A Housing Portfolio Channel of QE Transmission*

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Abstract

We document a housing portfolio channel of quantitative easing (QE) transmission exploiting household-level and regional variation in German data. We show that QE induces households with larger initial bond holdings to rebalance more their portfolios toward 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 to buy and let, and more financially literate and bank-advised households. We also document a stronger 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, consistent with the transmission channel that we posit.

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

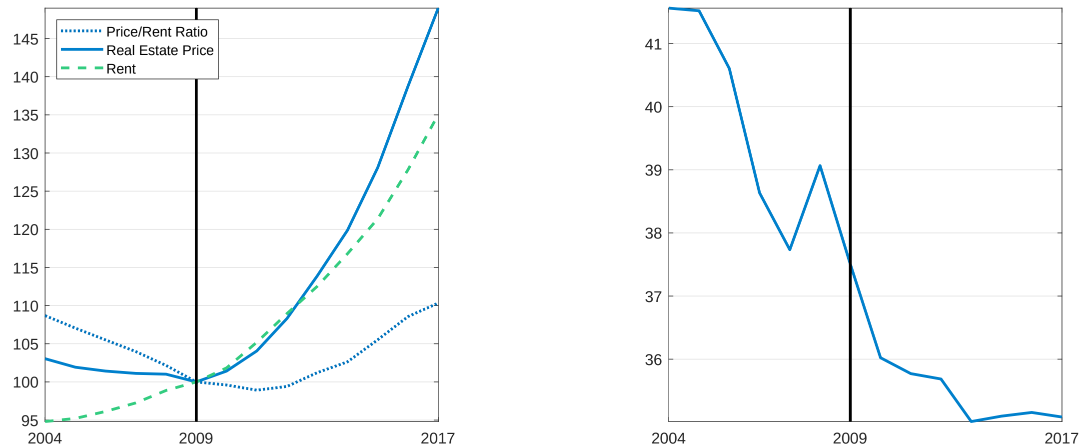
During and after the global financial crisis (GFC), the Fed and other advanced-economy central banks expanded their policy toolkit by adopting unconventional monetary policies. To support the economy with the policy rate near the zero lower bound, they started to purchase long-term bonds and other risky 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 the macroeconomy as a whole.

In this paper, we document a housing portfolio channel of QE transmission in Germany, employing a difference-in-differences strategy at the household level and using the pre-QE bond portfolio share as exposure measure. We estimate that a household with an ex-ante 10-percentage point higher bond share, which approximately corresponds to the interquartile range of this variable, increases its second-home housing share by 1.78-1.95 percentage points more than the median household relative to the pre-QE period. This portfolio rebalancing is stronger for high-income and church-affiliated households, which in Germany benefit from substantial tax advantages when holding second homes for rental purposes. Rebalancing is also stronger for financially more literate households and those that are actively advised by their bank on how to allocate their assets best. Finally, when we evaluate the impact of this channel on housing outcomes by exploiting regional variation in the data, we find consistent evidence that regions more exposed to rental market tightness and depth experience larger rental yield declines and a lower decline in the number of rental listings relative to sale listings in response to QE.

To illustrate the working of this channel of QE transmission 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

Figure 1 Germany: a Housing Boom without a Credit Boom

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



Note. Panel A plots national residential house price and rent indexes, and 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.

among cash, bonds, and local houses. In response to QE, as the bond supply declines, the preferred habitat bond investor and local households lower their bond holdings. The bond price increases. Provided that the bond and house payoffs are positively correlated, and hence the two assets are substitutes, local households increase their demand for houses and bid up house prices. Meanwhile, preferred habitat real estate holders sell houses to richer (i.e., optimizing) households. The total expected future portfolio return declines, and if the equilibrium house holding is large enough, both the bond and housing components of the total return decline. In this channel, therefore, QE works through household portfolio rebalancing, rather than bank portfolio rebalancing and higher credit supply to households. House sales and purchases are cash transactions in our model.

