A Housing Portfolio Channel of QE Transmission*

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Abstract

We document and quantify a housing portfolio channel of quantitative easing (QE) transmission. We identify this channel using household-level and regional data from Germany. We show that QE induces households with larger initial bond holdings to rebalance more their portfolios toward housing and particularly, second homes, consistent with a buy-to-let motive. This rebalancing is stronger for higher-income and church-affiliated households, who are more exposed to tax incentives for buying-to-let, and more financially literate and bank-advised households. We also document a larger impact of QE on housing outcomes in more exposed regions, with house prices increasing more than rents and sale listings declining more than rental ones.

Keywords: Asset Market Segmentation, Buy-to-let, Germany, Housing Returns, Household Portfolio Rebalancing, Quantitative Easing, Rental Yields.
JEL Classification: E3, E4, E5, R3

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1 Introduction

During and after the global financial crisis (GFC), the Fed and other advanced-economy central banks expanded their policy toolkit by adopting unconventional monetary policies. To support the economy with the policy rate near the zero lower bound, they started to purchase long-term bonds and other risky assets—the so-called quantitative easing policies (QE). The European Central Bank (ECB) also continued to use interest rate policy by setting a negative rate on its deposit facility (NIRP). A large literature quickly developed investigating the financial and real effects of QE on asset prices, firm and bank behaviors, and on the macroeconomy as a whole.

In this paper, we identify a housing portfolio channel of QE transmission at the household level in Germany employing a difference-in-differences strategy and using a household's pre-QE bond share as exposure measure. We also evaluate its impact on housing outcomes at the regional level. We estimate that a household with an initial 10-percentage point higher bond share, which corresponds approximately to the interquartile range of this variable, increases its housing portfolio share by 1.8-2.0 percentage points more after QE, relative to the pre-QE period. The household portfolio rebalancing that we document is stronger when we focus on purchases of second homes, consistent with a buy-to-let motive. The effects are also stronger for high-income and church-affiliated households, which benefit from substantial tax advantages when holding second homes for rental purposes in their portfolios in Germany, for financially more literate households and those that are actively advised by their bank on how to best allocate their assets. Finally, we show that regions more exposed to rental market tightness or depth experience larger rental yield declines and higher house price than rent growth, and a lower decline in the number rental than sale listings.

To illustrate the working of the QE transmission channel that we propose and to discipline our empirical analysis, we also set up a simple housing portfolio model with asset market segmentation and preferred habitat investors. In the model, local real estate investors and a national bond investor specialize in holding houses and bonds, respectively. Local households arbitrage among cash, bonds and local houses. In response to QE, as the bond supply declines, the referred habitat investors and local households lower their bond holdings and the bond price increases. Provided that the bond and house payoffs are positively correlated and hence these risky assets are substitutes, local households increase demand for houses and bid up house prices. Meanwhile, preferred habitat real estate holders sell houses to richer (i.e., optimizing) households. The the total expected future portfolio return declines, and if the equilibrium house holding is large enough, both its bond and housing components decline.

In this channel, therefore, QE works through portfolio rebalancing and cash purchase of homes, rather than bank portfolio rebalancing, higher credit supply or equity extraction from mortgage refinancing. House sales and purchases are cash transactions in our model. At the core of our new mechanism is the portfolio rebalancing by households. Nevertheless, the paper's contention is not that other channels working through housing market (or other markets) are not in the German data, but rather that the housing portfolio channel we investigate is present and conspicuous for housing outcomes alongside the other traditional channels.

Table 1 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
Real Estate/Bonds	8.43	8.51	9.00	8.75	8.91	8.63	9.20	9.24	9.46	10.12	9.91
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 Second Home (in %)	-	-	25.8	-	-	29.5	-	-	31.3	-	-
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 aggregate flow of funds data from the Federal Statistical Office (Destatis), as well as German homeownership rates from the OECD. 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; 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. Data on households with second homes or exposure to the bond market (directly and indirectly through holdings of mutual funds or insurances) are not available at an aggregate level. The reported statistics are based on the Bundesbank's PHF survey data utilized in the paper.

Real estate represents the lion's share of households' total assets in Germany, increasing by two percentage points during our sample period, from 55% in 2009-2010 to 57% in 2018 (Table 1). The transmission implied by our model is also consistent with the declining home ownership rate by about two percentage points during this period (from an already very low level by international standard), implying a substantial increase in the share of renters and landlords.[1] Table 1 also shows an increasing ratio of real estate assets to bonds during the 2010-2019 period.[2] Next, Table 1 shows that household leverage is low and on a declining trend in Germany during this period, consistent with an even lower (and equally declining) share of home owners with housing credit. Indeed, anecdotal evidence suggests that many residential real estate transactions are cash purchases during our sample period driven by a buy-to-let motive, especially before **DATE**. In fact, Table 1 also shows that there is a strong increase in the share of households owning a second home. At the same time, the share of households owning bonds decreases substantially, which speaks to portfolio rebalancing from cash to housing being a main driver of these dynamics.

Our argument that household portfolio rebalancing is a key driver of aggregate declines in home ownership is plausible because, in Germany, more than 60% of all renting households rent from other households (see Sagner and Voigtländer, 2021). In other words, small landlords play a much more important role than large institutional investors or REITs in the German rental market.

We investigate this housing portfolio 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 been going through a housing boom without a credit boom since 2009. Figure 2 plots national aggregate residential rent and price indexes and households' mortgage credit. The figure shows a stark negative correlation between housing and credit market dynamics since

[1] This increase is slightly less than half of the swing in the US home ownership rate during the subprime boom-bust cycle.

[2] "Equity to Total Assets" and "Deposits to Total Assets" are not reported but are slightly increasing and constant, respectively, over this period. The average share of equity assets in total assets is 8.5% during the sample period. SPLIT EQUITY AND DEPOSIT AND NOTE THAT NIER SHOULD DELIVER A DECLINING DEPOSIT SHARE.

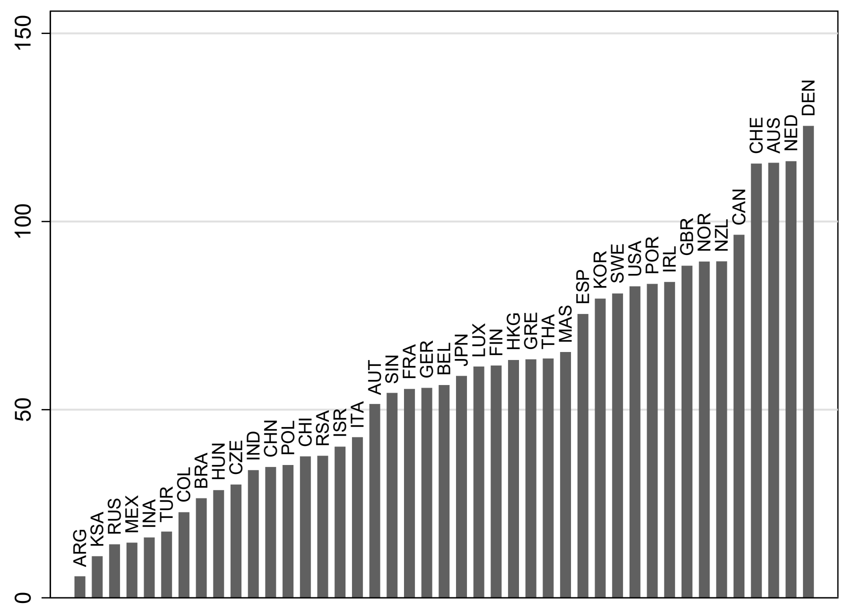
the beginning of the recovery in 2009. In the run up to the GFC, house prices (and rents) decline, while credit expands. Since 2009, the two markets move in opposite direction. This stylized fact is not only consistent with the evidence of declining household leverage in Table 1, but also a striking example of a housing boom without a credit boom.

The German post-GFC housing boom is not the only one that differs from the intensively studied US boom-bust cycle of the 2000s. The household demand side of China's housing boom has been largely creditless. Historically, emerging markets have long experienced boom-bust cycles in housing and consumption, despite chronic domestic financial underdevelopment (Cesa-Bianchi, Cespedes and Rebucci 2015 and Cesa-Bianchi, Ferrero and Rebucci 2018). At slightly more than 50% of GDP, even during the 2010-2017 period, the level of household credit in Germany is close to the median of the main advanced and emerging economies in the BIS data (Figure 1). More generally, Cerutti, Dagher and Dell'Ariccia (2017) estimate that 19 out of 83 housing booms that they identify are not associated with a credit boom. Even in the US case, the importance of credit for the boom-bust cycle of the 2000s remains a hotly debated issue—see, for instance, Favara and Imbs (2015), Favilukis, Ludvigson and Van Nieuwerburgh (2017), Kaplan, Mitman and Violante (2020), and Greenwald and Guren (2021).

To assess and quantify this channel of QE transmission empirically, we assemble a rich data set, including household-level, regional, and aggregate data, all of which we describe in detail in the paper. Our household-level data come from the Deutsche Bundesbank's Panel on Household Finances (PHF) which contains detailed portfolio, credit and income survey data on in total 12-14,000 households interviewed in 2011, 2014, and 2017.

To achieve identification, we estimate difference-in-differences specifications around the year in which the ECB formally adopted QE in **2015 or 2014 WE SAID 2014 IN THE PAPER**, employing a household's pre-QE share of wealth invested in bonds as an exposure measure. We show that after QE more exposed households raise their housing portfolio shares relative to less exposed ones. In economic terms, a household with an

Figure 1 HOUSEHOLD CREDIT AS A SHARE OF GDP: INTERNATIONAL COMPARISON



NOTE. The figure plots average household credit as a share of GDP during 2010-2017. Data source: BIS.

from liquid assets towards housing without necessarily borrowing.

