Credit Constraints and the Composition of Housing Sales. Farewell to First-time Buyers?

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Abstract
During the housing bust of 2008–2009, home prices and transaction volumes fell across the entire United Kingdom. However, while the fall in prices was similar across housing types, transaction volumes fell more for homes at the lower end of the market. I document this fact and use an overlapping-generations model to relate it to the reduction in loan-to-value ratios by British banks and to derive additional predictions. As down-payment requirements increase, young households with scarce financial resources are priced out by older owners who retain their previous housing for renting when trading up. Recent changes in aggregate housing tenure as well as changes in the number of sales and rentals in areas with different age composition are consistent with the model predictions. The insights presented here inform recent policy discussions about reduced access to home ownership by the young.

1 Introduction

Between the last months of 2007 and the first of 2008, home prices and trans-action volumes started falling across all UK regions. By mid 2009, the Land Registry price index had experienced a nominal drop of 17% from its peak while transactions had fallen by 60%. In this paper I show that while the reduction in prices was similar across home types, transaction volumes fell more for homes at the lower end of the market. To document this fact I use an administrative dataset on the universe of private housing market transactions in England and Wales. Figure I illustrates this result. The left panel plots the median percentage change in prices between 2007 and 2009 against a measure of housing quality (described below). We see that the relationship is close to being flat. The right panel shows the same plot for the median percentage change in transactions. In this case we see that the fall in transactions was substantially higher for lower-quality homes.[1]

My proposed explanation for this change in transactions relates to the tightening of credit conditions in the UK during 2008, and in particular to the sharp reduction of the Loan-to-Value ratios of mortgages offered by British banks. On account if this, I propose a housing ladder model with borrowing constraints and renting in which credit conditions affect the composition of sales. In the model, greater downpayment requirements hinder home pur-chases by young households with less wealth. In turn, older and wealthier households become 'accidental landlords' who keep their previous home and rent it instead of selling it when moving up the housing ladder. The fact that these entry-level homes are rented instead of being sold is what drives the change in the composition of transactions: sales of lower quality homes make up a smaller fraction of the total when downpayment requirements increase. In addition to reproducing the stylized fact outlined above, the model deliv-ers additional predictions that are tested empirically: tighter credit leads to an increase in private renting, a negative cross-sectional correlation between renting and transactions and less purchases by the young. Using highly disag-gregated geographical data I test these implications and find support for the underlying mechanism.

The results presented in this paper inform recent policy debates in the United Kingdom and, more generally, concerns in this and other countries about how credit affects access to home-ownership. According to several

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[1]The linear correlation between quality and the change in prices is 0.04 while for quality and the change in transactions it is 0.19.

FIGURE I

MEDIAN CHANGE IN PRICES AND TRANSACTIONS BY HOME QUALITY

FIGURE I

MEDIAN CHANGE IN PRICES AND TRANSACTIONS BY HOME QUALITY
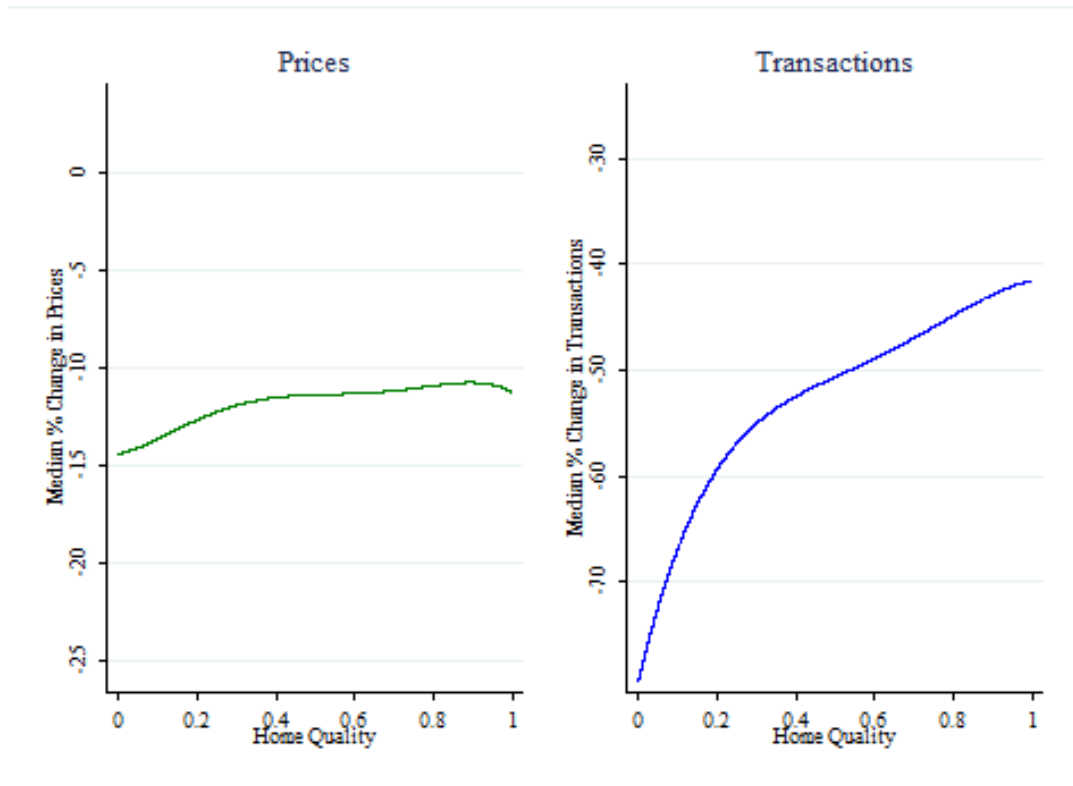
market participants and government officials, the difficulties faced by young households trying to buy their first homes have held back the housing market recovery. Alistair Darling, chancellor of the Exchequer, declared in 2010: "The housing market has now stabilized and has begun a slow recovery. But many first-time buyers, particularly those without large deposits, still find it hard to get a mortgage." His and subsequent governments have tried several policies to help first-time buyers. Given these interventions, understanding the mechanism through which changes in lending conditions affect housing tenure for different households has significant policy implications.

This paper contributes to the empirical literature studying housing cycles for different market segments within cities. Previous studies have documented how the prices for homes of different qualities change over the housing cycle, particularly during boom periods such as the early 2000s in the US.[2]

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[2]Smith and Tesarek (1991) study the evolution of home prices across qualities during a boom-bust episode in the 80s. Several studies seek to explain within-city changes in prices during the recent US housing boom (e.g. Ferreira and Gyourko (2011), Glaeser, Gottlieb and

Instead, this paper documents the evolution of both prices and transactions, and focuses on a bust period 2007-2009 and on the UK. Incorporating transactions into the analysis is relevant because, as shown below, in the period studied here the disparity between segments is larger in the dynamics of transaction volumes than in the dynamics for prices.

My contribution is also related to the theoretical literature on the effects of credit constraints on housing prices and transaction volumes. Stein (1995) presents a partial equilibrium model linking down-payment requirements and sale volumes. Its mechanism is cast into a housing model with endogenous prices in Ortalo-Magne and Rady (1999) and Ortalo-Magne and Rady (2006). In these studies the change in the time series for transactions emerges from capital gains (or losses) on starter homes. While the model below partially builds on the framework present in Ortalo-Magne and Rady (2006) I propose an alternative mechanism relating borrowing constraints and sales by emphasizing the link between housing ladder transitions and the supply of rented homes. In this sense, I draw attention to the relationship between the composition of sales and changes in home-ownership rates. Moreover, the qualitative predictions from my model refer to the variation in the impact of borrowing constraints on sale volumes across home types rather than on the time series of total transactions.

Finally, this paper also related to the empirical literature studying the co-movement of prices and transactions on housing markets. Evidence of the positive time series correlation is presented in Berkovec and Goodman (1996), Lamont and Stein (1999) for the US and Andrew and Meen (2003), Ortalo-Magne and Rady (1999), Benito (2006) for the UK. This is already a well established fact and a qualitative feature of several housing market models. My contribution is to study how this co-movement varies across home qualities, how simultaneous changes in prices and transactions were different for different housing segments.

The data used in the empirical sections of this paper is presented in section 2. To document the main stylized fact on transactions and prices I use the Price Paid Dataset offered by the UK Land Registry. This rich administrative dataset covers all regular residential transactions in England and Wales. Its

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Tobio (2012) and Guerrieri, Hartley and Hurst (2013)). Landvoigt, Piazzesi and Schneider (2012) do document a change in *both* transactions and prices for different market segments in San Diego between 2000 and 2005. They focus on matching the joint distributions of wealth, income and qualities using an assignment model which takes the quality distribution of traded homes as given.

high coverage is essential in order to study possible changes in transactions for different qualities over time. Section 3 presents recent trends in UK housing and credit markets.

In Section 4 I document how home prices and transactions changed between 2007 and 2009 for different segments within English and Welsh metropolitan areas.[3] To do so, I propose two different estimates of unobserved quality. The first uses location, home type and sale prices of observed transactions to construct a proxy. As an alternative, I restrict the sample to repeat-sales and use previous selling prices to estimate the quality of individual homes. Reassuringly, both methods yield similar results. Homes of different qualities experienced a similar fall in prices. In contrast, transactions fell substantially more for lower quality homes in all metropolitan areas, changing the composition of sales. Section 5 documents the robustness of these empirical results.

The findings are interpreted in the context of recent academic and policy discussions highlighting the role of credit constraints in housing markets and their effect on young households. Section 6 presents a housing ladder model with renting and credit constraints in which households differ in age and income. Using this framework I show that steady states with tighter lending conditions have a lower number of first-time buyers, a right-shifted composition of traded qualities and higher levels of renting. In addition, tighter credit leads to more *let-to-buy* (households keeping their homes and renting them when trading up) and less *buy-to-let* (households buying a home as an investment). All of these results are driven by the pricing out of young buyers by wealthier, older households when credit is tighter.

Evidence supporting these model implications and the underlying mechanism is presented in Section 7. Using disaggregated information on the evolution of housing tenures I show a strong negative correlation between the fall in transactions and the increase in renting. This correlation is consistent with the model predictions and is robust to changes in local economic conditions. In addition, I show that the change in transactions had a clear age profile. Using census data on age of residents, I distinguish between *young* and *old* areas within a city. Analysing prices and transactions for these two groups, results are similar to those obtained for quality levels: the change in price is similar across neighbourhoods but transactions fell more in young areas, even after controlling for neighbourhood quality.

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[3]The definition of metropolitan area used is the Travel-To-Work Area, which is analogous to a Local Labour Market in the United States.

Other explanations which could also account for the change in composition of home sales are discussed in Section 8. I study whether negative equity, changes in internal migration patterns or increases in repossessions explain my results. I find no evidence in this direction. Finally, Section 9 concludes by discussing policy implications and avenues for further research.

2 Data

Price Paid Dataset

Throughout most of this paper I use Land Registry data covering the vast majority of residential transactions in England and Wales.[4] In particular, I use the Price Paid dataset available at the Land Registry's website. It includes freehold and leasehold transactions for the 1995-2013 period recording the transaction price, postcode, address, an indicator of dwelling type (detached, semi-detached, terrace or flat), contract type (freehold or leasehold) and whether the home is a newbuild.

The price paid data for the 1995-2013 period includes a total of 18,744,353 transactions of which 22.9% are leasehold transactions. Given that these transactions do not include information of the lease term I exclude them from the analysis. I also exclude all of the 1,905,779 newbuild sales as they are related to construction activity which fell abruptly after its peak in 2007. As will be shown below, neither of these restrictions have a qualitative effect on my findings. Finally, I drop all transactions missing location data as this information is crucial in both my baseline and repeat-sales estimates. This implies losing a further 18,640 observations. These sample restrictions are summarized in Table I.

Detailed account of sample restrictions for the Land Registry dataset.

The final transactions dataset encompasses a total of 12,537,180 transactions for the 1995-2013. In Section 4 I focus on a Repeat-sales sample of homes sold at least twice over my sample period. There are a total of 9.4342.390 transactions in my Repeat-sales dataset.

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[4]The Price Paid dataset excludes properties bought by corporate bodies or businesses, homes sold as part of an asset portfolio, repossessed homes, sales of homes having an existing mortgage, and transfers under court order.

TABLE I

SAMPLE RESTRICTIONS

	Observations	% of Full Sample
Full Sample	18,744,353	100%
Leaseholds	4,301,626	22.9%
Newbuilds	1,904,779	10.2%
Missing Postcodes	18.640	0.1%
Final Sample	12,537,180	66.8%
Repeat-Sales Sample	9,342,390	49.8%

Other Data Sources

Population counts and age structures at the Lower Super Output Area level are obtained combining population estimates by the Office for National Statistics (ONS) and census data for 2001 and 2011. Disaggregated Data on housing tenure distributions is taken from the 2001 and 2011 census. Internal migration data is obtained from the ONS. Finally, data on the housing stock and the number of vacant homes, both at the Local Authority District level, are obtained from the Housing Strategy Statistical Appendix (HSSA). Data on aggregate tenure distributions is obtained from the English Housing Survey.

I use the National Statistics Postcode Lookup Directory to match this geographical information with the Land Registry dataset. The NSPL links postcodes with all the relevant geographies in the UK.

Geographies

Throughout the paper I use data at different levels of geographical disaggregation. When speaking about aggregate quantities I refer to England and Wales only. Scotland and Northern Ireland have separate Land Registries and home sales taking place there are not included in my data on transactions. My working definition of housing markets is the Travel-to-Work Area (TTWA). TTWAs are analogous to local labour markets for the US and are built using information on UK commuting patterns. There are a total of 186 travel-to-work areas in England and Wales.

Within TTWAs I use information at the lower super output area, postcode sector and postcode district levels. Lower super output areas (LSOAs) are defined for the collection and publication of data by the ONS. They represent the smallest area at which census data is disclosed. There are 34,753 LSOAs

in England and Wales, of which 34,374 have at least one transaction in the Land Registry dataset. Postcode sectors (PS) are aggregations of actual postcodes devised for mail sorting purposes. On average a postcode sector contains 2,995 households housing 7,272 people. There are 8,464 postcode sectors with at least one transaction in the Land Registry dataset. Postcode districts are aggregations of postcode sectors. There are roughly 2,900 postcode districts in the UK and 2,345 postcode districts with positive sales in my Land Registry dataset.