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 experienced a housing boom without a credit boom since 2009. Figure 1 plots national aggregate residential rent and price indexes and households' mortgage credit. The figure

Table 1 GERMAN AGGREGATE HOUSEHOLD BALANCE SHEET

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Real Estate/Total Assets	0.55	0.55	0.56	0.56	0.55	0.55	0.55	0.55	0.56	0.57	0.56
Bonds/Total Assets	0.066	0.065	0.062	0.063	0.062	0.064	0.060	0.060	0.059	0.059	0.056
Equities/Total Assets	0.081	0.083	0.075	0.078	0.083	0.085	0.089	0.091	0.095	0.085	0.095
Deposits/Total Assets	0.168	0.169	0.170	0.170	0.169	0.169	0.168	0.170	0.169	0.171	0.170
Loans/Total Assets	0.15	0.15	0.14	0.14	0.14	0.13	0.13	0.13	0.12	0.12	0.12
Homeownership (in %)	-	53.2	53.4	53.3	52.6	52.5	51.9	51.7	51.4	51.5	51.1
Homeownership (with loans, in %)	-	27.8	28.1	28.0	27.6	26.6	26.2	26.2	25.7	25.6	25.8
Households with 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 flow of funds data from the Federal Statistical Office (Destatis), as well as German homeownership rates from the OECD and the Bundesbank's Panel of Household Finance Survey. Real estate assets are the sum of buildings, structures, and land; bonds include all direct short-term and long-term debt securities held by households and their indirect holdings via mutual funds and insurances; deposits are currency and deposits; equities are all direct stock holdings; loans are equal to all liabilities; and total assets are all financial and non-financial assets. The household sector includes households and non-profit institutions serving households. 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 presented in the data section of the paper.

shows a stark negative correlation between housing and credit markets from the beginning of the recovery in 2009 to 2014-15, with a modest credit expansion since the mid-2010s.[1]

The transmission implied by our model is consistent with several aggregate stylized facts of the German housing boom since 2009. First, real estate represents the lion's share of households' total assets in Germany and increases by two percentage points during our sample period, from 55% in 2009-2010 to 57% in 2018 (Table 1), while the share of bond holdings in total assets declines by about one percentage point over the same period. Table 1 also shows a significant increase (decrease) in the share of households (directly) owning a second home (bonds), which speaks to portfolio rebalancing from bonds to second homes as the main driver of the aggregate dynamic. Second, the declining homeownership rate by about two percentage points during this period (from an already very low level by international standards), is also consistent with the transmission implied by our model, implying an increase in the share of renters and landlords.[2] Third, Table 1 shows that household leverage is

[1] In the run-up to the GFC, house prices (and rents) decline while credit expands through 2005-06. The data points before the GFC are not plotted as the price and rent indexes start in 2004.

[2] This increase is slightly less than half the swing in the US homeownership rate during the subprime

low and on a declining trend during this period, consistent with an even lower (and equally declining) share of homeowners with housing credit. Fourth and finally, "Equity to Total Assets" and "Deposits to Total Assets" are slightly increasing and constant, respectively, over this period. The constant deposit share implies that the ECB's negative interest rate policy is unlikely to be the main driver of our results. As for rebalancing toward equity, while we see an increase in the aggregate after QE, we note that the equity shares are still relatively small compared to the pre-GFC values (not reported).

To assess this channel of QE transmission empirically, we assemble a rich data set, including household-level and regional data, that we describe in detail in the paper. The household-level portfolio data comes from the Deutsche Bundesbank's Panel on Household Finances (PHF), which contains detailed income and wealth data on nearly 15,000 households interviewed in three waves in 2011, 2014, and 2017. The regional data on rent and price indexes, as well as on rental yields that we use as predictors of housing returns, are from Bulwiengesa AG, a reputable proprietary data provider that supplies also the ECB and Bundesbank, and cover all 401 German administrative regions from 2010 to 2017.[3] Listing data are aggregated at the regional level from Immoscout 24, the largest German online real estate listing platform.

To achieve identification, we estimate a difference-in-differences specification around the year in which the ECB formally adopted QE in 2015, employing a household's pre-QE share of wealth invested in bonds as an exposure measure, consistent with existing literature on bank portfolio rebalancing in response to QE in line with the literature on *bank* portfolio rebalancing (e.g., Rodnyansky and Darmouni, 2017; Luck and Zimmermann, 2020).