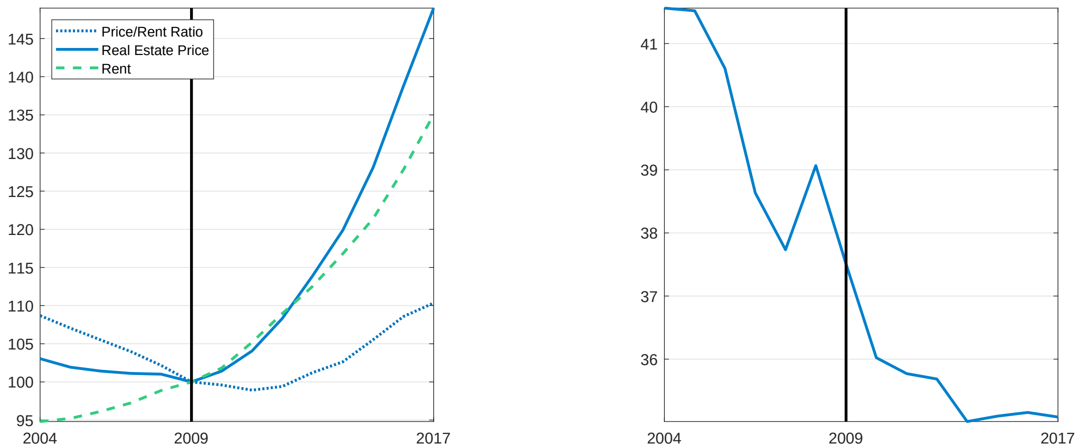
These results are very robust. They always hold after controlling for a large set of household characteristics, such as net worth, the number of household members or risk aversion. They are also robust to using alternative measures of the household-level bond share to proxy for exposure to QE and different specifications of the dependent variable. Finally, our results also survive when we control for the negative interest rate policy in the euro area.

In order to estimate the impact of this QE transmission channel on housing outcomes, we assemble an annual panel data set covering all 401 German administrative regions from 2010 to 2017.[3] The data set contains regional rent and price indexes as well as rental yields that, as Appendix D shows is a good predictor of expected future housing returns and its three components in German data, as in the case of the United States (e.g., Cochrane 2011).

[3]To be precise, we use the German "Landkreise" as the regional unit of analysis. This regional aggregation level is comparable to the American county level.

Figure 2 Germany: A Housing Boom without 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 their ratio (equal to 100 in 2009). Panel B plots the stock of mortgage credit to households as a share of GDP. The vertical line marks the beginning of the German recovery in 2009. See the Data Appendix for variable definitions and data sources.

These data are from Bulwiengesa AG, a reputable German real estate data provider that supplies also the ECB and Deutsche Bundesbank. As predicated by our model, we document that regions that are more exposed to rental market tightness or depth—as proxied by the regional share of renting households and the regional share of refugees housed in independent accommodations—see a larger decrease in their expected future housing returns, with a weaker response of rent growth relative to house price growth. In economic terms, our estimates imply that a one-standard deviation increase in QE (approximately 4.3 pp higher debt securities share of GDP) reduces the rental yield in more exposed regions at the 75th percentile of the exposure distribution, relative to a less exposed one at the 25th percentile, by an additional 2 basis points per year This is a large number given that the average rental yield is only equal to 7.4% with a standard deviation of only 1.6%. Finally, we also show that, in more exposed regions, rental listings increase relative to sale listings.

Related Literature Our paper relates to the literature along multiple dimensions. First, 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, 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) show that QE softens lending standards and raises bank risk-taking. Chakraborty, Goldstein and MacKinlay (2019) show that banks more exposed to QE increase their mortgage lending. Berg, Haselmann, Kick and Schreiber (2022) 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 induced 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 negative interest rate policy, QE can induce deposit-dependent banks to reduce their corporate credit supply. Todorov (2020) finds that the ECB's Corporate Sector Purchase Programme increased prices, liquidity, and firms' issuance in the corporate bond market. Luck and Zimmermann (2020) show that QE leads firms to increase employment. The housing portfolio channel of QE transmission that we propose does not rely on credit and focuses on household, rather than bank or firm, behavior.

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 similar to those specified in our model to link portfolio rebalancing with yield changes **and find that bond yields on average declined by 65 basis points across countries (60 bps in Germany).** Bergant, Fidora and Schmitz (2020) show that euro area investors, in particular households and investment funds, rebalanced from bonds targeted by the ECB's QE to foreign debt securities. We also take a portfolio approach, but we focus on local residential real estate markets and household portfolio rebalancing. This is consistent with Korevaar (2022), who shows that bond return declines also induced a portfolio rebalancing towards real estate in 18th-century Amsterdam.

Second, **our paper complements the vast literature on the collateral and wealth channels of monetary policy transmission.** Several papers study the relationship among interest rates, house prices, and economic activity via collateral or wealth effects. As it is well known, QE lowers the term spread and mortgage rates. Chaney, Sraer and Thesmar (2012) show that a reduction in mortgage rates can increase house prices in regions with a more restricted land supply, raising collateral valuations and boosting firm investment. Aladangady (2017) shows that lower mortgage rates can also increase consumption. Adelino, Schoar and Severino (2015) provide evidence of collateral effects on small business employment. Many papers also explore the wealth effect of house or equity price on consumption. Closely related to our work, Mian, Rao and Sufi (2013) show that differences in household leverage drive the geographic distribution of consumption declines during the Great Recession. A critical difference with our setup is that our housing portfolio channel does not depend on higher house prices relaxing binding collateral constraints or raising household wealth. Instead, the transmission works through a decline in expected future housing returns, similar to Drechsler, Savov and Schnabl (2020), but via risky houses rather than safe deposits. **Househlds level analysis.**

Third, our new 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 financial assets. Similarly, Yao and Zhang (2005) study the importance of housing in shaping the portfolio of other assets 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 between housing and other risky assets following a QE adoption and its implications for consumption and output, without explaining the cross-section variation in bond or equity holdings. Our model relies on the segmented asset market hypothesis through preferred habitat investors, as proposed by Vayanos and Vila (2021). The novelty of our contribution is to focus on the portfolio implications of preferred habitat investing in the residential real estate market, which can be applied in countries in which housing finance is underdeveloped or other asset markets are repressed. 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).

Finally, we also contribute to a growing literature that studies the recent German house price boom. For instance, Kindermann et al. (2020) look at how households form their expectations during a housing boom. Bednarek et al. (2021) focus on how an international bank flow shock transmits through the commercial real estate sector. **THERE ARE SEVERAL OTHER PAPERS. WE PICK REFEREEES HERE.**

The rest of the paper is organized as follows. Section 2 presents the model and its empirical implications. Section 3 presents the data. Section 4 discusses the research design and identification strategies. Section 5 reports the evidence on household-level rebalancing, while Section 6 reports estimation results on the impact of housing outcomes. Section 7 concludes. The Appendix reports model and data details, robustness analyses, and additional estimation results.

2 Model

In this section, we build a simple model to illustrate the housing portfolio channel that we want to study empirically.

2.1 Agents and Markets

Consider a regional representative household that solves a portfolio problem including local houses, national bonds, and cash (modeled as transaction technology). Regional houses and national bonds are risky assets. Their 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 $\text{Cov}(\varepsilon_1, \varepsilon_2) = \sigma_{12}$. Here we focus on a one-region economy, while Appendix B.2 shows that all results extend to a two-region environment.

There are three agents trading: two preferred habitat investors in each risky asset 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

$$\tilde{h} = -\alpha_1(P - \beta_1), \tag{1}$$

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

$$\tilde{b} = -\alpha_2(Q - \beta_2), \tag{2}$$

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

The preferred habitat investors are passive in the model in the sense that they buy (sell) the excess supply (demand) of the regional households at given market prices. Unlike regional 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, absorbing excess demand or supply. They can also represent *poor* (not optimizing) homeowners that transact with *wealthy* (wealth-maximizing) regional households, who can either consume more housing themselves or buy-to-let.[4]

One important assumption is that the regional household has a mean-variance utility (or equivalently power utility over end-of-period wealth), and hence limited risk-bearing capacity. Otherwise, the price of risky assets would only reflect the expected payoffs with no price impact stemming from changes in the quantity of assets supplied. 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.

$$\max_{h,b,x} \quad E[W'] - \frac{\gamma}{2}Var(W') = h\mu_1 + b\mu_2 + x - \frac{\gamma}{2}(h^2\sigma_1^2 + b^2\sigma_2^2 + 2hb\sigma_{12}) \tag{3}$$

$$\text{s.t.} \quad W = Ph + Qb + x, \ (\lambda) \tag{4}$$

$$W' = h(\mu_1 + \varepsilon_1) + b(\mu_2 + \varepsilon_2) + x \tag{5}$$

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

$$\lambda Q = \mu_2 - \gamma b\sigma_2^2 - \gamma h\sigma_{12} \tag{6}$$

$$\lambda P = \mu_1 - \gamma h\sigma_1^2 - \gamma b\sigma_{12} \tag{7}$$

$$\lambda = 1. \tag{8}$$

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.

[4] Recall that homeownership declined in Germany during the sample period (Table 1).

2.2 Market Clearing and Equilibrium

The total supply of risky assets is fixed in the model, while the central bank supplies cash elastically as demanded. In equilibrium, market clearing requires:

$$h + \tilde{h} = \bar{h} \tag{9}$$

$$b + \tilde{b} = \bar{b} \tag{10}$$

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, $\{h, \tilde{h}, b, \tilde{b}\}$—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.

2.3 QE and Portfolio Rebalancing

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

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

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 bond price, Q, and reducing the bond holdings of both investors. Other things equal, the regional household lowers her demand for bonds in response to the QE intervention to increase the risk-adjusted payoff as we can see from equation (6). In contrast, the impact of a reduction in $\bar{b}$ on the local housing market is ambiguous depending on the covariance between the bond and house payoffs, σ_{12}, as the following proposition illustrates.

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 Appendix B.1. □

Houses and bonds are substitutes in the household's portfolio when their payoffs are positively correlated, as is also the case in our data. A drop in bond holdings, b, increases the risk-adjusted payoff of housing investment through the last term in equation (7). In equilibrium, for a given supply of houses, the local household increases her exposure to houses (either through more housing consumption herself or through buying-to-let), the house price increases to accommodate the higher demand through the sales of the preferred habitat investor—the real estate agent serving the seller or the poor household selling directly.

As the following corollary states, it follows immediately from Proposition 1 that the housing portfolio share of the regional households increases with QE.

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

The transmission channel from QE to the housing market relies on the payoff structure of risky assets and the risk-aversion assumption. The response of the housing component in the household portfolio to QE is zero when the payoff correlation between bonds and houses is zero, i.e., $\sigma_{12} = 0$ or the agent's risk aversion is zero, i.e., $\gamma = 0$. Note that, while the representative household' risk aversion is exogenous and constant in the model, it can be time-varying in richer set-ups and in the data. So one can think about QE transmission as working through its impact on risk aversion as well. In our model, both a lower γ and lower $\bar{b}$ imply a higher risk-adjusted housing payoff. However, a decline in γ implies a different transmission mechanism. Namely, in our model, lower γ induces portfolio rebalancing from cash to *both* risky assets, bonds and houses.[5] In contrast, a lower $\bar{b}$ implies a portfolio rebalancing from national bonds to local houses.