3   The UK Housing Market

In the late 80s rising mortgage rates and a worsening of labour market conditions affected affordability (Jowsey (2011)) in UK housing markets. The resulting contraction in demand put downward pressure on prices which fell between 1990 and 1995.

Home prices started to increase again after 1997 and continued to rise up to November of 2007, the month in which the Land Registry's Repeat sales index hit its maximum for the 1995-2013 period. The rapid growth in prices, particularly between 2004 and 2007, was often interpreted as evidence of a housing bubble in UK markets, in parallel to bubbles in other economies such as the US or Spain.

Figure II shows the series of de-seasonalized housing transactions for the 1995-2013 period. Before the financial crisis, the monthly number of home sales increased from around 70,000 in 1995 to 100,000 after 1998 and then oscillated around this figure until the last quarter of 2007.

After a brief period of stagnation house prices began to drop steadily and by April 2009 the Land Registry's index reached its trough. This supposed a 17% drop in nominal home prices (20.4% in real terms). Simultaneously, 2008 saw a fast decrease in transaction volumes: December 2008 recorded 51% less housing purchases than the same month in 2007.

More than six years after the bust started, prices and transactions have not fully recovered. While this may be attributed to the existence of a bubble before 2007, this explanation seems unlikely to fit the protracted stagnation in transaction volumes. In 2013, yearly sales were still lower than in every year between 1997 and 2007. The analysis bellow shows that this reduction in transactions was not neutral across different segments of the housing ladder. In addition, it provides some insights into why transactions have remained so

FIGURE II
EVOLUTION OF TRANSACTIONS AND PRICES
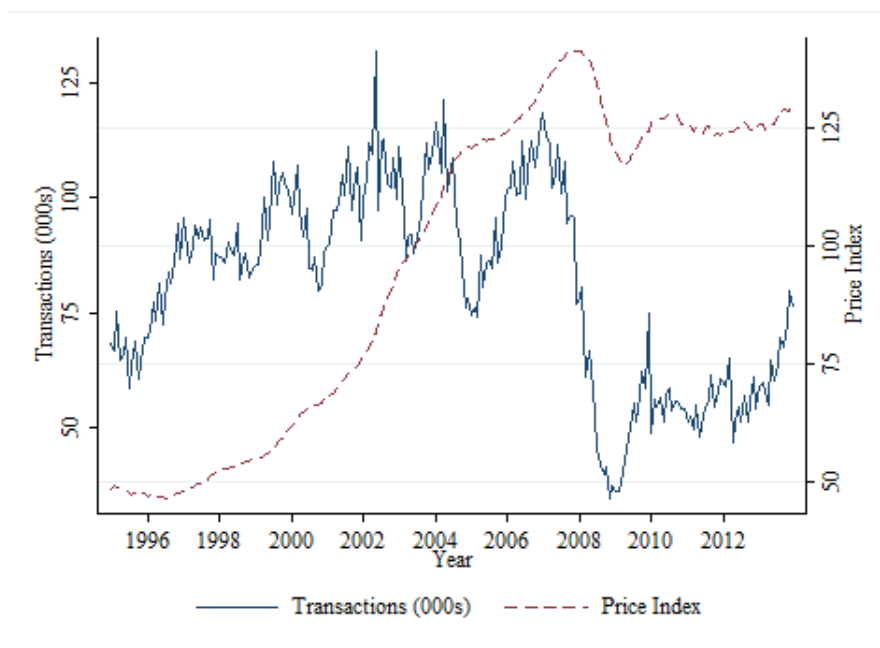
Data for England and Wales. Left vertical axis corresponds to transactions and right vertical axis corresponds to prices. Number of transactions in thousands. The price index is the repeat-sales index built by the Land Registry (base set to June 2003).

low.

Regarding trends in housing tenure, the 1981-2001 period saw an increase in home-ownership from 59% to 69%. This increase has been related to the relaxation of credit conditions by several studies (see Muellbauer and Murphy (1997), Ortalo-Magne and Rady (1999), Stephens, Whitehead and Munro (2005)). However, in 2001 the rate of home-ownership started to fall at the expense of private renting. Between 2002 and 2008, the percentage of homes living as renters increased from 10% to 12.8% , mainly through increases in purchases by home-owners for investment purposes. Renting increased faster during the crisis, going from 12.8% to 16.4% in 2012, a change that has often been attributed to tighter credit conditions.

3.1   Mortgage Markets

Following the de-regulation of mortgage markets in the early eighties,[5] the UK witnessed a proliferation of high Loan-to-Value (LTV) mortgages. The left panel in Figure III shows that the availability of high LTV ratio mortgages that started in 1982 was sustained for decades. During this period, the typical FTB could buy a home by paying a deposit of 10% of the total home value and obtain a loan on the remaining 90%.[6] With the advent of the financial crisis median LTVs for this group decreased abruptly from 90% in early 2007 to roughly 75% by 2009.

This change in median was the result of a broader change in the whole distribution of LTVs. The right panel of Figure III, shows how the cumulative distribution of mortgage LTVs to first-time buyers changed between 2006 and 2009. We can see that much of the mass of the distribution shifted to the left. between 2007 and 2009 By 2009 more than 90% of the cumulative frequency of lending to first time buyers corresponded to LTVs of less than 90%. High loan-to-value mortgages, which had been typical for years, all but disappeared from the market between 2008 and 2009.

The change in LTV ratios increased the deposit required to FTBs applying for a mortgage. The Council of Mortgage Lenders (CML) estimated that

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[5]The deregulation brought about in 1986 first by the Housing Societies Act and next by the 'Big Bang' in the City's financial markets expanded the availability of mortgage credit to unprecedented levels.

[6]Evidence from the Wealth and Assets Survey and the Survey of Building Society Mortgages show that first-time-buyers are the group taking up the largest LTV mortgages. This is a consequence of the fact that they have lower accumulated wealth and hence are less capable of paying large deposits.

FIGURE III

LOAN-TO-VALUE RATIOS
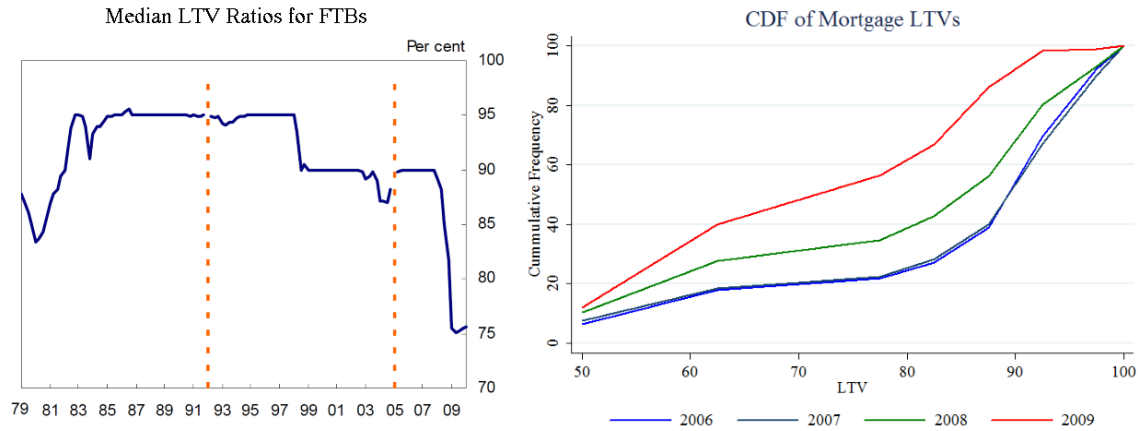
Left: Vertical axis plots the median Loan-to-Value ratio on mortgages granted to first-time buyers in percentage and the horizontal axis plots years. Graph extracted from Kuvshinov (2010). Original data from Council of Mortgage Lenders (CML). Right: Cumulative distributions of LTVs for First Time Buyers for years 2005, 2007, 2008 and 2009. (Source: CML).

the typical FTB deposit increased from 12,700 to 32,300 pounds between early 2007 and early 2010. To put this change into perspective note that this implies a change from 37% to 100% of annual individual income (CML estimates). Many young households became unable to meet the necessary down-payment and were, as a result, excluded from home-ownership. In the years after the bust, the size of the required deposit has often been cited as the main barrier to buying a home by households seeking to jump on the property ladder (see Blackwell and Park (2011), LSL First-Time Buyer Barometer (2014)).

Evidence from the Bank of England Credit Conditions Survey (CCS) indicates that this change in lending was partly supply driven. Respondents reported a reduction in maximum *offered* loan-to-value ratios after the last quarter of 2007. The CCS indicates that part of this change was attributed to the tightening of wholesale funding conditions and changes in the economic outlook although, admittedly, housing price expectations also played a role.

Another element which have affected availability of high LTV mortgages could be the anticipation of regulatory changes. During 2008, following the demise of Northern Rock, the Financial Services Authority announced it would modify reserve requirements for banks. Moreover, in early 2009, it announced it would accelerate the adoption of so-called Basel 2.5 regulation, which changed

the risk weighting of high LTV products in the computation of banks' capital requirements. Even though all of these changes were rolled out progressively, it is clear that the soft-touch approach to banking regulation took a serious blow during 2007/2008.[7] In anticipation of actual changes, banks may have also changed lending patterns. This is consistent with evidence from the CCS indicating that changes in banks' appetite for risk affected high LTV lending.

In the analysis below, I treat the change in credit availability as exogenous from the point of view of individual households.

4 Stylized Fact: The Bust by Home Qualities

In this section I study how different homes and neighbourhoods within Travel-to-Work-Areas fared during the crisis. In particular, I study how prices and transactions fell for homes of different quality levels.

I find that the peak-trough change in house prices between 2007 and 2009 was similar for low and high quality homes, with some heterogeneity across cities. Regarding transactions I find that there was a clear change in the composition of home sales during 2008: while transactions fell across most segments, they fell the most in cheap, young markets. This implies that homes in these markets took up a smaller share of total transactions than in the benchmark period. This change in composition is observed in the 10 largest TTWAs and in the vast majority of smaller ones. As a consequence, it appears to be the result of an aggregate shock affecting England and Wales.

After documenting the change in the composition of home sales I study its timing. Findings indicate that the differential change in the evolution of transactions for cheap and expensive homes occurred during mid and late 2008. This change coincides in time with the tightening of credit conditions and the increase in deposit requirements discussed above.

In order to study how homes of different qualities fared in the market during the crisis I first need a workable definition of quality that can be applied to my transaction data. I will define the quality of a home as a fixed, unobservable attribute which is desirable for households seeking to reside in a home and will hence be positively correlated with prices in equilibrium. Note that I am not seeking to estimate quality as a structural parameter in household

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[7]Lord Adair Turner, chief of the FSA in 2008, eloquently declared 'the days of light-touch regulation in the City are over'.

preferences but rather to obtain a ranking of homes in terms of this unobservable trait.

For this purpose suppose price for a home i sold in quarter t can be decomposed as follows:

$$p_{it} = \delta_{it}^{TTWA} + \alpha_i + \xi_{it}.$$

Where p_{it} is the logarithm of the transaction price, δ_t^{TTWA} is a set of (TTWA specific) time dummies. The error term ξ_{it} captures random variation in the transaction price that is not fixed or home specific (e.g.: specific to the buyer-seller match). Quality is defined as α_i and is fixed and unobservable. The challenge is to obtain an estimate for this parameter and use it to rank homes by it. For this purpose I propose two methods, both of them inspired in the house price index literature.

4.1 Home Groups

The first method uses data on type of dwelling (detached, semi-detached, terrace, flat) and/or location to group homes and then takes mean prices within these groups as proxies for α_i. In using this information I follow the spirit of *hedonic* or spatial house price indices which use homes characteristics to eliminate changes in the composition of sales (see Hill (2012) for a survey). Location and home types are important determinants of home prices and explain a large fraction of their cross-sectional variance. Moreover, location-dwelling type groups have stable price rankings within each TTWA (see Section 5). Both of these conditions make them reasonable proxies for α_i.

Formally, the method proceeds by estimating the following specification by OLS:

$$p_{it} = \delta_{it}^{TTWA} + \mu_j + \xi_{it}.$$

Again p_{it} corresponds to the log of price for home i sold at quarter t. Parameter μ_j is a dummy for location or location-type group j, δ_{it}^{TTWA} is a set of city specific time effects and ξ_{it} is an error term. The purpose is to use estimated values of $\widehat{\mu}_j$ as proxies for quality in each group j. Once I obtain $\widehat{\mu}_j$, I compute how transactions and prices changed between 2007 and 2009 across different groups. Finally, I compare these figures with the groups' ranking in the quality distribution. In this way, I document the relationship between quality and the fall in prices and transactions.

As an initial example I focus on the case of the London TTWA and group homes by postcode district. There are roughly 270 postcode districts in this metropolitan areas and fixed effects at this level explain 77% of the cross sectional variance in log prices for London. Once I estimate $\widehat{\mu}_j$ I split into postcode districts into estimated quintiles. I do the same for the change in transactions and the change in average prices at the postcode district level. In both cases the change is taken over the 2007 and 2009 periods.

I illustrate these results in the map shown in Figure IV. The upper panel displays a map of London's postcode districts in which darker shades of red correspond to higher quality (more expensive) districts. Unsurprisingly, we observe that central London and the South West are high quality areas whereas the East is cheaper. In the middle panel I portray the change in transactions in each district with darker shades of blue corresponding to larger decreases in the number of sales in 2009 relative to 2007. Finally, the bottom panel displays the change in prices for each area with darker shades of green corresponding to stronger drops in transactions.

The comparison between the maps is illustrative of the stylized fact documented in this paper. Comparing the top and middle panels we can observe that places with higher quality (dark red) correspond to moderate reductions in transactions (light blue in the middle panel). Take, for example, the case of central London and the South West. In both cases we observe a corridor of high quality - moderate reductions in transactions. The converse happens in the East London. The picture for prices is less clear. In the third panel we observe that several districts in the South West rank high in the distribution of price reductions. The correlation between price drops and low quality is only clear in the east and less so than in the case of transactions.

I now turn to a more refined analysis, combining more disaggregate location information with information on dwelling types in my estimation of quality. For this purpose I define groups at the postcode sector - dwelling type level. A postcode sector dwelling-type group identifies a type of home in a specific location.[8] A total of 36,085 postcode sector - dwelling type (PS-DT) groups had at least one sale during the 1997-2007 period. I now re-estimate the price equation above using this definition of groups. Parameter μ_j now corresponds to a PS-DT dummy for group j.

