Housing Consumption and Macroprudential Policies in Europe: An Ex Ante Evaluation*

Qizhou Xiong † Antonios Mavropoulos ‡

September 17, 2018

Abstract

In this paper, we use the panel of the first two waves of the Household Finance and Consumption Survey by the European Central Bank to study housing demand of European households and evaluate potential housing market regulations in the post-crisis era. We provide a comprehensive account of the housing decisions of European households between 2010 and 2014, and structurally estimate the housing preference of a simple life-cycle housing choice model. We then evaluate the effect of a tighter LTV/LTI regulation via counter-factual simulations. We find that those regulations limit homeownership and wealth accumulation, reduces housing consumption but may be welfare improving for the young households.

Keywords: Housing Consumption, Macroprudential policies, LTV/LTI regulation
JEL Classifications: D14, D31, D91

*This is an early draft of the paper, comments and advices are highly appreciated. Please find the latest version in the following link: `http://qizhouxiong.com/eu-housing-consumption.html`

†Otto-von-Guericke University Magdeburg and Halle Institute for Economic Research (IWH), Germany. E-mail: qizhou.xiong@iwh-halle.de

‡Halle Institute for Economic Research (IWH), Germany. E-mail: antonios.mavropoulos@iwh-halle.de

1 Introduction

After the painful and costly lesson from the Great Recession, loan-to-value (LTV) and loan-to-income (LTI) regulations have become part of the widely accepted macroprudential policy toolkits. There have been worldwide application of such policies to ensure healthy micro level household indebtedness and prevent the housing bubble from resurfacing by curbing the housing demand through borrowing constraint. The necessity and effectiveness of such regulation depend on the household housing demand and how much are they credit constrained. While there have been some successful cases proven by ex post policy evaluation (Mitra et al., 2015), we still need to be cautious in claiming universal effectiveness. Moreover, most of the policy evaluations heavily focus on the market aggregate and macroeconomic indicators but remain silent on the micro level impacts on household finance and welfare.

Some European countries, especially Germany, have witnessed substantial housing price increase and low mortgage rates in the past few years. The concern of over leveraged household portfolio and housing market bubble building has led to the discussion of implementing housing related macroprudential policies in the eurozone countries. For instance, German Ministry of Finance had proposed a draft law aimed at tightening residential mortgage lending market regulations in late 2016. The essential information we need to make sensible policy decisions is the answers to the following two questions: first, how do European households make housing consumption decisions; second, what will be the consequences of specific policy implementation? We answer the first question by positively documenting the housing consumption choices at both intensive and extensive margin and structurally estimate the parameters that primarily govern the housing consumption preferences: the consumption share and the elasticity of substitution between the housing and non-durable good consumption. We then answer the second question by simulating multiple policy scenarios of potential LTV/LTI regulations to conduct ex ante policy evaluation.

First, we provide novel empirical evidence of the recent housing demand (2010-2014) in Europe at the household level. According to the European Systemic Risk Board statistics, in this period, most of the western European countries do not have any LTV regulation in place. [1] We investigate the untethered housing consumption decision at both intensive and extensive margins using the observed housing size change and tenure transition between 2009/2010 and 2014 in European countries. The two-wave short panel of the Household Finance and Consumption Survey (HFCS) of the ECB enables us to accurately identify the renters who transitioned to home-owners between 2010/2009 and 2014. We use this

[1] please see `https://www.ecb.europa.eu/pub/fsr/html/measures.en.html`. The only exception is the Netherlands, which reduced tax exemption for the mortgage payment. Ireland started implementing LTV/LTI regulation after 2014.

well-identified housing tenure transition to study the main driving forces of housing demand change, similar to Blickle and Brown (2016) which use the Swiss Household Panel (SHP) to study the treatment effect of exogenous wealth transfer on homeownership. The panel part of HFCS includes the observations from Belgium, Cyprus, Germany, Italy, Malta, and the Netherlands. It contains information on 7449 households in two waves, the first one in 2010 and the second in 2014.

We find that around 60 percent of both renters and owners adjust their housing consumption at the intensive margin between 2010 and 2014 without changing their tenure status. Although the total percentage of intensive adjustment accumulates during the four year period, the share of households adjusting their housing consumption is high, especially for owners. We also observe that there are more households trading-up than trading-down for both renters and owners, which is in line with the prediction of the typical life cycle model that as households amass their wealth, they start to consume more both nondurable goods and housing. Moreover, on top of a substantial proportion of intensive housing consumption adjustment, many household also report housing size adjustment without changing their primary residence. This suggests that European households actively adjust their housing consumption without incurring the costly sale and repurchase process.

We then look into the housing consumption decision at the extensive margin through the lens of the standard optimal portfolio model with a focus on housing and mortgage. We employ a highly stylized model, in line with the classic housing choice theories (Henderson and Ioannides, 1983; Grossman and Larogue, 1990; Campbell and Cocco, 2003), to guide the empirical exercises. We find that housing preference shocks, such as family size and marital status, have a positive impact on the homeownership transition as predicted in the previous studies. However, the background risk like income growth and volatility do not have a significant impact. These findings confirm the previous theoretical and empirical results in the literature. To our surprise, we find that households are less willing to transition to homeownership where the house prices are increasing quickly, which suggests that the future housing value may not be the primary driving force of housing decision.

Second, we build a life-cycle housing decision model in partial equilibrium setting à la (Campbell and Cocco, 2015; Li et al., 2016; Landvoigt, 2017) and then structurally estimate the housing preference. We assume the housing market conditions (housing supply and housing prices), labor income and financial market conditions (mortgage rates, return on liquid financial assets) are exogenous and stochastic. At each period, households make forward-looking decisions on whether to purchase a residence and how much housing to consume for both renters and owners. We allow the households to breach their borrowing constraint only through mortgage taking and obtain a significant terminal value at the end

of the mortgage. We also impose that the households face transaction cost purchasing a new property and also aim to reduce their outstanding loans when remaining stable on housing tenure. We apply a two-step process proposed by Bajari et al. (2007) to numerically solve the model and structurally estimate the parameters of interest. We find that European households have almost unit elasticity of substitution between housing and non-durable goods and have a relatively high consumption share compared with the previous results found in the US data.