As the regional household responds to QE by adjusting her portfolio, the total return on wealth changes. To see this, define the total expected return on wealth, $E[R]$, as

$$E[R] = \frac{E[W']}{W} = \frac{h\mu_1 + b\mu_2 + x}{W} \tag{11}$$

$$= 1 + \underbrace{\frac{h(\mu_1 - P)}{W}}_{\equiv E[R^h]} + \underbrace{\frac{b(\mu_2 - Q)}{W}}_{\equiv E[R^b]} \tag{12}$$

$$= 1 + \frac{\gamma}{W}(h^2\sigma_1^2 + b^2\sigma_2^2 + 2hb\sigma_{12}), \tag{13}$$

where the last expression derives from using the budget constraint and the optimality conditions of the household. In equilibrium, the total expected portfolio return 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 a portfolio rebalancing with regional agents holding fewer national bonds, b, and more local houses, h, and both asset prices increasing. The third term in equation (12) shows that the bond component of the total return, $E[R^b]$, always declines, since the bond price increases while the bond holding declines in response to QE for given initial wealth, W. 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 in opposite directions. Thus, the QE impact on the total portfolio return depends on the relative contribution of the two assets to the

[5] In fact, 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}.

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 $E[R^h]$. However, 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 Appendix B.1. □

The intuition is as follows. The relationship between housing returns and the equilibrium house holdings has an 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 holdings h also increases, lowering the housing return too.

2.4 Model Implications for Empirical Analysis

Albeit simple, our model provides a useful set of priors that we use to inform and guide our empirical analysis. Specifically, following a reduction in the net supply of traded government bonds, the model implies that bond holdings decline (both for preferred habitat investors and households) and bond prices increase. Assuming that bonds and houses are substitutes and the house holding is large enough, the model implies that the house holdings also increase, accommodated by the sales of the local preferred habitat investors, the housing portfolio share increases, local house prices increase, and the expected total portfolio return as well as *both* its two components decline.

In our empirical analysis, we first provide direct evidence on household portfolio rebalancing toward housing, and particularly rebalancing toward second homes as purchases of investment properties are most closely tied to the mechanism embedded in our model. We then examine both "price" and "quantity" housing market outcomes exploiting regional variation in rental yields and listings data.

The rental yield is an outcome variable that is theoretically closely liked to the notion of portfolio rebalancing in our model because it must predict either future expected returns, rental income growth, or future rental yields, as we discuss and document for German regional data in Appendix D. Listings data are not directly linked to our model, but they arguably provide indirect evidence on the quantity impact of QE in both the sale and the rental markets. The differential response of the latter, in particular, can be informative about the extent to which a buy-to-let motive consistent with our model may be at work in the prortfolio rebalancing that we document empirically at the household level.

3 Data

To conduct our empirical analysis, we rely on household-level data from the Bundesbank's Panel on Household Finances survey and regional and national data from various sources. In this section, we discuss the main variables that we use in the empirical analysis. Appendix C provides further details and summary statistics.

3.1 Household Data

The source of our household-level 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 about 1,650 households.[6] We use the PHF rather than the German Socio-Economic Panel because the PHF has a more granular description of household wealth and its composition. The PHF is the German module of the Eurosystem Household Finance and Consumption Survey. Like the US Federal Reserve Board's Survey of Consumer Finances, it collects data on households' financial investment activity and borrowing behavior, saving, and income.

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 specifications, we follow Kindermann et al. (2020) and only use the first of the five alternative sets of imputed values for each variable (henceforth just "implicate" for brevity). This procedure is reasonable because most of the variables we use in the analysis are non-imputed so that the values for all five implicates are the same. In unreported specifications, we show that our results are virtually unchanged when we use all five implicates.

Our main outcome variable is the change in a household's housing portfolio share. Consistent with our model, we measure the housing portfolio share as real estate wealth over 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. We include both types of bond holdings in our calculation of the housing share, as we observe that households hold bonds both directly and indirectly through intermediaries. In the aggregate flow of funds data, we see

[6]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). See Table A1 for the exact number of households interviewed in each wave.

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 insurances by 52% and 15%, respectively. Importantly, we correct bond and housing wealth for valuation changes, so that higher housing shares imply an increase in real housing wealth. Specifically, we deflate both variables using the *national* German bond index (the REXP index) and our *regional* residential house price data discussed below, setting the base year to 2011. For robustness, we also scale housing wealth by total assets.

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. To minimize information losses, 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 before and after the formal QE adoption by the ECB as a function of several household characteristics, fixed at their values in the 2014 pre-QE wave. Importantly, we employ the pre-QE household's share of wealth invested in bonds as a proxy of how exposed households are to this channel of QE transmission, in line with the literature on *bank* portfolio rebalancing (e.g., Rodnyansky and Darmouni, 2017; Luck and Zimmermann, 2020). Since some household records miss 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. For robustness, we show that our results are similar when we do not impute missing bond values, or when we use only households' direct bond holdings (and setting missing direct bond holdings to zero). Similarly, as the

ECB adopted both QE and negative interest rates, we also control for a household's initial deposit shares, computed as the value of all deposits held over the total portfolio.

Household control variables that we consider in our analysis, and discuss in more detail below, are income per capita, the age of a household's head, a dummy equal to one if a household is formally affiliated to the 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 selecting the portfolio allocation, and financial literacy. The latter is a continuous variable and measures a household's number of correct answers to three simple questions on the difference between real and nominal interest rates, compound interest, and portfolio diversification.

In order to show the extent to which household borrowing 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.

3.2 Regional Data

To explore the implications of household portfolio rebalancing for housing outcomes, we employ regional price, rent, and rental yield indexes from a reputable and well-known proprietary provider, Bulwiengesa AG.[7] Bulwiengesa constructs these indexes using both unit-specific valuation and transaction data from building and loan associations, research institutions, 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 traded in 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

[7] Bulwiengesa supplies housing data to the Bundesbank and the ECB for the construction of their German national series.

estate listing platform.[8] Specifically, based on these data, we compute the regional total number of sale listings per year, the total number of rental listings, and their ratio.

In order to proxy for regional exposure to portfolio rebalancing, and hence our transmission channel, ideally, we would 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, regional averages would not be representative, as our panel data set has about 1,500 observations, while the total number of regions is 401.[9] Thus, as a source of exposure to our channel that varies at the regional level, we employ the pre-QE (2008) 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 has significant variation across German states. 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, arguably capturing rental market tightness.[10]

For robustness, as a measure of 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 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

[8] We use the following 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 on these data, see Breidenbach and Schaffner (2020).

[9] The PHF survey is designed to be representative for Germany as a whole, but not at the level of individual regions.

[10] The relevance and orthogonality conditions for the use of this instrument are discussed extensively in Bednarek et al. (2021). See, in particular, Table 2 and Appendix Section D.1.3. One important difference in the setting, here, is that we use all 401 administrative regions of Germany, while Bednarek et al. (2021) focus on a significantly smaller subset. As Bednarek et al. (2021) report, several other studies use refugees as an instrument. See, for instance, Jaschke et al. (2022), for a recent application. See also the Model Appendix, which shows the conditions under which $\frac{dE[R]}{dh} > 0$.

buy-to-let investors more attractive.

The empirical analysis also relies on several other observable region characteristics, including region-level population, demographic variables, and the number of building permits to control for construction activity. The variables describing regional characteristics are sourced from the INKAR database and cover the period of 2010-2017.

In the regional regressions, 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 over GDP, might also be affected by the ECB's long-term refinancing operations that channelled liquidity to the banking sector without directly affecting households' incentives to change portfolio structures. Sources and definitions of other national variables used in the empirical analysis are reported in Appendix C.

3.3 A First Look at the Data

In this section, we take a first look at the summary statistics for critical variables. Appendix C reports the full set of statistics. As Table A3 shows, both the total housing share and the share of second homes in the portfolio increase substantially during our sample period. In particular, on average, the second home (total) housing share increases by 0.65% (0.67%) from one survey wave to the other, which implies an overall average increase during the sample period of about 1.3% (=2*0.65(0.67)), consistent with the aggregate increase reported in Table 1. The number of second homes that a household owns also increases by 0.1, on average. Also consistent with the aggregate picture in Table 1, mortgage credit growth is negative, on average, and the outstanding amount of mortgage debt over a household's housing wealth (as a proxy for leverage) is very low at 13%.

The mechanism that we quantify in this paper is a housing portfolio rebalancing channel that works even in the absence of a credit supply increase, through cash purchases. How plausible is such a hypothesis? The average model-consistent total portfolio value in our sample is 360,000 euro, with a 99th percentile of about 3 million euro. Our baseline household-level bond share (Bondshare Measure 1 in Table A3) has a 25th percentile of about 5%, and a 75th percentile of 18%. Therefore, the more exposed households, relative to the less exposed ones, can raise their housing investment by 47,000 euro on average (=(18%-5%)*360,000) or by 390,000 euro for the very wealthy ones (=13%*3 million). This back-of-the envelope-calculation shows that selling bonds can be sufficient to purchase an apartment despite the lumpiness of housing. This claim is strengthened when, as we show below, we allow for the possibility that households also use some of their other liquid assets (i.e., deposits) to increase exposure to second homes, consistent with the predictions of our simple model.

4 Research Design and Identification Strategy

In this section we discuss the research design and the identification of our channel, focusing on portfolio rebalancing first, and then housing outcomes.

4.1 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 post-QE period. The regression is specified as follows:

$$\Delta Y_{h,t} = \alpha_t + \alpha_h + \beta \cdot (\text{Post}_t \times \text{Bonds}_{h,2014}) + \epsilon_{h,t} \tag{14}$$

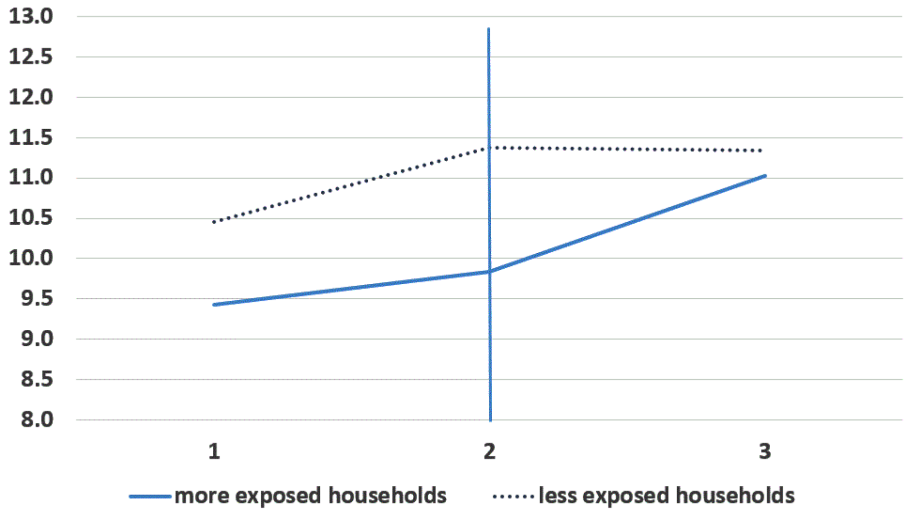
where $\Delta Y_{h,t}$ is the household-level *change* in the housing share from 2011 to 2014 and from 2014 to 2017, respectively. Most of the estimation results that we report focus on households' rebalancing towards second homes, so that the dependent variable captures rebalancing toward this component of the household housing wealth as opposed to total housing wealth. The main variable of interest is the interaction between the Post_t dummy, which is equal to one in the third wave and zero otherwise, and an ex-ante time-invariant measure of household-level exposure to QE. Consistent with the literature on bank portfolio rebalancing in response to QE, we use the share of wealth invested in bonds in 2014, the pre-QE period, labeled $\text{Bonds}_{h,2014}$. The corresponding β coefficient quantifies the extent to which households more exposed to QE rebalance more strongly towards second homes after QE adoption.