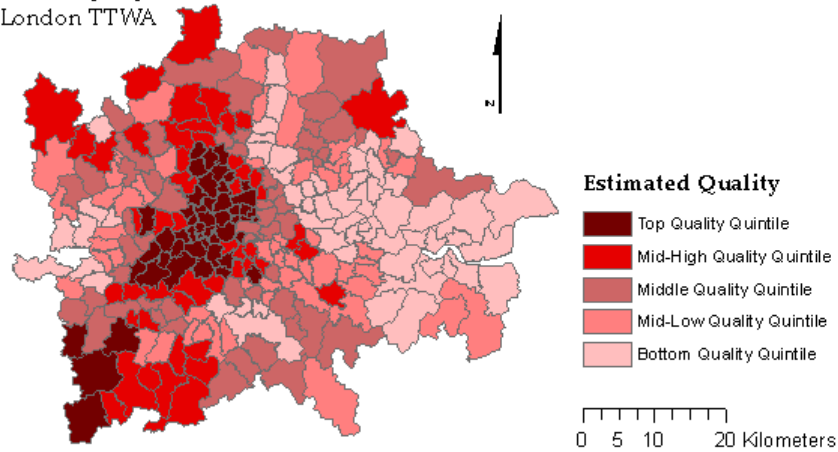I use the estimated values at this detailed level of disaggregation and ob-

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[8]For example: detached homes in postcode sector E1 4, semi-detached homes in postcode sector WC2A 2 or detached homes in postcode sector CV4 7.
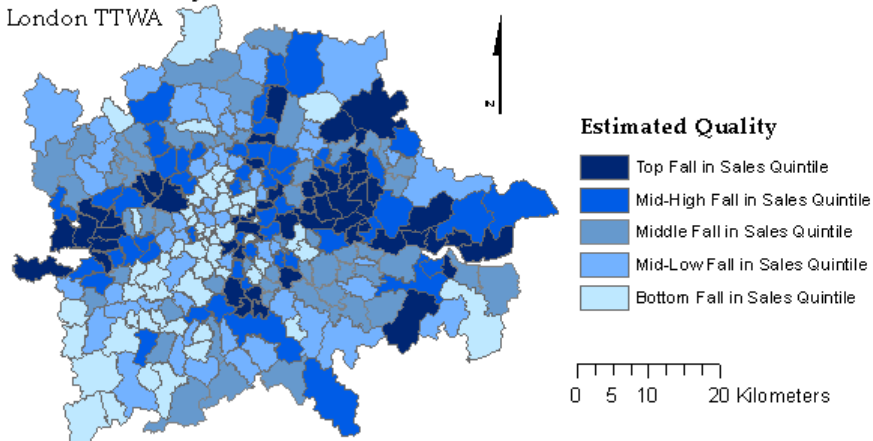
FIGURE IV

POSTCODE DISTRICTS IN LONDON TTWA

Quality by Postcode District
London TTWA

Estimated Quality

- Top Quality Quintile
- Mid-High Quality Quintile
- Middle Quality Quintile
- Mid-Low Quality Quintile
- Bottom Quality Quintile

0 5 10   20 Kilometers

Fall in Sales by Postcode District
London TTWA

Estimated Quality

- Top Fall in Sales Quintile
- Mid-High Fall in Sales Quintile
- Middle Fall in Sales Quintile
- Mid-Low Fall in Sales Quintile
- Bottom Fall in Sales Quintile

0 5 10   20 Kilometers

Fall in Prices by Postcode District
London TTWA

Estimated Quality

- Top Fall in Prices Quintile
- Mid-High Fall in Prices Quintile
- Middle Fall in Prices Quintile
- Mid-Low Fall in Prices Quintile
- Bottom Fall in Prices Quintile

0 5 10   20 Kilometers

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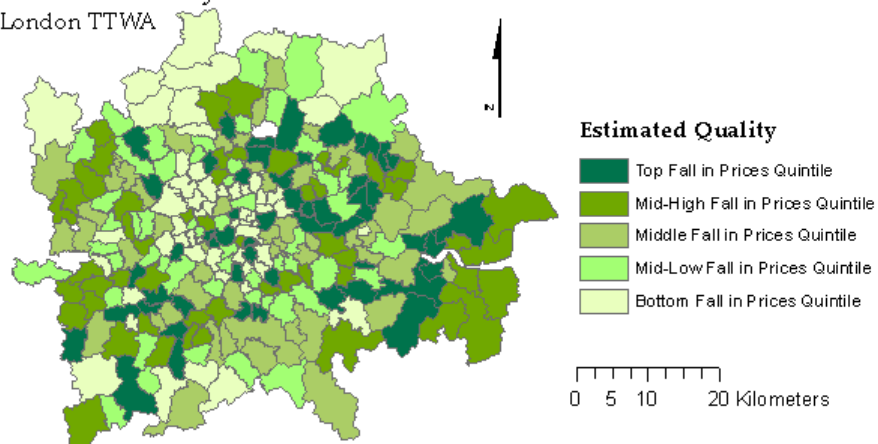
tain $\widehat{\mu}_j$ as proxies for quality in each group j. The estimation of only uses data on the benchmark period in order to avoid possible changes in relative prices after 2008.[9] For all PS-DT pairs having positive sales in 2007 and 2009 I compute the percent difference in mean prices between peak (2007) and trough (2009) as well as the difference in average yearly transactions between both years. Figure V plots these differences against the within-TTWA rank of estimated quality. I estimate bivariate kernel densities over the data and report their contour plots for ease of interpretation.

The change in prices is shown in the top panel. We can see that the change in prices was on average negative as expected, and that it was fairly homogeneous across qualities. The correlation on the kernel density estimate appears close to 0 or slightly positive. In order to further explore this I divide homes into high and low quality by splitting them with respect to the TTWA-specific median and estimate price indexes for each of these groups. After their peak in late 2007, prices fell for both groups to their lowest level in 2009. The fall was not quite symmetric, the index low homes fell by 18% while the one for high homes fell by 16%. Still, the difference is rather modest and masks substantial heterogeneity between cities.

Turning to transactions, the bottom panel of Figure V displays a visible positive correlation: the percentage drop in transactions was lower for homes higher up in the quality distribution with the correlation being roughly 17%. The pattern is observed consistently in the vast majority of TTWAs including the 10 largest ones. The fact that the number of transactions fell more for lower quality homes implies a change in composition: the fraction of total transactions corresponding to them was reduced after 2008.

Alternatively, I estimate the change in prices and transactions for different location-type groups by estimating the following specifications using OLS and data for years 2007 and 2009 only:

$$log(\overline{price})_{jt} = \beta_1^{price} rank_j + \beta_2^{price} rank_j \Delta Post_t + \eta_t^{price} + \epsilon_{jt}^{price}$$

$$trans_{jt} = \beta_1^{trans} rank_j + \beta_2^{trans} rank_j \Delta Post_t + \eta_t^{trans} + \epsilon_{jt}^{trans}$$

The dependent variables $log(\overline{price})_{jt}$ and $transactions_{jt}$ correspond to the logarithm of the mean price and the the number of transactions for group j

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[9]The period over which this proxy is estimated (benchmark, crisis or both) does not affect the results.

FIGURE V

CHANGE IN PRICES AND TRANSACTIONS BY QUALITY
Postcode Sector - Dwelling Type Pairs
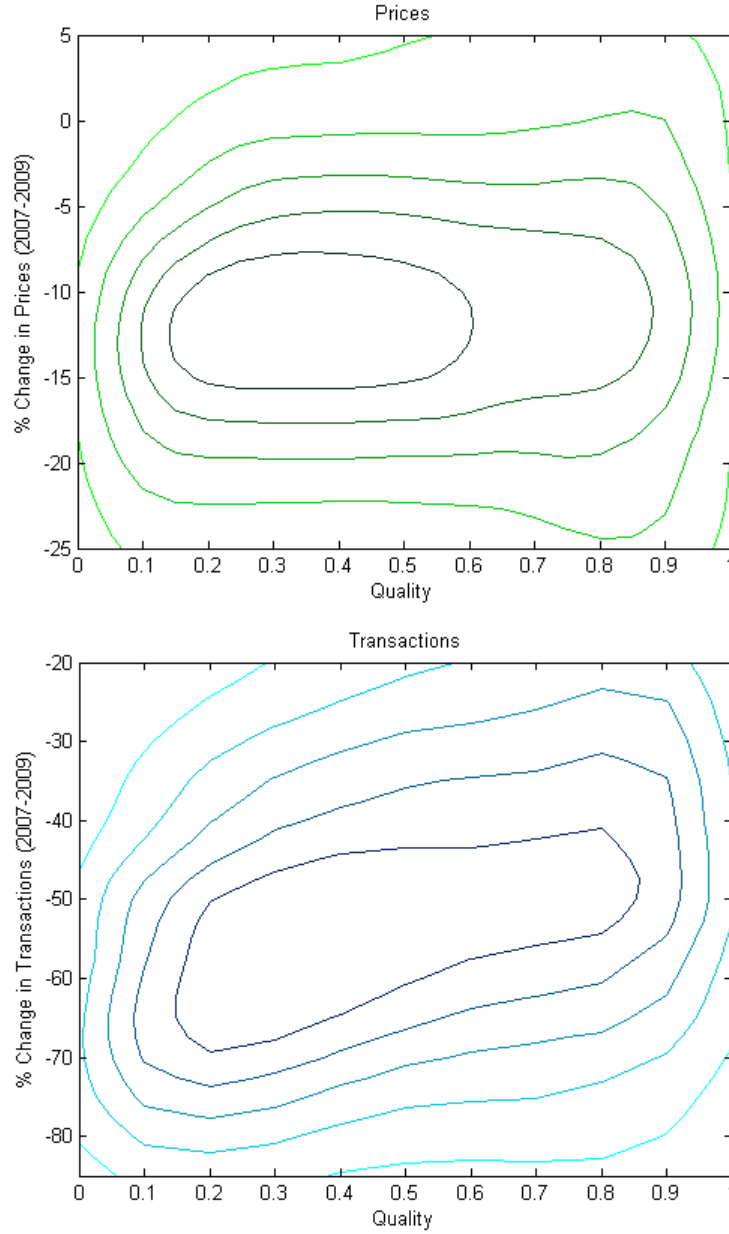
Top: plots the change in prices between 2007 and 2009 against the within-TTWA quality rank. Bottom: plots the change in yearly transactions between and 2009 periods against the within-TTWA quality rank. In both cases the unit is the postcode sector-dwelling type pairs with positive sales in both years. The figure plots the contour plot of an Normal kernel density estimate with bandwidth chosen according to Silverman's rule-of-thumb.

in year t, respectively.[10] In both cases the variables are normalized so that the relevant coefficient can be interpreted in terms of 2007 standard deviations of the dependent variable. Variable $Post_t$ is a dummy taking value 1 in 2009. The coefficients of interest in this context are β_2^{price} and β_2^{trans} which measure the respective changes in the slopes of the quality-price and quality-transactions relationships. Results from estimating these specifications are reported in Table II.

TABLE II

STYLIZED FACT - QUALITY ESTIMATED BY GROUPS

	(1) $log(\overline{price})$	(2) $log(\overline{price})$	(3) $trans$	(4) $trans$
Quality Rank*Post	0.0671***	0.0671***	0.498***	0.811***
	[0.0131]	[0.0185]	[0.0216]	[0.0346]
Quality Rank	3.180***		-0.546***	
	[0.0161]		[0.0337]	
Time Effects	Yes	Yes	Yes	Yes
Time TTWA Effects	Yes	Yes	Yes	Yes
Group Fixed Effects	No	Yes	No	Yes
Obs.	48442	48442	53067	53067

In columns 1 and 2 the dependent variable is the normalized logarithm of mean prices. The mean in prices is taken within each group and the normalization amounts to dividing the variable by the within TTWA standard deviation. In columns 3 and 4 the dependent variable is the logarithm of transactions plus one. Columns 1 and 3 are estimated via OLS including city-year dummies. Columns 2 and 4 are fixed effects panel regressions at the location-type level including city-year effects. Standard errors are clustered at the postcode district level.

The coefficients of interest β_2^{price} and β_2^{trans} are presented in the first row of Table II in specifications 1 through 3 and 4 through 6 respectively. We can see that in all cases the coefficients are positive and significant. A coefficient of 0.067 in column 3 indicates that the log price of homes of the highest quality increased there difference with the log price of homes of the lowest quality in 0.067 standard deviations after 2009. Meanwhile, the coefficient 0.811 in

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[10]The fact that I consider the log of prices and not the log of transactions is motivated by the fact that transactions is a count variable which often takes value 0. An alternative specification involving a transformation of log transactions variable to ensure it exists for 0 values yields similar results.

column 6 indicates that the number of transactions for homes of the highest quality increased their difference with the number of transactions in the lower end of the market in 0.811 standard deviations. Note that 0.811 is more than 10 times larger than 0.067 so while there was a slight increase in the difference in prices between the lower and higher ends of the market in 2009 the difference in transaction volumes between both groups changed much more. This is another expression of the stylized fact documented above. While the fall in prices between 2007 and 2009 was fairly similar for homes of different qualities transactions fell much more in the lower end of the market.

Other coefficients reported in Table II indicate that the specifications are also reproducing the broad facts in other dimensions. First, the time effect in columns 2 and 5 are strongly negative and significant, reproducing the fall in both prices and transactions between 2007 and 2009. Secondly, quality rank correlates strongly with prices in column 1.

4.2 Repeat-Sales

The second method used to estimate home qualities is inspired by the *repeat-sales* method proposed initially by Bailey, Muth and Nourse (1963) and popularized after Case and Shiller (1989). For this purpose I focus on the subsample of units which have been sold at least twice between 1995 and 2013. Having more than one sale allows me to estimate quality from historical selling prices at the home level. To do so I estimate $p_{it} = \pi_t^{TTWA} + \alpha_i + \xi_{it}$ by fixed effects to obtain an estimate for α_i. I next use this noisy estimates to compute deciles of the α_i distribution for each TTWA and classify homes using these estimated deciles. Finally, I compute the change in transactions and prices for each of these groups. Results are presented in Figure VI.