We find that households with larger ex-ante bond shares increase their housing portfolio share more relative to less exposed ones. In economic terms, a household with an initially

boom-bust cycle. The argument that our portfolio rebalancing mechanism is a critical driver of the aggregate decline in homeownership during this period is plausible because, in Germany, more than 60% of all renters lease from other households (see Sagner and Voigtländer, 2021).

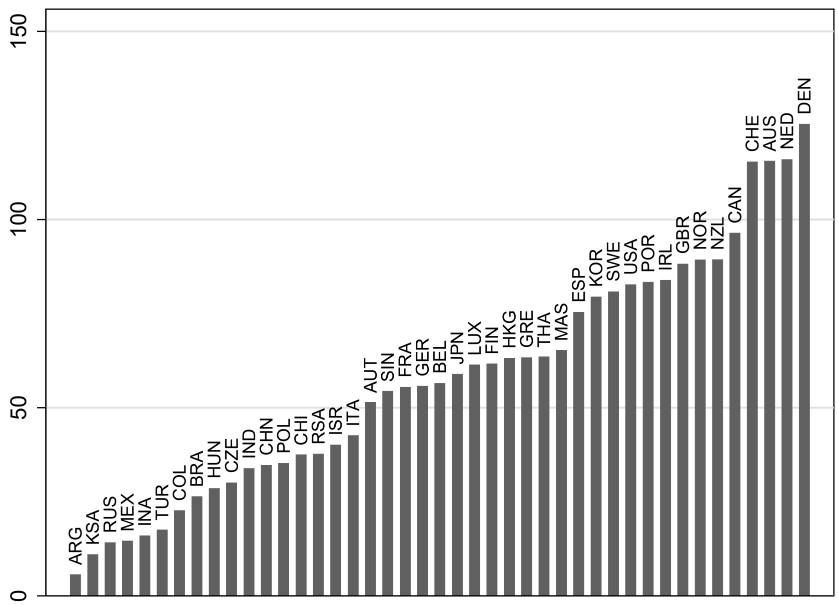
[3]To be precise, we use the German "Landkreise" as the regional unit of analysis that is comparable to the American county level.

10-percentage point higher bond share, which roughly corresponds to the interquartile range of this variable, increases its secondary housing portfolio share by 1.78-1.95 percentage points relative to the pre-QE period. Rebalancing is stronger for high-income households (and hence high-marginal-tax rate households) and church-affiliated households (who must devolve an extra 8-9 % of their tax bill to the church). This evidence is consistent with a buy-to-let motive because, as we summarize in Appendix A, rented-out second homes (or second homes declared to be for letting in the future) enjoy a sizable tax advantage relative to main residences in Germany. The effects are also stronger for households aged 40-60, financially more literate households, and those that are actively advised by their bank on how to best allocate their assets, consistent with the findings in the existing literature on the impact of financial literacy on portfolio rebalancing (Bianchi, 2018). In contrast, household leverage and mortgage credit do not seem to affect our estimates. Overall, this is strong evidence that richer, more financially sophisticated, households drive our housing portfolio channel by rebalancing from liquid assets to housing for investment purposes without necessarily borrowing.

These results are very robust. They hold after controlling for a large set of additional household characteristics, such as net worth, the number of household members, and risk aversion. They are also robust to using alternative measures of the bond share that captures exposure to this channel of QE transmission, and to alternative definitions of the housing portfolio share. Finally, our results also survive when we control for negative interest rate policy more explicitly or rebalancing toward equities.

In line with the predictions of our model, we also show that regions that are more exposed to rental market tightness or depth—as proxied by the share of refugees housed in independent accommodations and the share of renting households in a given region, respectively—see a larger decrease in rental yields, with a stronger increase in house prices, compared to rents. As we argue in the paper, these estimates imply an interquartile regional rental yield differential that is sizable relative to the average regional rental yield decline (and hence the change in the market valuation) between 2014 and 2017. Finally, we show that, in more exposed regions, rental listings decline less than sale listings; a finding that can be reconciled with the broad implications of our model assuming that sale and rental listing declines reflect lower property inventories as the housing boom progresses.