The regressions also include time and household fixed effects. The former are important to control for common shocks across households. The latter capture time-invariant household heterogeneity.[11] Some specifications include income quartile-time fixed effects in order to control for income cohort-specific, time-varying effects. We also run regressions including time-varying household controls, such as net worth, age, risk aversion, and financial literacy and we present specifications where we fix these household variables at their 2014 value and interact them with the Post_t dummy. These specifications rule out that the significance of our main interaction term is driven by the potential correlation between the bond share and other household characteristics, and not, as intended, by household-level exposure to QE. 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 main assumption underlying our difference-in-differences analysis is that, in the absence of QE, both more and less exposed households behave identically. Unfortunately, our regressions already exploit all three available waves of the PHF, so we cannot run a placebo regression estimating Equation (14) based on a sample period that has not experienced QE treatment. Yet, Figure 3 provides 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 2015, the dynamics diverged with more exposed households

[11] Note that, due to these fixed effects, we also cannot estimate coefficients for the individual Post-dummy and bond exposure variable, as they are absorbed by the fixed effects.

Figure 3 Parallel Trends Before QE Adoption



Note. The figure plots the average level of the household shares of wealth invested in second homes (in % of the total portfolio) by households' exposure to QE. For each PHF wave on the x-axis, and separately for more and less exposed households—defined as households with a 2014 share of wealth directly or indirectly invested in bonds larger than 1%, which approximately corresponds to the sample median (solid blue line) and below 1% (dotted black line), the lines trace the value of the within-group average shares of second-home in total wealth. Data Source: PHF.

accumulating more second homes and less exposed households reducing their portfolio share of second homes.

4.2 Controlling for Household Characteristics

As the 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 (14) by including a triple interaction between the post dummy, the ex-ante bond share, and household characteristics evaluated in 2014, as subsumed in the $X_{h,2014}$ vector:

$$\Delta Y_{h,t} = \alpha_t + \alpha_h + \gamma \cdot (\text{Post}_t \times \text{Bonds}_{h,2014} \times \text{X}_{h,2014}) + \delta \cdot (\text{Post}_t \times \text{Bonds}_{h,2014}) + \nu \cdot (\text{Post}_t \times \text{X}_{h,2014}) + \epsilon_{h,t}, \quad (15)$$

where all double interactions that are not absorbed by the fixed effects are also added to the regression. In particular, $X_{h,2014}$ includes household income per capita in 2014. As we spell out in Appendix Section A, second homes are subject to substantial tax advantages relative to the main residence 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, this advantage is larger for higher-income households. We thus expect the impact of QE to be stronger for high-income households.

Equation (15) also explores other household characteristics. First, $X_{h,2014}$ includes a dummy which is equal to one for households that were actively advised by their bank in their asset allocation. In Germany, banks typically also operate their own real estate agency. We expect banks to recommend households rebalancing toward housing in order to generate brokerage fees from their customers acquiring real estate.[12] This, in turn, should imply a stronger effect for this subset of households. Second, we look at financial literacy, assuming that more financially literate households are more likely to invest in second homes, better understanding the impact of QE on their portfolio. Third, we add the household's main residency tenure status. This specification is useful because it shows whether only households that already own their main residency purchase second homes after the adoption of QE or also renters engage in this trade. Fourth, we include dummies related to a household head's age (one for household heads below 40, one for household heads between 41 and 60, and one for household heads older than 60 years). This is important to gauge whether rebalancing is driven by bequest motives of the elderly or by middle-aged individuals near their lifetime income maximum who could derive tax incentives from purchasing a second home. Finally, we examine the extent to which credit may also affect households' rebalancing toward second homes. To this end, we introduce households' leverage (as measured by mortgage credit over housing wealth) and credit growth (measured as the change in the logarithm of mortgage credit), which are the two credit variables that we can access in the PHF survey.

[12] This commission, in Germany, is about 3.5% of the purchase price.

4.3 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 in our model. Unfortunately, the PHF only provides limited information on house price expectations and does not allow us to measure housing returns, or the rent-growth component of this return, consistent with our model's implications. In addition, as we noted earlier, aggregating and matching portfolio shares at the regional level is not feasible with 1,500 households observations scattered over 401 regions, leaving us with 3-4 observations per region at best. For this step of the empirical analysis, therefore, we exploit data variation at the regional level. In particular, we look at evidence of both price impact, as summarized by the response of the regional housing rental yield, and quantity impact, as captured by rental and sale listings aggregated at the regional level.

The specification that we adopt is as follows:

$$\mathrm{Y}_{r,t} = \alpha_r + \alpha_t + \gamma \cdot (\mathrm{QE}_{t-1} \times \mathrm{Exposure}_r) + \varepsilon_{r,t}, \tag{16}$$

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 either the regional share of refugees or the share of renters. The idea here is that a higher share of refugees housed in independent accommodations captures residential housing market tightness, while a market with a larger share of renters characterizes deeper and more liquid local markets. As we discussed earlier, both these two characteristics can potentially attract more buy-to-let investors, and yet they are arguably uncorrelated with other sources of regional variation in the housing outcomes considered.

Notice here that, as we will see below, portfolio rebalancing toward second homes is stronger in urban relative to rural regions. At the same time, both regional exposure variables 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. Thus, these variables can also capture higher exposure to household portfolio rebalancing toward real estate.

The specification also includes time and region fixed effects, α_r and α_t, to control for region-specific, time-invariant variables, such as the size of a region, and aggregate factors that affect all regions homogeneously, such as the German business cycle. The sample period is 2010-2017 in order to have a sufficient number of pre-QE observations, which serve as the reference groups in the interpretation of the double interaction coefficient, γ.[13] The standard errors are clustered at the regional level in order to take into account the potential correlation of residuals within a region and over time. In a series of robustness checks, we also control for other regional characteristics (e.g., construction activity, population, demography, land scarcity) that correlate with our exposure measures and might affect housing outcomes.

5 Estimation Results: Portfolio Rebalancing

In this section, we present the results of portfolio rebalancing. We first describe our benchmark estimates, then present the outcomes of several robustness checks. Next, we study whether our benchmark estimates are stronger for households with certain characteristics, focusing particularly on the distinction between low-and high-income households that are differentially exposed to the tax incentives to hold real estate for investment purposes.

5.1 Benchmark Rebalancing Results

Table 2 shows that households ex-ante more exposed to QE rebalance their portfolios towards housing more strongly, and 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 more exposed households raise their model-consistent housing portfolio shares (i.e., the

[13] 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.

share of second homes in wealth, defined as housing, deposits, and bonds). In economic terms, a household with an initially 10-percentage point higher bond share, which corresponds approximately to the interquartile range of this variable distribution, increases its second-home housing share by 1.78-1.95 percentage points more than the median household.

This benchmark result is robust to scaling second home housing shares by the total household portfolio and not only the model-consistent one (column 3). It is also robust when we consider the response of households' total housing wealth and not only their second home wealth (column 4). Note here, however, that the coefficient on the Bond$\times$Post interaction term, in this case, is only twice as large as the corresponding estimate in column (1), while the change in total housing shares is about 2.5 times as large as the change in second home housing shares. This implies that, in economic terms, rebalancing happens more strongly towards second homes. This main result is present also 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 that a household owns or the exact price dynamics of a household's real estate, we can only approximately correct for valuation changes with national bond and regional housing prices—a strategy that cannot completely rule out valuation effects. However, column (5) clearly indicates that valuation effects are not driving the rebalancing that we document.

In column (6), we control for the interaction between the post-dummy and a household's pre-QE deposit shares that can capture the incentive to rebalance due to the introduction of negative interest rates in June 2014 (the so-called NIRP policy). The estimate shows that our results are robust to the inclusion of this additional regressor. Interestingly, the deposit share interaction is also positive and highly statistically significant, which could indicate that NIRP also transmit through our housing portfolio channel. However, there is an alternative—arguably more plausible—interpretation of the statistically significant deposit double interaction. The finding could indicate that households more exposed to QE also use some of their non-bond liquid assets (i.e., deposits) to raise their investment in second homes

Table 2 Household Portfolio Rebalancing: Benchmark Results

	Benchmark Estimates		Different dependent variables			Control for deposits	Different bond shares	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bonds × Post	0.196***	0.178***	0.341***	0.186***	0.002**	0.121**	0.412***	0.462***
	(0.047)	(0.048)	(0.055)	(0.045)	(0.001)	(0.047)	(0.102)	(0.170)
Deposits × Post	-	-	-	-	-	0.128***	-	-
						(0.027)		
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	2954	2954	2954	2968	3072	2952	2954	2954
R^2	0.345	0.347	0.390	0.344	0.430	0.354	0.344	0.340

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 variables are measured as changes in the portfolio share of second homes, where the portfolio assets in the denominator are the sum of bonds, housing, and deposits in columns (1), (2), (6), (7), and (8), and total household assets (housing and all financial assets) in column (3). Column (4) studies changes in the portfolio share of total housing, where the portfolio assets in the denominator are the sum of housing, bonds, and deposits. The dependent variable in column (5) is the *number* of second homes that a household owns. The main regressor is the post dummy that is equal to one for the third wave and zero before, interacted with household-level shares 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 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 household wealth invested in deposits in 2014. 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.

after the adoption of QE. This latter explanation 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 results.[14]

Finally, in columns (7)-(8), we employ alternative bond share measures. While column (7) uses a household's indirect and direct bond holdings without the imputations described in Section 3.1, column (8) employs only a household's direct bond holdings and hence neglects its indirect holdings via mutual funds and insurance companies. The results are unaffected.

