Choice variables c_{th} and $c_{t\emptyset}$, correspond to consumption in period $t = \{1,2\}$ for households buying a new build and households renting, respectively. For a sufficiently large value of h, this condition is always satisfied given the assumption in footnote 3. The second condition is required to ensure households buying property in period 1 are able to meet their liabilities in period 2. This is satisfied given that $P < \frac{1}{1-\gamma}$ and assumption $w > \frac{\gamma}{1-\gamma}(1 + r)$. Finally, the third condition determines demand $Q_D = 1 - F_e((1 - \gamma)P)$.

Derivatives of Equilibrium Price and Quantities w.r.t. γ and ν

Competitive equilibrium results in $Q^* = \Big(1 - F_e\big((1 - \gamma)\nu Q^*\big)\Big)$. Total differentiation w.r.t. γ leads to:

$$\frac{dQ^*}{d\gamma} + f_e\big((1 - \gamma)\nu Q^*\big)\nu \left[(1 - \gamma)\frac{dQ^*}{d\gamma} - Q^*\right] = 0 \qquad \text{(A.1)}$$

$$\Rightarrow \frac{dQ^*}{d\gamma} = \frac{\nu f_e\big((1-\gamma)\nu Q^*\big)Q^*}{1 + f_e\big((1-\gamma)\nu Q^*\big)\nu(1-\gamma)} > 0$$

Similarly, total differentiating the equilibrium equation w.r.t. ν and re-arranging terms we obtain:

$$\frac{dQ^*}{d\nu} = \frac{-(1 - \gamma) f_e\big((1 - \gamma)\nu Q^*\big)Q^*}{1 + f_e\big((1 - \gamma)\nu Q^*\big)\nu(1 - \gamma)} < 0$$

To obtain the derivatives for equilibrium prices, note that the supply schedule is $P = \nu Q$. Therefore, we will have that:

$$\frac{dP^*}{d\gamma} = \nu \frac{dQ^*}{d\gamma} > 0 \quad \text{and} \quad \frac{dP^*}{d\nu} = Q^* + \nu \frac{dQ^*}{d\nu} = \frac{1}{1 + f_e\big((1-\gamma)\nu Q^*\big)\nu(1-\gamma)} > 0$$

Proof of Proposition 1

Consider the general case in which e distributed according to a general pdf $f_e(\cdot)$. If we differentiate A.1 with respect to ν, we obtain:

$$\left[1+\nu(1-\gamma)f_e\big((1-\gamma)\nu Q^*\big)\right]\frac{dQ^*}{d\gamma d\nu}= \qquad \text{(A.2)}$$

$$f_e\big((1-\gamma)\nu Q^*\big)\left[Q^*+\nu\frac{dQ^*}{d\gamma}-(1-\gamma)\frac{dQ^*}{d\nu}\right]$$

$$-f_e{}'\big((1-\gamma)\nu Q^*\big)\nu\left[(1-\gamma)Q^*+\nu(1-\gamma)\frac{dQ^*}{d\nu}\right]\left[(1-\gamma)\frac{dQ^*}{d\gamma}-Q^*\right]$$

The term in square brackets in the first line is strictly positive. The term in square brackets in the second line is strictly *negative* as long as $\nu(1-\gamma)>f_e(\cdot)\ \forall e$. To see this, simply replace the expressions for $\frac{dQ^*}{d\gamma}$ and $\frac{dQ^*}{d\nu}$ above. Finally, if this condition holds, the first term in square brackets in the first line is positive and the second is negative.

Note that, under a uniform distribution of e, the term $f_e{}'\big((1-\gamma)\nu Q^*\big)$ is equal to 0. Therefore $\frac{dQ^*}{d\gamma d\nu}<0$. To prove that $\frac{dP^*}{d\gamma d\nu}>0$, we differentiate the expression for the supply schedule $P=\nu Q$ by γ and ν to obtain:

$$\frac{dP^*}{d\gamma d\nu}=\frac{dQ^*}{d\gamma}+\nu\frac{dQ^*}{d\gamma d\nu} \qquad \text{(A.3)}$$

Replacing the expressions for $\frac{dQ^*}{d\gamma}$ and $\frac{dQ^*}{d\gamma d\nu}$ in the uniform case, we obtain $\frac{dP^*}{d\gamma d\nu}>0$.

