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A HOUSING PORTFOLIO CHANNEL OF QE TRANSMISSION

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ABSTRACT

We document a housing portfolio channel of quantitative easing (QE) transmission exploiting variation in German household data in a difference-in-differences setting around QE adoption in 2015. We find that QE encourages households with larger initial bond positions to rebalance more toward second homes. Rebalancing is especially pronounced among higher-income and church-affiliated households with stronger tax incentives to purchase and rent out properties. We also show that, in regions more exposed to this channel, house prices increase more than rents, and sale listings decrease more than rental ones, suggesting that the rental supply may increase in response to QE.

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"*Unlike in cities such as New York or London, local agents [in Cologne, Germany] say rapid price growth has not been driven by international buyers ... Instead, agents blame the recent price rises on an influx of domestic buy-to-let purchasers.*" Financial Times, October 19, 2017, square bracket added.

"*Due to a growing demand for rental properties in Germany, renting out properties has become a great source of income (https://howtogermany.com, online information resources for expatriates in Germany).*"

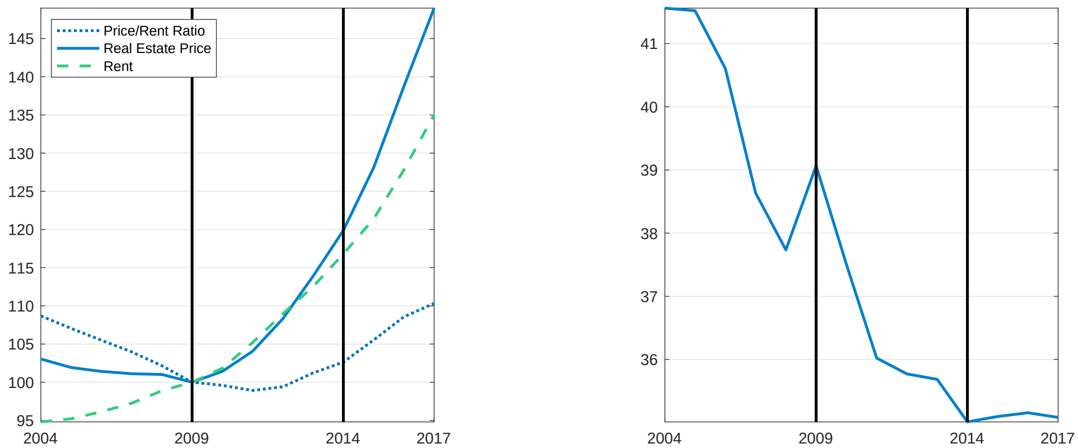
1 Introduction

A large body of research examines the effects of central banks' quantitative easing (QE) policies via the portfolio rebalancing of *banks*. Our paper presents evidence of QE transmission via *household* portfolio rebalancing that aligns with the anecdotal evidence quoted above and evaluates its impact on housing outcomes in Germany. We estimate that a more exposed household, i.e., with an ex-ante 10-percentage point higher bond share, approximately equal to the distribution's interquartile range for this variable, increases the share of second homes in their portfolio relative to the pre-QE period by about 2 percentage points more than less exposed ones. We also find that this portfolio rebalancing channel operates alongside the traditional credit channel, but is not driven by credit access or growth.

According to our channel, an ECB's bond purchase reduces the net supply of bonds available to the private sector, increasing (decreasing) the price (expected return) of bonds. Under mild assumptions, it is possible to show that households holding a portfolio of houses, equities, bonds, and deposits reallocate their investments away from deposits and bonds towards the other two risky assets, houses and equities. Furthermore, this housing portfolio rebalancing channel can operate either independently or alongside the credit channel since housing purchases can be funded from the liquidation of other portfolio assets or could be facilitated by credit and leverage. Thus, whether the degree of household portfolio realloca-

Figure 1 Germany: a Housing Boom without a Credit Boom

Panel A: Residential house price and rent indexes (2009=100) B: Mortgage credit to households (% GDP)



Note. Panel A plots national residential house price and rent indexes, and the price-to-rent ratio (equal to 100 in 2009). Panel B plots the stock of mortgage credit to households as a share of GDP. The vertical lines mark the beginning of the German recovery in 2009 and 2014. See the Appendix for variable definitions and sources.

tion induced by QE is independent of credit is an empirical question. To illustrate and guide our empirical analysis and to help interpret our results, in Appendix C, we also develop a simple model of housing portfolio rebalancing with segmented asset markets and preferred habitat investors. In this setting, QE works through risk premia rather than through future short-term rates or bank reserves and loan supply.[1]

We investigate this transmission channel by studying the impact of the ECB's QE policy in Germany. Germany is an ideal laboratory for our empirical analysis because it has experienced a housing boom without a credit boom since 2009. Figure 1 plots national aggregate residential rent and price indexes and households' mortgage credit. The figure shows a stark negative correlation between housing valuation and credit from the beginning of the recovery in 2009 to 2014-15. After the formal introduction of QE in January 2015, in the aggregate, we can see a modest credit recovery associated with an acceleration of the housing boom that is evidenced by an increasing price-to-rent ratio.

[1]The model does not include equities for simplicity but it is straightforward to extend it in that direction. Credit could also be introduced by adding one asset that can be shorted, as in Flavin and Yamashita (2002).

The German post-GFC housing boom is not unique in differing from the intensively studied US boom-bust cycle of the 2000s, which was largely driven by household mortgage borrowing and securitization. Cerutti, Dagher and Dell'Ariccia (2017) estimate that 19 out of 83 identified housing booms are not associated with a credit boom. Even the 2000s US boom-bust cycle and the US post-GFC recovery involved cash transactions and non-bank intermediaries—Alter and Dernaoui (2020), Lambie-Hanson, Li and Slonkosky (2019), Chinco and Mayer (2016), Garriga, Gete and Tsouderou (2023a), Garriga, Gete and Tsouderou (2023b)—alongside credit whose critical importance remains a hotly debated issue—e.g., Favara and Imbs (2015), Favilukis, Ludvigson and Van Nieuwerburgh (2017), Kaplan, Mitman and Violante (2020), and Greenwald and Guren (2021).

Our household-level estimation results are remarkably consistent with several aggregate stylized facts of the German housing boom since 2009. Table 1 shows the evolution of the household sector balance sheet before and after the formal adoption of QE in early 2015. First, real estate represents the lion's share of households' total assets in Germany and increases by one percentage point during our sample period, from 55% in 2014 to 56% in 2018 (Table 1), while the share of bond holdings in total assets declines by about half a percentage point over the same period. Second, the declining homeownership rate by about two percentage points during this period (from an already very low level by international standards) is also consistent with our results, implying an increase in the share of renters and landlords.[2] Third, Table 1 shows that household leverage declined by one percentage point from 2014 to 2017, in line with an even lower (and equally declining) share of homeowners with housing credit. Fourth and finally, "Equity to Total Assets" and "Deposits to Total Assets" are slightly increasing and constant, respectively, over this period. The constant deposit share suggests that the ECB's negative interest rate policy, which was only passed on very large deposits during our sample period, is not a likely driver of portfolio reallocation.

[2]This increase is slightly less than half the swing in the US homeownership rate during the subprime boom-bust cycle. The argument that our portfolio rebalancing mechanism is a likely driver of the aggregate decline in homeownership during this period is plausible because more than 60% of all renters lease from other households in Germany (see Sagner and Voigtländer, 2021 and Zander et al., 2015).

Table 1 GERMAN AGGREGATE HOUSEHOLD BALANCE SHEET

	2009	2010	2011	2012	2013	**2014**	2015	2016	2017	2018	2019
Real Estate/Total Assets	0.55	0.55	0.56	0.56	0.55	**0.55**	0.55	0.55	0.56	0.57	0.56
Bonds/Total Assets	0.066	0.065	0.062	0.063	0.062	**0.064**	0.060	0.060	0.059	0.059	0.056
Equities/Total Assets	0.081	0.083	0.075	0.078	0.083	**0.085**	0.089	0.091	0.095	0.085	0.095
Deposits/Total Assets	0.168	0.169	0.170	0.170	0.169	**0.169**	0.168	0.170	0.169	0.171	0.170
Loans/Total Assets	0.15	0.15	0.14	0.14	0.14	**0.13**	0.13	0.13	0.12	0.12	0.12
Homeownership (in %)	-	53.2	53.4	53.3	52.6	**52.5**	51.9	51.7	51.4	51.5	51.1
Homeownership (with loans, in %)	-	27.8	28.1	28.0	27.6	**26.6**	26.2	26.2	25.7	25.6	25.8
Households with Bond Exposure* (in %)	-	-	60.4	-	-	**60.0**	-	-	57.4	-	-

NOTE. The table reports selected aggregate variables on the composition of the German household balance sheet based on flow of funds data together with German homeownership rates from the OECD and the Bundesbank's Panel of Household Finance Survey. Real estate assets are the sum of buildings, structures, and land; bonds include all direct short-term and long-term debt securities held by households and their indirect holdings via mutual funds and insurances; deposits are currency and deposits; equities are all direct stock holdings; loans are equal to all liabilities; and total assets are all financial and non-financial assets. The household sector includes households and non-profit institutions serving households. Starred variables (*) are sample averages from our household survey data and include the share of households being exposed to the bond market (due to direct or indirect holdings of bonds).

As for rebalancing towards equity, in our estimation results, we will find that the equity shares decline, rather than increase, for households with higher ex-ante bond shares, suggesting that the aggregate increase is driven by other segments of the household distribution.

To achieve identification, we estimate a difference-in-differences specification around the time the ECB formally adopted QE in early 2015 using granular household portfolio survey data. Following the literature on bank portfolio rebalancing in response to QE (e.g., Rodnyansky and Darmouni, 2017; Luck and Zimmermann, 2020), we exploit idiosyncratic heterogeneity in the household portfolio share of wealth invested in bonds before QE adoption as an exposure measure to QE. As we discuss in the context of our model in the appendix, the larger this ex-ante bond share, the stronger the need to rebalance to restore the target allocation when the central bank reduces the bond supply to the market.

We find that households with larger ex-ante bond shares increase their housing portfolio share, especially the share of second homes, more relative to less exposed ones after QE adoption. In economic terms, a household with an initial 10-percentage point higher bond share, roughly corresponding to the interquartile range of this variable, increases its portfolio share of second homes by 1.72-1.87 percentage points more relative to the pre-QE period.

Rebalancing is stronger for higher-income households, who face higher marginal tax rates, and for church-affiliated households, who must devolve an extra 8-9% of their tax bill to the church. Rebalancing is also stronger for more informed households already holding second homes in the pre-QE period, and particularly for those who report earning rental income from those holdings. This evidence points toward a buy-to-let motive because rented-out second homes (or second homes declared to be for letting in the future) enjoy a sizable tax advantage relative to main residences or stocks in Germany, as we explain in detail in Appendix B.2.

We also establish that households with larger ex-ante deposit shares rebalance more toward second homes and we find that the deposit share declines (even though the latter is not estimated precisely). This suggests that households fund the increase in the second home share also by liquidating their deposits. As we argue in the paper, this result is not driven by the ECB's negative interest rate policy, as banks only started to pass on negative rates to households with deposits below 100,000 euro after the end of our sample period in 2017. When we investigate other household characteristics, we find that rebalancing is stronger for households aged 40-60, financially more literate households, and those that are actively advised by their bank on how to best allocate their assets, consistent with the findings in the existing literature on the impact of financial literacy on portfolio rebalancing (Bianchi, 2018).

Despite the aggregate evidence of low and declining household leverage reported above, controlling for QE's impact on housing portfolio rebalancing through the credit channel is essential because a policy objective of QE is to increase commercial banks' reserves and stimulate loan supply, including mortgage lending. When we control for the credit channel of QE transmission at the household level, our results suggest that credit access and growth are not driving portfolio rebalancing towards second homes. In particular, rebalancing is not stronger for households with higher access to credit before QE or higher credit growth after QE adoption. Moreover, including these variables as additional controls in the baseline specification only marginally reduces the magnitude of the rebalancing coefficient without affecting its statistical significance. Nonetheless, we also find that credit growth has an independent impact on portfolio rebalancing after QE adoption, consistent with the notion that the two channels can operate in parallel, but independently.

In principle, the portfolio rebalancing mechanism that we propose can work through any risky asset, particularly through equities. When we check for this possibility, relying on the insights from our model in the appendix, we find that controlling for households' risk aversion does not affect our main results, suggesting that rebalancing towards second homes is not picking up rebalancing towards all risky assets. More strikingly, as we have already noted, valuation-adjusted equity shares decline for households with larger ex-ante bond shares. This result further implies that, in the data, German households also sell stocks to fund second-home purchases, in addition to bonds and deposits.

Our benchmark portfolio rebalancing results are quite robust. They hold after controlling for a large set of household characteristics, such as net worth, demographics, the number of household members, financial literacy, and risk aversion, that are plausible determinants of households' target bond allocations. They are also robust to using alternative measures of the bond share that capture exposure to QE and to alternative definitions of the housing portfolio share. Our results are also unaffected when we control for the ECB's negative interest rate policy explicitly. Finally, we show that our results are driven by second-home buyers who generate rental income. This is direct evidence that our mechanism is driven by buy-to-let investors and not by households buying a vacation home or by commuters buying a second home to live closer to their workplace.

When we turn to housing market outcomes, we find that regions that are more exposed to rental market tightness—as proxied by the share of refugees housed in independent accommodations as in Bednarek et al. (2021)— see a larger decrease in rental yields, with a stronger increase in house prices, compared to rents. Finally, and importantly, we show that the ratio of rental listings declines less in more exposed regions than sale listings, arguably implying a relative increase in the supply on the rental market. This is an important result because it shows that our household portfolio QE transmission channel has potentially benign implications for housing affordability to the extent to which it leads to an increased supply of rental housing.

Related Literature Our paper relates to the literature along multiple dimensions. First, our paper is closest to Korevaar (2023), who examines investors' yield-seeking behavior in a low-interest rate environment and how it affects the housing market. Using data from 18th-century Amsterdam, the paper shows that wealthy investors shift portfolios toward real estate and other high-yielding assets when bond yields are low, resulting in a boom and bust in house prices and changes in rental yields that exacerbate housing wealth inequality. Gomes et al. (2022) use granular data from a brokerage firm to establish that individual investors invest in more risky assets the lower the interest rate. Other closely related papers are Daniel et al. (2021) and Gargano and Giacoletti (2022). The former finds that lower interest rates induce households to rebalance their portfolios towards income-generating assets. The latter employs Australian tax filing data to show that lower interest rates raise the share of households becoming landlords. We document a household portfolio rebalancing in response to QE through changes in risk premia and argue that our results are driven by a buy-to-let motive fuelled by tax incentives favoring rental properties.

Second, our transmission channel speaks to the literature on housing as a risky asset in household portfolios. For example, Flavin and Yamashita (2002) study the impact of real estate on the optimal holding of other asset classes. Similarly, Yao and Zhang (2005) study the importance of housing in shaping the portfolio composition in a model in which households can also choose between owning and renting. Cocco (2005) looks at housing as a determinant of the cross-sectional variation in stock market participation, relying on a fixed participation cost rather than modeling the housing-tenure decision. In line with these studies, we also stress the importance of housing as a driver of household portfolio choices. However, we study the impact of rebalancing from deposits and bonds to housing and equities following QE adoption without focusing on explaining the cross-sectional variation in the target allocation. Our critical assumption that local real estate markets are segmented is consistent with the empirical and quantitative evidence in Gete and Reher (2018) and Greenwald and Guren (2021).

Also related to the housing portfolio literature, Alter and Dernaoui (2020) illustrate the salient role of non-bank intermediaries and cash transactions in the US housing market. Lambie-Hanson, Li and Slonkosky (2019) find that deep-pocket, non-bank investors entering the multi-family sector significantly contributed to the housing market recovery in the aftermath of the subprime crisis. Chinco and Mayer (2016) show that out-of-town second-house buyers drive mispricing in the housing market during the 2000s US boom. Garriga, Gete and Tsouderou (2023a) show that, after the sub-prime crisis in the United States, small, local real estate investors entered the market, with an impact on housing affordability that critically depends on the local supply elasticity. Our paper illustrates how households' cash purchases of second homes can also contribute to these dynamics.