Figure 2 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.

The transmission mechanism that we document is relevant for other countries and other shocks. 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 long-lasting housing boom has been creditless until the mid 2010s. 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 2). 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).

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.

Second, 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. Like these papers, we also take a portfolio approach but focus on portfolio rebalancing toward residential real estate. Indeed, the closest to our paper is Korevaar (2022) also showing that bond return declines induce portfolio rebalancing towards real estate in 18th-century Amsterdam. Finding results consistent with ours, Daniel et al. (2021) show that that lower interest rates induce households to rebalance their portfolios towards income-generating assets, similar to Gargano and Giacoletti (2022), who employ Australian tax filings data to show that lower interest rates raise the share of households becoming landlords. While we document a similar finding for QE, we argue that our results are driven by a buy-to-let motive fuelled by tax incentives that favor rental properties.

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).

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 portfolio rebalancing, while Section 6 reports estimated effects of housing outcomes. Section 7 concludes. An Appendix reports model and data details, robustness analyses, and additional estimation results.

2 Theoretical Framework

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

2.1 Agents and Markets

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

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

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.

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

[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}.

wealth changes. To see this, define the total expected return on wealth, $E[R]$, as

$$\begin{aligned} E[R] &= \frac{E[W']}{W} = \frac{h\mu_1 + b\mu_2 + x}{W} && (11) \\ &= 1 + \underbrace{\frac{h(\mu_1 - P)}{W}}_{\equiv E[R^h]} + \underbrace{\frac{b(\mu_2 - Q)}{W}}_{\equiv E[R^b]} && (12) \\ &= 1 + \frac{\gamma}{W}(h^2\sigma_1^2 + b^2\sigma_2^2 + 2hb\sigma_{12}), && (13) \end{aligned}$$

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 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 data from the Bundesbank's Panel on Household Finances survey and regional from various sources. In this section, we discuss the main variables of interest. Appendix C provides sources and definitions of all variables used in the empirical analysis and a complete set of 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

[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.

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 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 estate listing platform.[8] Specifically, based on these data, we compute the total regional number of sale listings per year, the total number of rental listings, and their ratio, focusing only on apartment sales and rentals for consistency with Bulwiengesa data.

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 observa-

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

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

tions, 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.

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 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 analysis, we employ a continuous QE indicator. We use total debt securities held by the ECB over nominal euro area GDP. Alternative measures, such as the total size of the ECB balance sheet might also be affected by the ECB's long-term refinancing operations that channeled liquidity to the banking sector without directly affecting households' incentives to rebalance their portfolios.

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

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

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:

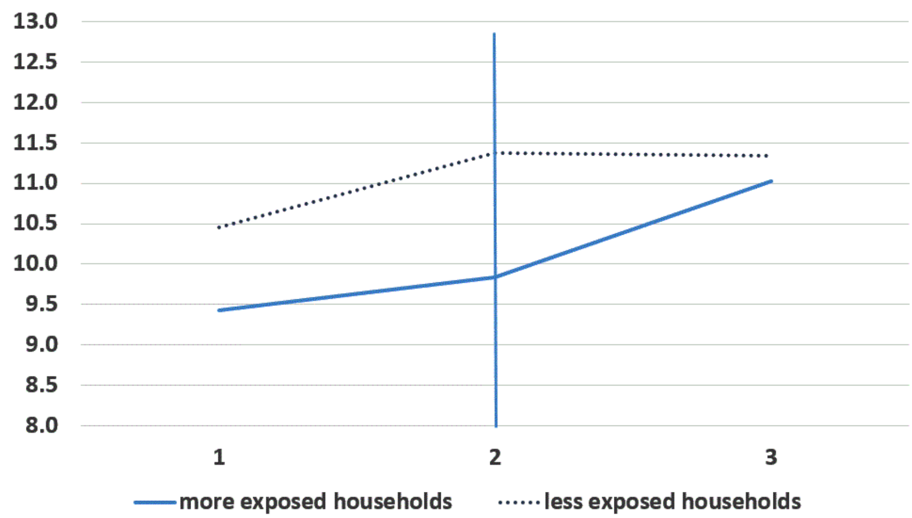
$$\Delta Y_{h,t} = \alpha_t + \alpha_h + \beta \cdot (\text{Post}_t \times \text{Bonds}_{h,2014}) + \epsilon_{h,t} \tag{14}$$

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 (e.g., Rodnyansky and Darmouni, 2017; Luck and Zimmermann, 2020), 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.[10] 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

[10] 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.