Finally, we investigate the possible change of a tighter LTV and LTI regulation: the LTV decreases from 80% to 60% and LTI ratio at 4.5.[2] We find that those tighter regulations have a significant effect on households' choice of housing tenure and housing size. We choose two representative households for the ex ante evaluation of the policies: a 20-year-old household with average income and no wealth and a 30-year-old household with average income and average wealth. We find that the regulations limit the entry to the housing market at an early stage of their life cycle and slow the wealth accumulation. Moreover, the regulation also forces the households to choose smaller housing units as they finally transition to homeownership. The wealth difference caused by the tighter regulation can be as substantial as 20,000 euros by the LTV regulation and 40,000 euros by LTI regulation. However, the welfare level computed using the empirical utility estimated from the structural model suggests that such regulation tightening may be welfare improving. This is likely due to the fact that those regulations prevent households from prematurely invest in risky housing assets.

We believe that this paper makes a few empirical contributions to the housing service demand literature and the ongoing discussion of housing market regulations. First, this paper provides a comprehensive account of the housing decisions of European households in multiple countries during the post-crisis period when the mortgage rates and real interest rates are low. The comparison shows that households in Europe make significantly different housing choices than the Americans. Second, we are among the first to structurally estimate the housing demand using a partial equilibrium life-cycle model in the European context. Third, the ex ante policy evaluations offer valuable insights on the possible financial and welfare consequences to the households if certain housing market policies were implemented.

The remainder of the paper is structured as follows. Section 2 presents the empirical evidence on housing size adjustment, and section 3 presents the empirical results of the renter to owner transition. Section 4 builds a simple theoretical framework to illustrate household housing demand and the housing tenure transition conditions. In section 5, we discuss the strategy of the numerical solution and structural estimation. Section 6 presents the ex ante evaluation of LTV and LTI regulation. Finally, section 7 concludes.

[2]The LTI is defined as the ratio of loan to the annual gross income of the household.

2 Data and Summary Statistics

We use the Household Finance and Consumption Survey (HFCS) by the European Central Bank, which is a centralized effort in collecting European household finance data via the national central banks of the Euro-system and many national statistical institutes. The HFCS collects detailed information about the finance and consumption at a household level.[3] The first wave of the data was surveyed in 2008, 2009 and 2010[4] and the second wave was surveyed in 2014. There are six countries whose central banks follow up the households in the first wave and construct a short panel data with a unique household identifier. They are Belgium, Cyprus, Germany, Italy, Malta, and the Netherlands. A total of 7.449 households show up in both waves.

The main driving force of housing demand usually comes from the new purchase of houses from either owner buying the second house or renters becoming owners. As the data shows a deficient percentage of multiple homeownership, we only break down the demographics of the renter-to-owner transition to answer the question who are becoming new owners in Europe. In Table 2, we present the summary statistics of the most relevant variables for housing tenure transition decisions. With only 8.88 percent of the initial renters purchasing houses, about half of our sample is with male heads of households, which makes this sample balanced in gender. Almost 25 percent of them have finished tertiary education, which is also consistent with the overall sample average. Almost half of the sample are employees or have their own business, and almost 50 percent of the whole sample is married. Our variables proxying for a preference shock display that 3.8 percent had a positive employment shock, 6.7 percent got married in between the two waves and that in 6.9 percent of the households, family size increased. For background risk, we observe the average 1.04 percent income growth from the previous period, and that Income Expectations are truncated to the positive side, as we formulate this discrete variable 1 when income expectations have positively changed, 2 when they remained the same and 3 when there was an adverse expectation change. For our future value or the investment motive of a transition to homeownership, we have distinguished between the assigned mean and volatility values between the two waves. We observe that originating from 2011 (the year that the first wave of the survey was conducted) and three years before that; house prices were on average ascending but were quite volatile. Then the average values from 2011 till 2014 for growth and volatility display a small on average decrease in house prices and a much lesser variance than in the first wave.

The data also shows a significant country difference in homeownership and housing con-

[3]Some individual information is also collected, which enables intra-household economic analysis as well.

[4]The first wave of the data was surveyed at a different time in different countries. The data from Spain was surveyed in 2008, Finland and the Netherlands in 2009, and the rest of the countries in 2010.

sumption. In EMU countries, despite the single currency and integrated financial market, there is significant country heterogeneity in home-ownership. Figure 1 shows the cross-country housing tenure differences in details [5]. We can see that due to cultural or institutional differences, the housing tenure composition is highly heterogeneous within the euro-zone. For instance, complete ownership of residence is particularly low in Austria and Germany compared to other developed economies in western Europe like France, Belgium, and the Netherlands.

Moreover, Free use of the residence, presumably from parents and relatives, takes around 10 percent of the possible source of housing with Italy having the highest among developed western European economies. Furthermore, we look at the transition of housing tenure on a country-average level to provide more evidence on the cross-country difference in Table 3. We can see that the overall homeownership in Europe has increased mildly between the two waves, but the dynamics of housing tenure is profoundly different. For instance, Malta has seen a 33.3 percent increase in homeownership likely due to speculative investment from the Russian wealthy, while Austria and Netherlands witnessed a slight decline in homeownership. We do not and cannot afford to investigate the country heterogeneity in housing options and decisions. The summary statistics, however, suggest that simply ignoring it would be an oversight.

This illustrates the importance of taking the institutional differences, especially tax incentives, into account when we study the housing decisions. Another explanation for the high Dutch homeownership rates is the availability of credit[6]. As Clapham et al. (2012) explain, after the financial crisis of 2007 there was a decline in the formation of new households in the UK. They argue that the main reason for this decline was the lack of credit availability. Stricter macro-prudential regulation on the housing market, via less lax credit supply standards and lower thresholds for LTV ratios, averts households from progressing into home-ownership. In the U.S. 82.1 percent of home-owners have acquired their primary residence through a mortgage[7]. In Europe, the percentage is significantly lower (57 percent in our sample dataset). Unfortunately, we do not observe any changes in the macro-prudential regulation within the period of the data. We take a simplified approach to account all the cultural and institutional difference by adding a country fixed effect to the baseline empirical exercise.

We first look at the extensive margin of housing decisions of the six countries in the panel

[5]To have a bigger picture of the housing tenure in Europe, we also include the countries that are not in the panel.