Third, similar to our paper, Peydró, Polo and Sette (2021) and Koijen, Koulischer, Nguyen and Yogo (2021) focus on banks' and other institutional investors' portfolio rebalancing driven by asset return differentials. Using Italian credit and security data, Peydró et al. (2021) document that less capitalized banks substitute lower-yield securities for riskier loans during periods of distress. Using security-level European investor holdings, Koijen et al. (2021) study portfolio rebalancing during the March 2015—December 2017 QE period. They estimate a system of government bond demands to link portfolio rebalancing with yield changes and find that bond yields decline in Germany because of QE. Bergant, Fidora and Schmitz (2020) show that euro area investors, in particular households and investment funds, rebalance from bonds targeted by the ECB's QE to foreign debt securities. Albertazzi et al. (2021) show that banks rebalance towards risky assets and loans after the euro area QE intervention. Like in these papers, we also take a portfolio approach but focus on household portfolio rebalancing towards residential real estate holdings.

Finally, several papers document that QE works through the classical credit and bank-lending channel by stimulating credit supply and affecting bank and firm behaviors. For example, among several others, Rodnyansky and Darmouni (2017) show that banks' exposure to QE increases their corporate loan supply. Using loan officer survey data, Kurtzman, Luck and Zimmermann (2017) find that QE softens lending standards and raises bank risk-taking. Chakraborty, Goldstein and MacKinlay (2019) find that banks more exposed to QE increase their mortgage lending. Berg, Haselmann, Kick and Schreiber (2023) employ German supervisory data and show that German banks more affected by QE reallocate their loan supply to real estate asset management firms. Acharya, Eisert, Eufinger and Hirsch (2019) provide evidence that the ECB's OMT program induces banks with greater bond exposure to expand loan supply, especially to low-quality (zombie) borrowers. However, Bittner, Rodnyansky, Saidi and Timmer (2021) document that, when implemented together with a negative interest rate policy, QE can induce deposit-dependent banks to reduce their corporate credit supply. The housing portfolio channel of QE transmission that we document does not necessarily rely on credit and focuses on household, rather than bank or firm, behavior.[3]

The rest of the paper is organized as follows. Section 2 presents the data. Section 3 states our hypotheses and discusses the empirical strategy we pursue to investigate them empirically. Section 4 reports the evidence on portfolio rebalancing, while Section 5 reports estimated effects on housing outcomes. Section 6 concludes. Three appendices at the end of the paper (not for publication) provide details on the institutional setting and the data, as well as a simple portfolio rebalancing model that helps guide the empirical analysis, discuss the instrumental variables that we use, and interpret our estimation results.

[3]Note, however, that we do not claim that household credit does not affect the transmission of QE or other shocks. We contend that, in our German setting, increased borrowing or prior access to credit does not drive household portfolio rebalancing toward second homes for rental purposes.

2 Data

To conduct our empirical analysis, we rely on household data from the Bundesbank's Panel on Household Finances survey and regional data from various sources. In this section, we discuss the main variables of interest. Appendix A provides sources and definitions for all variables used in the empirical analysis and a complete set of summary statistics.

2.1 Household Data

The source of our household data is the Deutsche Bundesbank's Panel on Household Finances (PHF). This survey covers about 4-5,000 households per wave over three waves in 2011, 2014, and 2017, from which we construct a panel of 1,651 households.[4]

The PHF is the German module of the Eurosystem Household Finance and Consumption Survey. Similar to the US Federal Reserve Board's Survey of Consumer Finances, it collects data on households' financial investment activities, borrowing behavior, savings, and income. According to the Deutsche Bundesbank, the survey is representative at the national level, although there is evidence that aggregated HFCS data do not match national accounts data (Engel et al., 2023). An additional advantage of the data is that they have a good representation of wealthy households, who play an important role for our QE transmission channel.

The PHF relies on imputing estimated values to address non-responses based on reported variables that provide information on the missing ones. In our baseline specification, we follow Kindermann et al. (2020) and only use the first of the five alternative sets of imputed values for each variable (henceforth "implicate" for brevity). This is because most variables used in the analysis are non-imputed. In unreported specifications, we show that our results are virtually unchanged when we use all five implicates.

[4]See Table A1 for the precise number of households interviewed in each wave. We use the PHF rather than the German Socio-Economic Panel because the PHF has more detailed information on household wealth composition. We use the following PHF versions: `https://DOI10.12757/Bbk.PHF.01.04.01` (Wave 1), `https://DOI10.12757/Bbk.PHF.02.04.01` (Wave 2), and `https://DOI10.12757/Bbk.PHF.03.02.01` (Wave 3).

Our main outcome variable is the change in a household's housing portfolio share between waves 2 and 3. We measure the housing portfolio share as real estate wealth over total household assets. Importantly, we correct bond, stock, and housing wealth for valuation changes so that higher housing shares imply an increase in real housing holdings. We deflate these variables using the *national* German bond (REXP) and stock (DAX) index and *regional* residential house price data indexes discussed below, setting the base year to 2011. For robustness, to be consistent with our theoretical model, we also scale housing wealth by the sum of real estate and liquid wealth, where liquid wealth is given by the sum of deposits and households' direct and indirect bond holdings through intermediaries. Note in this respect that, in the aggregate flow of funds data, we see that mutual funds (pension and insurance companies) invested an average of 52% (15%) of their assets in bonds over the period 2011-2017. To compute households' indirect bond holdings, we multiply their amount invested in mutual funds and insurance by 52% and 15%, respectively.

The richness of the PHF survey allows us to restrict the definition of the housing portfolio share to include only the households' "other property values" (i.e., second homes) in most specifications. The idea is that if households increase their holdings of residential real estate for investment purposes driven by a buy-to-let motive, this should primarily affect the holding of second homes. We replace missing values for the value of a household's main residence with zeros for households that declare to be renters. Similarly, for households that report not to own property apart from the main residence, we replace missing data on properties with zeros.

In the analysis, we model housing portfolio shares as a function of household characteristics, fixed at their values in the 2014 pre-QE wave. As we discuss in Section 3, we employ the wave-2, pre-QE household-level share of wealth invested in bonds (directly and indirectly via mutual funds and insurances) as a proxy of how exposed households are to the QE transmission channel we want to identify. Since some household records have missing data on direct bond holdings, to construct this variable, we impute missing observations by calculating average direct bond holdings for each of the ten deciles of the net wealth distribution and replace missing observations with the respective averages. Our results, however, are robust when we do not impute missing bond values, or when we use only households' direct bond holdings (setting missing direct bond holdings to zero). Similarly, since the ECB adopted both QE and negative interest rate policy, we also control for a household's initial deposit shares, computed as the share of all deposits in the total portfolio.

The observable household characteristics that we consider in our analysis are income per capita, the age of a household's head, a dummy equal to one if a household is formally affiliated to a church and zero otherwise, an indicator variable of whether the household rents the main residence, a dummy measuring whether a household was actively advised by his/her bank in selecting the portfolio allocation in the recent two years and is likely to follow any bank recommendations in the future, and financial literacy. The latter is a continuous variable and measures a household's number of correct answers to three questions on the difference between real and nominal interest rates, compound interest, and portfolio diversification as described in the Appendix.

To evaluate the extent to which household credit may affect our estimation results, we also consider two variables measuring households' leverage and borrowing behavior. These are the share of mortgage credit over the total housing wealth as a proxy for leverage and the change in the logarithm of mortgage borrowing.[5]

2.2 Regional Data

To explore the implications of our channel for housing outcomes, we employ price, rent, and rental yield indexes for all 401 administrative regions of Germany from a reputable and well-known proprietary provider, Bulwiengesa AG.[6] Bulwiengesa constructs these indexes

[5]To increase the number of observations, we set the logarithm of mortgage volumes equal to zero when the actual volumes are zero.

[6]To be precise, we use the German "Kreise" as the regional unit of analysis that is comparable to the US county level. Bulwiengesa supplies housing data to the Bundesbank and the ECB to construct its German national series.

using both unit-specific valuation and transaction data from building and loan associations, research institutions, and realtor associations, as well as the chambers of industry and commerce. The data is at annual frequency and the series that we use covers owner-occupied existing apartments in multi-family homes with at least six units, which are no older than 20 years.

To quantify the extent to which QE and portfolio rebalancing also affect the number of apartment units on the market (and not just prices, rents, and returns), we also use regional listing data, which we aggregate from Immoscout 24, the largest German online real estate listing platform.[7] Specifically, based on these data, we compute the total regional number of sale listings per year, the total number of rental listings, and their ratio, focusing only on apartment rentals and sales for consistency with the Bulwiengesa data.

To proxy for regional exposure to portfolio rebalancing, and hence our transmission channel, ideally, we would like to use aggregated household-level bond shares at the regional level. Unfortunately, a large number of regions is not represented in the PHF survey, and even for those that are covered, the number of households per region is very low. Hence, such regional averages are not representative, as our panel data set has about 1,500 observations, while the total number of regions is 401.[8] Thus, as a source of exposure to our channel that varies at the regional level, we employ the 2008 pre-QE share of refugees housed in independent accommodation, as in Bednarek et al. (2021), assuming that a larger share of refugees makes buy-to-let investment in residential real estate more attractive. Specifically, this variable is computed as the share of refugees in total German refugees allocated to a particular region, multiplied by the state share of refugees housed in independent accommodations as opposed to mass accommodation centers, which displays significant variation across German states.

For robustness, as a measure of regional exposure, we also employ a region's 2011 share of renters, which is based on the German 2011 census. The rationale here is that a region

[7] We use Immoscout 24 versions `10.7807/immo:red:wk:suf:v5` for "flats for sales", and `10.7807/immo:red:wm:suf:v5` for "flats for rent." For more information, see Breidenbach and Schaffner (2020).

[8] By design, the PHF is representative of Germany as a whole but not at the level of individual regions.

with a larger share of renters before QE was adopted must have had a more developed and liquid rental market, thus capturing market depth, and again making investment in second homes for buy-to-let investors potentially more attractive.

In the regional analysis, we employ a continuous QE indicator. Specifically, we use the total debt securities held by the ECB over nominal euro area GDP. Alternative measures, such as the total size of the ECB balance sheet, might also be affected by the ECB's long-term refinancing operations that channeled liquidity to the banking sector without directly affecting households' incentives to rebalance their portfolios. Appendix B.1 provides a detailed description of the ECB's QE non-conventional monetary policies, focusing particularly on QE implementation.

2.3 Summary Statistics

Table A3 reports a full set of summary statistics. Here, we focus on the critical variables. The table shows that the housing portfolio share and the share of second homes increased during our sample period. In particular, on average, in waves 2 and 3, the second home (total) housing share increases by 0.65% (0.67%), consistent with the aggregate increase reported in Table 1. On average, the number of second homes a household owns also increases by 0.1. In contrast, consistent with the aggregate picture in Table 1, mortgage credit growth is negative on average, and the outstanding amount of mortgage debt relative to a household's housing wealth (as a proxy for leverage) is very low at 13%.

Table 2 reports stylized facts on the household characteristics of buyers and sellers of a first (second) home in the post-QE wave 3, and of households owning or not bonds in the pre-QE wave 2 (assumed to be more exposed to QE and hence more likely to rebalance towards housing). These statistics show that in the sample used to estimate the benchmark regression in column (1) of Table 3, 197 (51) households purchased a second (first) home after QE. The table also shows that there are 136 (18) sellers of second (first) homes in this panel, roughly balancing each other.

Table 2 House Buyers and Sellers

Variable	$+\Delta FirstHous.$	$+\Delta Sec.Hous.$	$-\Delta FirstHous.$	$-\Delta Sec.Hous.$	*Bonds*	*NoBonds*
Observations	51	197	18	136	928	556
Net wealth	57000	364000	413500	534000	290110	157450
Income per. cap.	24365.5	27700	22825	33137.5	27791.7	21500
Housing wealth	0	260000	365000	407000	230000	132500
Age	50	58	71	62.5	56	68
Δ Mortgage credit	162.9	0	0	0	0	0

Note. The table reports the median value of a household's wave 2 net wealth, income per capita, nominal housing wealth, age, as well as the contemporaneous growth in mortgage credit for six different groups of households: households buying a first or second home in wave 3 (i.e., those that increased holdings during wave 3, $+\Delta FirstHome$ and $+\Delta SecHome$, respectively); households selling a first or second home in wave 3 (i.e., those that decreased holdings during wave 3, $-\Delta FirstHome$ and $-\Delta SecHome$, respectively); and households directly or indirectly owning or not owning bonds in wave 2 (*Bonds* and *NoBonds*, respectively). We restrict the sample to households included in the sample used to estimate our benchmark regression in Table 3, column (1). See Table A2 for data definitions and sources.

The data further suggest that buyers of second homes are wealthier, have higher income per capita, and are older than buyers of first homes. They also already own houses and do not finance their purchases via credit. Selling first homes is seemingly associated with the downsizing motives of older people, whereas selling second homes prevails amongst the wealthiest and highest-income households. Sellers of second homes are older than the buyers of second homes, but younger than the sellers of first homes. Importantly, for the transmission channel that we postulate, almost two-thirds of the households in the panel own bonds directly or indirectly, and these households have income, wealth, and age similar to the buyers of second homes.

3 Hypotheses and Empirical Strategy

In this section, we spell out the housing portfolio channel we focus on and discuss the empirical strategy to identify it in the household portfolio and regional housing data.

3.1 A Housing Portfolio Channel of QE Transmission

The transmission channel that we postulate relies on households' portfolio rebalancing from bonds to houses in response to the ECB's formal adoption of QE in early 2015. In Appendix C, we set up a simple model to frame it more transparently. In this model, there is a representative local household with mean-variance preferences that manages a portfolio of bonds, houses, and cash. The model omits equities and leverage to keep the derivations tractable and to obtain a simple analytical solution. Preferred habitat investors in both the national bond and the local house markets segment these markets.

In this simple model, QE reduces the fixed net supply of bonds available to the private sector—as Appendix Figure A2 documents in the data. A lower bond supply increases the price of bonds and decreases their expected return. Under the plausible assumption that bonds and houses are substitutes, households rebalance toward housing to restore their optimal or benchmark portfolio allocation, increasing their housing portfolio shares and bidding up house prices; the more so, the larger the initial bond share. Further assuming that the optimal housing holding is large enough, as it is likely to hold in the data, this rebalancing depresses expected housing returns—the more so, the lower the housing supply.

In this environment, house purchases are funded through portfolio reallocation, and hence from the sale of bonds and possibly cash. The model, however, does not restrict the cash share to increase or decrease as bond prices increase, and the quantities decline in response to QE, which makes the response of the bond share and cash shares to QE ambiguous. We thus investigate the cash share empirically. Similarly, since leverage and credit are not in our model, we control for their influence on portfolio rebalancing in our empirical analysis, as we detail below. In the same vein, if equities were in the model, households would increase or decrease their demand for equities in response to QE depending on the return covariance between bonds and housing and the initial holdings. In our empirical analysis, we directly test for portfolio rebalancing towards equity and find that more exposed households reduce, rather than increase, their equity positions after QE.

In our empirical analysis, we first provide direct evidence of portfolio rebalancing toward housing, particularly rebalancing toward second homes that are more likely held for investment rather than consumption purposes and are thus more closely tied to the mechanism embedded in our model. We then examine both "price" and "quantity" housing outcomes exploiting regional variation in rental yields and listings data. The rental yield is an ideal outcome variable to investigate the prediction of our model because it is closely tied to portfolio rebalancing given that it must predict future expected returns and their three components—the discount factor, rental income growth, and future rental yields—as we document in Appendix D. Listings data are not directly linked to our model, but they arguably provide indirect evidence of the working of our channel. The differential response of rental and sale listings, in particular, can be informative about the extent to which a buy-to-let motive may be driving the portfolio rebalancing that we see at the household level.