For a general pdf $f_e(\cdot)$ – as long as we assume $\nu(1-\gamma)>f_e(\cdot)\ \forall e$, we can operate with A.2 and A.3 to prove the following: If e distributed according to pdf $f_e(\cdot)$ with $f_e(\cdot)$ strictly decreasing in e and $\nu(1-\gamma)>f_e^{-1}(e)\ \forall e$, then $\frac{dQ^*}{d\gamma d\nu}<0$. If $f_e(\cdot)$ is strictly increasing in e and $\nu(1-\gamma)>f_e^{-1}(e)\ \forall e$, then $\frac{dP^*}{d\gamma d\nu}>0$.

It is important to note that conditions imposed on $f_e(\cdot)$ are sufficient and not necessary. Consider the case in which $e\sim\beta_{3,1}$. This pdf is strictly *increasing*, yet it can be shown that an increase in γ from 0.6 to 0.7 will result in a smaller increase in quantities when $\nu=4.5$ rather than $\nu=4$.[32]

Proof of Proposition 2

If F_c is the distribution of costs, then total profits are given by $\Pi(\mathrm{P})=\int_0^P P-c\ dF_c$. Given the assumption on F_c above, this boils down to $\Pi(\mathrm{P})=\int_0^P P-\frac{c}{\nu}\ dc=\frac{2\nu-1}{2\nu}P^2$, which is strictly increasing in P. Given that $\frac{dP^*}{d\gamma}>0$, it follows that $\frac{d\Pi(\mathrm{P}^*)}{d\gamma}>0$.

[32] Code available upon request.

References

Benetton, M., Bracke. P., Cocco, J.F. & Garbarino, N. (2019). Housing Consumption and Investment: Evidence from Shared Equity Mortgages. Bank of England Working Paper No. 790, April.

Best, M. C., & Kleven, H. J. (2017). Housing market responses to transaction taxes: Evidence from notches and stimulus in the UK. *Review of Economic Studies*, 85(1), 157-193.

Black, S. E. (1999). Do better schools matter? Parental valuation of elementary education. *Quarterly Journal of Economics*, 114(2), 577-599.

Blanden, J. and S. Machin (2017). Home Ownership and Social Mobility. CEP Discussion Paper No. 1466, January.

Bostic, R. W., & Gabriel, S. A. (2006). Do the GSEs matter to low-income housing markets? An assessment of the effects of the GSE loan purchase goals on California housing outcomes. Journal of Urban Economics, 59(3), 458-475.

Carozzi, F. (2019). Credit constraints and the composition of housing sales. Farewell to first-time buyers? Appears in: *Journal of the European Economic Association*.

Chetty, R., Friedman, J. N., Olsen, T., & Pistaferri, L. (2011). Adjustment costs, firm responses, and micro vs. macro labor supply elasticities: Evidence from Danish tax records. *The quarterly journal of economics*, *126*(2), 749-804.

Deng, Y., Quigley, J. M., Van Order, R., & Mac, F. (1996). Mortgage default and low downpayment loans: the costs of public subsidy. *Regional Science and Urban Economics*, 26(3-4), 263-285.

Duca, J. V., Muellbauer, J., & Murphy, A. (2011). House prices and credit constraints: Making sense of the US experience. *Economic Journal*, 121(552), 533-551.

Einav, L., Finkelstein, A., & Schrimpf, P. (2017). Bunching at the kink: implications for spending responses to health insurance contracts. *Journal of Public Economics*, 146, 27-40.

Favara, G., & Imbs, J. (2015). Credit supply and the price of housing. *American Economic Review*, 105(3), 958-92.

Fetter, D. K. (2013). How do mortgage subsidies affect home ownership? Evidence from the mid-century GI bills. American Economic Journal: Economic Policy, 5(2), 111-47.

Finlay, S., Williams, P., & Whitehead, C. (2016). Evaluation of the Help to Buy Equity Loan Scheme. Department for Communities and Local Government.