[6]The loan-to-value threshold in the Netherlands for new homeowners is 106 percent and will change in 2018 to 100 percent of the total value of the household

[7]The Census Bureau Residential Finance Survey (RFS)

data. The transition matrix in Table 4 illustrates how the households in those six countries adjust their housing demand at the extensive margin between 2010 and 2014. We do not the consider free use as an option of housing consumption for the moment, and focus on the trade-off between renting and owning. For each household, the HFCS reports the housing tenure status (i.e., whether the household owns or rents the dwelling in which it lives). A household which was a renter in the first wave and a home-owner in the second wave is defined as $Renter - to - Owner = 1$. On the other side, those who rent in both waves are classified as $Renter - to - Owner = 0$. Out of these households, 8.79 percent became home-owners in the second wave; while only 1.71 percent of home-owners became renters in the second wave. Such asymmetry in housing tenure transition confirms the theoretical prediction of the life cycle of household finance that households slowly move towards ownership as they age. However, despite the four-year gap between two waves of the panel data, we do not see a significant fraction of households make housing tenure change. We can see that the majority of renters and owners retain their housing tenure status.

As housing decision has a strong life-cycle pattern and age cohort effect, we then look at the country difference in housing tenure transition in different age groups. Figure 3 depicts the age profile of households which transition in different countries. Interestingly, young Dutch households have a high propensity to home-ownership thanks to the tax deductions through mortgages, and the Netherlands also have one of the loosest loan-to-value regulations. The highly irregular pattern of housing tenure transition is the Cyprus case, where many senior citizens decided to own houses. We suspect that there is the financial tax heaven effect mainly due to Russian rich in the country that might have distorted the housing decisions. Therefore we remove Cyprus data in the principal analysis to avoid bias.

Moreover, we break down the housing tenure transition concerning age, income and wealth in Table 5. With the limited young households in the survey, we can still see that the younger households are more likely to move across all categories. Overall there is no substantial difference between movers and stayers regarding income and wealth. However, we do observe that higher income owners are more likely to move to a new property, and young households with more wealth are more likely to move (likely to become a new homeowner).

The expectation of a much higher house price in the near future also encourages people to purchase houses according to standard housing tenure choice models (Landvoigt, 2017; Davidoff, 2006). We, therefore, collect house price growth data from Eurostat to see whether there has been a substantial housing bubble in recent years. Figure 2c shows the self-evaluated house price per squared meters according to the owners in our survey data. We can see that there exists substantial house price heterogeneity across countries. It is the most evident that the Netherlands have much higher average house prices compared with other

western European countries. Another important aspect of housing price is that the subjective belief of price can be self-realizing just like the inflation in classic macroeconomic models. Thus we use the self-evaluated house prices reported in the survey to see whether it deviates from the realized house price growth. This may shed light on how optimistic the European households are about the house prices. Figure 2d shows that the self-evaluated house price show a moderate level of optimism as we can see that when households perceive higher growth when the house price is on the rise and lower drop when the house price decreases. However, there is no misconception about the housing market from the households, whereas the self-evaluated house prices are reasonably close to the levels observed on the market. More interestingly, the three countries that experienced a house price decline from 2010 to 2014 are also the countries we see a decline in homeownership in Table 3.

We now look at the intensive margin to see how households adjust their housing consumption regarding housing size. Figure 4 shows the housing consumption regarding the actual size measured by square meters in four different tenure transition groups. We can see that most of the household who do not change their tenure status do not adjust their housing consumption size often; and for those who do, the adjustment for renters and owners seem to be symmetric. The renter-to-owners are more likely to trade up, and owner-to-renters are more likely to trade down. Table 6 summarizes housing size change in different housing tenure groups. The owners seem almost to have the identical percentages of trading up, trading down and no change. In the classic housing choice theory, we often assume that the homeowners are locked in with their house and mortgage contract and much less likely to adjust housing size. However, it seems that European homeowners are as active in adjusting housing consumption as renters even when we only look at the owners with one property. Owners of only property do not have the option of moving back and forth in their properties, which makes the change in housing size more likely to be sales and repurchase of houses.

3 Empirical Evidence on Housing Consumption

In this section, we investigate the driving forces of housing tenure transition and housing consumption level in the post-crisis Europe. We first look at the extensive margin of the housing tenure choice – the housing tenure status change, to test the impact of the candidate factors guided by the previous researches. Then we move on to study the intensive margin housing consumption adjustment when households do not switch their housing tenure status. However, this does not mean that the households do not change their primary residence. Home-owners moving to a new property with a different level of housing service also count as the intensive margin housing consumption adjustment.

3.1 Housing Tenure Choice

Housing tenure choice plays a critical role in inter-temporal consumption smoothing and has great asset pricing implications (Grossman and Larogue, 1990; Chambers et al., 2009; Flavin and Yamashita, 2002; Flavin and Nakagawa, 2008; Chetty et al., 2017). The marginal owners (renter-to- owner transition) offer us great insight into the precise decision-making process of housing tenure choice. Our empirical analysis of housing tenure transition follows the housing choice models lead by Henderson and Ioannides (1983), which illustrate the complexity and principal drivers of housing decision: household characteristics, ownership preference/premium, housing price and future price expectation, capital market conditions (i.e. mortgage rates, risk-free return), labor income growth, and down-payment restrictions (Gete and Reher, 2016; Cameron and Tracy, 1997; Blickle and Brown, 2016; Davidoff, 2006; Fuster and Zafar, 2016). We employ a simple reduced form logit model for the baseline analysis of the determinants of transition to home-ownership in the six eurozone countries. We set the dependent variable Renter-to-Owner $RtO = 1$ if a household transitioned from renting to owning and to $RtO = 0$ if the household remains a renter in the second wave. Similarly, we construct the binary variable $OtR = 1$ as owners transition to renters. We then apply a probit model to analyze the determinants of housing tenure choices:

$$Pr(RtO = 1 \quad \text{or} \quad OtR = 1|X) = [1 + e^{-(X'\beta+\epsilon_i)}]^{-1} \tag{1}$$

$$X'\beta = \beta_0 + \beta_1 h_i + \beta_2 PS_i + \beta_3 BR_i + \beta_4 FV_i + \beta_5 c_i \tag{2}$$

We categorize the main independent variables into three groups: preference shocks, background risks and future value of housing. For instance, family size is one of the most significant predictors in favoring home ownership for a household. We categorize that as the preference shock, which affects the relative weight between housing consumption and nondurable good consumption. Meanwhile, we include household income and the subjective income growth expectation in background risk group as the indicator of the income growth variable in the theoretical models. Moreover, we also include households' self-evaluated housing price change in two waves as the indicator of housing price growth in the near future. Finally, we also include country fixed fact to control for the institutional and cultural difference. To sum up, the latent variable is described in Equation 2 as a function of country effects c_i and a vector of household characteristics h_i. Furthermore, PS_i is a vector of variables which indicate changes in preferences, and BR_i and FV_i are vectors of variables respectively regarding background risk and future value.