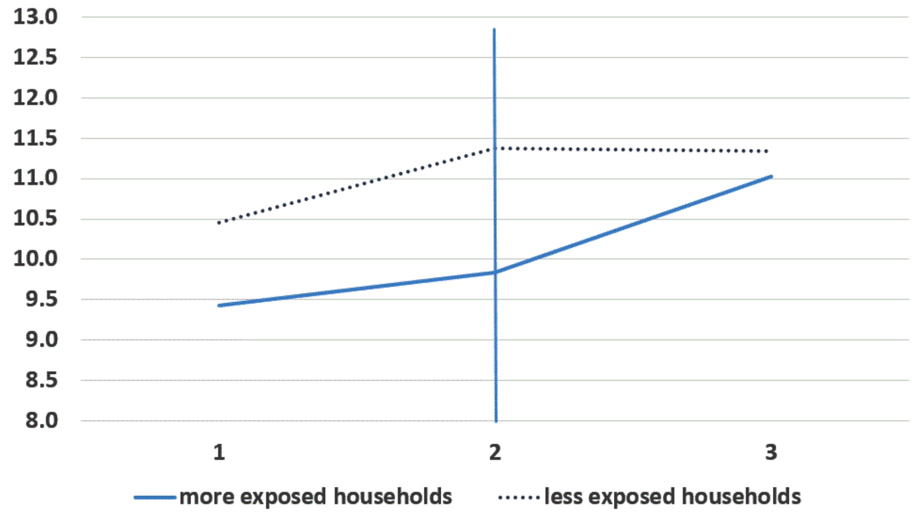
3.2 Benchmark Specification for Portfolio Rebalancing

To estimate the impact of QE on households' portfolio rebalancing, we pursue a difference-in-differences strategy that exploits the formal adoption of QE in January 2015. We treat the second wave of the PHF, conducted in 2014, as the pre-QE period and the third wave, conducted in 2017, as the post-QE period. Our difference-in-differences regressions compare changes in the housing share in the third (post-QE) survey wave with those in the second (pre-QE) wave, depending on the degree of exposure, as measured by the ex-ante bond share. The frequency of our household survey data, which is available every three years, is not problem for our analysis. This is because the portfolio rebalancing process towards housing is much slower than in the case of liquid assets.

The regression specification is as follows:

$$\Delta Y_{h,t} = \alpha_t + \alpha_h + \beta \cdot (\text{Post}_t \times \text{Bonds}_{h,2014}) + \epsilon_{h,t} \tag{1}$$

Figure 2 PARALLEL TRENDS BEFORE QE ADOPTION
(SURVEY WAVES 1, 2, AND 3)



NOTE. The figure plots the average second home portfolio share of more and less exposed households, in the three PHF waves on the x-axis. More (solid blue line) and less (dotted black line) exposed households are defined as households with a 2014 share of wealth directly or indirectly invested in bonds above or below 1%, which approximately corresponds to the sample median. Data Source: PHF.

where $\Delta Y_{h,t}$ is the *change* in the housing share from 2011 to 2014 and from 2014 to 2017. In most regressions, the outcome variable is the change in the share of second-homes. The main variable of interest is the interaction between Post_t (equal to 1 in the third wave) and our measure of household-level exposure to QE, which is the pre-QE bond investment share in wave 2, $\text{Bonds}_{h,2014}$, consistent with existing literature on bank portfolio rebalancing (e.g., Rodnyansky and Darmouni, 2017; Luck and Zimmermann, 2020), and as we also motivate in the context of our model in Appendix Section C.2.1. The resulting β coefficient measures how households with stronger incentives to rebalance because of larger initial bond positions adjust their housing shares after QE adoption. The main hypothesis is that the higher the initial bond share, the stronger the rebalancing should be in the third wave. As a continuous treatment indicator may be difficult to interpret in a difference-in-differences setting (Sun and Shapiro, 2022; Callaway et al., 2021), in unreported specifications, we also estimate our benchmark model using a dummy treatment indicator that is equal to one for household bond shares above the in-sample median and zero otherwise, and our results are unaffected. The standard errors are heteroskedasticity-robust throughout this part of the analysis, but the magnitude of the standard errors is virtually unchanged when we cluster them by region.

The critical assumption underlying this difference-in-differences analysis is that, in the absence of QE, both more and less exposed households behave identically. Unfortunately, there are only two PHF survey waves before the QE adoption by the ECB, and we cannot run a standard placebo regression estimating Equation (1) based on a sample period that has not experienced the QE treatment. Yet, Figure 2 provides reassuring evidence that the parallel trends assumption is not violated. In particular, it shows that before the ECB's formal adoption of QE in January 2015, both more and less exposed households (as measured by their pre-QE bond shares) experienced a similar increase in the share of wealth invested in second homes. However, after formal QE adoption in early 2015, the dynamics significantly diverge, with more exposed households accumulating more second homes and less exposed households reducing their portfolio share of second homes.

To investigate this issue further, we perform two additional indirect placebo tests. First, we define households as treated vs non-treated based on a variable that is arguably unrelated to QE—households' share of wealth initially invested in non-financial, non-housing assets such as cars, arts, and jewelry. As column (1) of Table A4 in the appendix shows, we find that, in this case, "treated" and "untreated" households do not behave differently. Second, we maintain the treatment definition, the ex-ante bond share, but replace the outcome variable in Equation (1) with the share of wealth invested in non-financial, non-housing assets. Again, column (2) of Table A4 shows that the interaction coefficient is not statistically different from zero. Albeit indirect, both placebo tests lend strong support to the assumption that, in the absence of QE, treated and untreated households' housing shares have parallel trends.

It is important to note here that, in our setting, households' treatment status cannot be assumed to be random. Indeed, the correlation between households' initial bond shares and typical portfolio determinants, such as demographics, wealth, risk aversion, and financial literacy, are small but statistically significant. On the other hand, most of these characteristics are very persistent across survey waves with correlations typically above 50-60%. We treat this challenge by pursuing a two-pronged strategy.

First, our regressions include time and household fixed effects. The former is essential to control for shocks common to all households. The latter captures time-invariant observable household heterogeneity. Since idiosyncratic household characteristics should not change significantly between survey waves 2 and 3, these fixed effects are the main controls for their potential impact on our outcome variable. In other words, they control for changes in the housing share between waves 2 and 3 that are not due to the postulated rebalancing channel.[9]

Second, following Roberts and Whited (2013), we run regressions that control for households' idiosyncratic pre-QE characteristics interacted with the Post_t dummy. These specifications rule out that the significance of our key interaction term is driven by the correlation between bond shares and these additional idiosyncratic household characteristics. As we see below, their inclusion does not affect our estimation results substantially, implying that the non-random treatment of households does not threaten our identification.

3.3 Controlling for Household Characteristics and Credit

As a next step in the empirical analysis, we examine the extent to which our benchmark results are stronger for certain groups of households. To this end, we expand Equation (1) by including a triple interaction between the post dummy, the ex-ante bond share, and certain household characteristics evaluated in 2014, as subsumed in the $X_{h,2014}$ vector:

$$\Delta Y_{h,t} = \alpha_t + \alpha_h + \gamma \cdot (\text{Post}_t \times \text{Bonds}_{h,2014} \times \text{X}_{h,2014}) + \delta \cdot (\text{Post}_t \times \text{Bonds}_{h,2014}) + \nu \cdot (\text{Post}_t \times \text{X}_{h,2014}) + \epsilon_{h,t}, \quad (2)$$

[9] In these specifications, we cannot estimate separate coefficients on the Post-dummy and the bond exposure in linear terms, as they are absorbed by the fixed effects. However, our results are robust to dropping the household fixed effects. Without fixed effects, the regressions include a larger number of observations since we do not need to restrict the sample to panel households. The specification with household fixed effects is preferable because we can compare the same household over time and check whether it changes its housing portfolio share after QE adoption, thus strengthening identification.

with the double interactions also added to the regression. In particular, $X_{h,2014}$ includes household income per capita in 2014. As we spell out in Appendix Section B.2, second homes are subject to substantial tax advantages relative to main residences in Germany due to a long-standing housing policy framework that supports rental market development and housing affordability. With marginal tax rates increasing in income, the advantage is larger for higher-income households. We thus expect the impact of QE to be stronger for higher-income households.

$X_{h,2014}$ also includes a dummy variable for households actively advised on asset allocation by their bank. These households should be better informed about the QE impact on their portfolios. In Germany, banks typically operate their real estate agencies. So banks could also recommend households to rebalance towards housing to generate brokerage fees from customers acquiring real estate. Both motives would imply a stronger effect on these households.

We then look at financial literacy, assuming that more literate households are more likely to invest in second homes, better understanding the impact of QE on their portfolio. Next, we consider the household's main residency tenure status. This specification is helpful as it shows whether only households that already own a primary residence purchase second homes after QE or renters also engage in the trade. We then include three dummies controlling for the household head's age (one for age below 40, one for age between 41 and 60, and one for age older than 60). These dummies gauge whether rebalancing is driven by a bequest motive of the elderly or by middle-aged individuals near their lifetime income peak, who derive tax benefits from purchasing a second home. Finally, and importantly, we examine how credit may affect households' rebalancing by introducing households' access to credit (i.e., leverage, as measured by mortgage credit over housing wealth) and credit growth (measured as the change in the logarithm of mortgage credit).

3.4 Estimating Impact on Housing Market Outcomes

As the final step of our empirical analysis, we investigate the impact of QE on selected housing outcomes that are most closely tied to portfolio rebalancing.

Unfortunately, the PHF only provides limited information on house price expectations and does not allow us to directly measure housing returns or the rent-growth component of the return that is informative about the workings of the mechanism we want to document. In this step of the analysis, therefore, we exploit house price and rent data variation at the regional level. A second challenge we face is that, as noted earlier, aggregating and matching household portfolio shares at the regional level is not feasible with 1,500 observations scattered over 401 regions, leaving us with 3-4 households per region at best. To address this problem, we look at evidence of both the price impact, as summarized by the response of the regional housing rental yield, and the quantity impact, as captured by rental and sale listings, in a specification that takes the following form:

$$\mathrm{Y}_{r,t} = \alpha_r + \alpha_t + \gamma \cdot (\mathrm{QE}_{t-1} \times \mathrm{Exposure}_r) + \varepsilon_{r,t}, \tag{3}$$

where $\mathrm{Y}_{r,t}$ is the regional rental yield or a regional listing indicator, QE_{t-1} is the lagged value of debt securities held by the ECB over nominal euro area GDP, and $\mathrm{Exposure}_r$ is the regional share of refugees housed in independent accommodations. The idea here is that a higher share of refugees housed in independent accommodations captures residential housing market tightness as in Bednarek et al. (2021). As we discussed earlier, a hot housing market can potentially attract more buy-to-let investors, and yet this variable is arguably uncorrelated with other sources of regional variation in the housing outcomes considered. In particular, as Bednarek et al. (2021) document both in a model and in the data, a higher share of refugees exerts more demand pressure in local rental housing markets and reduces the net supply to the rest of the market.[10] As a robustness check, here, as an exposure

[10] The relevance and orthogonality conditions for the use of this instrument are discussed extensively in Bednarek et al. (2021)—in particular, Table 2 and Appendix Section D.1.3. See also the Model Appendix

measure, we also consider the region's share of renters based on the idea that a market with more renters is deeper and more liquid, and hence more attractive to buy-to-let investors.

Note here that both regional exposure variables we use take higher values in urban regions—the refugee (rental) share is on average 21% (70%) in urban areas, compared to 10% (46%) in rural ones. At the same time, as we will see below, household portfolio rebalancing towards second homes is stronger in urban relative to rural regions. The indicators of market tightness and depth discussed above, therefore, can also capture higher exposure to household portfolio rebalancing toward real estate.

The specification above also includes time and region fixed effects, α_r and α_t, to control for region-specific, time-invariant variables, such as region size and agglomeration, and aggregate factors that affect all regions homogeneously, such as the business cycle. The sample period is 2010-2017 to have a sufficient number of pre-QE observations, which serve as the reference group in the interpretation of the double interaction coefficient, γ.[11] The standard errors are clustered at the regional level to take into account the potential correlation of residuals within a region and over time.

4 Housing Portfolio Rebalancing

In this section, we first present our benchmark portfolio rebalancing results along with several robustness checks. Next, we investigate rebalancing out of deposits or towards equity. We then explore whether our benchmark estimates are stronger for households with specific characteristics and control for the credit channel of QE transmission. Finally, we investigate households' rebalancing motives.

C.3.1 in this paper that spells out the conditions under which $\frac{d}{dh}\left(\frac{dE[R]}{db}\right) > 0$ in our portfolio model. One critical difference concerning the setting in Bednarek et al. (2021) is that, in this paper, we focus on housing rather than GDP growth outcomes. As Bednarek et al. (2021) discuss, several other studies use the distribution of refugees as an instrument. See, for instance, Jaschke, Sardoschau and Tabellini (2022), for a recent application.

[11] When we start the sample in 2014, and thus have only one year of pre-QE observations, in unreported specifications, we find that the results are similar but the coefficients of interest are estimated less precisely.

Table 3 HOUSEHOLD PORTFOLIO REBALANCING: BENCHMARK RESULTS

	Benchmark Estimates		Different Dependent Variables			Bond and Deposits	Different Bond Shares	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔSEC. HOUSING	ΔSEC. HOUSING	ΔSEC. HOUSING (2)	ΔHOUSING	ΔUNITS	ΔSEC. HOUSING	ΔSEC. HOUSING	ΔSEC. HOUSING
Bonds × Post	0.187***	0.172***	0.196***	0.351***	0.002**	0.122***	0.403***	0.420***
	(0.045)	(0.046)	(0.047)	(0.053)	(0.001)	(0.044)	(0.095)	(0.154)
Deposits × Post	-	-	-	-	-	0.116***	-	-
						(0.025)		
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Income-Time FE	No	Yes	No	No	No	No	No	No
Obs	2968	2968	2954	2968	3072	2966	2968	2968
R^2	0.344	0.346	0.345	0.394	0.430	0.353	0.343	0.338

NOTE. All regressions are based on our panel of households from the PHF. The number of observations varies depending on the constraints imposed by the right-hand side variables. We do not include households that move between regions during our period of observations. Including these observations does not change the results. The dependent variable in columns (1), (2), (6), (7), and (8) is the portfolio share of second homes, with portfolio assets in the denominator defined as total household assets (housing plus all financial assets). In column (3), the portfolio share of second homes is relative to the sum of bonds, housing, and deposits. Column (4) studies the change in the portfolio share of *total housing*, with portfolio assets in the denominator defined as total household assets. The dependent variable in column (5) is the *number* of second homes that a household owns. The main regressor is the post dummy equal to one for the third wave and zero before interacting with the household-level share of wealth invested in bonds, evaluated in 2014. While columns (1)-(6) compute the latter taking into account both direct and indirect bond holdings and imputing missing direct bond holdings, column (7) refrains from doing this imputation. Column (8) only takes into account households' direct bond holdings. In column (6), we control for the interaction between the post-dummy and ex-ante share of household wealth invested in deposits. The regressions include time and household fixed effects. Column (2) also adds income quartile-time fixed effects. Heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

4.1 Benchmark Results and Evidence on the Cash Share

Table 3 shows that households exposed to QE rebalance their portfolios towards housing more strongly, particularly toward second homes, after QE adoption. Specifically, in columns (1)-(2), the coefficient on the interaction term between the initial bond share and the post dummy is positive and statistically significant at the 1% level. It implies that households with larger bond shares in wave 2 of the survey raise their housing portfolio shares (i.e., the share of second homes in total household assets) more significantly in wave 3. In particular, a household with an initially 10-percentage point higher bond share, which approximately corresponds to the interquartile range for this variable, increases its second-home housing share by 1.72-1.87 percentage points more than the median household after QE adoption.

This benchmark result is robust to scaling second-home shares by the model-consistent portfolio size consisting of housing wealth, bonds, and deposits only (column 3). It is also robust to considering the response of total housing wealth and not only their second home wealth (column 4). Further, the result does not change when we look at the number of second homes that a household owns (column 5). This specification is particularly important. Since we do not have information on either the exact type of bond or stock that a household owns or the price dynamics of a household's real estate, we can only approximately correct for valuation changes with national bond and stock, as well as regional house price series. Therefore, column (5) is important to show that valuation effects are not driving the results. In columns (7)-(8), we employ alternative bond share measures. Column (7) uses a household's indirect and direct bond holdings without the imputations described in Section 2.1, while column (8) employs only a household's direct bond holdings and hence neglects its indirect holdings via mutual funds and insurance companies. The results become even stronger in these cases.