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 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, $\text{X}_{h,2014}$ 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, $\text{X}_{h,2014}$ 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.[11] 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

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

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.

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 directly, or the rent-growth component of this return, consistent with our model's implications. For this step of the empirical analysis, therefore, we exploit house price and rent data variation at the regional level. A second challenge that we face is that, as we noted earlier, aggregating and matching household 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. Hence we cannot estimate the direct impact of portfolio rebalancing aggregated at the regional level on housing outcomes. Instead, 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 that can be aggregated at the regional level.

The specification that we adopt is as follows:

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

where $\text{Y}_{r,t}$ 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 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. In particular, as Bednarek et al. (2021) document both in a model and in the data, a higher share of refugees exerts more demand pressure in local rental housing markets and reduces the net supply to the rest of the market, arguably capturing the rental market tightness.[12]

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

[12]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. See also the Model Appendix B, which spells out conditions conditions under which $\frac{dE[R]}{dh} > 0$ in our model in the proof to Proposition 2. One critical difference with respect to the setting in Bednarek et al. (2021) is that, in this paper, we are focusing on housing rather than GDP growth outcomes. As Bednarek et al. (2021) discuss, several other studies use the distribution of refugees as an instrument. See, for instance, Jaschke, Sardoschau and Tabellini (2022), for a recent application.

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 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

[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.

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.

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×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 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

[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.

(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 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 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. Finally, in unreported specifications, we also examined whether households with higher ex-ante bond shares rebalance more strongly toward equities after QE adoption, but the results were statistically insignificant.

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 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

[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.

(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 split the sample into households that are church members and those that are not. In Germany, church members devolve an additional 8-9% of their tax bill to the church (depending on the state). Hence, the tax advantages of second homes are stronger for these households, and we expect them to rebalance their portfolios more strongly. 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.

We conclude that, 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 and can generate brokerage fees while advising customers. In addition, in line with the next result on more financially literate households, bank-advised households may rebalance more strongly because better informed about their portfolio decisions, as banks understand that it is a sensible strategy to sell bonds and buy houses in response to QE. Column (1) of Table 4 validates this conjecture, with an estimated triple interaction statistically significant at the 5% level.

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

Third, we consider the household tenure status. This experiment can show whether only households that own their main residency purchase second homes or also those that rent the main residency engage in the trade. Column (3) shows that both renters and owners of their main residence rebalance towards second homes, but the effect is economically stronger for owners. Nonetheless, as the corresponding triple interaction is insignificant, the rebalancing sensitivities of renters and owners are statistically 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' rebalancing 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 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

Table 4 PORTFOLIO REBALANCING AND 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.

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. The two outcome variables that we focus on are the regional rental yield, which Appendix D shows is a good predictor of housing returns and their components, and the total number of sale and rental listings. In all specifications, the main regressor is the interaction between the lagged stock of ECB debt securities as a share of GDP and our exposure variable, measured with the share of refugees or the share of renters.

6.1 Price Impact

As we document in the Appendix D, the rental yield is a good predictor of future housing returns and all three 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. The advantage of focusing on the rental yield is that we can capture all three return components without distinguishing them.[16] Nonetheless, we also investigate the impact of QE on the regional rent and house price growth, separately, to provide indirect evidence on the extent to which the portfolio rebalancing that we documented affects rental markets by increasing the supply of properties to let.