We report the results of logit regression in Table 9 and the average marginal effects in Table 10. Both tables report four specifications of the above model, progressing from a simpler

version (Column I) where we regress the dependent variable on household characteristics to a more elaborate one (Column IV) where we fully extend the regression to cover equation (2). From a simplistic model with only household characteristics as regressors, we progress to the testing of our factors of interest. We first regress with our preference shock variables, then we add background risk, and finally, we extend our specification to check whether house price growth and volatility constitute drivers of a transition towards homeownership.

Household characteristics matter for the housing tenure transition choices. First, it is evident that the wealthier households are, the more likely they are to transit towards homeownership. Second, age and gender do not have any significant impact on the decision. This deviates from the empirical results found in American household surveys. For instance, Han (2010) and Davidoff (2006) both find a significant impact of age on homeownership using US data; Davidoff (2006) also finds the female head of households are more likely to transition from renting to owning. Our results are, however, in line with the UK evidence found in Battu et al. (2008).

From Table 9 we extract that households on the 2nd tertile of each country's income distribution are 25 percent more likely to become homeowners than the ones which lie on the first tertile, whereas those in the upper tertile have an approximate 10 percent propensity towards homeownership than the baseline level. The reason that the coefficient of the 2nd wealth tertile is larger than the 3rd one is purely descriptive, as most of the new homeowners in our sample derive from this specific tertile. A possible answer could be that affluent households have already become homeowners (Di and Liu (2007)) or even the positive correlation between job mobility and wealth as in Holmlund (1984) and Cameron and Tracy (1997).

In columns II, III and IV of Table 9, we obtain that households which got married in-between the first and the second wave have more chances to change their housing tenure status which is in line with Lauster and Fransson (2006). A positive employment shock, on the other hand, is not correlated with increased homeownership probabilities. An increase in family size is also associated with a tendency towards homeownership. An increase in the members of the household should signify a need for an increase in all consumption levels, so of course also in housing consumption. This rise in housing consumption needs is a perfect opportunity for rethinking the decision to buy a house. The marginal effects for these variables show that they are not significant at the 5 percent level. This is not something that should induce doubt for the effects of the marriage and family size shock on the dependent variable. They continue to be significant at the 10 percent level of significance, but we cannot converge on the coefficient to extract the exact effect that this shock has on the probabilities of a transition to homeownership.

In column III, we add our indicators of background risk. The three variables that we

use is income growth from the previous period, where its coefficient is almost 0 and not significant. Since we extract a non-significant correlation between an employment shock, this result is to be expected. We assume that the households might consider an income shock as transitory as they might not be able to foresee if their income will hold stable in the future. This leads us to check on the other two variables, which indicate a positive and a negative income expectation change. These self-assessed measures, which contribute to our volatility proxy, fail to produce a statistically significant result as the one that the literature suggests.

Regarding our last factor of interest, the future value or the investment motives of a transition to homeownership, we find that when house prices portray a decreasing tendency, then homeownership becomes more attractive. The housing sector, along with its importance as an economic factor, entails a paradoxical market behavior. From our experience, we have observed that as house prices grew in the past, houses became more attractive of an investment. According to this result, we argue that housing consumption is not responsible for bubble build-up, as new homeownership become less attractive when house prices grow. From Table 5, we also observe that house price growth and volatility coefficients remain robust, whereas other variables lose their significant effects on the dependent variable. Furthermore, we extract that households undervalue the utility they extract from the terminal housing value in our model, which translated into the fact that the transition to homeownership is taking place for housing consumption motives and investment incentives. Our measure of house price volatility is also significant and negative, in line with Turner and Seo (2007). In this case, we argue that since the house owning decision is made for housing consumption purposes, it nevertheless entails some investment risk. Overall these results suggest that households are drawn into homeownership when prices are low, thus making the initial investment in housing cheaper, and also when house price variance is also on low levels, overall reducing the risk of their investment.

As we can see from the descriptive results within age groups in Figure 3, mostly the young age cohorts are more likely to transition to homeownership. The standard life-cycle prediction is that as households age and grow in size, the housing needs also increase, thus we will observe a growing trend of housing consumption increase (in size), maybe hump-shaped. It is also likely that the middle age households are more likely to transition to homeownership. However, we do not observe this pattern here. The possible explanation to this is that some households have a very low premium in owning, thus choose to rent the housing service for their entire life cycle. Alternatively, they have already transitioned to ownership at a younger age thus showing less percentage in transition in middle age. That is likely the case with the Netherlands pattern.

3.2 Housing Consumption: Size Adjustment

We turn to the intensive margin of the housing consumption by examining carefully the households who remain renters or owners in both waves. The primary motivation of this empirical exercise is to investigate how freely or frequently household adjust their housing consumption. Due to the moving and mortgage termination cost for the owners, the theories often assume that the housing size of home-owners remains constant or much less flexible compared with the renters. (Grossman and Larogue, 1990; Flavin and Yamashita, 2002) Moreover, the empirically observed housing adjustment inflexibility has more significant implications for asset pricing and macroeconomics as pointed out by Flavin and Nakagawa (2008) that a non-convex adjustment cost of housing consumption can deliver similar implications as habit persistence model without invoking unreasonably high risk aversion.

Since the European Sovereign debt crisis, the European Central Bank has maintained a relatively loose monetary policy, which leads to a steady decline of average mortgage rate in the majority of European countries (see Figure 2b). The conventional wisdom in housing tenure transition predicts that when households face a lower mortgage rate, they are more likely to transition to home ownership. However, the results in Figure 1 seems to suggest otherwise. In the four years interval between 2010 and 2014, we do not observe significant homeownership increase in European countries, except for Portugal and Slovakia. To make it even more puzzling, countries like Austria, Belgium and Netherlands, we even observe a mild decline in homeownership. Given the magnitude of mortgage reduction (from 5% annualized interest rate to around 2%) is substantial, we have to consider that some other major constraining factors prevent Europeans from owning homes.