Finally, in column (6), we control for the interaction between the post-dummy and a household's pre-QE deposit shares. This is an important step because our model does not unambiguously predict the cash share's response to QE. The estimates show that the baseline rebalancing impact coefficient from column (1) is robust. Interestingly, the deposit share interaction is also positive and highly statistically significant in this regression. The result can be interpreted in two ways. On the one hand, this coefficient can capture the incentive to rebalance due to the introduction of negative interest rates in June 2014 (the so-called NIRP policy), rather than QE. On the other hand, the result can also imply that households more exposed to QE use both bonds and deposits to increase investment in second homes after QE adoption. Arguably, the second interpretation is more plausible because German banks did not start to pass on negative rates to retail customers until 2019, so NIRP is unlikely to drive this result.[12] In unreported regressions, we also test directly for the response of the deposit share to QE and find that it declines for households with larger ex-ante bond shares, even though the interaction term is not estimated precisely. Therefore, we interpret the result in Table 3 as suggesting that households fund second-home purchases out of both bonds and deposits.

4.2 Robustness Checks and Rebalancing Towards Equities

The baseline results above are robust along several other dimensions, as Table 4 shows. First, our benchmark estimates become even stronger statistically and economically once we control for the following set of *time-varying* household characteristics in column (1): a household's logarithm of net worth, the age of the household head, the number of household members, financial literacy and risk-aversion. Second, in columns (2)-(6), we also consider these variables fixed at their pre-QE 2014 values in double interactions with the post-QE dummy.[13] These additional controls make sure that the household bond shares capture households' exposure to QE as intended, and that this interpretation is not threatened by the correlation between bond shares and these possible confounders. As the results show,

[12] Specifically, most banks initially only charged negative rates on deposits exceeding 500,000 euros. Between 2015 and 2019, the threshold was gradually lowered to 100,000, but only starting in 2019—after our sample period ended —some banks started to charge negative rates on all deposits.

[13] We find the same results when we fix these idiosyncratic household characteristics in wave 3 rather than wave 2.

the concern is not warranted and our benchmark estimate lies very robustly in the range of 0.19-0.23—compared with an estimate of 0.19 in the benchmark regression. The results imply that the possibly non-random treatment of households discussed above does not pose a threat to our identification strategy—see Roberts and Whited (2013).

Finally, and importantly, in column (7) of Table 4, we also examine whether households with higher ex-ante bond shares rebalance more strongly toward equities after QE adoption. To this end, we replace the dependent variable with the share of a household's, directly and indirectly, held stocks over the total portfolio value. We find that more exposed households *reduce*, rather than *increase*, their equity shares. This rules out the possibility that our estimates pick up rebalancing towards *all risky assets* and equities in particular, and implies that cash purchases of second homes can also be funded by lowering exposure to equities, in addition to rebalancing out of bonds and drawing down deposit balances. In our model, this result can in principle be rationalized with the covariance matrix of bond, equity, and housing returns.

4.3 Specific Household Characteristics

We now look at the role of specific household characteristics in driving our portfolio rebalancing results. We do so by introducing triple interaction terms between the Post dummy, the initial bond share, and one additional household characteristic at the time, fixed at its 2014 pre-QE level unless otherwise noted, including exposure to leverage and credit growth.

First, we consider a dummy taking the value of one for households actively advised by their bank on how to best allocate their wealth. In Germany, most banks own their real estate agency and can generate brokerage fees while advising customers. Bank-advised households may also rebalance more strongly because they are better informed about their portfolio decisions—banks understand that it is a sensible strategy to sell bonds and buy houses in response to QE. Column (1) of Table 5 shows that bank-advised households rebalance more aggressively, with an estimated triple interaction statistically significant at the 5% level.

Table 4 Household Portfolio Rebalancing: Additional Robustness Checks

	(1) ΔY	(2) ΔY	(3) ΔY	(4) ΔY	(5) ΔY	(6) ΔY	(7) ΔEQUITIES
Bonds × Post	0.230***	0.227***	0.193***	0.190***	0.187***	0.190***	-0.042**
	(0.061)	(0.072)	(0.046)	(0.045)	(0.046)	(0.045)	(0.021)
Net Worth$_{t-1}$	-5.378***						
	(1.246)						
Members$_{t-1}$	4.191**						
	(1.626)						
Age$_{t-1}$	-0.402						
	(0.301)						
Fin. Lit.$_{t-1}$	-1.514						
	(1.082)						
Risk Aversion$_{t-1}$	1.104						
	(1.337)						
Net Worth$_{2014}$ × Post		-0.493					
		(0.530)					
Members$_{2014}$ × Post			1.047				
			(0.887)				
Age$_{2014}$ × Post				0.048			
				(0.053)			
Fin. Lit.$_{2014}$ × Post					-0.012		
					(1.183)		
Risk Aversion$_{2014}$ × Post						1.080	
						(1.556)	
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2798	2866	2968	2968	2968	2964	3072
R^2	0.370	0.344	0.345	0.344	0.344	0.345	0.382

Note. All regressions are based on our panel of households from the PHF. The number of observations varies depending on the constraint imposed by the right-hand side variables. We do not include households that move between regions and between survey waves. Including these observations does not change the results. The dependent variables are the changes in household-level wealth invested in second homes over the total portfolio size, as in column (1) of Table 3. Instead, in column (7) the dependent variable is the share of directly and indirectly held stocks over the total portfolio value. The main regressor, again as in column (1) of Table 3, is the interaction between a Post dummy that equals to one for the third wave and zero before, and the ex-ante share of wealth invested in bonds in 2014. Column (1) controls for the following lagged time-varying, household characteristics: the household logarithm of net worth, the age of the household head, the number of household members, financial literacy, and risk-aversion. The remaining columns control for the interactions between the Post dummy and one of these characteristics at a time, fixed at their 2014 values. Data details are in Table A2. The regressions include time and household fixed effects. Heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Second, we consider financial literacy. In line with the literature on households' portfolio choice (e.g., Bianchi, 2018), we find that financially more literate households rebalance their portfolio more actively, in our case, towards second homes.

Third, we consider the household tenure status. This experiment checks whether only households that own their main residency purchase second homes or those that rent the main residency engage in the trade. Column (3) shows that both renters and owners of their main residence rebalance towards second homes, but the effect is economically stronger for owners. Nonetheless, the corresponding triple interaction is only statistically significant at the 10% level, implying that the rebalancing sensitivities of renters and owners are not very different from each other. Given the tax advantages of buying second homes to let, renting the main residency and owning a second home is a rational strategy that, as this result shows, several households pursue.

Fourth, we consider age. This permits controlling whether rebalancing is driven by older households—and hence by deeper-seated bequest motives—or by middle-aged agents, typically close to their lifetime income peak and arguably optimizing their tax burden by purchasing a second home. To do so, we add to the benchmark regression the corresponding triple interactions with a dummy equal to one for household heads aged between 41 and 60 (middle-aged), and an indicator equal to one for household heads aged at least 61 (older-aged). Households below the age of 40 serve as the reference group. The corresponding estimate in column (4) shows that middle-aged households with larger initial bond shares rebalance towards second homes after the adoption of QE. In contrast, older households also rebalance more than the under-40 reference group, but the corresponding estimate is not statistically significant at conventional levels. We conclude from these results that bequest motives do not seem to play a salient role in driving our results.

Table 5 PORTFOLIO REBALANCING AND OTHER HOUSEHOLD CHARACTERISTICS

	(1)	(2)	(3)	(4)	(5)	(6)
Bonds × Post	0.022	-0.086	0.467***	0.060	0.175***	0.169***
	(0.059)	(0.084)	(0.143)	(0.054)	(0.046)	(0.045)
Financial Advice × Post	-0.349					
	(3.431)					
Financial Literacy × Post		-2.101				
		(1.479)				
Renter × Post			0.448			
			(2.924)			
Middle Age × Post				-2.693		
				(3.949)		
Older Age × Post				-1.374		
				(3.632)		
Mortgage to Housing × Post					-0.054	
					(0.052)	
$\Delta Mortgage$ × Post						0.004
						(0.004)
Bonds × Post × Financial Advice	0.297**					
	(0.131)					
Bonds × Post × Financial Literacy		0.117***				
		(0.037)				
Bonds × Post × Renter			-0.274*			
			(0.155)			
Bonds × Post × Middle Age				0.264**		
				(0.134)		
Bonds × Post × Older Age				0.107		
				(0.071)		
Bonds × Post × Mortgage to Housing					0.001	
					(0.002)	
Bonds × Post × $\Delta Mortgage$						0.001
						(0.000)
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	892	2968	2968	2968	2968	2968
R^2	0.341	0.347	0.346	0.347	0.345	0.357

NOTE. All regressions are based on our panel of households from the PHF. The number of observations varies depending on the constraint imposed by the right-hand side variables. We do not include households that move between regions and between survey waves. Including these observations does not change the results. The dependent variables are the changes in wealth invested in second homes over the total portfolio size, as in column (1) of Table 3. The main regressor, again as in column (1) of Table 3, is the double interaction between a Post dummy and the share of wealth invested in bonds, measured in 2014. In addition, we also include triple interactions between the Post dummy, the bond share, and a dummy equal to one when households are actively advised by their bank (column 1), a financial literacy indicator (column 2), a renter indicator (column 3), and dummies for the household head's age between 40 and 60 and above 60 (column 4), the mortgage credit-to-housing wealth ratio (column 5), and the change in the logarithm of mortgage credit (column 6), respectively. The first five household characteristics are fixed at their 2014 values, and the sixth is calculated between 2014 and 2017. Data details can be found in Table A2. The regressions include time and household fixed effects. Heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

4.4 Controlling for the Credit Channel of QE Transmission

We now investigate whether credit access or increased credit availability affects households' rebalancing toward second homes. Controlling for the credit channel of QE transmission is important because a direct effect of QE is also to increase banks' reserves, expanding their lending capacity. To do so, we employ two variables in the PHF survey related to credit usage—household leverage evaluated at the pre-QE level in 2014 (mortgage loans over housing wealth), and the change in the logarithm of mortgage loans from the pre-QE (2014) to the post-QE (2017) period.

We first check whether households with higher initial leverage, and hence better access to credit, possibly including equity extraction, and households with higher credit growth in the post-QE period rebalance more, using the same triple interaction specification that we adopted to control for the other household characteristics. As it is evident from columns (5)-(6) of Table 5 above, the triple interactions with the two credit characteristics are not statistically significant, implying that housing portfolio rebalancing is not stronger for households with better access to credit.

Next, we check whether restricting the sample to households that did not increase their mortgage borrowing between the pre and post-QE period weakens our benchmark results. Column (1) of Table 6 shows that our results are unaffected.

Finally, we include the previous two credit-access household characteristics (leverage measured in 2014 and mortgage credit growth between 2014 and 2017), interacted with the post dummy, as additional controls without the triple interactions. Columns (2) and (3) of Table 6 show that these two credit variables only marginally reduce the economic and statistical significance of our benchmark bond share-post interaction coefficient without affecting its statistical significance. As one may expect, however, column (3) shows that households obtaining additional mortgage credit also raise their investment in second homes. This last result confirms that our portfolio rebalancing channel works independently but alongside the traditional credit channel.

Table 6 Household Portfolio Rebalancing, Leverage and Credit Growth

	Households with No Credit Growth	All Households	
	(1)	(2)	(3)
	ΔY	ΔY	ΔY
Bonds × Post	0.175***	0.178***	0.175***
	(0.045)	(0.045)	(0.045)
Mortgage to Housing × Post		-0.040	
		(0.033)	
ΔMortgage Credit × Post			0.009***
			(0.003)
Household FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Obs	2952	2968	2968
R^2	0.362	0.345	0.354

Note. All regressions are based on our panel of households from the PHF. The number of observations varies depending on the constraint imposed by the right-hand side variables. We do not include households that move between regions and between survey waves. Including these observations does not change the results. The dependent variables are changes in household wealth invested in second homes over the total portfolio size, as in column (1) of Table 3. The main regressor, again as in column (1) of Table 3, is the double interaction between the post dummy and the household-level shares of wealth invested in bonds, measured in 2014. Column (1) restricts the sample to all households with no mortgage credit growth between wave 2 and wave 3; columns (2) and (3) are estimated on the full household panel and include as an additional regressor the household's mortgage credit-to-housing ratio in 2014 and the change in the logarithm of mortgage credit between the second and third wave as controls to the baseline regression estimated on the full sample interacted with the post dummy, respectively. Data details are in Table A2. The regressions include time and household fixed effects. Heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

4.5 Portfolio Rebalancing Motive

An interesting question is whether the rebalancing towards second homes that we identify is driven by investment purposes (i.e., buy-to-let) or by housing consumption motives (e.g., households buying second homes for vacation purposes or because they are commuters and wish to live closer to their workplace). In this section, we delve deeper into the motivations behind the portfolio rebalancing behavior that we have documented. This step in the analysis arguably establishes that our results are driven by housing investment purposes, specifically buy-to-let, in line with the model that we proposed in the Appendix to frame our analysis.

4.5.1 Rebalancing and the Tax Advantages of Second Homes

Appendix B.2 documents that second homes that are either rented out or intended to be rented out benefit from large tax advantages in Germany compared to main residences. This differential tax treatment is often seen as a critical driver of the low German homeownership rate (e.g., Kaas et al., 2021). These advantages are larger the higher the level of household income, as the German tax system is quite progressive.

Given the institutional setting, we first examine whether our benchmark results are stronger for higher-income households. To this end, we interact the post-dummy not only with the household's initial bond share but also the income per capita in the 2014 pre-QE survey wave. Indeed, column (1) of Table 7 shows that households with larger ex-ante bond exposure and higher income in 2014 rebalance more towards second homes. The corresponding triple interaction is positive and statistically significant at the 10% level. However, both the economic and statistical significance significantly strengthen once we control for the corresponding triple interaction with households' initial deposit shares (column 2).

Second, in columns (3)-(4), we split the sample into households located in urban and rural areas. On the one hand, Amaral et al. (2022) find that housing returns are driven by rental income in German rural regions, and by capital gains in urban ones. On the other hand, while owner-occupied properties are exempt from capital gain taxes independent of

Table 7 Portfolio Rebalancing and Household Income

	Full Sample		Urban	Rural	Church Aff.	No Church Aff.
	(1)	(2)	(3)	(4)	(5)	(6)
Bonds × Post	0.141**	0.043	0.128	0.126	0.132*	0.171**
	(0.057)	(0.060)	(0.084)	(0.087)	(0.071)	(0.087)
Deposits × Post		0.071**				
		(0.029)				
Income × Post	-0.024	-0.098**	-0.013	-0.105**	-0.036	-0.013
	(0.025)	(0.039)	(0.020)	(0.053)	(0.041)	(0.028)
Bonds × Post × Income	0.002*	0.004***	0.003**	0.002	0.003*	0.000
	(0.001)	(0.001)	(0.001)	(0.003)	(0.002)	(0.003)
Deposits × Post × Income		0.002**				
		(0.001)				
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2968	2966	1062	1906	1744	1194
R^2	0.345	0.359	0.394	0.324	0.359	0.325

Note. All regressions are based on our panel of households from the PHF. The number of observations varies depending on the constraint imposed by the right-hand side variables. We do not include households that move between regions and between survey waves. Including these observations does not change the results. The dependent variables are the changes in wealth invested in second homes over the total portfolio size, as in column (1) of Table 3. The main regressor, again as in column (1) of Table 3, is the double interaction between a Post dummy and the shares of wealth in bonds in 2014. In addition, we also include a triple interaction between the Post dummy, the bond share, and households' income per capita, also measured in 2014. Column (2) controls for the corresponding triple interaction including households' initial deposit shares. Columns (1)-(2) estimate this specification for the full sample of households. Columns (3)-(4) distinguish between urban and rural areas. Columns (5)-(6) distinguish between church and non-church affiliated households. Data details can be found in Table A2. The regressions include time and household fixed effects. Heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

how long they have been owned, rented properties are exempted only after 10 years. In contrast, rental income is always taxed based on the household's tax rate. Thus, we expect the result in column (1) of Table 7 to hold more strongly in urban areas, where high-income households may not only benefit from tax advantages when purchasing a second home (same for urban and rural areas) but also from tax exemptions on the main driver of their return (the house price increase). Indeed, columns (3) and (4) show that the triple interaction is larger and estimated more precisely for households living in urban areas.