The results are qualitatively the same as those obtained estimating quality using postcode sector-dwelling type groups. The peak-trough change in prices across the quality distribution (pictured on the top panel) shows no clear pattern and is fairly homogeneous. On the other hand, transactions (pictured on the bottom panel) fell more for relatively lower quality homes, confirming the change in composition discussed above. In addition, this shift is present in the overwhelming majority of TTWAs.

Both methods yield similar result so I conclude that during the crisis transaction volumes where on average lower for low quality homes. But was this specific to the changes in demand and supply between 2007 and 2009? To answer this question I construct a panel of PS-DT pairs at the quarterly fre-

Figure VI

Change in Prices and Transactions by Quality
Repeat-Sales Method
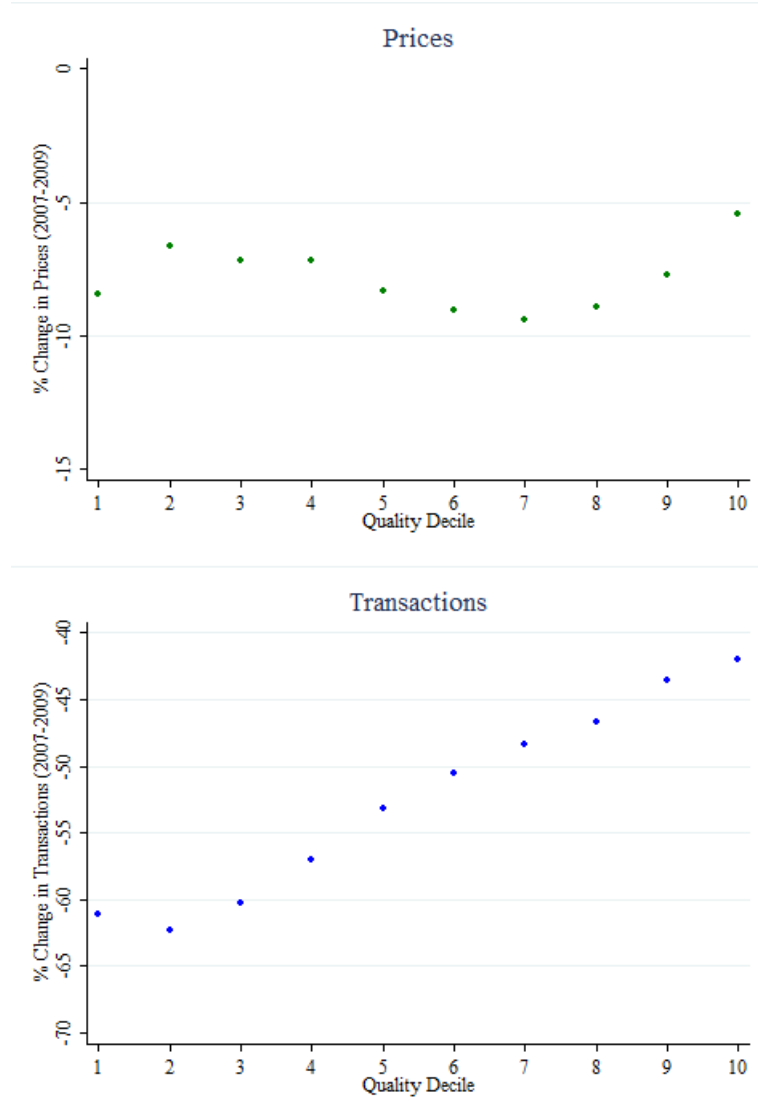
Top: Change in average prices between Q4 2007 and Q2 2009 (peak and trough of the aggregate price index series) for within-TTWA quality deciles. Bottom: Average change in yearly transactions between the benchmark (1995-2007) and crisis (2008-2013) periods for within-TTWA quality deciles. Quality estimated at the level of individual homes in the repeat-sales sample.

FIGURE VII

CORRELATION BETWEEN QUALITY AND TRANSACTIONS
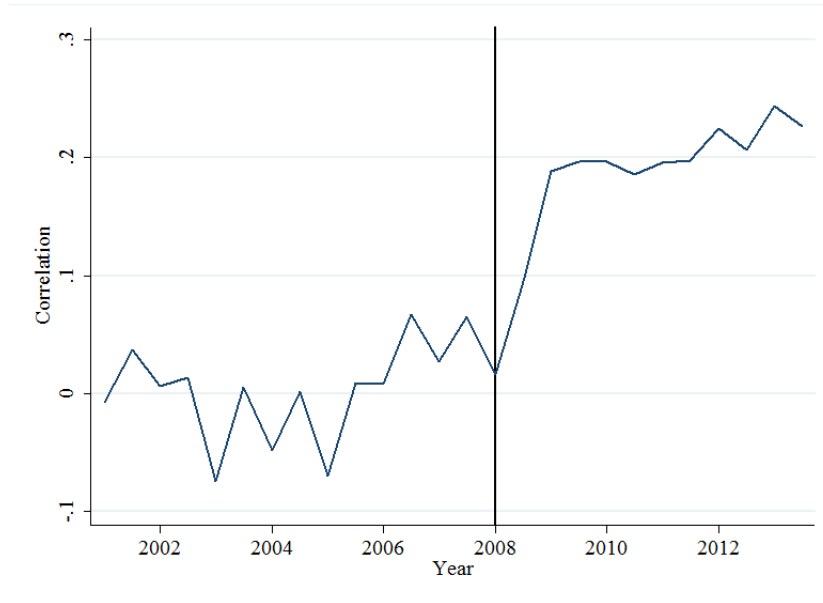
Plot of the cross-sectional correlation between estimated quality and the number of transactions for each semester between 2000 and 2013. Units are the 36,085 PS-DT pairs with positive sales in the 1997-2007 period.

quency. For each pair I estimate quality using the method outlined above and then I calculate the correlation between quality and the number of transactions for every quarter. The correlations are plotted in figure VII.

We can see that over the 2000-2007 period, the correlation between quality of traded homes and transactions was relatively stable around 0. We can clearly see that correlations increase abruptly in late 2008 and oscillated around -0.025 thereafter. The timing of this shift largely coincides with the change in borrowing conditions in UK credit markets. While, admittedly, this time-series evidence is not conclusive, it is consistent with the hypothesis that the stylized fact was related to the increase in LTVs.

5 Robustness

In this section I discuss the robustness of the empirical analysis in the previous section. First, I show that my estimates of quality are stable over time: a home which has a high estimated quality in one period is very likely to have a high price when sold again, which amounts to validating my quality mea-

sures. Next, I restrict my definition of quality to dwelling type and compare the highest quality type (detached homes) with the lowest quality type (terraced homes). Studying how these homes fared during the crisis confirms the results obtained for more refined definitions of quality. Finally, I report that the findings above are robust to the inclusion of leaseholds and new-builds in the dataset.

Quality is defined above as a fixed attribute of a home. However, it is clear that the price a home may seek in the market at different times may differ substantially. It be remodelled or upgraded, its neighbourhood may change its composition, become gentrified or enter a phase of decay. Hence, the assumption that quality is (approximately) fixed is not trivial. In order to evaluate whether it is adequate I compute quality estimates for the same home for different time periods. I then check whether these estimates fall in similar places of the cross sectional quality distribution.

In the case of my *hedonic* method I estimate quality for Postcode Sector-Dwelling type pairs for three time periods: 1998-2002, 2003-2007 and 2008-2012. Next I construct diagrams comparing quality estimates in these periods. Results are presented in Figure VIII. They show the rank correlation plots for estimated qualities for estimated in 2003-2007 and 1998-2002 (top-left), 2008-2012 and 2003-2007 (top-right), and 2008-2012 and 1998-2002 (bottom). In all cases the estimated correlation is larger than 0.9. This indicates that qualities estimated using this method are stable and that the assumption of fixed quality is reasonable for the period under consideration.

A similar analysis can be performed for the repeat-sales method. Given that in this case the method requires that a home is sold at least twice to obtain an estimate of its quality I consider estimated qualities obtained over only two periods: (1998-2005) and (2006-2013). The correlation between quality ranks is again high (0.90) and I interpret this as validating my repeat-sales method.

In order to show the salience of the stylized fact in Section 4 I now consider a much simpler definition of quality: dwelling type. Detached and Terraced homes combined amounted to over 65% of all transacted dwellings since 2000. These types have, respectively, the highest and lowest average prices in most markets. I consider these two groups of homes and track the evolution of their share of total sales volumes as well as their prices.

Results are presented in Figure IX. In the left panel we can see that the price indices for both dwelling types followed each other quite closely after the beginning of 2008. Terraced homes prices fell by 15.1% between late 2007 and mid 2009. The price drop for detached homes was slightly more modest

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FIGURE VIII

QUALITY RANK CORRELATIONS
Postcode Sector - Dwelling Type Pairs
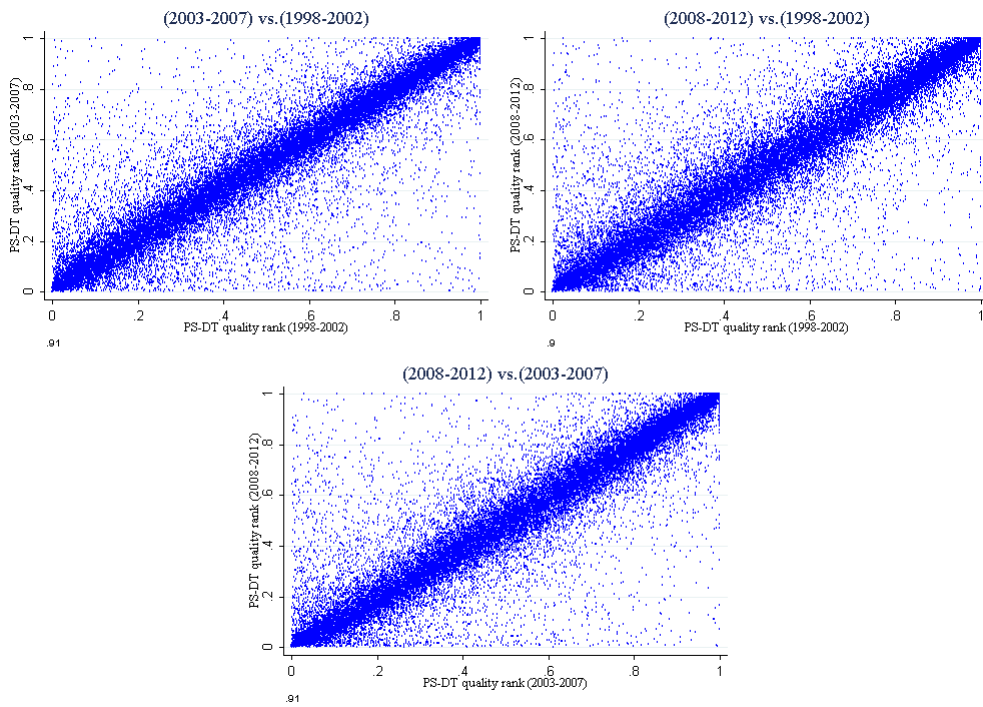
Rank correlation plots of the quality estimates for periods (1998-2002), (2003-2007) and (2008-2012). Qualities estimated estimated at the level of PS-DT pairs. Top-Left: Rank correlation plot for quality estimated in (2003-2007) and (1998-2002). Top-Right: Rank correlation plot for quality estimated in (2008-2012) and (2003-2007). Bottom: Rank correlation plot for quality estimated in (2008-2012) and (1998-2002).

FIGURE IX

DETACHED AND TERRACED HOMES
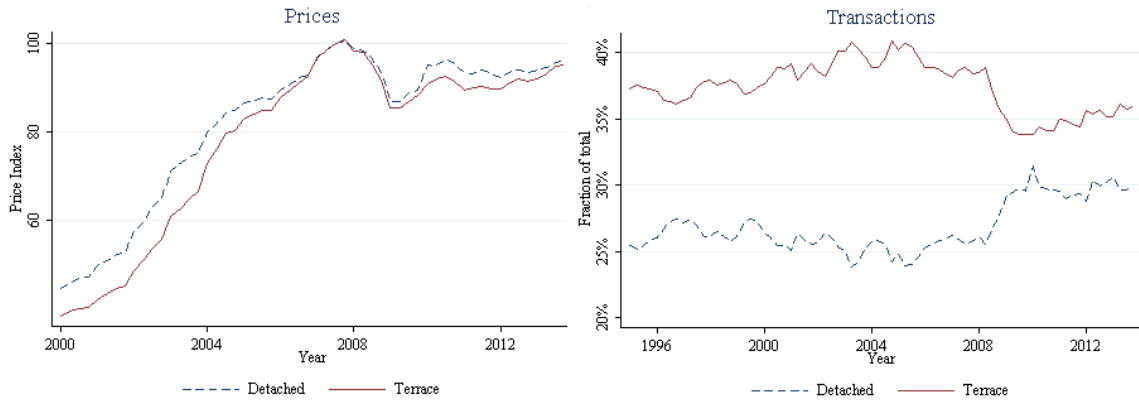
Left: Evolution of prices for detached and Terraced homes. Normalized to 100 at Q1 2008. Price indices constructed using repeat-sales methodology. Right: Fraction of total transactions corresponding to detached and terraced homes.

FIGURE X

INCLUDING NEWBUILDS AND LEASEHOLDS
Postcode Sector - Dwelling Type Pairs
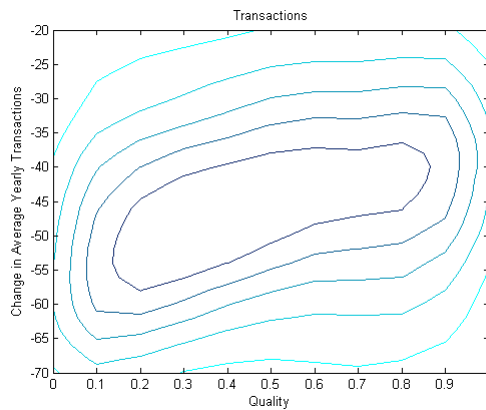
Plot of the change in yearly transactions between 2007 and 2009 periods against the within-TTWA quality rank. The unit in both cases is the postcode sector-dwelling type pair. The figure plots the contour plot of an Normal kernel density estimate with bandwidth chosen according to Silverman's rule-of-thumb. Leaseholds and newbuilds included.