We know that housing decision is never a static choice that only maximize the utility of the current period. Instead, it affects the future choices and wealth accumulation of the households. Papers like Campbell and Cocco (2003) has emphasized the importance of housing as means of saving and hedging against future housing consumption and nondurable good consumption. This requires us to look into the investment alternatives and the housing market, which has been assumed exogenous in this paper. First, for the financial market conditions, we look at the real average deposit rate in the most represented countries in our sample in **??**, which shows that the financial return on safe asset has been low since the sovereign debt crisis. The financial assets as an alternative to store value do not seem to be very attractive during the recent years. Second, the housing markets in Europe has been booming, but not without volatility. We look at the housing price index based on the ECB data warehouse series in Figure 2a.

There is another puzzling empirical finding that households report in the survey that they remain in the same property for longer than the period between 2010 to 2014. Meanwhile,

a substantial amount of households also report they have a different level of housing size. To clear that concern of reporting errors, we consider all the housing size change less than ten sqm as the reporting mistake. However, even after controlling for reporting errors, we still observe a significant amount of households adjusting their housing size without selling and repurchasing. It is understandable that households living in single unit detached houses can construct an additional room or letting the old garage fall and replace it with a garden. However, for the households living in apartments and attached houses, it is tough to adjust their housing by construction or lack of maintenance. We thus believe that they are engaged in the exercise of renting part of the property out or getting it back between two waves.

4 A Parsimonious Model of Dynamic Housing Decisions

We build a parsimonious partial equilibrium model based on Landvoigt (2017), Campbell and Cocco (2003, 2015), Li et al. (2016) and Corradin (2014) to illustrate how do households make housing decisions in terms of housing size, tenure choice, and mortgage decisions in a life-cycle consumption smoothing model. Our model is closely related to the stylized model in Bajari et al. (2013). However, there are a few key differences from the previous models. First, we introduce the asymmetric structure of financial asset holding – indebted households are more likely to reduce the outstanding loan. This also coincides with many recently European regulations focusing on amortization requirement such as Netherlands introduce a law making mortgage payment only tax deductible when households amortize at a minimum rate. In general, households also have the incentive to reduce the indebtedness, as indebtedness has certain negative psychological effect on household psychological wellbeing. (see (Brown et al., 2005; Gathergood, 2012)) Second, we adopt a more flexible utility function of constant relative risk aversion instead of log utility function without assuming constant elasticity of substitution between housing and non-durable good consumption. Third, we emphasize the housing adjustment friction from adjustment costs and borrowing constraints, but abstain from mortgage default, home equity extraction and different mortgage contracts for the tractability and lack of corresponding empirical cases observed in the data.

4.1 Household Preferences

Consider a representative household, who derives utility from both nondurable consumption C_t and housing service H_t with a finite horizon. We assume that households live for a finite T periods and make dynamic decisions to maximize the life time utility and then obtain a terminal value based on their total wealth, W_T. We do not consider mortality for the moment. When we think about households as a unit, there are usually multiple members.

The possibility of all them perishing is very low. There are two ways for the households to obtain housing service: renting housing service with the market rental price and owning residential property (possibly) with collaterized mortgage loans. In the baseline model, we do not consider the rare case when household own housing in places they do not live and rent their main residence. However, it is possible for people organizing their housing investment as such.

Denote $\tau_t = \{0, 1\}$, the tenure choices of the household at time t, and let h_t^o and h_t^r be there housing service obtained from owning and renting respectively. The total housing service is as follow:

$$H_t = \tau_t e^{\kappa_t} h_t^o + (1 - \tau_t) h_t^r \tag{3}$$

where κ_t is the housing ownership preference. When κ_t is positive, households derive more housing service from owning than renting at the same housing size. Observing the life cycle of housing consumption, we also further assume that this housing preference parameter is age dependent – $\kappa_t = f(a_t) + \varepsilon_t^{\kappa}$.

The household preference is given by

$$U(\{C_t, h_t^o, h_t^r\}_{t=0}^T) = \mathbb{E}_t \sum_{t=1}^{T} \beta^{t-1} u(C_t, H_t) + b\beta^T V(W_T), \tag{4}$$

where β is the time discount factor, and b is the parameter that governs the bequest motive. We interpret the bequest motive the combined utility one derives from altruistic bequest motive and consumption value of the remaining wealth after the terminal period. Housing can serve as both consumption and saving thanks to its durability and resale value. Therefore the terminal wealth comprises both cash at hand and the resale price of the housing equity the households holds at the terminal period.

4.2 Labor income and house price

We assume that each household has a level of endowment wealth W_0 entering period $t = 1$. Such wealth is the sum of cash at hand and real estate value abstracted by total outstanding of mortgage loan. Through the life cycle, households also receive constant stream of labor income at each period, which cannot be traded nor used as collateral. The labor income grows with age and follows a life cycle that is well studied in the labor economics literature. We thus assume that the natural log of labor income, $l_t \equiv log(L_t)$, follows a random walk with a life cycle trend:

$$l_t = l_{t-1} + f(a_t) + \varepsilon_t^L \tag{5}$$

where $f(a_t)$ is the deterministic age profile of labor income, and $\varepsilon_{i,t}$ is the individual random shock with zero mean and variance $\sigma^2_{\varepsilon^L}$. For the simplicity of the baseline model, we do not consider the heterogeneity of the labor income age profile, which is dependent on time-invariant individual characteristics such as gender and education.

Similar to labor income, the natural log of house price, $p_t^H \equiv log(P_t^H)$, follow a random walk with a common housing market drift.

$$p_t^H = p_{t-1}^H + \omega^H + \varepsilon_t^H \tag{6}$$

where ω^H is the average expected house price growth in the housing market, and ε_t^H has zero mean and variance $\sigma^2_{\varepsilon^H}$. However, for house owners and potential owners, they may have different expectation in house price growth, which causes heterogeneous extensive and intensive housing consumption decisions *ceteris paribus*. Moreover, we assume that $\varepsilon = (\varepsilon^L, \varepsilon^H)$ is independently distributed over time. But they may be correlated contemporaneously — $\sigma_{\varepsilon^H \varepsilon^L, t} > 0$.