[16] 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 Refugees$_{r,2008}$ × QE$_{t-1}$	-0.0003**	0.0100**	0.0023			
	(0.0001)	(0.0042)	(0.0016)			
Share of Renters$_{r,2011}$ × QE$_{t-1}$				-0.0014***	0.0141**	0.0088***
				(0.0002)	(0.0063)	(0.0026)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	3080	3080	3080	3208	3208	3208
R^2	0.937	0.781	0.813	0.939	0.781	0.812

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

Table 5 reports the estimation results. Columns (1)-(3) employ the regional share of refugees housed in independent accommodation as an exposure variable, while columns (4)-(6) use the regional share of renters. Columns (1) and (4) of Table 5 show that QE is associated with lower rental yields in more exposed regions, with a larger and more precisely estimated coefficient when we use the share of renters as exposure measure. In economic terms, these estimates imply that a one-standard-deviation increase in QE, which corresponds to an approximately 4.3 pp higher ratio of ECB debt securities to GDP, reduces the rental yield in regions at the 75th percentile of the exposure distribution, relative to those at the 25th percentile, by 2-12 basis points more per year, using the share of refugees shares or the share of renters as exposure measure, respectively.[17] As the share of debt securities held by the ECB increased from 7% in 2014 to 24% at the end of our sample period in 2017, these estimates imply a cumulative rental yield decline evaluated at the regional interquartile range between 8 and 48 basis points during that period. Such a range, in turn, looks sizable relative to the average regional rental yield (market valuation increase) decline of 1.4 percentage points, from 7.4% in 2014 to 6% in 2017.

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

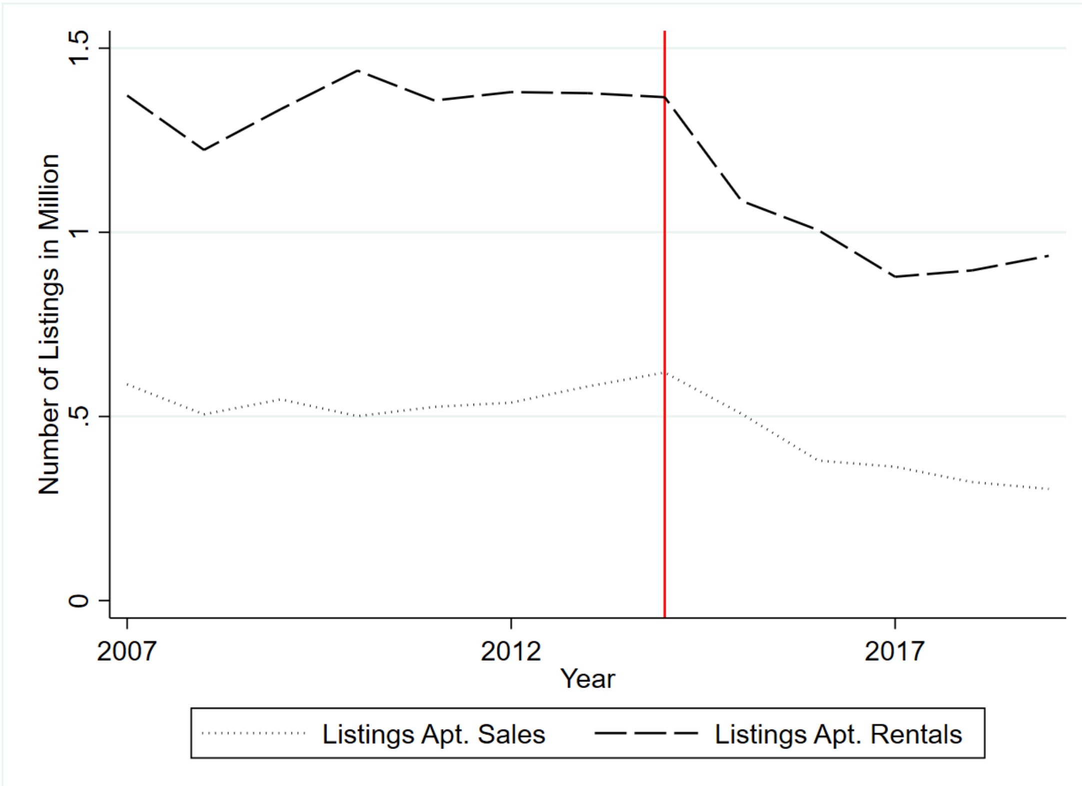
Looking at the source of the decline in the rental yield, columns (2-3) and (5-6) of Table 5 illustrate the breakdown between price and rent growth. They show that house price increases exceed rent growth in more exposed regions during the sample period, again, with the impact on rent growth estimated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