Finally, we split the sample based on whether households are formally affiliated with the church. In Germany, church members must devolve an additional 8-9% of their tax bills to the church (depending on the state). Hence, the tax advantages from second homes are stronger for those households, and we expect them to rebalance their portfolios more strongly. In line with this, columns (5)-(6) illustrate that the triple interaction between the post-dummy, the bond share, and income is only statistically significant for church members. For non-church members, the incentives to rebalance are independent of income.

4.5.2 Rebalancing and Prior Exposure to Buy-to-Let

To further probe households' motivation to rebalance, we first split households into two groups, those who already owned a second home in the pre-QE period and those who did not. We then exploit a question in the PHF survey that asks respondents whether the household is obtaining rental income from second homes,[14] assuming that households with second homes generating rental income in the pre-QE period are more likely to buy-to-let in the post-period. In fact, these households must be more informed about the tax incentives and the market opportunities to do so. In contrast, second-home pre-owners who do not generate rental income are arguably more likely to use second homes for vacation or commuting purposes.

Table 8 reports the results. Columns (1) and (2) show that our benchmark estimates are driven by households that already own a second home in the pre-QE period. Households initially *not* owning a second home do not rebalance in the post-QE period. Columns (3) and (4) show that, among households already owning a second home in the pre-QE period, those that report generating rental income from their second home holdings before the implementation of QE rebalance much more strongly (henceforth just buy-to-let investors) than those that own a second home but do not obtain rental income in the pre-QE period. The coefficient in column (3) is not only larger, but also much more precisely estimated than the one in column (4).[15] This result is in line with findings in Gargano and Giacoletti (2022) showing that the main motive for Australian households to rebalance towards real estate is "searching for income".

Taken together, the results reported in this section provide strong evidence that the

[14] Specifically, the survey asks the following: "Did you / Did your household / Did the household receive any income from renting real estate in xxx?"

[15] The sub-sample households used to estimate the model in column (4) is not only smaller but could also include households that invest in second homes for buy-to-let reasons but have not yet found a tenant.

Table 8 Rebalancing, Pre-owned Second Homes, and Rental Income

	Pre-own	Not Pre-own	Pre-own & Inc.	Pre-own & No Inc.
	(1)	(2)	(3)	(4)
Bonds × Post	0.821***	0.000	0.824***	0.641*
	(0.178)	(0.018)	(0.255)	(0.426)
Household FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Obs	712	1786	484	138
R^2	0.392	0.512	0.380	0.312

Note. All regressions are based on our panel of households from the PHF. The number of observations varies depending on the constraints imposed by the right-hand side variables. We do not include households that move between regions and between survey waves. Including these observations does not change the results. The dependent variable is the change in the portfolio share of second homes over the total portfolio size, as in column (1) of Table 3. The main regressor is the post dummy interacted with the portfolio bond share in 2014. The regressions include time and household fixed effects. In column (1), the sample only includes households that own a second home in the pre-QE wave. In column (2), the sample only includes households initially not owning a second home. In column (3), we only include households owning a second home during the pre-QE period *and* generating rental income. In column (4), there are only households owning a second home in the pre-wave but not generating rental income. Heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

household portfolio rebalancing towards second homes that we document in the paper in response to QE is likely driven by investment rather than consumption purposes.

5 Housing Outcomes

In this section, we assess the impact of QE on those housing outcomes that are closely tied to the portfolio rebalancing in our model. The two outcome variables we focus on are the regional rental yield and the total number of sale and rental listings. In all specifications, the main regressor is the interaction between the lagged stock of ECB debt securities as a share of GDP and our exposure variable, measured by the share of refugees in independent accommodation.

5.1 Price Impact

In section C.3.1 of the Appendix, we show that expected housing returns should decline more in regions where the housing supply is tighter, for example, as captured by the share of refugees in independent accommodation. On the other hand, Appendix D also illustrates that the rental yield is a good predictor of all three components (discount rates, cash flow, and bubble component) of future housing returns 1-3 years out in our panel of German regional data. While in our simple two-period model the only source of return variation is the house price, the rent growth component could be important in the data. The advantage of focusing on the rental yield is that we can capture all three return components without distinguishing them. Nonetheless, we also separately investigate the impact of QE on the regional rent and house price growth to provide at least indirect evidence on the extent to which the portfolio rebalancing that we documented affects rental markets by increasing the supply of properties to let.[16]

Table 9 reports the estimation results. Columns (1)-(3) employ the regional share of refugees housed in independent accommodation as an exposure variable, while columns (4)-(6) use the regional share of renters for robustness. Columns (1) and (4) of Table 9 show that QE is associated with lower rental yields in more exposed regions, as predicted by our model, with an even larger and more precisely estimated impact coefficient when we use the share of renters as an exposure measure. In economic terms, these estimates imply that a one-standard-deviation increase in QE, which corresponds to an approximately 4.3 pp higher ratio of ECB debt securities to GDP, reduces the rental yield in regions at the 75th percentile of the exposure distribution relative to those at the 25th percentile, by 2-12 basis points more per year, using the share of refugees or the share of renters as exposure measure, respectively.[17] As the share of debt securities held by the ECB increased from 7%

[16] Note that we cannot estimate the specification in (3) separately including the three sub-components of the regional housing return obtained from the fitted value of the predicting regressions A36-A38, since the only region-specific elements are the constant and the loading on the rental yield.

[17] The yield differential increases to 5-24 basis points when we compare regions at the 5th vs 95th percentile of the respective exposure distribution.

Table 9 QE IMPACT ON HOUSING RETURNS, PRICES, AND RENTS

	(1) Rental Yield	(2) Price Growth	(3) Rent Growth	(4) Rental Yield	(5) House Growth	(6) Rent Growth
Share of Refugees$_{r,2008}$ × QE$_{t-1}$	-0.0003**	0.0100**	0.0023			
	(0.0001)	(0.0042)	(0.0016)			
Share of Renters$_{r,2011}$ × QE$_{t-1}$				-0.0014***	0.0141**	0.0088***
				(0.0002)	(0.0063)	(0.0026)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	3080	3080	3080	3208	3208	3208
R^2	0.937	0.781	0.813	0.939	0.781	0.812

NOTE. The table reports the effects of QE on the rental yield, real house price growth, and real rent growth, respectively. The regressions are based on annual region-level data from 2010 to 2017. The dependent variables are the rent-to-price ratio, the cumulative real house price growth, and the cumulative real rent growth. The main regressor is the interaction term between one-year lagged QE (the share of debt securities held by the ECB over GDP) and a regional exposure measure, as proxied by the 2008 share of refugees or the 2011 share of renters, respectively. All regressions include region and time-fixed effects. The heteroskedasticity-robust standard errors clustered at the region level are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

in 2014 to 24% at the end of our sample period in 2017, these estimates imply a cumulative rental yield decline, evaluated at the regional interquartile range, between 8 and 48 basis points during that period. Such a range, in turn, is sizable relative to the average regional rental yield decline of 1.4 percentage points, from 7.4% in 2014 to 6% in 2017.

Looking at the source of the decline in the rental yield, columns (2)-(3) and (5)-(6) of Table 9 illustrate the breakdown between price and rent growth. These regressions show that house price increases exceed rent growth in more exposed regions during the sample period, again, with the impact on rent growth estimated more precisely with the share of renters. More formally, the Campbell-Shiller decomposition of the German regional housing returns reported in Appendix D, using VAR-implied estimates iterated for three periods (k=3), suggests that only about 5% of the return variation can be attributed to discount rate differentials, 36% to lower future rent growth, and 70% to future price-to-rent increases during our sample period, consistent not only with the evidence in Kindermann et al. (2020), but also with the idea that portfolio rebalancing is associated with an increase in the supply of rental properties and hence a future rent growth decline.

We finally note that the significance of our main QE-regional exposure interactions remains largely unchanged when we control for a rich set of other regional characteristics, such as demography, population, or the number of building permits, interacted with the continuous QE measure. The attendant results are available upon request.

5.2 Quantity Impact

As the final step in our empirical analysis, we provide some evidence on the impact of QE on the volume of transactions, following the same estimation strategy as in Table 9. The quantity outcome variables we consider are the total number of rental and sale listings based on data from the largest German online listing platform (Immoscout 24).

In our model, households purchase housing for investment rather than consumption purposes. Moreover, we have shown that portfolio rebalancing toward housing is arguably driven by a buy-to-let motive in the data, fuelled by tax incentives toward such holdings. To check whether changes in housing outcomes are consistent with these findings and their interpretation, we estimate the impact of QE on both sale and rental listings of the same type of property and then compare the strength of the responses. Our prior is that if a buy-to-let motive drives the portfolio rebalancing documented, one should observe evidence of increased supply in the rental market relative to the sale market, including particularly a bigger increase (or smaller decline) in rental listings than sale listings.

Our model does not have predictions for the response of listing to QE. However, looking at our listing data aggregated at the national level, Figure 3 shows that both sale and rental listings are roughly constant till 2014 and then significantly decline thereafter. Thus, we first assume that these trend declines in Figure 3 reflect a shrinking inventory of properties for lease or sale as the German housing boom progresses (see also Figure 1). We then focus on the *relative* strength of the rental and sale listing declines across regions, assuming that this variable is informative about the relative inventory response in the two market segments.

Table 10 reports the estimation results. As before, columns (1)-(3) measure exposure with the share of refugees, while columns (4)-(6) use the share of renters. Columns (1)-(2)

Table 10 QE Impact on Sale and Rental Listings

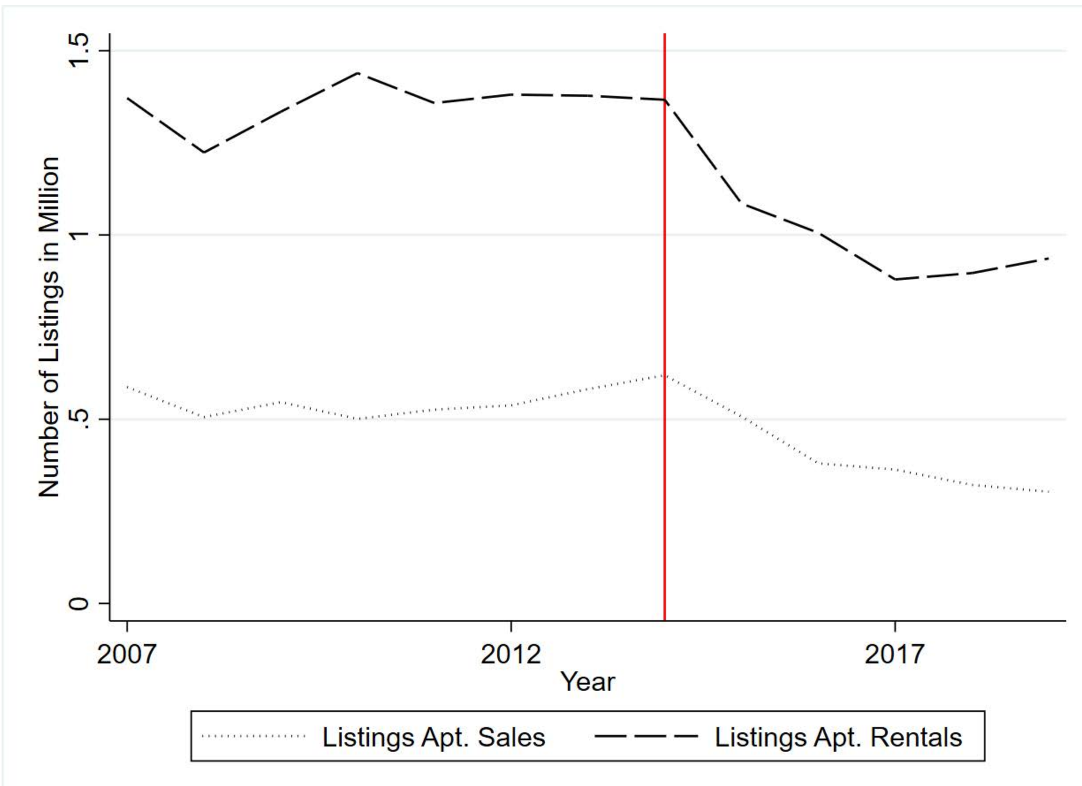
	(1) Sale List.	(2) Rental List.	(3) Sale/Rental List.	(4) Sale List.	(5) Rental List.	(6) Sale/Rental List.
Share of Refugees$_{r,2008}$ × QE$_{t-1}$	-1.795***	-7.234***	-0.00007**			
	(0.287)	(0.847)	(0.00003)			
Share of Renters$_{r,2011}$ × QE$_{t-1}$				-1.170***	-3.818***	-0.00051***
				(0.312)	(1.190)	(0.00008)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	3080	3080	3080	3208	3208	3208
R^2	0.944	0.967	0.770	0.936	0.954	0.770

Note. The table reports the effects of QE on sale and rental listings. The regressions are based on annual region-level data from 2010 to 2017. The dependent variables are the total number of sale and rental listings, as well as their ratio. These data are from Immoscout 24, accessed via the Bundesbank's RDSC. The main regressor is the interaction term between one-year lagged QE (the share of debt securities held by the ECB over GDP) and the exposure measure, which is the 2008 share of refugees or the 2011 share of renters. All regressions include region and time-fixed effects. The heteroskedasticity-robust standard errors clustered at the region level are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

and (4)-(5) show that for both exposure measures, QE *reduces* the total number of sale and rental listings in more exposed regions, in line with the aggregate evidence in Figure 3. Note, however, that the economic magnitude of the coefficients associated with the outcomes cannot be compared, as they are not standardized. Therefore, in columns (3) and (6), we also study the effect of QE on the share of sale over rental listings and we find that sale listings decrease significantly more than rental listings in more exposed regions; a finding that is broadly in line with our model's implications and the evidence that we reported earlier, pointing to a relative increase in the supply of rental properties in the market after QE adoption.

Taken together with our results on the tax motives for household portfolio rebalancing, this latter finding is of significant policy relevance to the ongoing debate around housing affordability. It suggests that there are alternative housing tax policies to those prevailing in the United States that could help mitigate concerns around negative spillovers to housing affordability associated with central banks' QE policies. This is because buy-to-let investments raise housing valuations, but at the same time may also have the dual effect of increasing the supply of rental units, as our results suggest.

Figure 3 Total Number of Sale and Rental Listings Before and After QE (2007-2019, In Million)



Note. The figure plots the aggregate time series of the total number of apartment sales and rental listings. The vertical line is 2014, the year before the formal QE adoption in January 2015. Data Source: Immoscout 24.

6 Conclusions

In this paper, we document a housing portfolio channel of QE transmission working through household portfolio rebalancing toward second homes for investment rather than consumption purposes, possibly fuelled by a tax regime that favors rental properties in Germany.

We find that, following QE, more exposed households rebalance their portfolios toward second homes more significantly, but not toward equities. This portfolio rebalancing is economically sizable and is stronger when we focus on higher-income and church-affiliated households, which benefit more from the significant tax advantages afforded by the German tax code to rented properties or properties that may be rented in the future, consistent with a buy-to-let motive. The rebalancing is also stronger for more financially literate households and those actively advised by their bank on asset allocation. Finally, we find that portfolio rebalancing is not driven by household leverage or increased mortgage borrowing. When we look at the impact of QE on housing outcomes, we find that regions with a tighter or more developed rental market see larger declines in their rental yields and slower declines in the number of rental listings relative to sale listings. To interpret the evidence, we also propose a simple housing portfolio model with segmented housing markets and preferred habitat investors.

Our findings have potentially important policy implications for housing affordability to the extent to which the supply of rental housing increases in response to shocks that simultaneously boost housing valuations through buy-to-let investments.