We assume that rental price is pegged with the housing value for simplicity. We follow Poterba (1984) and Díaz and Luengo-Prado (2008) to assume that the rental price is a function of the safe asset interest rate and expected housing price growth. However, we leave the maintenance cost out of the equation for the simplicity of the structural model. Therefore we have the rent-to-price ratio as follow:

$$\rho_t = \frac{P_t^r}{P_t^H} = r_t - \mathbb{E}[exp(\Delta p_t^H)] - 1 = r_t - exp(\omega^H) - 1 \tag{7}$$

where r_t is the one period risk-free interest rate. The ratio is deterministic for the baseline model, but we can introduce time-varying aspect later to make it more realistic.

4.3 Mortgage contracts

We assume that borrowing constraint is tight, a household cannot obtain loan against her human capital. Therefore, the only way to circumvent the borrowing constraint is mortgage debt with the house value as the collateral. At any period of t, one can borrow as much as

$$X_t \geq -(1-d) P_t^H h_t^o. \tag{8}$$

where d is the minimum home equity requirement by mortgage providers or regulation at period t. The down-payment requirement is the thus main friction for young households transitioning from renting to owning. They will have to save up to cover the down-payment

and the transaction fees. Gete and Reher (2016) also points out that even without down-payment requirement by the regulator, the mortgage providers will also internalize the default risk (to certain extent) and exercise an endogenous down-payment rate due to the costly foreclosure and process of housing assets.

However, households do not necessarily have to borrow to the limit. We model the level of mortgage debt as one of the endogenous choice by the households. We only consider the net debt position here. When $X_{i,t} < 0$, the debt is mortgage collateralized by the housing value. Thus the loan-to-value ratio (LTV) and loan-to-income ratio (LTI) are defined as follow:

$$LTV_t = \frac{|X_t|}{P_t^H h_t^o} \tag{9}$$

$$LTI_t = \frac{|X_t|}{L_t}. \tag{10}$$

We only consider adjustable rate mortgage (ARM) here for simplicity. Furthermore, we assume that household aim to repay all the mortgage principle between the end of period T. Moreover, we also consider a more realistic case where households try to pay back the principle as they age towards the terminal period. This assumption corresponds to the recent regulations in Europe that incentivizes households to amortize instead of constantly holding very high level of debt. For instance, in the Netherlands, mortgage payment was fully tax deductible, which has led to the observation that Dutch households have much higher mortgage debt even at very senior age. Since 2016, new regulations in Netherlands aim to off set that incentive by reducing the tax deductible mortgage payment conditional on a minimum amortization rate. We therefore incorporate such regulation trend in the model. We assume that the net debt position of household cannot be decreasing and the principle pay back is at least even installment that pays back all the debt at period T:

$$X_t \geq X_{t-1} \quad \text{when } X_{t-1} < 0 \quad \& \quad \tau_t = \tau_{t-1} \tag{11}$$

However, households have the refinancing option to renegotiate the outstanding principle with the mortgage provider. Thus the net debt position X_t is an endogenous choice by households. We do not consider mortgage default in this paper simply due to the fact that we do not observe any default in the HFCS panel data.

4.4 Housing tenure choice and wealth accumulation

Household wealth evolves differently depending on their tenure choice and net asset position. Moreover, at the beginning of each period, households are hit by moving shocks, $M_t = \{0, 1\}$, that coerce them to move their residence. At each period, households receive cash at hand from labor income, investment in the previous period, and potential house sale value if she decides to sell. The wealth of households at period t,

$$W_t = L_t + X_{t-1}[1 + r_{t-1} + \lambda_{t-1}\mathbf{1}(X_{i,t-1} < 0)] + \tau_{t-1}P_t^H h_{t-1}^o, \tag{12}$$

where λ is the mortgage premium. Household then allocate the wealth among non-durable consumption, investment, housing expense and other costs. Thus we have the following budget constraint:

$$W_t = C_t + X_t + (1 - \tau_t)P_t^H \rho_t h_t^r + \tau_t P_t^H h_t^o(1 + \delta) \tag{13}$$

Recall that ρ_t is the rent to price ratio, and δ is the housing service adjustment cost. We assume that it is costly to adjust housing service, especially the tenure choice is owning. Consider that households often have to pay a significant percentage of total housing value as the commission fee and notary fee to complete the transaction, it is natural to assume that when households decide to own a new property, they have to face the transaction cost. For the simplicity of the model, we do not consider the moving cost of renters and owners since it can be highly heterogeneous and not necessarily proportional to the housing value. We also afford to ignore the moving cost given that it is usually much less than the transaction costs of property purchase. Moreover, the housing service adjustment cost also captures the cost of housing service adjustment without moving. Households can have the property partly reconstructed to adjust the total housing service, such as building an extra storage room in the garden or turning the basement into an additional living room. We assume that this type of adjust also incurs housing service adjustment cost similar to repurchasing. To sum up, households have to pay a housing service adjustment cost proportional to the housing value if one chooses to a different level of housing service.

4.4.1 Owners and Renters

Denote the households who do not own a house at period $t - 1$ as renters. Without housing as collateral, renters cannot have any mortgage, which makes the wealth at period is easy to compute:

$$W_t^R = L_t + X_{t-1}(1 + r_{t-1}). \tag{14}$$

Therefore the budget constraint of renters becomes

$$W_t^R = \begin{cases} C_t + X_t + P_t^H h_t^r \rho_t & \text{continues as a renter } \tau_t = 0 \\ C_t + X_t + P_t^H h_t^o (1+\delta) & \text{becomes an owner } \tau_t = 1 \end{cases} \tag{15}$$

For the households entering period t owning a house make similar decisions on housing tenure and size. Their budget constraints are therefore defined as follow:

$$W_t^O = \begin{cases} C_t + X_t + P_t^H h_t^o & \text{owning without adjustment: } \tau_t = 1,\ h_t^o = h_{t-1}^o \\ C_t + X_t + P_t^H h_t^o (\delta+1) & \text{owning with adjustment } \tau_t = 1,\ h_t^o \neq h_{t-1}^o \\ C_t + X_t + P_t^H h_t^r \rho_t & \text{moving to renting } \tau_t = 1 \end{cases} \tag{16}$$