(13.6%). This change is similar to the one documented above for more precise definitions of quality. Regarding transactions (right panel), the fraction of sales corresponding to each type changed abruptly during 2008. Detached homes increased their share of total sales by four percentage points, roughly the decrease in the fraction corresponding to terraced dwellings. Again, this is consistent with the differential fall in transactions documented in Section 4.

In my transactions sample I have excluded information on newbuilds and leashold transactions. Given that leasehold records do not include the lease term, I cannot use information on prices to construct the quality proxies. In the case of newbuilds, all information can be used. Figure X is analogous to the plot presented in the bottom panel of Figure V but including these two types of transactions. As we can see, the qualitative picture is the same: average yearly transactions after 2008 fell more for relatively lower quality homes.

6 Model: Housing Ladder, Credit Constraints and Renting

In this section I present an overlapping generations model of the housing ladder that reproduces the observations discussed above. In the model, tighter credit constraints lead to a different composition of sales and a larger stock of households living as renters. I show how including the possibility of buy-to-let and let-to-buy can provide scope for changes in the composition of transacted homes.[11]

The analysis is restricted to comparative statics around steady state values for transaction volumes and renting. This suffices to emphasize the pricing out of young buyers by older households mainly through the let-to-buy channel, a phenomenon that has been labelled by the press as the emergence of 'accidental landlords'. Given that transition dynamics are ignored, the effect of lock-in on indebted households (a mechanism emphasized in Stein (1995) or Ortalo-Magne and Rady (2006)) is not included in the model. However, the role of lock-in in affecting the composition of sales is discussed in Section 8.

Depending on parameter values the model can accommodate several different lifetime tenure transitions. Below, I consider a particular configuration in which i) the poorest young agents live with their parents ii) the richest

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[11]Recall a *but-to-let* transaction happens when an agent buys a low type home as an investment. *Let-to-buy* happens when an agent trades up the ladder and rents out the low home where she resided when young.

young agents live in high quality homes iii) old households who lived with their parents when young are renters when old, iv) only old households can be landlords. This configuration contains both but-to-let and let-to-buy. In addition, it is broadly consistent with lifetime tenure transitions and of home ownership by age.

6.1 Setup

Consider an overlapping generations economy in which agents live for two periods. Every period a mass 1 of households is born and a mass 1 of households dies, so at the end of each period population is constant and equal to 2. There is a fixed stock of housing units $\overline{S} = S_L + S_H$ with S_L and S_H being the stock of low and high type dwellings respectively. Below I assume $\overline{S} < 2$ which ensures positive rental prices. Households have preferences over housing and consumption. Their lifetime utility function is given by:

$$u(c,h) = (c_y + \beta c_o)h_o h_y$$

Consumption when young is given by c_y and consumption when old by c_o, the consumption good being the numeraire ($p_c = 1$). Utility depends on housing through h_y and h_o which take values ϕ when living with the parents, 1 when living in a type L home and ψ when living in a type H home, with $\phi < 1 < \psi$. Second period consumption is discounted by factor β. Households have an exogenous source of income e_i which they receive every period. Incomes are heterogeneous with $e_i \sim G(e)$ within cohorts with $G(e)$ continuous with positive support in an interval $[e_L, e_H]$. Income can be used for consumption, to buy homes or to pay for rent.

All households are born without a home. They can buy one in the property market by paying a price determined endogenously in equilibrium. Prices for low and high homes in period t are respectively P_L^t and P_L^t. After buying a home, households can enjoy the utility of residing there as owner-occupiers. Alternatively, they can act as landlords and rent out a low type home they own in exchange for a rent R^t.[12] Households who do not own a dwelling can become tenants and reside in a low type home for one period by paying rent. For simplicity, no household can own more that two homes at a time and only one home can be bought per period.

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[12]For simplicity, only low type homes can be rented. This simplification is justified by the fact that the bulk of renting is concentrated in cheap homes: more than two third of rented homes had values below the median in 2008 (source: English Housing Survey).

When buying a dwelling households can borrow at the exogenous interest rate r which is also the rate paid for savings. I assume that assume $r \leq \frac{1-\beta}{\beta}$. Credit constraints in the model through an exogenous borrowing limit: agents can borrow up to γ units so that buying a home of type j requires a down-payment $P_t^j - \gamma$. There is no default on debt.[13]

Timing is as follows. i) At the beginning of any period t, a mass 1 of households is born, ii) households born at t and $t-1$ receive income e_i, iii) the housing market opens. Agents born at t and $t-1$ can either buy, sell or rent a home, agents who where born in $t-2$ can sell their homes, iv) agents born at $t-2$ choose c_o and die, iv) h_y and h_o accrue for agents born at t and $t-1$ respectively, given their residence. iv) young households choose c_y and the period ends.

Note that at the beginning of each period agents born at $t-2$, $t-1$ and t coexist. Nonetheless, agents born at $t-2$ limit themselves to selling in the housing market before passing away so the effective demand for housing will have mass 2. Agents can save between periods at interest rate r.

In this context households solve their inter-temporal optimization problem choosing residence, whether to buy a second home and consumption. Preferences shown above, I can assume without loss of generality that $c_y = 0$. As a consequence, all consumption takes place immediately before exiting. While this is an unrealistic prediction for lifetime consumption, it greatly simplifies the analysis and ensures that proofs can be obtained analytically. This simplification of inter-temporal consumption choices is also present in Ortalo-Magne and Rady (2006).

I will restrict my attention to comparing steady states with different values of γ such that:

$$P_L^t = P_L, P_H^t = P_H \ and \ R^t = R \quad \forall t$$

Steady-States

As argued above, I restrict my attention to allocations of the form presented in Figure XI.

The relevant thresholds determining housing tenure decisions are given by

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[13]See Banerjee and Newman (1993) for a micro-foundation. The additive constraint implies that a reduction in credit has a stronger effect on borrowing capacity for young buyers who have low wealth and, on the margin, a larger loan to wealth ratio.

FIGURE XI

EQUILIBRIUM CONFIGURATION

Age 1

$\emptyset$ R L H

e_L θ_R^y θ_L^y θ_H^y e_H

Age 2

R L H HL

e_L θ_L^o θ_H^o θ_{HL}^o e_H
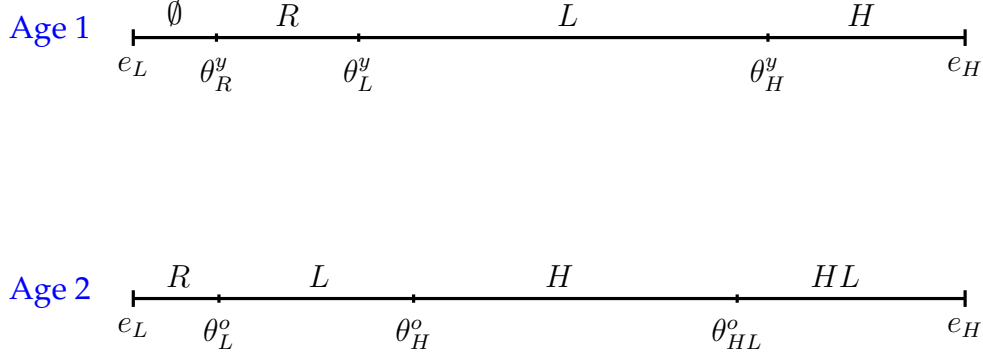
θ s. Notation is as follows: θ_L^y is the threshold which over which young agents can afford a low home. Likewise, θ_{HL}^o is the threshold over which old agents can afford both a high and a low home.

Young households live with their parents if their income is below a threshold θ_R^y. This threshold is determined by the trade off between foregone consumption from paying rent and the extra utility derived from residing in a type L home. Its closed form solution (see Appendix 1) is:

$$\theta_R^y = \frac{(2+r) - \phi}{(2+r)(1-\phi)} R$$

Note that some agents who would be able to afford a rent ($e_i \geq R$) choose not to do so in order not to forgo consumption.[14] This threshold does not depend directly on prices of high or low type homes and will determine the rental rate as long as the rental market exists (see below).

Young households rent if $\theta_R^y < e_i < \theta_L^y$. Threshold θ_L^y is determined solely by affordability as long as home ownership is worth the lost interest income ($rP_L < (1+r)R$). This implies that $\theta_L^y = P_L - \gamma$. Note that if $P_L < \gamma$ all agents would be able to buy a low type home and, given that $\overline{S} < 2$, the market would not clear. Likewise, if $P_L - \gamma < R$ no agents would rent.

Finally, threshold θ_H^y determines which households buy a high home when young. It can be determined either by the credit constraint or by the trade-off between the lost interest income and the extra utility from residing in a high type home. As argued in Appendix 1, for high values of ψ the affordability constraint is binding for the marginal agent so that $\theta_H^y = P_H - \gamma$.

---

[14]To see this note that for positive values of ϕ and r $\frac{(2+r) - \phi}{(2+r)(1-\phi)} > 1$ so $\theta_R^y > R$

Given these threshold values it is straightforward to note that period 1 demands are given by:

$$D_1^R = G(\theta_L^y) - G(\theta_R^y)$$
$$D_1^L = G(\theta_H^y) - G(\theta_L^y)$$
$$D_1^H = 1 - G(\theta_H^y)$$

The case of housing demands for agents born in $t - 1$ is slightly different because accumulated wealth is larger for these agents and all thresholds depend on previous choices. The thresholds θ_L^o, θ_H^o and θ_{HL}^o, are determined by the second period credit constraint. The required down-payments are $P_L - \gamma$, $P_H - \gamma$ and $P_H + P_L - \gamma$ for agents owning a low type home, a high type home and both a low and a high type home, respectively. Given these deposit requirements and previous period choices, the relevant thresholds θ_L^o, θ_H^o and θ_{HL}^o are determined (see Appendix 1). The demands for renting and owner occupation at age 2 will then be given by:

$$D_2^R = G(\theta_L^o)$$

$$D_2^L = G(\theta_H^o) - G(\theta_L^o)$$
$$D_2^H = 1 - G(\theta_H^o)$$

Rent supply is given by agents born at $t - 1$ that own two homes at time t. Given the thresholds above, rent supply is given by: $S^R = 1 - G(\theta_{HL}^o)$.

Equilibrium conditions are given by market clearing in the L and H markets together with the condition that the number of agents living with their parents is equal to the difference between the population and the number of homes.

$$D_1^L + D_2^L + S^R = S_L$$

$$D_1^H + D_2^H = S_H$$
$$G(\theta_R^y) = 2 - S_L - S_H$$

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The third equation pins down R in terms of model parameters. Renting does not depend on credit constraints and is pinned down by a market clearing condition: the number of agents living with their parents must be equal to the difference between population and the housing stock $2 - S_L - S_H$. The marginal agent is indifferent between renting and not renting, agents with higher e_i rent.

Re-writing the market clearing conditions for high and low type homes in terms of the relevant thresholds we are left with:

$$G(\theta_H^y) - G(\theta_L^y) + G(\theta_H^o) - G(\theta_L^o) + 1 - G(\theta_{HL}^o) = S_L \tag{1}$$

$$1 - G(\theta_H^y) + 1 - G(\theta_H^o) = S_H \tag{2}$$

It is clear from these equations that no closed form solution for prices and transaction volumes can be obtained unless distribution $G(.)$ is replaced for a suitable cdf. Nonetheless, some of the stylized facts presented in sections 3 and 4 can be obtained for a general distribution function. These results are summarized in proposition 1.

Proposition 1

In configurations characterized by $\theta_R^y < \theta_L^o < \theta_L^y < \theta_H^o < \theta_{HL}^o < \theta_H^y$, steady states with lower γ have i) lower values of $tr_L - tr_H$ and ii) higher values of S^R.

Both statements in Proposition 1 are related. Transactions of low type homes every period are given by purchases by first-time buyers, purchases by agents born in $t - 1$ who rented when young and purchases by let-to-buy landlords. Adding the mass in each of these groups I can write transactions of low homes in steady state as $tr_L = 1 - G(\theta_L^o)^{15}$. Likewise the number of transactions for high type homes is $tr_H = 1 - G(\theta_{HL}^o)$. The first statement of Proposition 1 requires that:

$$\frac{dtr_L}{d\gamma} > \frac{dtr_H}{d\gamma}$$

The mass of renters is equal to the supply of rental housing in equilibrium S^R so that the second statement of Proposition 1 requires $\dfrac{dS^R}{d\gamma} < 0$.

---

[15]Note that purchases by first-time buyers are $(G(\theta_H^y) - G(\theta_L^y))$, purchases by agents born in $t-1$ who rented when young are $(G(\theta_L^y))$ and purchases by let-to-buy landlords are $(1-G(\theta_H^y))$

The proof proceeds by contradiction after substituting the thresholds values for the expressions presented above and deriving the equilibrium conditions with respect to γ (see Appendix 1).

Intuitively, a higher borrowing limit implies higher prices in the low market while leaving rents unaffected. As a result the number of old households able to buy a low type home as an investment decreases. Insofar as $\dfrac{dP_L}{d\gamma} < 1$, an increase in γ reduces the stock of renters. Transactions of low type homes increase with loose credit as less households retain their homes when trading up.

The opposite happens with tighter credit. Prices for low type homes P_L are lower as young, low income agents are unable to meet down-payment constraints. Given that rents do not depend on γ and that prices are lower, more old agents are able to buy two homes and rent one out. This happens through increases in let-to-buy transitions and reduces tr_L.

A corollary implicit in the argument above is that, in steady states with tighter credit, let-to-buy becomes relatively more important than buy-to-let.
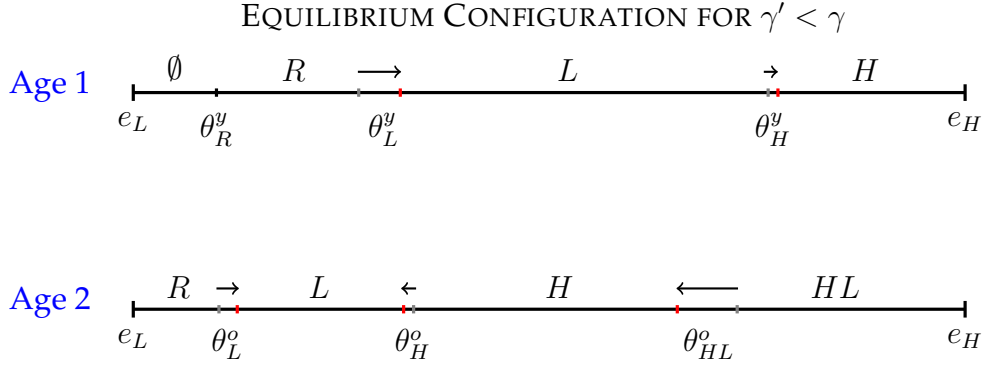
Corollary

In steady states with tighter credit the mass of buy-to-let landlords is lower and the mass of let-to-buy landlords higher.