Exploring the impact of this transmission channel on household consumption, as well as investigating its relevance in other institutional settings, such as China and other emerging markets, and for non-bank financial intermediaries in the United States are intriguing avenues for future research. Similarly, further examination of the distributive effects of QE policies under alternative housing tax regimes can provide insights into the worldwide housing affordability problem.

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Appendix

'A Housing Portfolio Channel of QE Transmission'

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A Data Sources and Summary Statistics

This appendix defines all variables that we use in the empirical analysis and provides their sources and summary statistics. Table A1 reports the number of households per survey wave and the number of panel households. Table A2 summarizes all variable definitions and sources. Table A3 reports summary statistics.

The first part of Table A3 shows household-level variables. On average, a household's share of housing wealth (secondary housing wealth) in the total portfolio increases by 0.67 (0.65) percentage points from one wave to the other. The number of second homes per household, on average, increases by 0.07. The average share of bond wealth in total wealth is 14.61% (4.31% if measured without decile imputation, and 0.96% if only direct holdings are considered). The average deposit portfolio share is 25.52%. The average household's per capita income is 35,180 EUR. 60% of the households are church members, 14% received an investment recommendation from their principal bank, and 33% are renters. 53% of the household's heads are 60 years old or older, 37% between 40 and 60 years, and 10% younger than 40 years old. The average change in the logarithm of mortgage credit is -12.1% between the two waves and the average value of mortgage credit over the total housing value is 13%.

The second part of Table A3 reports summary statistics for the regional variables. It shows that, on average, the share of renters in a region is 52%, so higher than in the household data and consistent with the aggregate figure reported in Table 1. The share of refugees in independent accommodation is 12.7%.

Table A1 The Number of Households per Wave

Wave	Implementation Window	No. Households	No. Household Panels
1	2010:Q3-2011:Q3	3565	1651
2	2014:Q2-2014:Q4	4461	1651
3	2017:Q1-2017:Q4	4942	1651

Table A2 Variable Definitions and Sources

Variable	Definition	Unit	Source
$\Delta HOUSING$	A household's change in housing wealth over the total portfolio size	%	PHF
$\Delta SEC.HOUSING$	A household's change in other (non-main residence) housing wealth over the total portfolio size[a]	%	PHF
$\Delta UNITS$	A household's change in the number of houses other than main residence	-	PHF
$\Delta STOCKS$	A household's change in directly and indirectly held stocks over the total portfolio size	%	PHF
Bonds	A household's share of bond holdings over the total portfolio value[b]	%	PHF
Deposits	A household's share of deposit value over the total portfolio size	%	PHF
Income	A household's total net income divided by the number of household members	-	PHF
Net Worth	A household's value of total assets less the outstanding liabilities	ln(x)	PHF
Members	The number of household members	-	PHF
Age	The household head's age	-	PHF
Risk Aversion	=1 if a household's self-reported degree of risk aversion is larger than the in-sample median	0/1	PHF
Church	=1 if the head of the household is a member of a church	0/1	PHF
Financial Advice	=1 if household received an investment recommendation by their principal bank	0/1	PHF
Financial Literacy	Classification on how financially literate a household is based on three simple questions[c]	0/1/2/3	PHF
Renter	=1 if the household is a renter in the main residence	0/1	PHF
Young Age	=1 if household head is below the age of 40	0/1	PHF
Middle Age	=1 if household head is between the age of 40 and 60	0/1	PHF
Older Age	=1 if household head's age is above 60	0/1	PHF
$\Delta MortgageCredit$	A household's change in the logarithm of mortgage credit	%	PHF
Mortgage to Housing	Value of mortgage credit over the total housing value	%	PHF
Rental Yield	Region-level rent-to-price ratios	%	Bulwiengesa AG, Riwis 2022
Price Growth	Region-level cumulative real house price growth	2009=100	Bulwiengesa AG, Riwis 2022
Rent Growth	Region-level cumulative real rent growth	2009=100	Bulwiengesa AG, Riwis 2022
Sale Listings	Region-level number of sale listings on Immoscout 24	-	Immoscout 24
Rental Listings	Region-level number of rental listings on Immoscout 24	-	Immoscout 24
Sale/Rental Listings	Region-level ratio of sale over rental listings	-	Immoscout 24
Share of Refugees	2008 Regional share of refugees over total German refugees, multiplied by the share of refugees housed in independent accommodation	%	See Bednarek et al. (2021)
Share of Renters	Regional share of people renting their main residence	%	Census 2011
QE	Total debt securities held by the ECB over nominal GDP	%	ECB
Post	=1 after the ECB adopts QE in January 2015	0/1	PHF

[a] Throughout the paper, the total portfolio size is calculated as the sum of housing and all financial assets. For robustness, we also scale other housing wealth by the sum of bonds, deposits, and housing only, in line with our theoretical model.

[b] We use three different bond share measures. The first calculates the share of bond value (both directly held and indirectly via insurance and mutual funds) in the total portfolio (housing and all financial assets). As data on direct bond holdings are missing for most households, we impute these values by replacing missing values with the average bond holdings in the corresponding net wealth decile. The second measure does not apply this imputation. Measure three only includes households' direct bond holdings and hence does not contain their indirect holdings.

[c] Financial literacy is measured based on three questions on the difference between real and nominal interest rates, compound interest, and portfolio diversification. The three questions are: 1) Let us assume that you have a balance of €100 in your savings account. This balance bears interest at a rate of 2% per year and you leave it for 5 years on this account. How high do you think your balance will be after 5 years? 2): Let us assume that your savings account bears interest at a rate of 1% per year and the rate of inflation is 2% per year. Do you think that in one year, the balance on your savings account will be the same as, more than or less than today? 3) Do you agree with the following statement: "Investing in shares of one company is less risky than investing in a fund containing shares of similar companies?"

Table A3 Summary Statistics

Variable	Observations	Mean	St. Dev.	5th	Median	95th
$\Delta HOUSING$	2954	0.67	23.50	-26.39	0	32.07
$\Delta SEC.HOUSING$	2954	0.65	19.87	-28.13	0	31.50
$\Delta UNITS$	2954	0.07	0.87	-1	0	1
$\Delta STOCKS$	2954	-1.91	9.52	-19.45	0	9.53
Bonds						
Bond Measure 1	2954	14.61	19.79	3.14	7.31	67.84
Bond Measure 2	2954	4.31	8.88	0	0.87	16.92
Bond Measure 3	2954	0.96	5.53	0	0	3.40
Deposits	2952	25.52	31.63	0.39	10.72	100
Income	2954	35.18	51.59	8.32	24.70	83.81
Net Worth	2852	11.96	1.84	8.38	12.41	14.22
Members	2954	2.31	1.08	1	2	4
Age	2954	57.69	14.50	31	59	79
Risk Aversion	2951	0.47	0.50	0	0	1
Church	2954	0.60	0.49	0	1	1
Financial Advice	1922	0.14	0.35	0	0	1
Financial Literacy	1477	2.61	0.68	1	3	3
Renter	2954	0.33	0.47	0	0	1
Young Age	2954	0.10	0.31	0	0	1
Middle Age	2954	0.37	0.48	0	0	1
Older Age	2954	0.53	0.50	0	1	1
$\Delta MortgageCredit$	2954	-12.10	400.80	-979.81	0	1049.13
Mortgage to Housing	2954	13.01	29.32	0	0	74.00
Rental Yield	3208	7.43	1.57	5.00	7.41	10.00
Price Growth	3208	110.11	19.21	88.28	104.09	149.36
Rent Growth	3208	104.54	8.59	94.89	102.10	121.33
Sale Listings	3080	1018.61	1534.19	65	512.5	3744
Rental Listings	3080	2777.20	4881.83	184	1196.5	10609
Sale/Rental Listings	3080	0.49	0.31	0.13	0.41	1.09
Share of Refugees	3080	12.71	18.81	0.77	6.79	42.62
Share of Renters	3208	52.33	12.95	36.45	48.83	76.75
QE	3208	8.90	4.27	4.90	7.30	18.97

Note. The table reports the summary statistics of all variables. The sample is restricted to households included in our benchmark regression in Table 3, column (1). See Table A2 for data definitions and sources. The maximum and minimum values or the values for households at the 1st and 99th percentile cannot be reported due to data confidentiality reasons.

Table A4 HOUSEHOLD PORTFOLIO REBALANCING: PLACEBO TESTS

	(1) ΔY	(2) ΔNon-Financial
Bonds × Post	-	-0.138
		(0.095)
Non-Financial × Post	-0.044	
	(0.036)	
Household FE	Yes	Yes
Time FE	Yes	Yes
Obs	2662	2486
R^2	0.346	0.324

NOTE. All regressions are based on our panel of households from the PHF. The number of observations varies depending on the constraint imposed by the right-hand side variables. The dependent variable in column (1) is the change in household wealth invested in second homes over total bonds, housing, and deposits as in column (1) of Table 3. In column (2), it is the non-financial, non-housing wealth over the total portfolio size. The main regressor is the double interaction between the post dummy and the household-level shares of wealth invested in non-financial, non-housing assets (column 1) or bonds (column 2), respectively, measured in 2014. Data details are in Table A2. The regressions include time and household fixed effects. Heteroskedasticity-robust standard errors are shown in parentheses. *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

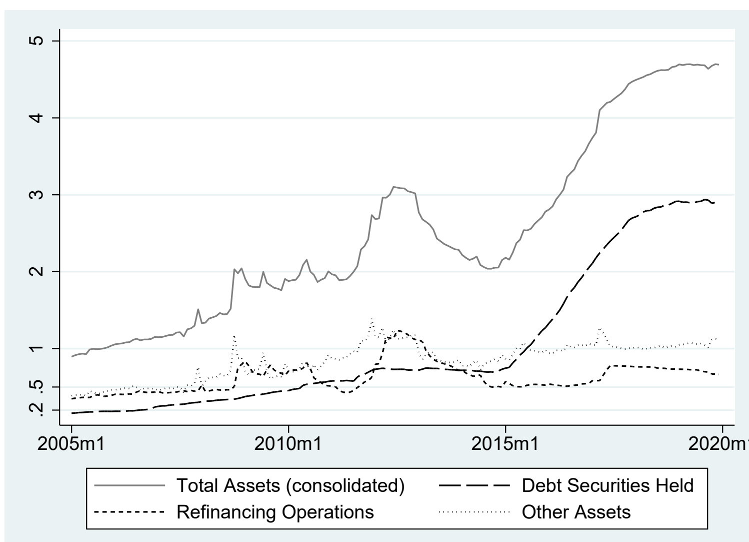
B Institutional Setting

This appendix provides institutional background on two important issues: the ECB's QE policy and the preferential tax treatment of second homes in Germany.

B.1 Non-conventional Monetary Policy in the Euro Area

Following the global financial crisis, once the ECB hit the zero lower bound, it adopted non-conventional monetary policy tools. As Figure A1 shows, before 2015, the increase in the ECB's total assets was mainly driven by refinancing operations—long-term liquidity channeled toward the banking system to stimulate bank loan supply (e.g., Bednarek et al., 2021). Starting in January 2015, the ECB officially announced its quantitative easing program, and the evolution of the ECB's total assets is driven by the holdings of debt securities. While the ECB initially only purchased government and a smaller amount of covered bonds, it also started buying private sector bonds as of June 2016 in the course of its Corporate Sector Purchase Program (CSPP). Relative to government bonds, the economic magnitude, however, is much smaller.

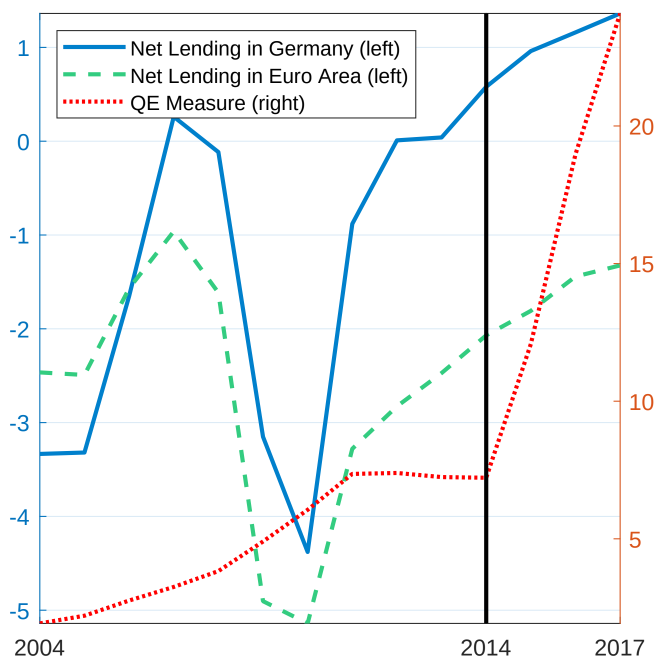
Figure A1 The Eurosystem's Balance Sheet



Note. This figure plots (in trillion euros) the Eurosystem's consolidated total assets and its main components: total refinancing operations, i.e., main (short-term) and long-term; the total amount of debt securities held, and other assets. Source: ECB.

In our model, ECB purchases of (government) debt securities reduce the *net* supply of bonds available to the market, increase bond prices, reduce bond returns, and therefore induce portfolio rebalancing towards housing. These effects, however, could be clouded if QE adoption in January 2015 was also accompanied by an increase in the *gross* supply of bonds, for example, driven by governments issuing more new bonds in response to the ECB's QE. However, Figure A2 shows that, around the time of QE adoption in the euro area, the German government did not increase or decrease its issuance of new bonds. Specifically, the ratio of net lending to GDP continued on its pre-trend. The same is true when we look at net lending over the GDP of the euro area as a whole, providing direct evidence that QE affected the net supply of bonds available to the market.

Figure A2 THE SUPPLY OF NEW BONDS REMAINS UNCHANGED



NOTE. This figure plots the German and euro area ratio of government net lending to GDP (blue-solid and green-dashed lines, respectively), as well as the share of debt securities held by the ECB in GDP (red-dotted line). Sources: ECB and the IMF's World Economic Outlook Database.

B.2 The Tax Treatment of Real Estate in Germany

In this appendix, we discuss the differential tax treatment of first and second homes. Consider a cash purchase like in our model of an apartment with a purchase price of 200,000 EUR, transaction costs (agent, property taxes, and notary) of 10% (20,000 EUR), and renovation costs of 15% (30,000 EUR). The maximum marginal tax rate is 42% in Germany.

If this purchase is a first home or main residence, a household can deduct only up to 1,200 EUR per year of the renovation costs, which implies a tax deduction of 504 EUR per year (=0.42*1,200). In contrast, if this purchase is a second home that is either rented out (or with the stated intention to rent it out in the future), in the first year, the household can deduct 2% of the purchase price (4,000 EUR), the full renovation costs (30,000 EUR), and 2% of the transaction costs (400 EUR), thus adding up to a 14,448 EUR tax deduction. In all subsequent years, households can reduce their taxable income by 2% of the apartment price (4,000 EUR) and 2% of the transaction costs (400 EUR) per year, which amounts to a further yearly deduction of 1,848 EUR.

The tax difference between first and second homes is even more substantial if we assume that households take out a mortgage, as mortgage interest payments for second homes can be deducted in full, while they cannot be deducted for the main residence.

The differential tax treatment between first and second homes is significant and a critical driver of the very low German homeownership rate—e.g., Kaas et al. (2021). The main reason for the preferential tax treatment of second homes, in turn, is historical. At the end of WWII, most of the housing stock in urban areas was destroyed while the credit supply was limited. Cognizant of the reconstruction needs, German housing policies have since been designed to support and foster rental markets.

C Theoretical Framework

To interpret our results, motivate our exposure variables, and illustrate the workings of our QE transmission channel, in this appendix, we set up a simple housing portfolio model with asset market segmentation and preferred habitat investors.

In the model, local real estate investors and national bond investors specialize in holding houses and bonds, respectively. Local representative household arbitrage among cash, bonds, and local houses.[A1] In response to QE, as the bond supply declines, both the preferred habitat bond investor and the local household lower their bond holdings. The bond price increases. Provided that the bond and house returns are positively correlated, and hence the two assets are substitutes, local households increase their demand for houses and bid up house prices, rebalancing their portfolios. Meanwhile, preferred habitat real estate holders sell houses to households. The total expected future portfolio return declines, and if the equilibrium house holding is large enough, both the bond and housing components of the total return decline. In this channel, therefore, QE works through household portfolio rebalancing, rather than bank portfolio rebalancing or higher credit supply to households. Moreover, house sales and purchases can be cash transactions.