One 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). Although the PHF does not include questions about households' motivations for buying a second home, in the next sub-section, we show that our results are driven by rebalancing in urban areas. As vacation homes are typically located in rural areas, this is clear evidence that the portfolio rebalancing that we document is more likely driven by buy-to-let motives. In the next sub-section, we also show that households' portfolio rebalancing is linked to the tax advantages afforded to second homes by the German tax code that we document in Appendix A. Households, however, only benefit from such tax advantages if the second home is rented out (or households can persuade the tax authorities that they intend to rent it out in the near future). This institutional context strengthens the case for interpreting the evidence of second home purchases as reflecting an investment rather than a consumption motive.

5.2 Additional Robustness Checks

As we show in Table A6 of the Appendix, the previous results are robust along several other dimensions. First, we show that our benchmark estimates become even stronger statistically and economically once we control for the following set of time-varying household

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

characteristics, lagged by one wave: a household's logarithm of net worth, the age of the household head, the number of household members, financial literacy and risk-aversion. Second, we also fix these variables at their 2014 values and control for their interactions with the post-QE dummy. These additional controls are important to make sure that, in fact, the household-level bond shares capture households' exposure to QE, and that this interpretation is not contaminated by the potential correlation between bond shares and these possible confounders. As the results show, this concern is not warranted and our benchmark estimate lies very robustly in the range of 0.12-0.27—compared with an estimate of 0.18 in our benchmark regression.

5.3 Portfolio Rebalancing and Tax Advantages of Second Homes

Appendix A documents that second homes that are either rented out (or intended to be rented uut) 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).[15] Given that the German tax system is quite progressive, these advantages are larger the higher the level of household income. Given this institutional setting, here we examine whether the previous 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 during the 2014 pre-QE survey wave. Indeed, column (1) of Table 3 shows that households with larger ex-ante bond exposure and higher income 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 increase once we control for the corresponding triple interaction with households' initial deposit shares (column 2).

In columns (3)-(4), we split the sample into households located in urban and rural areas. Amaral et al. (2022) show that housing returns are driven by rental income in German rural

[15]Another important reason, according to this study, are the large subsidies for social housing.

Table 3 Portfolio Rebalancing and Household Income

	Full Sample		Urban	Rural	Church Member	Non-Church Member
	(1)	(2)	(3)	(4)	(5)	(6)
Bonds × Post	0.140**	0.020	0.129	0.139	0.105	0.180**
	(0.062)	(0.060)	(0.090)	(0.092)	(0.076)	(0.090)
Deposits × Post		0.059**				
		(0.029)				
Income × Post	-0.026	-0.138***	-0.016	-0.103*	-0.072*	0.001
	(0.036)	(0.036)	(0.032)	(0.059)	(0.038)	(0.034)
Bonds × Post × Income	0.003*	0.005***	0.003**	0.001	0.004***	0.000
	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)
Deposits × Post × Income		0.003***				
		(0.001)				
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2954	2952	1056	1898	1766	1188
R^2	0.346	0.365	0.402	0.322	0.364	0.321

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 variables are the changes in wealth invested in second homes over total wealth defined as the sum of bonds, housing, and deposits as in column (1) of Table 2. The main regressor, again as in column (1) of Table 2, 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 members. 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.

regions, and by capital gains in urban ones. On the other hand, owner-occupied properties are always exempt from capital gain taxes, independent of how long they have been owned while rented properties are exempted only after 10 years. However, rental income is always taxed based on the household's individual tax rate. Thus, we expect the result in column (1) of Table 3 to hold more strongly in urban areas, where high-income households may not only benefit from tax advantages when purchasing a second home (an advantage that is the same in urban as in rural areas), but also from tax exemptions on the driver of their housing return (the house price increase, at least after ten years of ownership). Indeed, columns (3) and (4) show that the previous triple interaction is larger and estimated more precisely for households living in urban areas.

Finally, we also split the sample into households that are church members and households that are not. In Germany, church members pay an additional 8 or 9% of their tax bill due (depending on the state). Therefore, the tax advantages of second homes are stronger for church members, and we expect them to rebalance their portfolios more strongly toward second homes. In line with this prior, 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.

Taken together, these results provide strong evidence that household portfolio rebalancing towards second homes in response to QE is closely associated with the tax incentives toward holding properties to let.

5.4 Exploiting Other Household Characteristics

We now look at the role of other 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. First, we consider a dummy taking the value of one for households that are actively advised by their bank on how to best allocate their wealth. In Germany, most banks own their real estate agency. Hence, banks can generate brokerage fees from real estate intermediation while advising customers. Our results, therefore, should be stronger for actively-advised households. Column (1) of Table 4 validates this conjecture, with an estimated triple interaction statistically significant at the 5% level.[16]

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 in its main residence. This is interesting because it shows whether only households that already own their main residency purchase

[16] In line with the next set of results on more financially literate households, another interpretation of the finding in column (1) about bank-advised households is that it reflects more informed portfolio decisions, as banks easily understand that it is sensible to sell bonds and buy houses in response to QE.

second homes or also those that rent their main residency. As only second homes (and not first homes) are subject to the tax advantages in Germany, the latter is not uncommon. Column (3) shows that both renters and owners of their main residence rebalance towards second homes, but the effect seems economically stronger for owners. Nonetheless, as the corresponding triple interaction is statistically insignificant, this is evidence that, at least from a statistical point of view, the rebalancing sensitivities of renters and owners are not distinguishable from each other.

Fourth, we consider age. This permits controlling whether rebalancing is driven by older households—and hence bequest motives—or by middle-aged agents, typically close to their lifetime income peak, 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). The young households below the age of 40 serve as the reference groups. The corresponding estimate in column (4) shows that especially 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.

Finally, and importantly, we investigate whether increased credit availability affects households' incentives to rebalance towards second homes. For this purpose, we employ the two variables available in the PHF survey related to credit usage—an indicator of 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. As it is evident from columns (5)-(6), both triple interactions are not statistically significant, implying that household-level portfolio rebalancing is no stronger for households with higher credit usage. This result is consistent with the aggregate evidence

Table 4 Portfolio Rebalancing other Household Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
Bonds × Post	0.014	-0.084	0.462***	0.059	0.181***	0.177***
	(0.062)	(0.086)	(0.154)	(0.057)	(0.048)	(0.047)
Financial Advice × Post	-0.929					
	(3.617)					
Financial Literacy × Post		-1.872				
		(1.587)				
Renter × Post			-0.385			
			(3.166)			
Middle Age × Post				-3.317		
				(4.236)		
Older Age × Post				-1.596		
				(3.881)		
Mortgage to Housing × Post					-0.062	
					(0.054)	
$\Delta Mortgage$ × Post						0.004
						(0.004)
Bonds × Post × Financial Advice	0.324**					
	(0.138)					
Bonds × Post × Financial Literacy		0.122***				
		(0.039)				
Bonds × Post × Renter			-0.252			
			(0.166)			
Bonds × Post × Middle Age				0.281**		
				(0.140)		
Bonds × Post × Older Age				0.117		
				(0.077)		
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	890	2954	2954	2954	2954	2954
R^2	0.344	0.348	0.346	0.349	0.346	0.356

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 variables are the changes in wealth invested in second homes over total wealth defined as the sum of bonds, housing, and deposits as in column (1) of Table 2. The main regressor, again as in column (1) of Table 2, 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, 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.

presented in the Introduction of a housing boom without a credit boom.

In Appendix Table A7, we provide further evidence that our results are not primarily driven by households' usage of mortgage borrowing. Specifically, we first restrict the sample to households that did not raise their mortgage volumes between the pre- and post-QE period and our results are largely unaffected. Second, we include the previous two credit-related household characteristics (leverage measured in 2014 and mortgage credit growth between 2014 and 2017), interacted with the Post dummy as controls without the triple interactions, and this only marginally reduces the economic and statistical significance of our benchmark bond share-post interaction coefficient. Not surprisingly, Table A7 shows that, at least for the mortgage credit growth interaction in column (3), we obtain a positive and highly statistically significant estimate, indicating that households obtaining additional mortgage credit also raise their investment in second homes.

6 QE Impact on Regional Housing Outcomes

Here, we want to assess the impact of QE on housing outcomes closely tied to the portfolio rebalancing in our model, for which we found strong evidence at the household level in the previous section. 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 measure.

6.1 Price Impact

The price impact outcome on which we focus is the regional housing rental yield. As we document in the Appendix D, the rental yield is a good predictor of future housing returns and their components in our panel of German regional data. While the only source of return variation is the house price in our two-period model, the rent growth component could also be important in the data, as well as the bubble component—as documented, for example, in Kindermann et al. (2020). The advantage of focusing on the rental yield is that we can capture the three return components without distinguishing them.[17] We then investigate the impact of QE on the regional rent and house price index separately to provide evidence on some specifics of the transmission mechanism. However, by proceeding in this way, we cannot separate discounting from the bubble component of the local hosing returns.

Table 5 reports the estimation results. Columns (1)-(3), our benchmark estimates for this exercise, employ the regional share of refugees housed in independent accommodation as an exposure variable, while columns (4)-(6) use the regional share of renters. Column (1) of Table 5 shows that QE is associated with lower rental yields in more exposed regions, i.e., regions in which rental markets are tighter. In economic terms, a one-standard-deviation increase in QE (approximately 4.3 percentage points more debt securities on the ECB balance sheet) reduces the rental yield in regions at the 75th percentile of the exposure distribution, relative to the 25th percentile, by an additional 2 basis points per year. Comparing regions at the 95th vs the 5th percentiles of the exposure distribution, the yield differential doubles to 4 basis points. These are large effects given that the average rental yield is only equal to 7.4% with a standard deviation of 1.6%. Columns (2)-(3) show that price increases exceed rent growth. More formally, the Campbell-Shiller decomposition of the German regional housing returns reported in Appendix D, using the VAR-implied estimates iterated for three periods (k=3), suggests that about 5% of the return variation can be attributed to discounting, 36% to lower future rent growth and 70% to future price-to-rent increases. In columns (4)-(6), we use the regional share of renters as an exposure variable. The attendant estimates show that the previous results are unaffected.

Table A8 in the Appendix shows that this is also true when we control for the interactions between QE and other regional characteristics that correlate with our exposure measures and might have a direct impact on housing outcomes. In these robustness regressions, we first add the regional number of building permits in 2008 to control for the potential effects of

[17] In fact, we cannot estimate the specification in (16) including the three sub-components of the regional housing return separately, obtained from the fitted value of the predicting regressions A49-A51, as the only region-specific elements are the constant and the loading on the rental yield.