Define btl as the mass of households who became landlords through buy-to-let and ltb as the mass of households who became landlords through let-to-buy. The proof of this Corollary requires showing that $\dfrac{dbtl}{d\gamma} > 0$ and $\dfrac{dltb}{d\gamma} < 0$. As before, the proof proceeds by contradiction using equations (1) and (2) (see Appendix 1). The Corollary is important because it solves the puzzle of increased renting in a context of strong decreases in buy-to-let lending observed over the past few years in the UK. Moreover, it yields some of the testable implications presented below (see Section 7).

To sum up, the simple model with credit constraints matches observed changes in the UK housing market after credit tightening during 2008: an increase in the number of renters, a change in the composition of home sales, a decrease in buy-to-let and an increase in let-to-buy. The change in steady state allocations of homes is illustrated in Figure XII.

The next section presents evidence in support of this mechanism. Section 8

FIGURE XII

EQUILIBRIUM CONFIGURATION FOR $\gamma' < \gamma$

Age 1

$\emptyset \qquad R \quad \longrightarrow \qquad L \qquad\qquad \rightarrow \quad H$

$e_L \qquad \theta_R^y \qquad\quad \theta_L^y \qquad\qquad\qquad \theta_H^y \qquad\quad e_H$

Age 2

$R \quad \rightarrow \quad L \quad \leftarrow \quad H \quad \longleftarrow \quad HL$

$e_L \qquad \theta_L^o \qquad\quad \theta_H^o \qquad\qquad \theta_{HL}^o \qquad\quad e_H$

tests alternative explanations that could potentially generate predictions similar to those delivered by the model.

7 Supporting Evidence

In the model, credit tightening increases renting by the young. These agents are priced out of the ownership market by older/wealthier households who keep their homes when trading up. In this section I present evidence in support of this mechanism. On the first place, I show that the reduction in transaction volumes was stronger in areas where renting increased. This indicates that the rise in the number of rented dwellings was not supplied through increases in buy-to-let but rather through let-and-buy transitions. Moreover, as predicted by the model, buy-to let lending decreased significantly during 2008. Secondly, I show that there was also an age pattern in the fall in transactions with sales falling more in relatively young neighbourhoods. This reinforces the idea that it was homes typically bought by FTBs that experienced the strongest reduction in trades.

Finally, I show that the decrease in the correlation between transactions and renting on the one hand and the increase in the correlation between age and transactions on the other both appeared during late 2008 and early 2009, coinciding with the change in LTVs.

Evidence from the Rental Market

The evolution of the fraction of people living as renters is illustrated in the left panel of Figure XIII. This fraction increased from 12.8% in 2008 to 16.4% in 2012. In light of the proposition stated above I interpret this change as a

FIGURE XIII

RENTAL MARKET
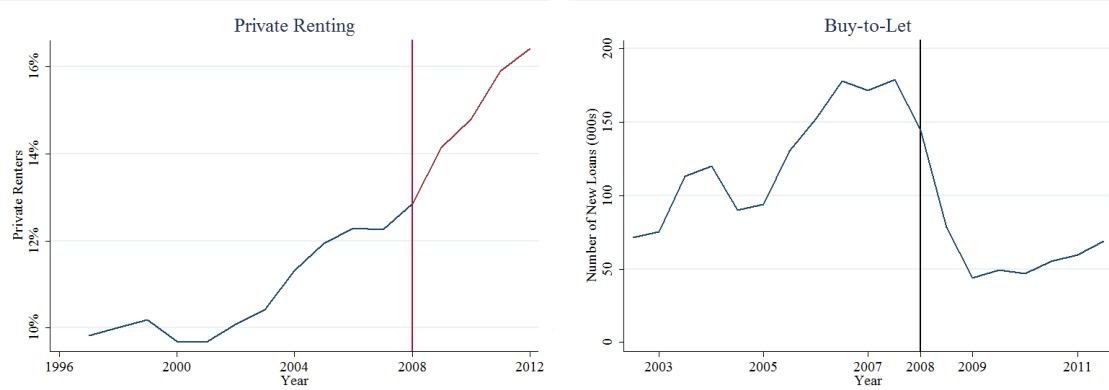
Left: Percentage of homes occupied through private rental. Vertical line corresponds to 2008. Source: English Housing Survey. Right: Number of buy-to-let loans (in thousands) distributed to UK households over the 2003-2012 period. Source: CML.

consequence of the tightening of credit conditions. But where did this extra supply of rented homes come from? As shown in the right panel of Figure XIII, the number of buy-to-let loans dropped abruptly after 2007. Hence, it is unlikely that buy-to-let could provide the supply to house the new renting households.

The Corollary presented in section 6 provides a clear answer to this question. In the model, buy-to-let is lower when credit is tighter, a prediction broadly consistent with the data. The extra supply of rental homes in steady states with tighter credit comes from increases in let-to-buy; old households keeping their previous home when trading up. This yields a testable prediction: in areas where renting increased more, transactions should have experienced a larger fall. It is straightforward to test this prediction.

In the 2001 and 2011 censuses UK households were asked about their current housing tenure. This information is available at the LSOA level and it divides homes into owner-occupiers, social renters and private renters. I use this information to compute the increase in the fraction of private renters over the 2001-2011 period. Given that my model predicts more renting through let-to-buy transitions in steady states with tighter credit, I expect the increase in renting between 2001 and 2011 to be negatively correlated with transactions.[16]

---

[16]As shown in Section 3, most of the increase in renting over this period took place after 2008. Moreover, the increase in renting between 2002 and 2008 was mainly fuelled by purchases by buy-to-let investors which should not have a negative effect on transactions.

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FIGURE XIV

CHANGE IN RENTING AND THE FALL IN TRANSACTIONS

The figure plots the drop in average yearly transactions at the LSOA level in the vertical axis against the increase in the fraction of renters over total households between 2001 and 2011 in the horizontal axis. 29,942 LSOAs in total. The slope of the fitted linear equation is -1.05 and is significant at conventional levels. An increase of one standard deviation in Δ renting implies a decrease of 0.34 standard deviations in the change in transactions.

The corresponding scatter plot is presented in Figure XIV.

While this is suggestive of the mechanism outlined above it may be a consequence of the fact that renting is concentrated in areas with low quality housing. In order to estimate the sign of this correlation after controlling for other factors I consider the following specification:

$$\Delta trans_j = \beta_1 \Delta Rent_j + BX_j + \epsilon_j$$

Where $\Delta trans_j$ is the proportional change in transactions between the benchmark and crisis periods in LSOA j, $\Delta Rent_j$ is the increase in the fraction of renters in the crisis period and X_j is a vector of controls. The controls may include the estimated home quality at the LSOA level, the change in the number of benefit claimants (a measure of deprivation in the area) and the change in job seekers during the crisis as well as TTWA fixed effects.

The resulting estimates are presented in Table III. Across specifications we observe that the coefficient on $\Delta Rent_j$ is negative and significant. The second

TABLE III

CHANGE IN RENTING AND TRANSACTIONS

	(1)	(2)	(3)	(4)
	$\Delta trans_{jt}$	$\Delta trans_{jt}$	$\Delta trans_{jt}$	$\Delta trans_{jt}$
Δ Renters	-0.336***	-0.263***	-0.267***	-0.204***
	[0.00607]	[0.00587]	[0.00629]	[0.00683]
$Quality$		0.342***	0.348***	0.425***
		[0.00590]	[0.00597]	[0.00779]
Δ Claimants			0.0104	0.000744
			[0.00665]	[0.00699]
Δ Seekers			0.0328***	0.0420***
			[0.00533]	[0.00576]
TTWA Effects	N	N	N	Y
R^2	0.134	0.263	0.265	0.326
Obs.	33003	33003	33003	33003

Standard errors robust to heteroskedasticity. The unit of observation is the Lower Super Output Area (LSOA). Dependent variable is the change in transactions between the benchmark (in this case (2001-2007)) and crisis (2008-2013) period. Variable Δ Renters is the difference in the ratio of renters over total households between the 2001 and 2011 censuses. $Quality$ is an estimate of quality at the LSOA level. Δ claim is the proportional change in the number of benefit claimants in the LSOA. All variables normalized to have a standard deviation equal to 1.

FIGURE XV

Δ RENTING AND TRANSACTIONS
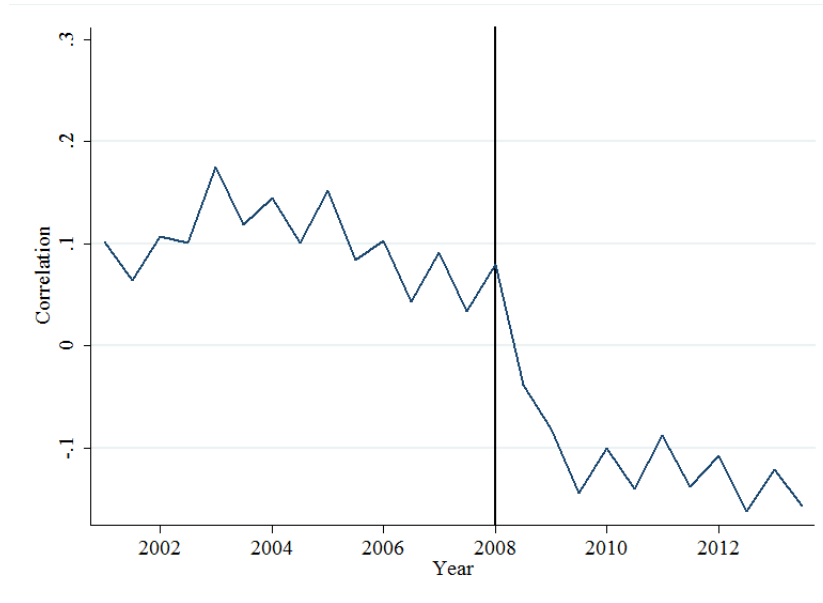
Plot of the cross-sectional correlations between the difference in the fraction of renters and the number of transactions for each semester between 2000 and 2013. Units are the 36,085 PS-DT pairs with positive sales in the benchmark period.

column controls for quality, the third adds changes in economic conditions in the area and the fourth includes metropolitan area effects. Coefficients show that increase of one standard deviation in the fraction of households renting implies a reduction in transactions of over 0.2 standard deviations in all columns. This confirms the robustness of the correlation reported in XIV.

While this correlation is suggestive, it is only consistent with the proposed explanation if it arises after 2008, when credit tightening took place. In order to test this I calculate the cross sectional correlations between the $\Delta Rent_j$ and $trans_j$ for every semester between 2001 and 2011. The correlations are plotted in figure XV. As we can see the change in sign of the correlation takes place during 2008, coinciding with credit tightening.

Transactions and Household Age

Young households move to neighbourhoods where other young people live in search for lower prices but also adequate local amenities, quality schooling,

etc.[17]   While the model in section 6 does not explicitly distinguish between young and old neighbourhoods it does predict less transactions by the young. In this section I analyse how transactions and prices changed across areas populated by different age groups.

For this purpose I use population and age structure data from the Office of National Statistics disaggregated at the Lower Super Output Area Level (see Section 2. This allows me to know the fraction of population by age for all the LSOAs in England and Whales. I combine this information with my transactions dataset to check if the drop in transactions and prices had an age profile.

The results are illustrated in Figures XVI. Figure XVI plots the change in average yearly transactions against the mean adult (over 25) population for each LSOA. The upward sloping pattern is clear: transactions dropped less in areas populated by older households with a correlation of 0.4.

In order to estimate the robustness of this correlation to other factors I consider the following specification:

$$\Delta trans_j = \beta_1 \overline{Age} + BX_j + \epsilon_j$$

Where $\Delta trans_j$ is the proportional change in transactions between the benchmark and crisis periods in LSOA j, $\overline{Age}$ is the mean age in the LSOA taken over 2001 and 2007 period and X_j is a vector of controls defined as in the previous subsection.

The resulting estimates are presented in Table IV. Across specifications we observe that the coefficient on $\overline{Age}$ is positive and significant. The second column controls for quality, the third adds changes in economic conditions in the area and the fourth includes metropolitan area effects. Coefficients show that areas with a one standard deviation higher mean adult age have roughly a third of a standard deviation more transactions during the crisis and confirms the robustness of the correlation reported in XVI.

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[17]The high persistence of average age the LSOA level is evidence of this. LSOAs experienced a median change in the average age of their residents of only -0.1 between 2001 and 2011 with 90% of changing by less than 3 years. The same picture emerges when focusing on young households only. This persistence imply that the young move with the young (and the old with the old) on average.

TABLE IV

MEAN AGE AND THE CHANGE IN TRANSACTIONS

	(1)	(2)	(3)	(4)
	$\Delta trans_{jt}$	$\Delta trans_{jt}$	$\Delta trans_{jt}$	$\Delta trans_{jt}$
$\overline{Age}$	0.348***	0.316***	0.320***	0.281***
	[0.00596]	[0.00572]	[0.00593]	[0.00694]
$Quality$		0.361***	0.363***	0.387***
		[0.00706]	[0.00711]	[0.00985]
Δ Claimants			0.0287***	0.0117
			[0.00733]	[0.00785]
Δ Seekers			0.00816	0.0183***
			[0.00545]	[0.00589]
TTWA Effects	N	N	N	Y
R^2	0.125	0.258	0.259	0.303
Obs.	33444	33444	33444	33444

Standard errors robust to heteroskedasticity. The unit of observation is the Lower Super Output Area (LSOA). Dependent variable is the change in transactions between the benchmark (in this case (2001-2007)) and crisis (2008-2013) period. Variable $\overline{Age}$ is the mean age in the LSOA taken over 2001 and 2007 period. $Quality$ is an estimate of quality at th LSOA level. Δ Claimants and Δ Seekers are the proportional change in the number of benefit claimants and job seekers at the LSOA level, respectively.