We can therefore update the budget constraint Equation 13 as follow.

$$W_t = C_t + X_t + (1-\tau_t) P_t^H \rho_t h_t^r + \tau_t P_t^H h_t^o [1 + \delta \mathbf{1}(h_t^o \neq h_{t-1}^o \text{ or } \tau_t > \tau_{t-1})] \tag{17}$$

In this partial equilibrium housing demand model, the state variables of the household's problem are: age (a_t), the net debt position (X_{t-1}), ownership (τ_{t-1}), labor income (L_t), house prices (P_t^H), risk-free interest rate (r_t), and the moving shock (M_t). The state variable vector is $S_t = \{a_t, X_{t-1}, \tau_{t-1}, L_t, P_t^H, r_t, M_t\}$. Households then make decisions at each period about: non-durable consumption (C_t), housing consumption (H_t), tenure choice (τ_t), net asset position (X_t). The decision vector is therefore $D_t = \{C_t, H_t, \tau_t, X_t\}$. The time varying parameters of the problem are: rent-to-price ratio (ρ_t), risk-free interest rate (r_t), mortgage premium (λ_{t-1}), and the minimum home equity (d_t). Denote $\theta_t = \{\rho_t, r_t, \lambda_{t-1}, d_t\}$ the vector of time-varying parameters. Finally, the time invariant parameters are $\Theta = \{\sigma_{\varepsilon^\kappa}, \omega^H, \sigma_{\varepsilon^H}, b, \beta\}$.

Given the state variables, choice space, and all the parameters, we can rewrite the household's optimization problem as the following Bellman equation:

$$V_t(S_t; \theta_t) = \max_{D_t} \{U(C_t, H_t) + \beta \mathbb{E}_t[V_{t+1}(S_{t+1}; \theta_{t+1})]\} \quad \text{for } t < T \tag{18}$$

Where $V_{t+1}(S_{t+1}; \theta_{t+1})$ is the continuation value at time T+1. For different types of households, their optimization problem are subject to different budget constraint as described in Equation 8, 11 and 17.

5 Estimation and Simulation

In this section, we describe the estimation procedure of the model. This model cannot be solved analytically. We, therefore, have to solve the dynamic optimization problem for different households using numerical solutions. One possible estimation method is to estimate the structural parameters using the simulated methods of moments similar to Landvoigt (2017) and Li et al. (2016). However, due to a large number of state variables and decision variables, it is very computationally costly to adopt the simulated methods of moments to map out the life cycle of decision trees conditional on all possible state variable realizations. We, therefore, adopt the method proposed by Bajari et al. (2007) to alleviate the computational burden. Moreover, Bajari et al. (2013) also has shown that the dynamic discrete and continuous choice of housing service and housing tenure fits the requirement of this relatively new method of estimating a dynamic model with higher computational efficiency.

The estimation takes two stages. In the first stage, we need to estimate the policy functions of endogenous state variables and the transition functions of the exogenous variables. Then we estimate the empirical value function by varying the realizations of state variables. In the second stage, we then apply the equilibrium condition of the optimal decision and vary the policy functions to estimate the parameter of interest by minimizing the violation of optimality in the observed sample.

5.1 Reduced Form Policy Functions of Endogenous State Variables

The first stage of Bajari et al. (2007) requires the estimation of reduced form policy functions of the decision variables. It is optimal to use non-parametric estimation to allow the maximal flexibility for the choices based on the state variables. However, due to the curse of dimensionality and lack of economic interpretation, we follow Bajari et al. (2013) and choose a semi-parametric approach to balance flexibility and economic interpretation. We assume, at time t, that the tenure choice can be discretized into four categories for owners and renters, which are governed by an unobservable latent variable $y^*_{i,t} = f(S_{i,t}, Z_{i,t}) + \varepsilon_{i,t}$. $S_{i,t}$ are the state variables, and $Z_{i,t}$ are the variables that affect the housing preference parameter. Depending on the realization of the latent variable, households make ordered discrete choices as follow:

$$D^O_{i,t} = \begin{cases} \text{Transition to renting} & \tau_{i,t} = 0 \\ \text{Owning but trade down} & \tau_{i,t} = 1 \text{ and } h^o_{i,t} < h^o_{i,t-1} \\ \text{Owning the same housing size} & \tau_{i,t} = 1 \text{ and } h^o_{i,t} = h^o_{i,t-1} \\ \text{Owning but trade up} & \tau_{i,t} = 1 \text{ and } h^o_{i,t} > h^o_{i,t-1} \end{cases} \tag{19}$$

This specification resembles the real world housing tenure choice that any type of adjustment in housing size is costly, especially in owning. If housing can be smoothly adjusted without cost, the discrete choices among the owning options would make no sense. We do not further specify the precise housing size adjustment once owners decide to transition to renting due to the rare occurrence in the data sample and limited additional contribution to the discussion. Similarly, we can derive the ordered discrete choices for renters as follow:

$$D_{i,t}^{R} = \begin{cases} \text{Keep renting} & \tau_{i,t} = 0 \\ \text{Owning but trade down} & \tau_{i,t} = 1 \text{ and } h_{i,t}^{o} < h_{i,t-1}^{r} \\ \text{Owning the same housing size} & \tau_{i,t} = 1 \text{ and } h_{i,t}^{o} = h_{i,t-1}^{r} \\ \text{Owning but trade up} & \tau_{i,t} = 1 \text{ and } h_{i,t}^{o} > h_{i,t-1}^{r} \end{cases} \tag{20}$$

Once again, due to the adjustment cost, housing tenure choice is often lumpy, and households expect the change of future housing consumption needs. Therefore looking into the housing size transition on top of the extensive tenure choice can help us identify that aspect of housing decision making. Moreover, since we assume zero adjustment cost in renting, we ignore the housing size adjustment when renters keep renting similar to the case of owners. However, in practice, due to a meager number of observations in renter-to-owner transition, we simplify the ordered probit model by binary probit model between owning and renting for the renter and entirely rely on the housing size choice estimation to capture the detailed transition decisions.

We estimate the reduced form policy function of the intensive adjustment margin, housing size choice, conditional on their tenure choice. Since the tenure choice has already defined the direction of adjustment for the owners, we therefore only look at the absolute value of housing size adjustment. While for the renters, we all full flexibility in housing size adjustment.