Table 5 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 $\text{Refugees}_{r,2008} \times \text{QE}_{t-1}$	-0.0003**	0.0100**	0.0023			
	(0.0001)	(0.0042)	(0.0016)			
Share of $\text{Renters}_{r,2011} \times \text{QE}_{t-1}$				-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 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.

construction activity. This control itself, however, is not statistically significant and does not affect our main coefficient of interest. In column (2) of Table A8, we add population size, which is important because the policy rule that allocates refugees across regions is mainly based on population. If anything, this control increases the size of our baseline estimate. In column (3), we introduce the regional share of people aged 18-25—an age cohort that is very active on the rental market. While this control reduces the size of our benchmark estimate slightly, the interaction between QE and this demographic characteristic is also not statistically significant, which makes sense since it can also be interpreted as an exposure variable to portfolio rebalancing. Finally, we perform a placebo analysis, running the same specification as in Equation (16) on the sample period of 2004-2008, before the ECB adoption of unconventional policies. In this case, as column (4) shows, the interaction between QE and our exposure variable is not statistically significant. This is an important result because it shows that, without QE, regions more or less exposed to portfolio rebalancing do not have different rental yield dynamics.

6.2 Quantity Impact

As the final step in our empirical analysis, we provide some evidence on the impact of QE on housing quantities, following the same estimation strategy as in Table 5. The quantity outcome variables that we consider are rental and sale listings based on data from the largest German online listing platform (Immoscout 24).[18] In our model, households purchase housing for investment, rather than consumption, purposes. Moreover, in the household data, we have also shown that portfolio rebalancing toward housing may be driven by a buy-to-let motive, arguably fuelled by tax incentives toward such holdings. To validate these interpretations of our main findings, we estimate the impact of QE on both sale and rental listings of the same type of property and compare the strength of the responses. A challenge, here, is that our model does not provide us with a strong prior on the behavior of listings during a house price boom. Looking at our data aggregated at the national level, Appendix Figure A1 shows that the total number of both sale and rental listings was more or less constant till **DATE**, significantly declining thereafter, with sale listing declining faster than rental listings. We will therefore focus on the *relative* strength of the rental and sale listing responses, conjecturing that, if a buy-to-let motive fuelled by tax incentives drives the data, we should see a decline in the sale listings that is stronger than that of rental listings.

Table 6 reports the estimation results. Columns (1)-(3) measure exposure with the share of refugees, while columns (4)-(6) use the share of renters. Columns (1)-(2) and (4)-(5) show that, for both exposure measures, QE *reduces* the number of listings in more exposed regions, consistent with the aggregate evidence in Figure A1. One interpretation of this result is that, during a housing boom, vacancies (and hence listings) may decline. Columns (3) and (6) show that sale listings decrease significantly more than rental listings; a finding that is broadly consistent with our model and the evidence that we reported earlier in the sense that it points to a (relative) increase in the supply of rental properties in the market

[18] In line with the Bulwiengesa data, we only focus on apartment sales and rentals, disregarding single-family homes. In the aggregate, single-family home listings behave similarly, with less pronounced drops after QE adoption.

Table 6 QE IMPACT ON SALE AND RENTAL LISTINGS

	(1) Sale Listings	(2) Rental Listings	(3) Sale/Rental Listings	(4) Sale Listings	(5) Rental Listings	(6) Sale/Rental Listings
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.

after QE adoption.

7 Conclusions

In this paper, we propose a new channel of QE transmission through residential housing markets that does not rely on credit. From a theoretical perspective, we establish that QE induces households to rebalance their portfolios from bonds to houses, increasing prices and lowering their expected future returns and thus stimulating consumption and output.

From an empirical perspective, we study this channel of QE transmission in a rich matched household-level and region-level data set. We first study household-level changes in housing portfolio shares around the ECB's adoption of QE employing a standard difference-in-differences strategy, where we use a household's pre-QE bond share as exposure measure to QE. In order to examine the impact of our channel on housing outcomes, we exploit regional variation in housing returns and their components, including rents and the the bubble component, as well as sale and rental listings. In this part of the analysis, we measure regional exposure to rebalancing with proxy variables for tight rental markets.

Our results show that, following QE, more exposed households rebalance their portfolios toward housing more significantly. The household portfolio rebalancing that we document is stronger when we focus on purchases of second homes, consistent with a buy-to-let motive. We gauge that this effect is stronger for high-income households, which benefit more from the substantial tax advantages of second homes in Germany, for financially more literate households and those that got actively advised by their bank on how to best allocate their assets. We also show that portfolio rebalancing is not primarily driven by increased mortgage borrowing of households. Finally, at the regional level, we show that regions with a more developed and tighter rental markets see larger drops in housing expected returns and a stronger price than rent increase. We also show that the number of rental listings increases relative to sale listings.

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Appendix

'A Housing Portfolio Channel of QE Transmission'

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A The Tax Treatment of Real Estate in Germany

In this appendix, we discuss the tax advantages of second homes relative to the main residence in Germany. Assume an apartment price of 200,000 EUR, with transaction costs (real estate agent, property taxes, and notary) of 10% (20,000 EUR) and renovation costs of 15% (30,000 EUR). Further assume a marginal tax rate of 42%, which is the maximum in Germany, and a cash purchase like in our model.

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 often seen as 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 very limited. Cognizant of the special needs posed by reconstruction, German housing policies have since been designed with the objective to support and foster rental markets.

B Model Details

In this Appendix, we provide the proofs of the Propositions in the main text and present an extension of the model to a two-region economy.

B.1 Proofs of Propositions 1, 2

The representative regional household problem is

$$\max_{h,b,x} \quad E[W'] - \frac{\gamma}{2}Var(W') = h\mu_1 + b\mu_2 + x - \frac{\gamma}{2}(h^2\sigma_1^2 + b^2\sigma_2^2 + 2hb\sigma_{12}) \quad \text{(A1)}$$

$$\text{s.t.} \quad W = Ph + Qb + x, (\lambda) \quad \text{(A2)}$$

$$W' = h(\mu_1 + \varepsilon_1) + b(\mu_2 + \varepsilon_2) + x. \quad \text{(A3)}$$

The first order conditions are:

$$\lambda Q = \mu_2 - \gamma b \sigma_2^2 - \gamma h \sigma_{12} \tag{A4}$$
$$\lambda P = \mu_1 - \gamma h \sigma_1^2 - \gamma b \sigma_{12} \tag{A5}$$
$$\lambda = 1. \tag{A6}$$

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

$$\bar{h} - h = -\alpha_1 (P - \beta_1) \tag{A7}$$
$$\bar{b} - b = -\alpha_2 (Q - \beta_2) \tag{A8}$$

Thus, the equilibrium levels of h and b are

$$h = \frac{(1/\alpha_2 + \gamma\sigma_2^2)(1/\alpha_1 \bar{h} + \mu_1 - \beta_1) - \gamma\sigma_{12}(1/\alpha_2 \bar{b} + \mu_2 - \beta_2)}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} \tag{A9}$$
$$b = \frac{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 \bar{b} + \mu_2 - \beta_2) - \gamma\sigma_{12}(1/\alpha_1 \bar{h} + \mu_1 - \beta_1)}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2}. \tag{A10}$$

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

$$\frac{dh}{d\bar{b}} = \frac{-\gamma\sigma_{12}/\alpha_2}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} \tag{A11}$$
$$\frac{db}{d\bar{b}} = \frac{(1/\alpha_1 + \gamma\sigma_1^2)/\alpha_2}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} > 0 \tag{A12}$$
$$\frac{dh}{d\bar{h}} = \frac{(1/\alpha_2 + \gamma\sigma_2^2)/\alpha_1}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2} > 0 \tag{A13}$$
$$\frac{db}{d\bar{h}} = \frac{-\gamma\sigma_{12}/\alpha_1}{(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2}. \tag{A14}$$

As the denominator in the RHS of equation (A11) is strictly positive by Cauchy–Schwarz inequality, the sign of $\frac{dh}{d\bar{b}}$ thus depends on σ_{12}. Moreover, from equation (A7), $\frac{dP}{d\bar{b}} = \frac{1}{\alpha_1}\frac{dh}{d\bar{b}}$. Therefore, $\frac{dh}{d\bar{b}}, \frac{dP}{d\bar{b}} < 0$ iff $\sigma_{12} > 0$. This proves Proposition 1.

Define now the expected total portfolio return as

$$E[R] = \frac{E[W']}{W} = \frac{h\mu_1 + b\mu_2 + x}{W} \tag{A15}$$
$$= 1 + \underbrace{\frac{h(\mu_1 - P)}{W}}_{E[R^h]} + \underbrace{\frac{b(\mu_2 - Q)}{W}}_{E[R^b]} \tag{A16}$$
$$= 1 + \frac{\gamma}{W}(h^2\sigma_1^2 + 2hb\sigma_{12} + b^2\sigma_2^2) \tag{A17}$$

To prove Propositions 2, we need to find conditions under which the following inequalities hold:

$$\frac{dX}{d\bar{b}} > 0 \tag{A18}$$

$$\frac{d}{d\bar{h}}\left(\frac{dX}{d\bar{b}}\right) < 0 \tag{A19}$$

where

$$X \in \{E[R], E[R^b], E[R^h]\}.$$

It is easy to see that

$$\frac{dE[R]}{d\bar{b}} = \frac{2\gamma[(h\sigma_{12} + b\sigma_2^2)/\alpha_1 + \gamma b(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)]}{\alpha_2 W[(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2]} > 0 \tag{A20}$$

$$\frac{dE[R^h]}{d\bar{b}} = \frac{2}{\alpha_1 W}\left(\frac{\alpha_1\mu_1 + \bar{h} - \alpha_1\beta_1}{2} - h\right)\frac{dh}{d\bar{b}} \tag{A21}$$

$$\frac{dE[R^b]}{d\bar{b}} = \frac{\gamma[(h\sigma_{12} + 2b\sigma_2^2)(1/\alpha_1 + \gamma\sigma_1^2) - \gamma b\sigma_{12}^2)]}{\alpha_2 W[(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2]} > 0 \tag{A22}$$

and that

$$\frac{d}{d\bar{h}}\left(\frac{dE[R]}{d\bar{b}}\right) = 2\gamma\sigma_{12}\frac{\frac{1}{\alpha_1\alpha_2} - \gamma^2(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)}{\alpha_1\alpha_2 W[(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2]^2} \tag{A23}$$

$$\frac{d}{d\bar{h}}\left(\frac{dE[R^h]}{d\bar{b}}\right) = \frac{(1/\alpha_2 + \gamma\sigma_2^2)(\gamma\sigma_1^2 - 1/\alpha_1) - \gamma^2\sigma_{12}^2}{\alpha_1 W[(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2]}\frac{dh}{d\bar{b}} \tag{A24}$$

$$\frac{d}{d\bar{h}}\left(\frac{dE[R^b]}{d\bar{b}}\right) = \frac{(1/\alpha_1 + \gamma\sigma_1^2)(\gamma\sigma_2^2 - 1/\alpha_2) - \gamma^2\sigma_{12}^2}{\alpha_2 W[(1/\alpha_1 + \gamma\sigma_1^2)(1/\alpha_2 + \gamma\sigma_2^2) - \gamma^2\sigma_{12}^2]}\frac{db}{d\bar{h}}. \tag{A25}$$