FIGURE XVI

DIFFERENCE IN TRANSACTIONS BY LSOA MEAN AGE
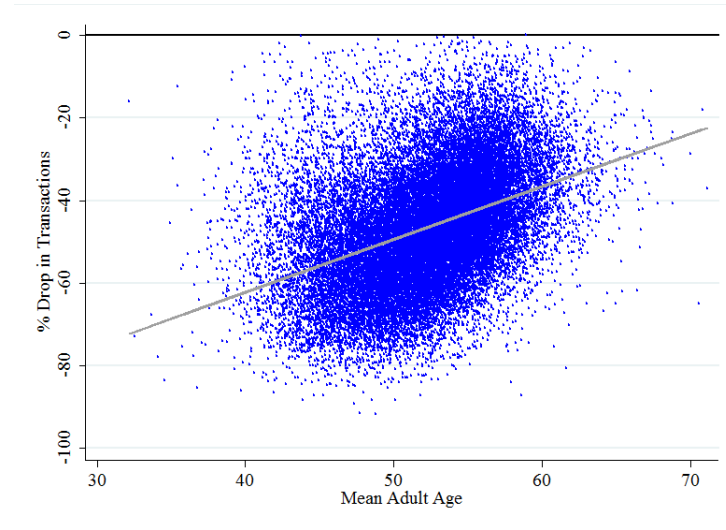
The figure plots the average change in yearly transactions between benchmark (1995-2007) and crisis periods (2008-2013) in the vertical axis and the mean adult age at the Lower Super Output Area level. Adults are defined as individuals of age above 25. The slope of the fitted linear equation is 1.27 and significant at conventional levels.

8 Alternative Explanations

This section discusses alternative explanations which could also account for increased renting and the change in the composition of home sales. First, I consider internal migration (within and between regions) as an alternative source of changes in composition. To explore this possibility I use internal migration data at the district level on moves from the Office for National Statistics. While internal migration fell in most markets, I find no evidence that this fall was skewed towards moves between cheaper districts.

Another possible source of the change in composition could be related to nominal loss aversion or negative equity of households facing a fall in home prices. Nonetheless, I show that excluding from the sample homes sold between 2005 and 2007 (those whose values are more prone to be under their previous selling prices during the crisis) does not change qualitative results.

Evidence from Best and Kleven (2013) shows that the stamp duty holiday decreed in September 2008 by the British government could have an effect on the composition of transactions. To study whether this is driving the change in the distribution of transactions I drop from my sample the period 2008-2009

in which the stamp duty holiday was in place. Comparing the benchmark period distribution with the distribution of sales in 2010-2013 the qualitative results are preserved.

Internal Migration

In the model, transactions are treated as steps in a ladder, with an upward life-cycle trajectory. But real transactions may also be driven by geographical moves whether between or within a region. This type of transitions have sometimes been emphasized by the literature about the interaction between housing and labour markets (see Head and Lloyd-Ellis (2012), Rupert and Wasmer (2012), Nenov (2012) and the references therein). These moves are horizontal rather than vertical in the sense that there is no obvious price ordering of different types of homes. In such cases, transactions are driven by moves between regional markets or moves within a market to reduce commuting distance.

With the 2008/2009 recession and the ensuing increase in unemployment, internal mobility rates in the UK decreased. This could, by itself, generate a change in the composition of transactions solely through changes in labour market conditions. Moreover, job market prospects for young, low income households suffered the most during the recession. If this change in job market conditions translated into less moves between cheaper areas it will have decreased housing transactions in these areas and cause the stylized fact in Section 4.

In order to explore this possibility I use data on internal migration from the Office of National Statistics. The dataset contains yearly matrices recording the number of moves between Local Authority Districts (LADs) for the 326 LADs in England and Wales over the 2003-2012 period.[18] First, I use a method similar to the one in section 4 to obtain a quality ranking of districts using observed transaction prices. I then analyse whether transactions fell the most between district pairs with lower quality. This amounts to estimating:

$$moves_{ot}^d = \alpha_{od} + Crisis_t \left(\beta_1 rank_o rank_d + \beta_2 rank_o + \beta_3 rank_d \right) + \delta_t + \epsilon_{it}$$

The dependent variable $moves_{ot}^d$ is the estimated number of moves from

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[18]Given that there is no mandatory requirement to report a move, this is a matrix of estimates constructed from different data sources. For details see Internal Migration Estimates Methodology Document - ONS Jun 2014

district o to d in quarter t from the ONS, α_{od} is a district pair dummy and δ_t is a full set of time dummies which can be region specific. Variables $rank_o$ and $rank_d$ indicate the rank of the origin and destination districts in the within region housing quality distribution. The coeficient of interest in this regression is β_1 which multiplies $rank_o rank_d Crisis_t$ which an interacts the rank variables and dummy tanking value one for years after 2008 ($Crisis_t$). A positive estimate for β_1 would indicate that after 2008 moves were relatively higher between districts with higher ranks (i.e.: higher $rank_o rank_d$).

Results are presented in table V. Note that in column 1 the coefficient for the crisis dummy is negative indicating that moves fell after 2007, as argued above. Column 2 uses the full sample with a full set of time dummies and columns 3 and 4 restrict attention to within and between region moves respectively. Across specifications we observe that β is negative and significantly different from 0 in columns 1 to 3 and small and not significant in column 4. This means that there is no evidence that the reduction of between district moves was concentrated in cheaper districts. In fact, if anything these results suggest that internal moves fell more between relatively high quality areas. If these movers are owner-occupiers trading between regions then this change in transactions would operate against the stylized fact reported in Section 4.

I interpret these findings as evidence that changes in job-related moves and internal migration did not generate the change in the composition of transactions.

Negative Equity and Nominal Loss Aversion

The literature has emphasized that nominal loss aversion may reduce the number of transactions when prices fall as households are unwilling to trade and accrue nominal losses relative to the original purchase price (Genesove and Mayer (2001)). In terms of prospect theory, the original purchase price would act as a reference point for owner occupiers wanting to sell.

Loss aversion could potentially explain the change in composition if we take into account that in some markets the fall in prices was moderately larger for cheap homes, even if the change in relative prices was small. Buyers of these homes would become unwilling to sell below their reference point, hence triggering a change in the composition of sales.

A similar outcome can occur as a consequence of negative equity: falling prices reduce the market value of a household's residence while leaving outstanding mortgages unaffected, often leading to a situation in which the loan

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TABLE V

MOVES BETWEEN DISTRICTS

	(1) mov_{ot}^d	(2) mov_{ot}^d	(3) mov_{ot}^d	(4) mov_{ot}^d
$high_o high_d Crisis_t$	-2.707**	-2.707**	-23.37***	0.372
	[1.124]	[1.124]	[8.431]	[0.269]
$high_o Crisis_t$	1.510**	1.510**	12.76**	-0.200
	[0.673]	[0.673]	[5.034]	[0.147]
$high_d Crisis_t$	1.207*	1.207*	11.27**	-0.327*
	[0.702]	[0.702]	[5.214]	[0.181]
$Crisis_t$	-1.839***			
	[0.485]			
Constant	22.79***	22.68***	98.91***	11.34***
	[0.0499]	[0.0586]	[0.423]	[0.0237]
Time Effects	No	Yes	Yes	Yes
Migration	All	All	Internal	External
Obs.	850208	850208	110096	740112

The unit of observation is the district pair, the dependent variable is the number of recorded moves between those districts and $Crisis_t$ is a dummy taking value one for years after 2007. Variables $high_o$ and $high_d$ correspond to dummies taking value 1 for origin and destination districts ranked above the regional median of the home quality distribution. Standard errors are clustered at the level of origin destination pairs. Columns 2, 3 and 4 are estimated using district-pair fixed effects. Column 3 restricts the sample to district pairs within the same region (*internal* moves) and Column 4 restricts the sample to district pairs where each district is located in a different region (*external* moves). Data on between district moves for years 2004-2011 obtained from ONS.

FIGURE XVII
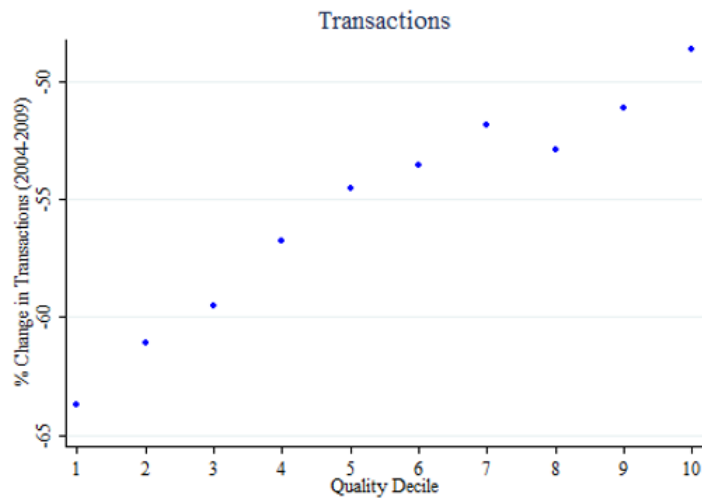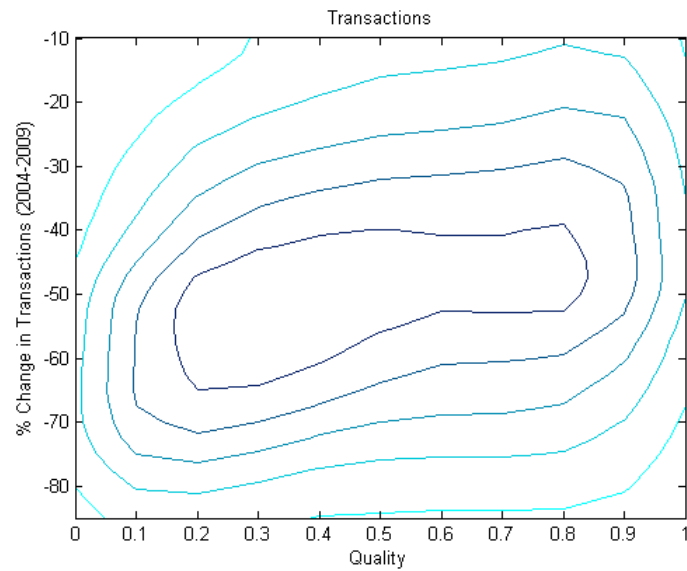
Change in yearly transactions between 2004 and 2009. The top panel uses quality estimated at the PS-DT level. The bottom panel uses the repeat-sales method and computes the difference in transactions by quality deciles.

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exceeds the market value of the asset it was mean to purchase (see Henley (1998), Ferreira, Gyourko and Tracy (2010) and the references therein). The rapid reduction in housing prices after 2007 combined with these two factors may explain part of the reduction in aggregate transaction volumes.

Moreover, negative equity could also explain the change in composition. Evidence from the Wealth and Assets Survey shows that households with large levels of outstanding mortgage debt before the crisis were, on average, young families living in cheap homes.[19] Hence, the appearance of negative equity following the fall in house prices would be concentrated in owners of low quality homes. If negative equity causes households to avoid selling this could, by itself, generate the documented change in composition.

In either the case of nominal loss aversion or of negative equity, the affected homes would be those purchased between 2005 and 2007. This suggests a method to test whether the change in composition was driven by lock-in or loss aversion. I re-draw the figures for changes in composition excluding from my transactions dataset all homes sold at least once in the 2005-2007 period. Figure XVII illustrates the results.

As we can observe, positive the correlation between quality and the change in yearly transaction is still present after this sample restriction. Loss aversion and lock-in may have contributed to the change in aggregate transaction volumes, moreover the correlation between the change in transactions and home quality falls slightly from 0.19 to 0.17 when excluding homes sold in the 2005-2008. This hints that a fraction of the change in composition may be explained by these factors. However, it is clear that these changes cannot explain away the differential change in transactions across qualities.

A possible concern regarding the role of negative equity is re-mortgaging by households buying before 2005. If re-mortgaging were widespread this could keep buyers close to their credit constraint and, in this context, a fall in prices would lead buyers into negative equity despite having bought at a lower price before 2004. Evidence in Mian and Sufi (2011) suggest this could be the case for the US in the run up to 2007 with the average home-owner extracting roughly a quarter of every dollar increase in home prices. However, data from the CML indicate that the bulk of homes with negative equity in mid-2009 had been bought in 2006 and 2007.[20]

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[19]Households headed by someone in the 30-34 age bracket have three times larger mortgage to value ratios that households in the 50-54 age bracket despite having cheaper homes. Source: Wealth and Assets Survey

[20]Housing Finance 01-2009 published by the Council of Mortgage Lenders

Stamp Duty Holiday

On September 2008, the UK government announced that it would raise the lower threshold for Stamp Duty Land Tax (a tax on real estate transactions) payment from 125,000 to 175,000. This policy (labelled *stamp duty holiday* by the press) was meant to stimulate the market and was effectively a tax exemption for homes between these two prices.

As argued in Best and Kleven (2013), the policy produced a change in the distribution of transactions which now bunched around the new 175,000 notch rather than at 125,000. Moreover, the authors of the study show that it not only reshuffled sales across the price distribution but also had a positive effect on transaction volumes. From the point of view of my analysis the effects on the intensive and extensive margin may partially offset each other (a change in the bunching transactions from the 125 to 175 thousand pounds notch together with an increase of sales below 175000 pounds). Nonetheless, the time of the policy almost coincides with the the differential change in transactions documented above so it is reasonable to ask whether Section 4 results were a consequence of this policy.

To test this I exclude from the sample transactions between September 2008 and December 2009 (the period in which the temporary stimulus was in place) and re-draw the figures for the change in the composition of sales shown in section 3. Results for the postcode sector-dwelling type dummies and repeat-sales methods are presented in Figure XVIII. The figures are qualitatively the same as the ones presented before including the *holiday* years.

I interpret this as evidence that the stamp duty holiday did not generate the documented change in distribution.

9   Conclusions

This paper presents evidence on a change in the composition of traded homes during the recent downturn in the UK housing cycle. Using several different methods to identify home types I arrive at the same conclusion: the fraction of total transactions corresponding to cheaper housing units decreased markedly during the crisis, breaking a pattern of relative stability which had endured during the boom.