C.1 Agent, Assets, Market Clearing and Equilibium

Consider a representative household that solves a portfolio problem, including local houses, national bonds, and cash (modeled as transaction technology). Houses and national bonds are risky assets. Their exogenous payoffs are $\mu_1 + \varepsilon_1$ and $\mu_2 + \varepsilon_2$, respectively, with $E[\varepsilon_1] = E[\varepsilon_2] = 0$, $\text{Var}(\varepsilon_1) = \sigma_1^2$, $\text{Var}(\varepsilon_2) = \sigma_2^2$ and $\text{Cov}(\varepsilon_1, \varepsilon_2) = \sigma_{12}$.

There are three agents trading: two preferred habitat investors in each risky asset market and one regional household that arbitrages between markets. Following Vayanos and Vila (2021), we assume that the preferred habitat investor in the local housing market has the following downward-sloping demand function

$$\tilde{h} = -\alpha_1(P - \beta_1), \tag{A1}$$

[A1] The model can be easily extended to include equity in the asset menu. We keep it simple to obtain clear closed-form solution expressions. For the same reason, we do not consider leveraged portfolios.

where $\alpha_1, \beta_1 > 0$ are parameters, P is the house price and $\tilde{h}$ is the quantity demanded. Similarly, we assume that the demand function of the preferred habitat investor in the national bond market is

$$\tilde{b} = -\alpha_2(Q - \beta_2), \tag{A2}$$

where $\alpha_2, \beta_2 > 0$ are parameters, Q is the bond price and $\tilde{b}$ is the quantity demanded.

The preferred habitat investors buy (sell) the excess supply (demand) of the households at given market prices. Unlike households, they do not arbitrage across markets and segment markets for risky assets. The rationale is that both housing and bond markets have a specialized investor base. In the local housing market, these investors can be interpreted as real estate agents who intermediate among households. They can also represent *poor* (not optimizing) agents that transact with *wealthy* (wealth-maximizing) households.

One important assumption is that the household is risk-averse and has mean-variance utility (or equivalently power utility over end-of-period wealth), and hence limited risk-bearing capacity. The price of risky assets would only reflect the expected payoffs with no price impact stemming from changes in the quantity of assets supplied if the household were risk-neutral. In addition to the two risky assets, the household also has access to a transaction technology, or cash x, that for simplicity, pays a zero return.[A2] In each period, the household chooses her portfolio of houses, h, bonds, b, and cash, x, solving the following problem:

$$\max_{h,b,x} \quad E[W'] - \frac{\gamma}{2}Var(W') = h\mu_1 + b\mu_2 + x - \frac{\gamma}{2}(h^2\sigma_1^2 + b^2\sigma_2^2 + 2hb\sigma_{12}) \tag{A3}$$

$$\text{s.t.} \quad W = Ph + Qb + x, \tag{A4}$$

$$W' = h(\mu_1 + \varepsilon_1) + b(\mu_2 + \varepsilon_2) + x \tag{A5}$$

where γ is the risk aversion parameter and $W(W')$ is initial (end-of-period) wealth. The first-order conditions are:

$$\lambda Q = \mu_2 - \gamma b\sigma_2^2 - \gamma h\sigma_{12} \tag{A6}$$

$$\lambda P = \mu_1 - \gamma h\sigma_1^2 - \gamma b\sigma_{12} \tag{A7}$$

$$\lambda = 1. \tag{A8}$$

These conditions are intuitive: households equate the marginal cost of investing one additional unit of wealth in each asset with its marginal benefit, which is the expected risk-adjusted payoff of that asset.

The total supply of risky assets is fixed with the central bank supplying cash elastically as demanded. In equilibrium, market clearing requires:

$$h + \tilde{h} = \bar{h} \tag{A9}$$

$$b + \tilde{b} = \bar{b} \tag{A10}$$

[A2] An alternative assumption, here, is to introduce short-term bonds as a third traded asset with an exogenous process for the short-term interest rate controlled by the central bank. Credit can be introduced, for example, as in Flavin and Yamashita (2002). We omit these features to keep the model analytically tractable.

where $\bar{h}$ and $\bar{b}$ are the total supply of local houses and national bonds, respectively.

An equilibrium is an asset allocation—i.e., a set of asset demands by the regional household and preferred habitat investors, $\{x, h, \tilde{h}, b, \tilde{b}\}$—and a set of asset prices, $\{P, Q\}$, such that (1) regional households solve the mean-variance problem; (2) the demand of the preferred habitat investors is satisfied in both markets; and (3) asset markets clear.

C.2 QE and Portfolio Rebalancing

We model QE (i.e., central bank purchases) as a reduction in the bond supply to the market, $\bar{b}$. To analyze the impact of QE, consider the following comparative statics to the total bond supply $\bar{b}$:

$$
\begin{aligned}
\frac{db}{d\bar{b}} &= \frac{(1/\alpha_1 + \gamma\sigma_1^2)/\alpha_2}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} > 0 \\
\frac{dQ}{d\bar{b}} &= \frac{1}{\alpha_2}\left(\frac{db}{d\bar{b}} - 1\right) = \frac{1}{\alpha_2}\frac{-(1/\alpha_1 + \gamma\sigma_1^2)\gamma\sigma_2^2 + \gamma^2\sigma_{12}^2}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} < 0 \\
\frac{dh}{d\bar{b}} &= \frac{-\gamma\sigma_{12}/\alpha_2}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} \\
\frac{dP}{d\bar{b}} &= \frac{1}{\alpha_1}\frac{dh}{d\bar{b}}.
\end{aligned}
$$

The impact of a reduction in $\bar{b}$ on the bond market is unambiguous, driven by the downward-sloping demand of the preferred habitat investor and the fixed supply. QE drives down the total bond supply available to both investors, pushing up the price, Q, which induces both investors to lower their holdings. Other things equal, the household rebalances her portfolio by lowering demand for bonds to compensate for the decline in the bond risk-adjusted expected return induced by higher Q, as equation (A6) shows. In contrast, the following proposition illustrates that the impact of QE on the local housing market is ambiguous, depending on the covariance between the bond and house payoffs, σ_{12}.

Proposition 1. ***(QE-induced Housing Portfolio Rebalancing)*** *A reduction in the supply of bonds, $\bar{b}$, i.e., a QE intervention, increases the local demand for houses and house prices (i.e., $\frac{dh}{d\bar{b}} \leq 0$ and $\frac{dP}{d\bar{b}} \leq 0$) if and only if housing and bond payoffs are positively correlated ($\sigma_{12} \geq 0$).*

Proof. See Section C.4. □

Houses and bonds are substitutes in the household's portfolio when their returns are positively correlated, as is also the case in our data. Under this assumption, all else equal, lowering bond holdings b increases the household's risk-adjusted return of house holdings through the last term in equation (A7). In equilibrium, for a given supply of houses, $\tilde{h}$, the household must therefore increase its exposure to houses to equate risk-adjusted returns, and the house price increases to accommodate this higher demand through the sales of the preferred habitat investor. It follows from Proposition 1 that the housing portfolio share of the regional households increases with QE, as the following corollary states.

Corollary 1. Define the housing portfolio share as $\alpha_h \equiv \frac{Ph}{W}$. Proposition 1 implies that $\frac{d\alpha_h}{d\bar{b}} \leq 0$, i.e., the housing portfolio share increases with QE when $\sigma_{12} \geq 0$.

Since the housing portfolio share increases in response to QE, the share of bonds *plus* cash must decrease, in equilibrium under the assumption made. However, to pin down the response of the cash share, $\alpha_x \equiv \frac{x}{W}$, we need to know the response of the bond share, $\alpha_b \equiv \frac{Qb}{W}$, which can increase or decrease because QE lowers b but increases Q. Therefore, whether rebalancing toward housing is also funded by cash is an empirical matter.[A3]

Note here that, in our simple model, the portfolio rebalancing above critically depends on the payoff structure of the risky asset menu and the risk-aversion assumption. Indeed, the portfolio shares would not change in response to QE if the risky asset payoff correlation were zero, i.e., $\sigma_{12} = 0$ or the agent's risk aversion was zero, i.e., $\gamma = 0$.

C.2.1 Model Implications for Identification with Household Data

Albeit simple and with a representative agent, the model above helps motivate the relevance condition of the ex-ante bond share as an exposure measure to our household rebalancing channel. It also helps to interpret the empirical evidence we report in the paper to support the assumptions needed to conduct our difference-in-differences analysis.

In our empirical analysis, for identification purposes, we exploit ex-ante household heterogeneity in portfolio shares, as captured by the portfolio allocation in wave two of the PHF survey. Thus, we assume that households with different idiosyncratic characteristics have ex-ante different optimal portfolios and bond shares. When QE takes place in early 2015, all households rebalance toward housing but to a different extent, depending on their individual observable and unobservable characteristics that determine the size of the ex-ante bond position and hence their incentives to rebalance. The larger this position, the more significant the unrealized capital gains from QE, and the stronger the incentive to rebalance. Critically, however, the characteristics that pin down the heterogeneous optimal ex-ante bond position should not be affected by QE itself as, otherwise, the optimal household-specific portfolio allocation would also change in response to QE.

For example, in our simple model, the optimal equilibrium bond share can be related to

[A3]It is easy to see that

$$\frac{d\alpha_b}{d\bar{b}} = \frac{1}{\alpha_2 W}\frac{(1/\alpha_1 + \gamma\sigma_1^2)(Q - \gamma b\sigma_2^2) + b\gamma^2\sigma_{12}^2}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2},$$

whose sign depends on $Q - \gamma b\sigma_2^2 + b\frac{\gamma^2\sigma_{12}^2}{1/\alpha_1 + \gamma\sigma_1^2} = \beta_2 - \frac{1}{\alpha_2}\bar{b} + b\left(\frac{1}{\alpha_2} - \gamma\sigma_2^2 + \frac{\gamma^2\sigma_{12}^2}{\frac{1}{\alpha_1} + \gamma\sigma_1^2}\right)$, with $b = \frac{(1/\alpha_1+\gamma\sigma_1^2)(1/\alpha_2\bar{b}+\mu_2-\beta_2)-\gamma\sigma_{12}(1/\alpha_1\bar{h}+\mu_1-\beta_1)}{(1/\alpha_1+\gamma\sigma_1^2)(1/\alpha_2+\gamma\sigma_2^2)-\gamma^2\sigma_{12}^2}$ in equlibium. By the same token, QE also has an ambiguous effect on the cash share α_x. In fact,

$$\frac{d\alpha_x}{d\bar{b}} = \frac{1}{W\alpha_2}\frac{\mu_1\gamma\sigma_{12} - \mu_2(1/\alpha_1 + \gamma\sigma_1^2) + 2\gamma(h\sigma_{12} + b\sigma_2^2)/\alpha_1 + 2\gamma^2 b(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2},$$

whose sign depends on the numerator.

the risk aversion parameter γ. Indeed, it is easy to show that $\frac{d\alpha_b}{d\gamma} < 0$, as

$$\frac{d\alpha_b}{d\gamma} = -\frac{\beta_2 - \frac{\bar{b}}{\alpha_2} + \frac{2}{\alpha_2}b}{W} \frac{1/\alpha_1 h\sigma_{12} + b/\alpha_1\sigma_2^2 + \gamma b(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} < 0.$$

Intuitively, a more risk-averse household will hold more cash, and hence have a smaller position in risky assets, which also implies a smaller bond share. Similarly, we can also show that the risk aversion parameter also affects the incentive to rebalance toward housing. In fact,

$$\frac{d}{d\gamma}\left(\frac{dh}{d\bar{b}}\right) = \frac{dh}{d\bar{b}} \frac{\frac{1}{\gamma\alpha_1\alpha_2} - \gamma(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2}, \tag{A11}$$

so under the mild condition that $\sigma_{12} < \sqrt{\sigma_1^2\sigma_2^2 - \sigma_{12}^2}$, $\frac{d}{d\gamma}\left(\frac{dh}{d\bar{b}}\right) > 0$, implying that a less risk-averse household (a lower γ) has a stronger incentive to rebalance towards houses when the covariance term is not too large. Of course, in the data, other idiosyncratic characteristics might determine the optimal portfolio allocation. In our empirical analysis, we use the initial bond share as a variable capturing the incentive to rebalance when QE occurs.

Turning to the orthogonality condition, our critical identification assumption is that household characteristics, such as risk aversion, the properties of the idiosyncratic income process, and the demographics that determine the ex-ante bond share distribution across households, do not respond to QE. Given the ex-ante distribution of bond shares, QE triggers rebalancing through capital gains on these initial bond positions. As long as the optimal portfolio allocation is not affected by QE, the ex-ante bond share is a valid instrument for the identification of our housing portfolio rebalancing channel.

Is this a plausible assumption? In the paper, we explore the persistence of household characteristics across survey waves and control for observable and unobservable household characteristics, including risk aversion. Here, we note that, while the representative household's risk aversion is exogenous in the model, it could be endogenous and time-varying in richer set-ups and in the data. So one can think about QE as also working through its impact on risk aversion, invalidating our identification assumptions. However, transmission through risk aversion is qualitatively different from the one through bond supply $\bar{b}$. In our model, a lower γ and lower $\bar{b}$ both imply a higher risk-adjusted housing return. However, lower γ induces portfolio rebalancing from cash to both risky assets, bonds and houses, as one can show that $\frac{db}{d\gamma}, \frac{dh}{d\gamma}, \frac{dP}{d\gamma}, \frac{dQ}{d\gamma} < 0$ regardless of the sign of σ_{12}. In contrast, lower $\bar{b}$ implies rebalancing from national bonds to local houses, as we find in the data.

C.3 QE and Housing Portfolio Returns

In this section, we elaborate on the model implications for the total portfolio return and its housing component, which we utilized to estimate the impact of QE on housing outcomes through our housing rebalancing channel.

As the households respond to QE by rebalancing their portfolios, the total return on wealth changes. To see this, define $E[R]$, the total expected return on wealth, as

$$E[R] = \frac{E[W']}{W} = \frac{h\mu_1 + b\mu_2 + x}{W} \tag{A12}$$

$$= 1 + \underbrace{\frac{h(\mu_1 - P)}{W}}_{\equiv E[R^h]} + \underbrace{\frac{b(\mu_2 - Q)}{W}}_{\equiv E[R^b]} \tag{A13}$$

$$= 1 + \frac{\gamma}{W}(h^2\sigma_1^2 + b^2\sigma_2^2 + 2hb\sigma_{12}), \tag{A14}$$

where the last expression derives from using the budget constraint and the optimality conditions of the household. In equilibrium, $E[R]$ is equal to the zero return on the safe asset plus a risk premium proportional to the total portfolio risk. As Proposition 1 states, with a positive covariance term $\sigma_{12} > 0$, QE induces rebalancing from bonds, b, to houses, h, with both asset prices increasing.

The third term in equation (A13) shows that the bond component of the total return, $E[R^b]$, always declines since Q increases while b declines in response to QE for given initial wealth, W. In contrast, the effect of QE on the expected housing return, $E[R^h]$, is ambiguous and depends on the relative strength of price and quantity responses to QE that push the housing return in opposite directions, as both h and Q increase with QE in the second term of equation (A13). Thus, the QE impact on the total portfolio return depends on the relative contribution of the two assets to the total portfolio risk, which in turn depends on the model's structural parameters.

The following proposition shows that if $\sigma_{12} > 0$, the decline in $E[R^b]$ is strong enough to guarantee that the total return always declines regardless of $E[R^h]$. Moreover, if the house price response is large enough, $E[R^h]$ also declines.