Therefore, we have

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

B.2 Two-region Extension

Without loss of generality, consider an economy with two regions. Each regional household has access to the local housing market, national bonds, and cash, without cross-region real estate investment.[A1] We denote the second region with a $*$. Like in our benchmark economy, representative regional households with risk-aversion γ (γ^*) choose local housing h (h^*), national bond b (h^*) and cash balances x (x^*) satisfying the following four optimality conditions:

$$P = \mu_1 - \gamma h \sigma_1^2 - \gamma b \sigma_{12} \tag{A26}$$
$$Q = \mu_2 - \gamma b \sigma_2^2 - \gamma h \sigma_{12} \tag{A27}$$
$$P^* = \mu_{1^*} - \gamma^* h^* \sigma_{1^*}^2 - \gamma^* b^* \sigma_{1^*2} \tag{A28}$$
$$Q = \mu_2 - \gamma^* b^* \sigma_2^2 - \gamma^* h^* \sigma_{1^*2}. \tag{A29}$$

There are now three preferred habitat investors. Combining their downward sloping demands with the market clearing condition for each market, we have

$$\bar{h} - h = -\alpha_1(P - \beta_1) \tag{A30}$$
$$\bar{h^*} - h^* = -\alpha_{1^*}(P^* - \beta_{1^*}) \tag{A31}$$
$$\bar{b} - b - b^* = -\alpha_2(Q - \beta_2). \tag{A32}$$

To solve for the model equilibrium, we first obtain the region house holdings using equations (A26), (A28), (A30), and (A31)

$$h = m_1 - m_2 b \tag{A33}$$
$$h^* = m_{1^*} - m_{2^*} b^*, \tag{A34}$$

where the m-coefficients are defined as

$$m_1 = \frac{\mu_1 - \beta_1 + \frac{1}{\alpha_1}\bar{h}}{1/\alpha_1 + \gamma\sigma_1^2} \tag{A35}$$
$$m_2 = \frac{\gamma\sigma_{12}}{1/\alpha_1 + \gamma\sigma_1^2} \tag{A36}$$
$$m_{1^*} = \frac{\mu_{1^*} - \beta_{1^*} + \frac{1}{\alpha_{1^*}}\bar{h^*}}{1/\alpha_{1^*} + \gamma^*\sigma_{1^*}^2} \tag{A37}$$
$$m_{2^*} = \frac{\gamma^*\sigma_{1^*2}}{1/\alpha_{1^*} + \gamma^*\sigma_{1^*}^2}. \tag{A38}$$

[A1] Considering a finite number of regions does not alter the main results.

From the remaining bond holding optimality conditions, we obtain

$$b = \frac{\gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*})(\bar{b}/\alpha_2 - \beta_2 + \mu_2 - \gamma\sigma_{12}m_1) + 1/\alpha_2(\gamma^*\sigma_{1^*2}m_{1^*} - \gamma\sigma_{12}m_1)}{[1/\alpha_2 + \gamma(\sigma_2^2 - \sigma_{12}m_2)]\,[1/\alpha_2 + \gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*})] - 1/\alpha_2^2}$$
$$b^* = \frac{\gamma(\sigma_2^2 - \sigma_{12}m_2)(\bar{b}/\alpha_2 - \beta_2 + \mu_2 - \gamma^*\sigma_{1^*2}m_{1^*}) + 1/\alpha_2(\gamma\sigma_{12}m_1 - \gamma^*\sigma_{1^*2}m_{1^*})}{[1/\alpha_2 + \gamma(\sigma_2^2 - \sigma_{12}m_2)]\,[1/\alpha_2 + \gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*}),] - 1/\alpha_2^2}.$$

Therefore,

$$\frac{db}{d\bar{b}} = \frac{\gamma^*/\alpha_2(\sigma_2^2 - \sigma_{1^*2}m_{2^*})}{[1/\alpha_2 + \gamma(\sigma_2^2 - \sigma_{12}m_2)]\,[1/\alpha_2 + \gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*})] - 1/\alpha_2^2} > 0 \tag{A39}$$
$$\frac{dh}{d\bar{b}} = -m_2\frac{db}{d\bar{b}} < 0 \tag{A40}$$
$$\frac{db}{d\bar{h}} = \frac{-\gamma\sigma_{12}\,[1/\alpha_2 + \gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*})]}{[1/\alpha_2 + \gamma(\sigma_2^2 - \sigma_{12}m_2)]\,[1/\alpha_2 + \gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*})] - 1/\alpha_2^2}\frac{dm_1}{d\bar{h}} < 0 \tag{A41}$$
$$\frac{dh}{d\bar{h}} = \frac{dm_1}{d\bar{h}} - m_2\frac{db}{d\bar{h}} > 0. \tag{A42}$$

Without loss of generality, we can analyze the regional total expected return in the first region. The results equally apply to the second region, as the model is symmetric. As before, the regional total expected return is:

$$E[R] = \frac{E[W']}{W} = \frac{h\mu_1 + b\mu_2 + x}{W} \tag{A43}$$
$$= 1 + \underbrace{\frac{h(\mu_1 - P)}{W}}_{E[R^h]} + \underbrace{\frac{b(\mu_2 - Q)}{W}}_{E[R^b]} \tag{A44}$$
$$= 1 + \frac{\gamma}{W}(h^2\sigma_1^2 + 2hb\sigma_{12} + b^2\sigma_2^2). \tag{A45}$$

As in the one-region economy, we want to find conditions under which the following inequalities hold:

$$\frac{dX}{d\bar{b}} > 0 \tag{A46}$$
$$\frac{d}{d\bar{h}}\left(\frac{dX}{d\bar{b}}\right) < 0, \tag{A47}$$

where

$$X \in \{E[R], E[R^b], E[R^h]\}.$$

After some algebra, it is possible to show that

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

and that

$$\frac{d}{dh}\left(\frac{dE[R]}{d\bar{b}}\right) = 2\Omega \times \left[\frac{1}{\alpha_1\alpha_2} - \gamma^2(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)\left(1 + \frac{1}{\alpha_2\gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*})}\right)\right]$$
$$\frac{d}{dh}\left(\frac{dE[R^h]}{d\bar{b}}\right) = \Omega \times \left[\frac{1}{\alpha_1\alpha_2} - \gamma^2(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)\left(1 + \frac{1}{\alpha_2\gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*})}\right) - \frac{\gamma\left(\alpha_1\sigma_1^2 - \alpha_2\sigma_2^2 - \frac{\sigma_2^2}{\gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*})}\right)}{\alpha_1\alpha_2}\right]$$
$$\frac{d}{dh}\left(\frac{dE[R^b]}{d\bar{b}}\right) = \Omega \times \left[\frac{1}{\alpha_1\alpha_2} - \gamma^2(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)\left(1 + \frac{1}{\alpha_2\gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*})}\right) + \frac{\gamma\left(\alpha_1\sigma_1^2 - \alpha_2\sigma_2^2 - \frac{\sigma_2^2}{\gamma^*(\sigma_2^2 - \sigma_{1^*2}m_{2^*})}\right)}{\alpha_1\alpha_2}\right]$$

where $\Omega \equiv \frac{\gamma\sigma_{12}}{W(1/\alpha_1+\gamma\sigma_1^2)}\frac{\gamma^*(\sigma_2^2-\sigma_{1^*2}m_{2^*})}{\left[1/\alpha_2+\gamma(\sigma_2^2-\sigma_{12}m_2)\right]\left[1/\alpha_2+\gamma^*(\sigma_2^2-\sigma_{1^*2}m_{2^*})\right]-1/\alpha_2^2}\frac{db}{d\bar{b}}\frac{dm_1}{dh} > 0.$

Therefore, we have

- $\frac{dE[R]}{d\bar{b}} > 0$
- $\frac{dE[R^h]}{d\bar{b}} > 0$ if $h > \frac{\alpha_1\mu_1+\bar{h}-\alpha_1\beta_1}{2}$, or $m_1 - m_2\frac{\gamma^*(\sigma_2^2-\sigma_{1^*2}m_{2^*})(\bar{b}/\alpha_2-\beta_2+\mu_2-\gamma\sigma_{12}m_1)+1/\alpha_2(\gamma^*\sigma_{1^*2}m_{1^*}-\gamma\sigma_{12}m_1)}{\left[1/\alpha_2+\gamma(\sigma_2^2-\sigma_{12}m_2)\right]\left[1/\alpha_2+\gamma^*(\sigma_2^2-\sigma_{1^*2}m_{2^*})\right]-1/\alpha_2^2} > \frac{\alpha_1\mu_1+\bar{h}-\alpha_1\beta_1}{2}$
- $\frac{dE[R^b]}{d\bar{b}} > 0$
- $\frac{d}{dh}\left(\frac{dE[R]}{d\bar{b}}\right) < 0$ if $\sigma_{12} < \sqrt{\sigma_1^2\sigma_2^2 - \frac{1}{\gamma^2\alpha_1\alpha_2}\frac{1}{1+\frac{1}{\alpha_2\gamma^*(\sigma_2^2-\sigma_{1^*2}m_{2^*})}}}$
- $\frac{d}{dh}\left(\frac{dE[R^h]}{d\bar{b}}\right) < 0$ if $\sigma_{12} < \sqrt{\sigma_1^2\sigma_2^2 - \frac{1}{\gamma^2\alpha_1\alpha_2}\frac{1}{1+\frac{1}{\alpha_2\gamma^*(\sigma_2^2-\sigma_{1^*2}m_{2^*})}} + \frac{\left(\alpha_1\sigma_1^2-\alpha_2\sigma_2^2-\frac{\sigma_2^2}{\gamma^*(\sigma_2^2-\sigma_{1^*2}m_{2^*})}\right)}{\gamma\alpha_1\alpha_2\left(1+\frac{1}{\alpha_2\gamma^*(\sigma_2^2-\sigma_{1^*2}m_{2^*})}\right)}}$

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

C Data Sources, Transformations, and Summary Statistics

This appendix defines all variables that we use in the empirical analysis and provides their sources and summary statistics. Table A1 characterizes the household survey. 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 a household's bond wealth in total wealth is 14.61% (4.31% if measured without decile imputation, and 0.96% if only direct holdings are being 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 household's 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%. The average number of building permits is about 1.8 per 1000 residents and the average population size is 200,000 per region. Further, on average, 8.3% of the population is aged between 18 and 25.