As I have shown, the large change in maximum Loan-to-Value offered by British banks can explain this change in composition. Moreover, it has often been cited as the main reason excluding young households from home-

FIGURE XVIII

EXCLUDING HOMES SOLD IN (2008-2009)
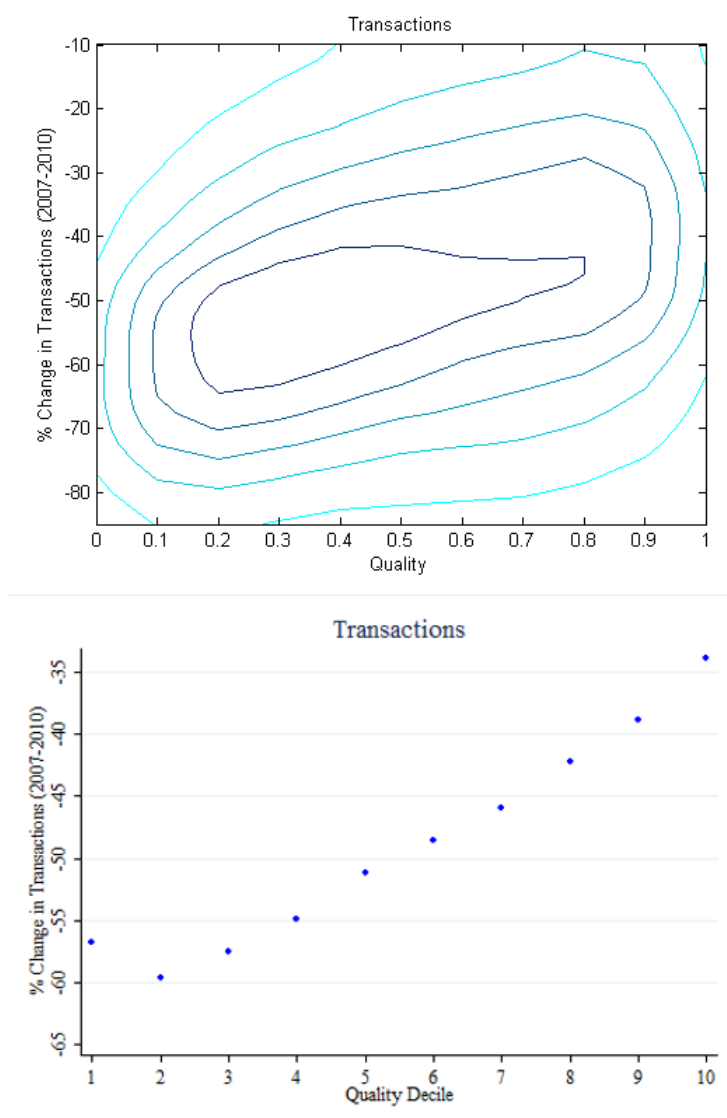
Relation between the change in yearly transactions between 2007 and 2010 and the within-TTWA quality. The top panel uses quality estimated at the PS-DT level. The figure plots the contour plot of an Normal kernel density estimate with bandwidth chosen according to Silverman's rule-of-thumb. The bottom panel uses the repeat-sales method and computes the difference in transactions by quality deciles.

ownership.

In my model, tighter credit constraints imply that younger, poorer households are priced out of the ownership market by richer households. This links the availability of credit to the composition of transactions and changes in housing tenure distributions. While admittedly an unambiguous test of this explanation is not provided, the model predictions are consistent with recent observed changes in the rental market and changes in transactions by age of neighbourhood residents.

The results are novel in several aspects. On the first place they show that the distribution of transactions may change over the cycle and provide a new stylized fact that could be used in other attempts to model the housing market. Secondly, I provide a rationale for these changes in composition by incorporating changes in rental supply into the analysis. Finally, the results suggest that deposit requirements can have a strong effect on housing tenures and present alternative mechanisms through which these changes may come to effect (buy-to-let and let-to-buy).

Implications for policy are clear. If the policy objective is to increase home-ownership, the model suggests that initiatives seeking to reduce deposit requirements can be effective. However, the analysis here does not take into account either worsening in affordability conditions associated with loose lending or an evaluation on the cost of these type of policies. Considering these questions in the context of the recent *Help to Buy* scheme is an interesting avenue for future work.

This paper opens several other directions for further research. On the first place, the analysis of the composition of transactions may be replicated for other countries or time periods. This could illuminate whether the finding above is a general feature of housing cycles (such as the price volume correlation) or something exclusive of the recent British experience. In addition, it provides a starting point for a detailed analysis of 'accidental landlords' which have grown with let-to-buy not only in the UK but also in the US.

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Appendix 1 - Model Proofs

In this Appendix I solve the model presented in section 6, proves Proposition 1 and Corollary 1. In doing so I proceed as follows: first I find the indirect lifetime utility functions for different transitions, then I use these to show the conditions necessary for the preference ordering between different tenure transitions for different income levels. Next I set up the relevant credit constraint for the purchase of L or H for agents born in t and $t-1$. These constraints determine the thresholds θ presented above. Using the expressions for these and the equilibrium conditions I then proceed to prove Proposition 1 and Corollary 1.

Indirect Utilities

Agents solve

$$\max_{\{c_y,c_o,hy,ho\}} (c_y + \beta c_o)h_o h_y)$$

By choosing the timing of consumption and their residence conditional on their budget and credit constraints. Given my assumption on the discount rate (namely, that $r \leq \dfrac{1-\beta}{\beta}$) we know the agent will choose to have $c_y = 0$ and delay all consumption to the moment before death. Agents pay the costs (and receive the benefits) of their housing decisions, save and consume. The budget constraint for a household who rents in both periods is:

$$(1+r)c_y + \frac{c_o}{1+r} = (2+r)(e_i - R)$$

Given that utility maximization ensures $c_y = 0$ it is straightforward to solve for c_o in the previous expression and substitute to obtain utility as a function of e_i for each lifetime path of tenure choices (e.g.: rent as young, buy low as old; buy high as young, invest in a low home when old). Indirect utilities for each path of lifetime tenure choices are the following:

$$v^{0R} = \phi(1+r)((2+r)e_i - R)$$
$$v^{RR} = (1+r)((2+r)(e_i - R))$$
$$v^{RL} = (1+r)((2+r)e_i - (1+r)R - rP_L))$$
$$v^{LL} = (1+r)((2+r)e_i - (\frac{r(2+r)}{1+r})P_L))$$
$$v^{LH} = \psi(1+r)((2+r)e_i - rP_L - \frac{r}{1+r}P_H)$$

$$v^{LHL} = \psi(1+r)((2+r)e_i - rP_L - \frac{r}{1+r}P_H)$$

$$v^{HHL} = \psi^2(1+r)((2+r)e_i - (\frac{r(2+r)}{1+r})P_H - \frac{r}{1+r}P_L + R)$$

Other alternative choices are possible but they are not present in the equilibrium configuration considered here.

Thresholds

The determination of the threshold θ_R^y depends on the value of e_i at which $v^{0R} = v^{RR}$. Note that for e_i above this value the utility of renting when young is higher than the utility of living with the parents. From this equality I obtain

$$\theta_R^y = \frac{(2+r) - \phi}{(2+r)(1-\phi)}R.$$

The other relevant thresholds are determined exclusively by credit constraints (as long as ψ is sufficiently high to endure that it always pays off to move to a high home if possible). Credit constrains for home-buyers are the following:

Young buyers of L homes for residence: $e_i \geq P_L - \gamma$ Old buyers of L homes for residence: $e_i \geq \dfrac{P_H - \gamma + rP_L}{2+r}$. Old buyers of L home for investment (buy-to-let): $e_i \geq \dfrac{P_H + P_L - \gamma + rP_H - R}{2+r}$

Young buyers of H homes for residence: $e_i \geq P_H - \gamma$ Old buyers of H home for residence (trade-up): $e_i \geq \dfrac{P_H - \gamma + rP_L}{2+r}$ Old buyers of H home for residence who keep their young L homes (let-to-buy): $e_i \geq \dfrac{P_H + P_L - \gamma + rP_L - R}{2+r}$

Together with the threshold for renting by the young, these equations determine the θs mentioned above. These are the following:

$$\theta_R^y = \frac{(2+r) - \phi}{(2+r)(1-\phi)}R$$
$$\theta_L^y = (P_L - \gamma)$$
$$\theta_H^y = (P_H - \gamma)$$
$$\theta_L^o = \frac{(P_L - \gamma) + (1+r)R}{(2+r)}$$
$$\theta_H^o = \frac{(1+r)(P_L - \gamma) + r\gamma + (P_H - P_L)}{2+r}$$
$$\theta_{HL}^o = \frac{(1+r)(P_H + P_L - \gamma) + r\gamma - R}{2+r}$$

Proof of Proposition 1

The equilibrium conditions are therefore:

$$G(\theta_H^y) - G(\theta_L^y) + G(\theta_H^o) - G(\theta_L^o) + 1 - G(\theta_{HL}^o) = S_L \tag{3}$$

$$1 - G(\theta_H^y) + 1 - G(\theta_H^o) = S_H \tag{4}$$

Substituting and taking derivatives with respect to γ:

$$\left(G'(\theta_L^y) + \frac{G'(\theta_L^o)}{2+r}\right)\left(\frac{\partial P_L}{\partial \gamma} - 1\right) + \frac{G'(\theta_{HL}^o)}{2+r}\left((1+r)\frac{\partial P_L}{\partial \gamma} - 1 + \frac{\partial P_H}{\partial \gamma}\right) = 0 \tag{5}$$

$$G'(\theta_H^y)\left(\frac{\partial P_H}{\partial \gamma} - 1\right) + \frac{G'(\theta_H^o)}{2+r}\left(r\frac{\partial P_L}{\partial \gamma} - 1 + \frac{\partial P_H}{\partial \gamma}\right) = 0 \tag{6}$$

Note that $tr_L = 1 - G(\theta_L^o)$ so the proposition requires that $\dfrac{d\theta_L^o}{d\gamma} < 1$. Given that:

$$\frac{d\theta_L^o}{d\gamma} = G'(\theta_L^o)\left(\frac{\partial P_L}{\partial \gamma} - 1\right)$$

It is sufficient to show that $\dfrac{\partial P_L}{\partial \gamma} \in (0,1)$.[21] To prove this consider the differentiated equations (5) and (6) and proceed by contradiction. Suppose $\dfrac{\partial P_L}{\partial \gamma} > 1$ in this case the first term in equation (5) is positive, requiring the second term in (5) to be negative (to ensure the equation equals 0). This, in turn, requires $\dfrac{\partial P_H}{\partial \gamma} < -r\dfrac{\partial P_L}{\partial \gamma}$. If this is the case, both the first and second terms of equation (6) are negative so the equality is violated. Proceeding analogously we can show that $\dfrac{\partial P_L}{\partial \gamma} < 1$ and $\dfrac{\partial P_L}{\partial \gamma} > 0$. Thus, we conclude that $\dfrac{\partial tr_L}{\partial \gamma} > 0$.

A similar procedure yields the proof of $\dfrac{\partial S_R}{\partial \gamma} < 0$ and $\dfrac{\partial tr_H}{\partial \gamma} < 0$ completing the proof of proposition 1.

Proof of Corollary

In order to prove the Corollary above it suffices to show that $\dfrac{d\,btl}{d\gamma} > 0$ and $\dfrac{d\,ltb}{d\gamma} < 0$. The number of buy-to-let transactions is equal to the number of

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[21]It is not necessary to show that $\dfrac{\partial P_L}{\partial \gamma} > 0$ but it is helpful for the rest of the proof.

owners of high type homes who buy a low type home as an investment. The number of let-to-buy transitions is equal to the number of owners who keep their home when trading up. Given these definitions I can write:

$$btl = 1 - G(\theta_H^y)$$

$$ltb = G(\theta_H^y) - G(\theta_{HL}^o)$$

Taking derivatives with respect to γ we can write:

$$\frac{d\,btl}{d\gamma} = -G'(\theta_H^y)\left(\frac{d\,\theta_H^y}{d\gamma}\right)$$

$$\frac{d\,ltb}{d\gamma} = G'(\theta_H^y)\left(\frac{d\theta_H^y}{d\gamma}\right) - G'(\theta_{HL}^o)\left(\frac{d\theta_{HL}^o}{d\gamma}\right)$$

Proving that $\frac{d\,btl}{d\gamma} > 0$ amounts to showing that $\left(\frac{d\theta_H^y}{d\gamma}\right) < 0$. To see this note that this expression determines the sign of the first term of the sum in equation (6). If this term is positive the same would be true for the second term of the sum and the sum would not equal 0. To see this note that if $\frac{\partial P_L}{\partial \gamma} \in (0,1)$:

$$\left(\frac{\partial P_H}{\partial \gamma} - 1\right) > 0 \Rightarrow \left((1+r)\frac{\partial P_L}{\partial \gamma} - 1 + \frac{\partial P_H}{\partial \gamma}\right) > 0$$

To prove that $\frac{d\,ltb}{d\gamma} < 0$ it suffices to show that $G'(\theta_{HL}^o)\left(\frac{d\theta_{HL}^o}{d\gamma}\right) > 0$. To see this note that $\left(\frac{d\theta_{HL}^o}{d\gamma}\right)$ is the second term in equation (5). Insofar as the first term in this sum is negative (as $\frac{\partial P_L}{\partial \gamma} \in (0,1)$), the second term has to be positive to satisfy the equality in (5). Therefore, $\frac{d\,ltb}{d\gamma} < 0$.

Hence, the Corollary is proved.

Appendix 2 - Data Sources

- The transactions data is made available by the **Land Registry** (go to https://www.gov.uk/government/organisations/land-registry for more information). As required by this government body I cite: Data produced by Land Registry ©Crown copyright 2015.

- I have also used information from the **Wealth and Assets Survey**. The citation for this study is the following: Office for National Statistics. Social Survey Division, Wealth and Assets Survey, Waves 1-3, 2006-2012 [computer file]. 3rd Edition. Colchester, Essex: UK Data Archive [distributor], October 2014. SN: 7215, http://dx.doi.org/10.5255/UKDA-SN-7215-3

- Information for housing tenure has been obtained from the **English Housing Survey**. The citation for this study is the following: Department for Communities and Local Government, English Housing Survey: Housing Stock Data. 4th Edition. Colchester, Essex: UK Data Archive [distributor], March 2013. SN: 7039, http://dx.doi.org/10.5255/UKDA-SN-7039-4

- **Internal migration** estimates were obtained fr the Office of National Statistics.

- Data from the Council of Mortgage Lenders was obtained from tabulations present in the CML's regular bulletins.