Proposition 2. ***(QE Impact on Total and Housing Expected Portfolio Returns)*** *If σ_{12} is positive, QE lowers the expected total portfolio return, i.e.,*

$$\frac{dE[R]}{d\bar{b}} > 0.$$

Moreover, if the equilibrium holding of houses is large enough, i.e.,

$$h > \frac{\alpha_1\mu_1 + \bar{h} - \alpha_1\beta_1}{2},$$

where

$$h = \frac{(1/\alpha_2 + \gamma\sigma_2^2)(1/\alpha_1\bar{h} + \mu_1 - \beta_1) - \gamma\sigma_{12}(1/\alpha_2\bar{b} + \mu_2 - \beta_2)}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2},$$

the QE impact on the house price (P) dominates the effect on the quantity (h), and the expected housing return $E[R^h]$ also declines, i.e.,

$$\frac{dE[R^h]}{d\bar{b}} > 0.$$

Proof. See Section C.4. □

The relationship between housing returns and the equilibrium house holdings is inverted U-shaped in the model. When the equilibrium holding is large enough, the expected housing return falls with higher h. Thus, in this case, as QE increases, the equilibrium house holding h increases, lowering the housing return too.

C.3.1 Model Implications for Identification in Regional Data

In our empirical analysis of the impact of portfolio rebalancing on housing market outcomes in Section 5, we rely on an exogenous source of regional variation in housing market tightness, the share of refugees in independent accommodations, as in Bednarek et al. (2021).

The relevance of this instrument can be easily seen by considering the impact of a change in the local housing supply on the total portfolio return and its components, which are given by Equations (A32)-(A34) in Section C.4. Thus,

$$\frac{d}{d\bar{h}}\left(\frac{dE[R]}{d\bar{b}}\right) = 2\gamma\sigma_{12}\frac{\frac{1}{\alpha_1\alpha_2} - \gamma^2(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)}{\alpha_1\alpha_2 W[(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2]^2} \tag{A15}$$

$$\frac{d}{d\bar{h}}\left(\frac{dE[R^h]}{d\bar{b}}\right) = \frac{(1/\alpha_2 + \gamma\sigma_2^2)(\gamma\sigma_1^2 - 1/\alpha_1) - \gamma^2\sigma_{12}^2}{\alpha_1 W[(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2]}\frac{dh}{d\bar{b}} \tag{A16}$$

$$\frac{d}{d\bar{h}}\left(\frac{dE[R^b]}{d\bar{b}}\right) = \frac{(1/\alpha_1 + \gamma\sigma_1^2)(\gamma\sigma_2^2 - 1/\alpha_2) - \gamma^2\sigma_{12}^2}{\alpha_2 W[(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2]}\frac{db}{d\bar{h}}. \tag{A17}$$

Given these expressions, it is possible to show that

- $\frac{d}{d\bar{h}}\left(\frac{dE[R]}{d\bar{b}}\right) < 0$ if $\sigma_{12} < \sqrt{\sigma_1^2\sigma_2^2 - \frac{1}{\gamma^2\alpha_1\alpha_2}}$
- $\frac{d}{d\bar{h}}\left(\frac{dE[R^h]}{d\bar{b}}\right) < 0$ if $\sigma_{12} < \sqrt{\sigma_1^2\sigma_2^2 - \frac{1}{\gamma^2\alpha_1\alpha_2} + \frac{\alpha_1\sigma_1^2 - \alpha_2\sigma_2^2}{\gamma\alpha_1\alpha_2}}$,
- $\frac{d}{d\bar{h}}\left(\frac{dE[R^b]}{d\bar{b}}\right) < 0$ if $\sigma_{12} < \sqrt{\sigma_1^2\sigma_2^2 - \frac{1}{\gamma^2\alpha_1\alpha_2} - \frac{\alpha_1\sigma_1^2 - \alpha_2\sigma_2^2}{\gamma\alpha_1\alpha_2}}$,

which imposes an upper limit on the degree of positive payoff correlation. Thus, our model implies that the tighter the housing supply, the stronger the impact of portfolio rebalancing on local housing returns, which is our main hypothesis in Section 5.1 of the empirical analysis.

C.4 Proofs of Propositions 1, 2

The representative regional household problem is

$$\max_{h,b,x}\quad E[W'] - \frac{\gamma}{2}Var(W') = h\mu_1 + b\mu_2 + x - \frac{\gamma}{2}(h^2\sigma_1^2 + b^2\sigma_2^2 + 2hb\sigma_{12}) \tag{A18}$$

$$\text{s.t.}\quad W = Ph + Qb + x, (\lambda) \tag{A19}$$

$$W' = h(\mu_1 + \varepsilon_1) + b(\mu_2 + \varepsilon_2) + x. \tag{A20}$$

The first-order conditions are:

$$\lambda Q = \mu_2 - \gamma b\sigma_2^2 - \gamma h\sigma_{12} \tag{A21}$$
$$\lambda P = \mu_1 - \gamma h\sigma_1^2 - \gamma b\sigma_{12} \tag{A22}$$
$$\lambda = 1. \tag{A23}$$

Combining market clearing with the demand functions of two preferred habitat investors, we obtain:

$$\bar{h} - h = -\alpha_1(P - \beta_1) \tag{A24}$$
$$\bar{b} - b = -\alpha_2(Q - \beta_2) \tag{A25}$$

Thus, the equilibrium levels of h and b are

$$h = \frac{(1/\alpha_2 + \gamma\sigma_2^2)(1/\alpha_1\bar{h} + \mu_1 - \beta_1) - \gamma\sigma_{12}(1/\alpha_2\bar{b} + \mu_2 - \beta_2)}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} \tag{A26}$$
$$b = \frac{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2\bar{b} + \mu_2 - \beta_2) - \gamma\sigma_{12}(1/\alpha_1\bar{h} + \mu_1 - \beta_1)}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2}. \tag{A27}$$

The responses of the equilibrium portfolio quantities, b and h, to changes in the fixed supply of the two risky assets, $\bar{b}$ and $\bar{h}$, are

$$\frac{dh}{d\bar{b}} = \frac{-\gamma\sigma_{12}/\alpha_2}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} \tag{A28}$$
$$\frac{db}{d\bar{b}} = \frac{(1/\alpha_1 + \gamma\sigma_1^2)/\alpha_2}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} > 0 \tag{A29}$$
$$\frac{dh}{d\bar{h}} = \frac{(1/\alpha_2 + \gamma\sigma_2^2)/\alpha_1}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} > 0 \tag{A30}$$
$$\frac{db}{d\bar{h}} = \frac{-\gamma\sigma_{12}/\alpha_1}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2}. \tag{A31}$$

As the denominator in the RHS of these equations is strictly positive by Cauchy–Schwarz inequality, the sign of $\frac{dh}{d\bar{b}}$ thus depends on σ_{12}. Moreover, from equation (A24), $\frac{dP}{d\bar{b}} = \frac{1}{\alpha_1}\frac{dh}{d\bar{b}}$. Therefore, $\frac{dh}{d\bar{b}}, \frac{dP}{d\bar{b}} < 0$ iff $\sigma_{12} > 0$, which proves Proposition 1.

To prove Proposition 2, we need to find conditions under which $\frac{dX}{d\bar{b}} > 0$ where $X \in \{E[R], E[R^b], E[R^h]\}$, as in equation A12 above. Given these expressions, it is easy to see that

$$\frac{dE[R]}{d\bar{b}} = \frac{2\gamma[(h\sigma_{12} + b\sigma_2^2)/\alpha_1 + \gamma b(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)]}{\alpha_2 W[(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2]} > 0 \tag{A32}$$
$$\frac{dE[R^h]}{d\bar{b}} = \frac{2}{\alpha_1 W}\left(\frac{\alpha_1\mu_1 + \bar{h} - \alpha_1\beta_1}{2} - h\right)\frac{dh}{d\bar{b}} \tag{A33}$$
$$\frac{dE[R^b]}{d\bar{b}} = \frac{\gamma[(h\sigma_{12} + 2b\sigma_2^2)(1/\alpha_1 + \gamma\sigma_1^2) - \gamma b\sigma_{12}^2)]}{\alpha_2 W[(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2]} > 0. \tag{A34}$$

Therefore, we have that

- $\frac{dE[R]}{d\bar{b}} > 0$
- $\frac{dE[R^h]}{d\bar{b}} > 0$ if $h > \frac{\alpha_1\mu_1+\bar{h}-\alpha_1\beta_1}{2}$, or $\frac{(1/\alpha_2+\gamma\sigma_2^2)(1/\alpha_1\bar{h}+\mu_1-\beta_1)-\gamma\sigma_{12}(1/\alpha_2\bar{b}+\mu_2-\beta_2)}{(1/\alpha_1+\gamma\sigma_1^2)(1/\alpha_2+\gamma\sigma_2^2)-\gamma^2\sigma_{12}^2} > \frac{\alpha_1\mu_1+\bar{h}-\alpha_1\beta_1}{2}$
- $\frac{dE[R^b]}{d\bar{b}} > 0$,

which shows the effect of QE on portfolio returns and proves Proposition 2.

D National and Regional Housing Return Predictability in Germany

Cochrane (2011) shows that the current rental yield can predict national future housing returns in the case of the United States. In this Appendix, we take this approach to regional housing returns in Germany. To do so, we start from the present value identity of Campbell and Shiller (1988) given by:

$$dp_t \approx \sum_{j=1}^{k} \rho^{j-1} r_{t+j} - \sum_{j=1}^{k} \rho^{j-1} \Delta d_{t+j} + \rho^k dp_{t+k} \tag{A35}$$

where $dp_t \equiv d_t - p_t = \log(D_t/P_t)$ is the log current rental yield, $r_t \equiv \log R_t$ is the log housing return, Δd_t is log rent growth and ρ is a constant of approximation.

As customary, we then run the following three regressions at the national and regional levels:

$$\sum_{j=1}^{k} \rho^{j-1} r_{t+j} = a_r + b_r^k \times dp_t + \varepsilon_{t+k}^r \tag{A36}$$

$$\sum_{j=1}^{k} \rho^{j-1} \Delta d_{t+j} = a_d + b_{\Delta d}^k \times dp_t + \varepsilon_{t+k}^{\Delta d} \tag{A37}$$

$$dp_{t+k} = a_{dp} + b_{dp}^k \times dp_t + \varepsilon_{t+k}^{dp}. \tag{A38}$$

At the national level, we estimate them using the Macro History Database of Jordà et al. (2017) and Jordà et al. (2019), which reports capital gains and rental yields separately, calculating housing returns based on population-weighted average sales prices for urban areas in West Germany. At the regional level, we use rental yields from Bulwiengesa, as described in the paper. Equipped with these times series, we run regressions for the future excess return and rent growth, and the future rent-to-price ratio on the current rental yield, as shown in equations (A36)-(A38), for the pre-sample period of 1964-2015, using a value for ρ equal to 0.96.

According to the present value identity, the coefficients in the regressions above should satisfy the following restriction:

$$1 \approx b_r^k - b_{\Delta d}^k + \rho^k b_{dp}^k. \tag{A39}$$

The results reported in Table A5 show that, at the national level, the identity holds in the case of Germany like in the US case of Cochrane (2011). These estimates can also be used to quantify the share of rental yield variation explained by each of the three components on the right-hand side of the equation (A35). The results reported indicate that, as the forecast horizon k lengthens, a larger fraction of the price-rent ratio volatility can be attributed to variation in expected returns, with a significantly smaller fraction explained by rent growth or the bubble component. At shorter horizons (i.e., $k = 1, 3$ years), however, all three components matter, with the bubble one dominating.

When we re-run the same analysis at the regional level we find similar results, as long as we control for time-fixed effects. Our regional panel data is much shorter than the Jordà et al. (2017) one. To deal with this limitation, we run the regressions (A36)-(A38) at the one-year horizon, we pool the coefficients across regions, and then we iterate forward to obtain predictions at the corresponding time horizons. While pooling, we consider three alternative specifications: pooled OLS, a panel regression with region-fixed effects, and a panel regression with both region and year-fixed effects.

Table A6 reports the results of the regional analysis, showing that the coefficient sign on the rental yield in the one-year return pooled and panel fixed effect regression are negative, and hence has the wrong sign from the perspective of the present value identity in Equation (A35) as well as our model. However, this sign turns positive—albeit weakly statistically significant—once we control for year-fixed effects. This is likely because of the short sample period in the regional analysis, with only 14 years of data from 2005 to 2019. When we estimate the regression with national data over the same 14-year period, we find that the sign of the coefficient on the rental yield in the one-year return regression is also negative.[A4] However, in the specification with the year-fixed effects, this sign is as in the national-level regression. So, when we take the one-year predictive regression and iterate it forward for 15 years to obtain implied restricted VAR estimates 15 years ahead, in Panel D of Table A6, we find the same pattern as in the national data. Based on this auxiliary evidence, when in the paper we evaluate the impact of QE on regional housing outcomes, we focus on regional rental yields as the variable most closely connected to the portfolio rebalancing documented at the household level.

[A4] In unreported regressions, we also estimate these predictive regressions for the three components of the housing return, region by region. On average, the coefficients on dp_t for r_{t+1}, Δd_{t+1} and dp_{t+1} are -0.113, -0.094, and 1.091 respectively, which is very close to the pooled OLS regression coefficients in Panels A and B of Table A6.

Table A5 Present Value Identity Regressions at the National Level

	$\sum_{j=1}^{k} \rho^{j-1} r_{t+j}$		$\sum_{j=1}^{k} \rho^{j-1} \Delta d_{t+j}$		dp_{t+k}			
	b_r^k	R^2	$b_{\Delta d}^k$	R^2	b_{dp}^k	R^2	Obs	$b_r^k - b_{\Delta d}^k + \rho^k b_{dp}^k$
k=1	0.033	0.024	-0.026*	0.057	0.980***	0.958	51	1.000
	(0.031)		(0.015)		(0.029)			
k=3	0.135*	0.073	-0.070*	0.067	0.899***	0.797	49	1.000
	(0.070)		(0.038)		(0.066)			
k=5	0.220**	0.111	-0.102*	0.072	0.833***	0.651	47	1.001
	(0.093)		(0.055)		(0.091)			
k=10	0.258**	0.109	-0.203**	0.120	0.816***	0.430	42	1.003
	(0.117)		(0.087)		(0.148)			
k=15	0.376**	0.138	-0.347***	0.197	0.513*	0.101	37	1.002
	(0.159)		(0.118)		(0.258)			

Note. The table reports the coefficients of the predictive regressions at the national level. The standard errors are in parentheses. The sample period is from 1964 to 2015. The frequency is annual.

Table A6 PRESENT VALUE IDENTITY REGRESSIONS AT THE REGIONAL LEVEL

	r_{t+1}	Δd_{t+1}	dp_{t+1}	$b_r^k - b_{\Delta d}^k + \rho^k b_{dp}^k$
Panel A: Pooled OLS				
	(1)	(2)	(3)	
dp_t	-0.057***	-0.061***	1.064***	1.025
	(0.003)	(0.003)	(0.003)	
Observations	5614	5614	5614	
R^2	0.055	0.057	0.967	
Panel B: Panel OLS with regional FE				
	(1)	(2)	(3)	
dp_t	-0.101***	-0.073***	1.095***	1.023
	(0.004)	(0.005)	(0.003)	
Observations	5614	5614	5614	
R^2	0.087	0.041	0.939	
Panel C: Panel OLS with regional and year FE				
	(1)	(2)	(3)	
dp_t	0.019*	-0.140***	0.890***	1.013
	(0.011)	(0.013)	(0.008)	
Observations	5614	5614	5614	
R^2	0.309	0.077	0.960	
Panel D: VAR-implied coefficients				
k=3	0.049	-0.362	0.705	
k=15	0.118	-0.871	0.174	

NOTE. The table reports the coefficients of the predictive regressions at the regional level. The regression equation is $y_{i,t+1} = \beta * dp_{it} + \varepsilon_{i,t+1}$, where $y_{i,t+1}$ is, alternatively, the future housing return ($r_{i,t+1}$), the future rental growth ($\Delta d_{i,t+1}$), and the future rental yield ($dp_{i,t+1}$), respectively. We report results for a pooled OLS regression, a panel regression with region-fixed effects, and a panel regression with both region and year-fixed effects. The sample includes all 401 regions from 2005 to 2019. The standard errors are clustered at the regional level in Panel B and C. In Panel D, we calculate the VAR-implied coefficients from the estimated one-year coefficients, using the estimates from Panel C.