Gabriel, S. A., & Rosenthal, S. S. (2010). Do the GSEs expand the supply of mortgage credit? New evidence of crowd out in the secondary mortgage market. Journal of Public Economics, 94(11-12), 975-986.

Guerrieri, V., & Uhlig, H. (2016). Housing and credit markets: booms and busts. In *Handbook of Macroeconomics* (Vol. 2, pp. 1427-1496). Elsevier.

Gibbons, S., & Machin, S. (2003). Valuing English primary schools. *Journal of Urban Economics*, 53(2), 197-219.

Gibbons, S., Machin, S., & Silva, O. (2013). Valuing school quality using boundary discontinuities. *Journal of Urban Economics*, 75, 15-28.

Gobillon, L., & Le Blanc, D. (2008). Economic effects of upfront subsidies to ownership: The case of the Prêt à Taux Zéro in France. Journal of Housing Economics, 17(1), 1-33.

Gyourko, J., & Molloy, R. (2015). Regulation and housing supply. In *Handbook of Regional and Urban Economics* (Vol. 5, pp. 1289-1337). Elsevier.

Hilber, C. A., & Robert-Nicoud, F. (2013). On the origins of land use regulations: theory and evidence from US metro areas. *Journal of Urban Economics*, *75*, 29-43.

Hilber, C. A., & Schöni, O. (2016). Housing policies in the United Kingdom, Switzerland, and the United States: lessons learned. Cityscape, 18(3), 291-332.

Hilber, C. A., & Vermeulen, W. (2016). The impact of supply constraints on house prices in England. *Economic Journal*, 126(591), 358-405.

Hilber, C. A., & Turner, T. M. (2014). The mortgage interest deduction and its impact on homeownership decisions. *Review of Economics and Statistics*, 96(4), 618-637.

Iacoviello, M., & Pavan, M. (2013). Housing and debt over the life cycle and over the business cycle. *Journal of Monetary Economics*, 60(2), 221-238.

Kiyotaki, N., Michaelides, A., & Nikolov, K. (2011). Winners and losers in housing markets. *Journal of Money, Credit and Banking*, 43(2-3), 255-296.

Kleven, H. J., & Waseem, M. (2013). Using notches to uncover optimization frictions and structural elasticities: Theory and evidence from Pakistan. *Quarterly Journal of Economics*, 128(2), 669-723.

Kleven, H. J. (2016). Bunching. *Annual Review of Economics*, 8, 435-464.

Koster, H.R., & Pinchbeck, E.W. (2017). How do Households Value the Future? Evidence from Property Taxes. *mimeo* LSE.

Ministry of Housing, Communities and Local Government. (2019). Help to Buy (Equity Loan scheme) Data to 30 September 2018, England. London: MHCLG.

Mian, A., & Sufi, A. (2009). The consequences of mortgage credit expansion: Evidence from the US mortgage default crisis. *Quarterly Journal of Economics,* 124(4), 1449-1496.

Ortalo-Magné, F., & Rady, S. (2006). Housing market dynamics: On the contribution of income shocks and credit constraints. *Review of Economic Studies*, *73*(2), 459-485.

Olsen, E. O., & Zabel, J. E. (2015). US housing policy. In Handbook of regional and urban economics (Vol. 5, pp. 887-986). Elsevier.

Saez, E. (2010). Do taxpayers bunch at kink points? *American Economic Journal: Economic Policy*, *2*(3), 180-212.

Saiz, A. (2010). The geographic determinants of housing supply. *Quarterly Journal of Economics*, *125*(3), 1253-1296.

Sommer, K., & Sullivan, P. (2018). Implications of US tax policy for house prices, rents, and homeownership. *American Economic Review*, *108*(2), 241-74.

Stein, J. C. (1995). Prices and trading volume in the housing market: A model with down-payment effects. *Quarterly Journal of Economics*, 110(2), 379-406.

Szumilo, N., & Vanino, E. (2018). Are Government and Bank Loans Substitutes or Complements? Evidence from Spatial Discontinuity in Equity Loans. *Real Estate Economics* forthcoming.

Turner, M. A., Haughwout, A., & Van Der Klaauw, W. (2014). Land use regulation and welfare. *Econometrica*, *82*(4), 1341-1403.

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