6.2 Quantity Impact

As the final step in our empirical analysis, we provide some evidence on the impact of QE on the volume of transactions, following the same estimation strategy as in Table 5. The quantity outcome variables that we consider are the total number of rental and sale listings based on data from the largest German online listing platform (Immoscout 24).

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

Figure 4 Total Number of Sale and Rental Listings Before and After QE (2007-2019, In Million)



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

A challenge here is that our model does not provide a prediction for the behavior of listings in response to QE. Looking at our listing data aggregated at the national level, Figure 4 shows that both sale and rental listings are roughly constant till 2014 but significantly decline thereafter. Thus, we first assume that the aggregate trend declines in Figure 4 reflect a shrinking inventory of properties for lease or sale as the German housing boom progresses over time. We then focus on the *relative* strength of the rental and sale listing declines across regions, as the relative strength of the two market segment responses arguably reflects portfolio rebalancing driven by buy-to-let motives.

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.

Table 6 reports the estimation results. As before, columns (1)-(3) measure exposure with the share of refugees, while columns (4)-(6) use the share of renters. Columns (1)-(2) and (4)-(5) show that for both exposure measures, QE *reduces* the total number of both sale and rental listings in more exposed regions in line with the aggregate evidence in Figure 4. However, columns (3) and (6) also show that sale listings decrease significantly more than rental listings; a finding that is broadly consistent with our model's implications 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 after QE adoption.

7 Conclusions

In this paper, we document a housing portfolio channel of QE transmission working through households that rebalance their portfolios toward second homes for investment rather than consumption purposes, possibly strengthened by a taxation regime that favors rental properties in Germany. From a theoretical perspective, we establish that QE can induce households to rebalance their portfolios from bonds to houses, increasing house prices and lowering their expected future returns as long as houses and bonds are substitute assets and house holdings are large enough. Housing purchases and sales are cash-based in this setting, and this QE transmission channel does not rely on the increased supply of credit. From an empirical perspective, we document this portfolio channel of QE transmission exploiting data variation both at the household and regional levels.

We find that, following QE, more exposed households rebalance their portfolios toward second homes more significantly. This portfolio rebalancing is economically sizable and is stronger when we focus on higher-income and church-affiliated households, which benefit more from the significant tax advantages afforded by the German tax code to rented properties or properties that may be rented in the future, consistent with a buy-to-let motive. The rebalancing is also stronger for households more financially literate and actively advised by their bank on asset allocation. Finally, we find that portfolio rebalancing is not primarily driven by household leverage or increased mortgage borrowing.

When we look at the impact of QE on housing outcomes, at the regional level, we find that regions with a tighter and more developed rental market see larger declines in their rental yields and slower declines in the number of rental listings relative to sale listings, broadly consistent with the implications of our model.

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Appendix

'A Housing Portfolio Channel of QE Transmission'

by D. Boddin, D. te Kaat, and C. Ma, and A. Rebucci

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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

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

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

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

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
Price Growth	Region-level cumulative real house price growth	2009=100	Bulwiengesa, Riwis
Rent Growth	Region-level cumulative real rent growth	2009=100	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
Price Growth	3208	110.11	19.21	88.28	104.09	149.36
Rent Growth	3208	104.54	8.59	94.89	102.10	121.33
Sale Listings	3080	1018.61	1534.19	65	512.5	3744
Rental Listings	3080	2777.20	4881.83	184	1196.5	10609
Sale/Rental Listings	3080	0.49	0.31	0.13	0.41	1.09
Share of Refugees	3080	12.71	18.81	0.77	6.79	42.62
Share of Renters	3208	52.33	12.95	36.45	48.83	76.75
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.