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[a]	%	PHF
$\Delta SEC.HOUSING$	A household's change in other (non-main residence) housing wealth over the total portfolio[b]	%	PHF
$\Delta UNITS$	A household's change in the number of houses other than main residence	-	PHF
Bonds	A household's share of bond holdings over the total portfolio value[c]	%	PHF
Deposits	A household's share of deposit value over the total portfolio value[d]	%	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[e]	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, Riwis
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
Building Permits	Region-level number of building permits per th. inhabitants in 2008	-	INKAR
Population	Region-level number of inhabitants in 2008	-	INKAR
Age 18-25	Regional population share of people aged 18-25	%	INKAR
QE	Total debt securities held by the ECB over nominal GDP	%	ECB
Post	=1 after the ECB's adoption of QE in January 2015	0/1	PHF

[a] The total portfolio is calculated as the sum of bonds, deposits and total housing. Note that, here and in all following definitions, bonds include direct and indirect bond holdings. In the aggregate flow of funds data, we can see that mutual funds (pension and insurance companies) invest, on average, from 2011-2017, 52% (15%) of their assets in bonds. To compute households' indirect bond holdings, therefore, we multiply their amount invested in mutual funds and insurance by 52% and 15%, respectively.

[b] As for total housing, the total portfolio is calculated as the sum of bonds, deposits, and housing. As a robustness check, we also scale by the sum of housing and all financial assets.

[c] We use three different bond share measures. The first measure 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 decile imputation. Measure three only includes households' direct bond holdings and hence does not contain their indirect holdings.

[d] The total portfolio is calculated as the sum of housing and all financial assets.

[e] Financial literacy is tested based on three simple questions on the difference between real and nominal interest rates, compound interest, and portfolio diversification. In particular, the questions are as follows: Question 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? Question 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's time, the balance on your savings account will buy the same as, more than or less than today? 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?" A household's financial literacy is very low (low/medium/high), i.e., it can answer none (one/two/three) out of three simple financial literacy questions correctly

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
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
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
Building Permits	3208	1.77	0.96	0.50	1.60	3.60
Population	3136	200502.7	227543	40454	145914.5	494048
Age 18-25	3208	8.34	0.91	7.20	8.30	10.00
QE	3208	8.90	4.27	4.90	7.30	18.97

Note. The table reports the summary statistics of all variables. We restrict the household-level statistics to those households that are included in our benchmark regression of Table 2, column (1). See Table A2 for data definitions and sources. We are not allowed to report the maximum and minimum values or those at the 1th and 99th percentiles due to confidentiality reasons.

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:

$$dp_t \approx \sum_{j=1}^{k} \rho^{j-1} r_{t+j} - \sum_{j=1}^{k} \rho^{j-1} \Delta d_{t+j} + \rho^k dp_{t+k} \tag{A48}$$

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:

$$\sum_{j=1}^{k} \rho^{j-1} r_{t+j} = a_r + b_r^k \times dp_t + \varepsilon_{t+k}^r \tag{A49}$$

$$\sum_{j=1}^{k} \rho^{j-1} \Delta d_{t+j} = a_d + b_{\Delta d}^k \times dp_t + \varepsilon_{t+k}^{\Delta d} \tag{A50}$$

$$dp_{t+k} = a_{dp} + b_{dp}^k \times dp_t + \varepsilon_{t+k}^{dp}. \tag{A51}$$

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 (A49)-(A51), 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:

$$1 \approx b_r^k - b_{\Delta d}^k + \rho^k b_{dp}^k. \tag{A52}$$

The results reported in Table A4 show that, at the national level, the identity holds in the case of Germany like in the US case in 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 (A48). 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.

Table A4 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 A5 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.

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 (A49)-(A51) 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 A5 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 regressions are negative, and hence has the wrong sign from the perspective of the present value identity in Equation (A48) and also 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. In fact, 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.[A2] 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 A5, 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.

[A2] 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 A5.

E Additional Estimation Results

Table A6 Household Portfolio Rebalancing: Additional Robustness Checks

	(1) ΔY	(2) ΔY	(3) ΔY	(4) ΔY	(5) ΔY	(6) ΔY
Bonds × Post	0.249***	0.274***	0.198***	0.120***	0.203***	0.198***
	(0.064)	(0.070)	(0.048)	(0.048)	(0.048)	(0.048)
Net Worth$_{t-1}$	-5.928***					
	(1.314)					
Members$_{t-1}$	4.691***					
	(1.714)					
Age$_{t-1}$	-0.386					
	(0.346)					
Financial Literacy$_{t-1}$	-1.481					
	(1.164)					
Risk Aversion$_{t-1}$	0.977					
	(1.421)					
Net Worth$_{2014}$ × Post		0.867*				
		(0.518)				
Members$_{2014}$ × Post			0.430			
			(0.048)			
Age$_{2014}$ × Post				0.056		
				(0.056)		
Financial Literacy$_{2014}$ × Post					1.506	
					(1.164)	
Risk Aversion$_{2014}$ × Post						0.495
						(1.685)
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	2788	2850	2954	2954	2954	2952
R^2	0.372	0.351	0.345	0.345	0.346	0.345

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 variables are the changes in household-level wealth invested in second homes over total bonds, housing, and deposits as in column (1) of Table 2. The main regressor, again as in column (1) of Table 2, is the interaction between a Post dummy equal to one for the third wave, zero before, and the household-level shares of wealth invested in bonds, measured in 2014. Column (1) controls for the following time-varying, lagged 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 other columns control for the interactions between the Post dummy and one of these characteristics at a time, fixed at their 2014 value. 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.

Table A7 HOUSEHOLD PORTFOLIO REBALANCING AND CREDIT

	Households with Non-Positive Credit Growth	All Households	
	(1)	(2)	(3)
	ΔY	ΔY	ΔY
Bonds × Post	0.183***	0.184***	0.183***
	(0.047)	(0.047)	(0.047)
Mortgage to Housing × Post		-0.047	
		(0.034)	
ΔMortgage Credit × Post			0.009***
			(0.003)
Household FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Obs	2580	2954	2954
R^2	0.367	0.346	0.354

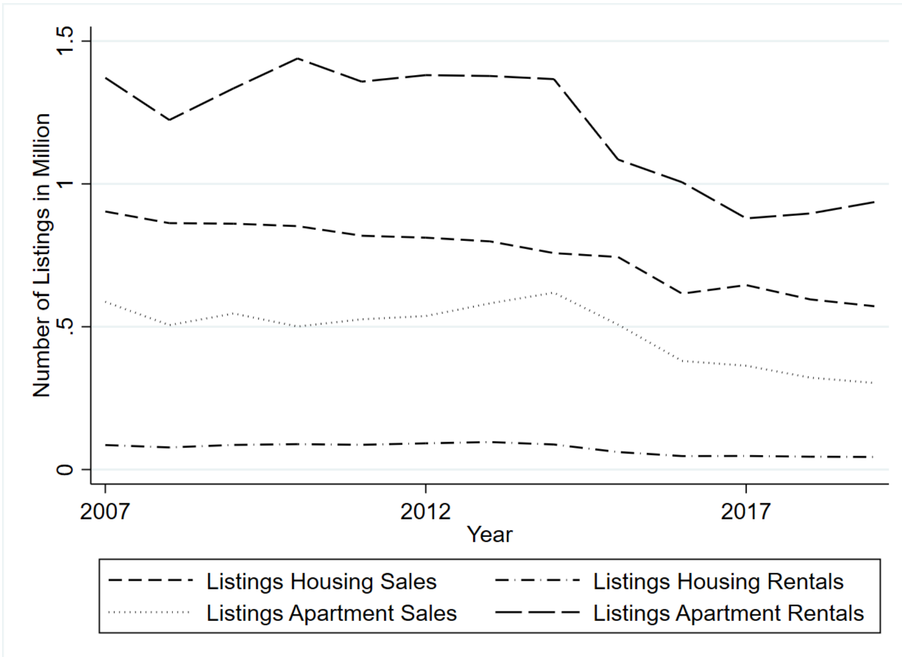
NOTE. All regressions are based on our panel of households from the PHF. The number of observations varies depending on the constraint imposed by the right-hand side variables. The dependent variables are the changes in household-level wealth invested in second homes over total bonds, housing, and deposits as in column (1) of Table 2. The main regressor, again as in column (1) of Table 2, is the double interaction between a dummy Post equal to one for the third wave, zero before, and the household-level shares of wealth invested in bonds, measured in 2014. Column (1) restricts the sample to all households without a mortgage credit increase between wave 2 and wave 3; columns (2) and (3), respectively, add 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. 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.

Table A8 QE and Housing Outcomes: Robustness Checks

	(1) Rental Yield	(2) Rental Yield	(3) Rental Yield	(4) Rental Yield
Share of Refugees$_{r,2008}$ × QE$_{t-1}$	-0.0003**	-0.0004**	-0.0002**	-0.0009
	(0.0001)	(0.0002)	(0.0001)	(0.0006)
Building Permits$_{r,2008}$ × QE$_{t-1}$	0.0008			
	(0.0027)			
Population$_{r,2008}$ × QE$_{t-1}$		0.0000*		
		(0.0000)		
Age 18-25$_{r,2008}$ × QE$_{t-1}$			-0.0132***	
			(0.0030)	
Time FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Obs	3080	3072	3080	1925
R^2	0.937	0.937	0.938	0.967

Note. The table reports robustness checks on the impact of QE on rental yields. The regressions in columns (1)-(3) are based on annual region-level data from 2010 to 2017; column (4) uses a pre-QE placebo time period (2004-2008). The dependent variable is the regional rent-to-price ratio. 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 2008 share of refugees. In columns (1)-(3), we control for the following regional characteristics measured in 2008: the number of building permits per 1000 inhabitants, population size, and the share of people aged 18-25. 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.

Figure A1 Total Number of Sale and Rental Listings: 2007-2019 (In Million)



Note. The figure plots the aggregate time series for the total number of sale and rental listings, for single-family homes and apartments. Data Source: Immoscout 24.