Finally, we specify the reduced form policy function for the remaining endogenous state variables – net asset position. For the renters, it is the savings accumulation, and for the owner, it is either savings or the total debt outstanding. When housing tenure transition happens, the net asset position often adjusts by a large margin by the downpayment and the mortgage contract. In the baseline model, for the simplicity of the estimation procedure, we only consider the net asset position and assume that households can adjust their net asset position relatively freely. By doing so, we reduce the dimension of endogenous state variables and keep the model parsimonious and traceable.

We acknowledge that this is a rather strong simplifying assumption to allow flexible adjustment of net asset position. Once the household has taken a mortgage contract, it is often tough to adjust the amortization speed or a lump-sum home equity increase in

one period. This is the results of a significant mortgage adjustment cost. Households do not hold both positive financial assets and mortgage debt in theoretical models due to the non-negative and significant mortgage premium. While, in reality, we do observe a large number households holding both. We, therefore, consider that households view these two as separate accounts and let two evolve relative independently. In other words, households making savings to a financial asset account and passively follow the initial structure of the mortgage contract regarding amortization and interest payment. However, when households are hit with a substantial shock on house value, income, liquidity, and mortgage interest rate, it is optimal to re-negotiate or default (Campbell and Cocco (2015)). We do not further complicate the model with those specific discrete choices for the moment. Moreover, we believe it is a rare circumstance especially in the European context since we observe zero mortgage default in more than 7000 observations. Nonetheless, those practical complications can reconcile with the simplifying assumption by viewing the non-mortgage assets being invested in a balanced portfolio that has the same rate of return as mortgage interest.

Once we have the policy functions for housing tenure choice, housing adjustment size, savings to the financial assets and mortgage account reduction, we can easily calculate the consumption using the budget constraints.

5.2 Transition Functions of Exogenous State Variables

We also estimate the rules of transition for the exogenous state variables such as housing price, real interest rate, mortgage premium, and income growth path. However, due to the limited time span of HFCS and the lack of information on actual housing prices, we turn to external macroeconomic time series for the transition functions of the exogenous state variables.

We assume that income process follows the typical life-cycle pattern with i.i.d. income shocks every period.[8] We take the country-specific labor income evolution from different sources. We do not have a long-standing panel of households to estimate the life-cycle of labor income. Instead, we use the findings from previous papers like Iacoviello and Pavan (2013) and Campbell and Cocco (2015) to calibrate the parameters of the income growth process that cannot be estimated.

We use the "Eurostat" times series on the country level housing price index and monthly mortgage rate index to formulate the transition functions of housing prices and mortgage premium process. We assume that all the Eurozone countries face the same real interest rate for simplicity and take the country average deposit rate time series to formulate the real

[8]For the baseline model, we do not consider the persistence of labor income shocks, but we can easily extend the model to incorporate the lasting effect of labor income shocks.

interest rate process. The house price growth and real interest rate may be correlated. We, therefore, consider the following VAR process:

$$r_t = b_{r0} + b_{r1} r_{t-1} + b_{r2} \omega_{t-1} + \varepsilon_{rt} \tag{21}$$

$$\omega_t = b_{\omega 0} + b_{\omega 1} \omega_{t-1} + b_{\omega 2} r_{t-1} + \varepsilon_{\omega t}. \tag{22}$$

The results of the vector autoregressive approach between the real interest rate and house price growth show a minimal correlation between the error terms of the two. We, therefore, move forward with independently distributed error terms for the real interest rate and house price index growth. Moreover, the country fixed effect appears to be absorbed by the first order time difference and explain the growth path of neither interest rate nor house price growth. Therefore, we consider real interest rate and house price growth as independent AR(1) processes.

5.3 Empirical Utility function

Before we estimate the utility function, it is necessary to specify a functional form. The essential trade-off is to decide whether housing service is a separate consumption stream irrelevant from the non-durable consumptions. (Campbell and Cocco, 2015; Cocco, 2004; Chetty et al., 2017). One of the simple utility function specifications is as follow:

$$U(C_t, H_t) = \frac{(C_t^{1-\xi} H_t^{\xi})^{1-\gamma}}{1-\gamma} \tag{23}$$

where γ is the relative risk aversion of the household, and ξ is the relative weight of non-durable consumption and housing consumption. However, this Cobb-Douglas utility between the housing and non-durable consumption leads to a simplified and strong assumption that the elasticity of substitution is constant and unit. As demonstrated in Bajari et al. (2013), such simplification can lead to a substantial difference in housing adjustment timing and size. Nonetheless, we also want to have a more traceable parameter in relative risk aversion unlike the log utility function in Bajari et al. (2013). Therefore, we follow Flavin and Nakagawa (2008) and adopt a relatively more complicated utility function as follow.

$$U(C_t, H_t) = \frac{[(1-\xi) C_t^{\varphi} + \xi H_t^{\varphi}]^{\frac{1-\gamma}{\varphi}}}{1-\gamma} \tag{24}$$

where the additional parameter φ governs the elasticity of substitution between non-durable consumption and housing.

We randomly select 100 households in the sample of the first wave and forward simulate

200 paths of exogenous state variables for 10 periods for each household. According to Bajari et al. (2007), by computing the discounted present value of all the periods of the forward simulation, we obtain a consistent estimate of the empirical value function. Note that all these forward simulations are conditional on the estimated reduced form policy functions and the parameter of interest nested within the utility function.

5.4 Estimation of the Structural Parameters

The primary interest of this paper is to measure the housing preference accurately. We thus focus on the following two parameters in the utility function: 1) the elasticity of substitution between the housing and non-durable good consumption; 2) the weighting parameter between the two consumption. It is also beneficial to limit the dimension of parameters we structurally estimate with such a simulation-based value function. As every realization of the value function requires a substantial amount of simulation, it is very time-consuming to optimize the objective function over higher dimensions. We calibrate the rest of the parameters as 20% for the weight of housing consumption and 0.98 for the discount factor (Campbell and Cocco, 2015).

The estimation criterion of Bajari et al. (2007) is similar to the minimum distance approach in the simulated method of moments. However, instead of minimizing the distance between observed and simulated moment, this approach uses the optimality of the equilibrium choices and minimizes the occurrence of the violation of optimality. Therefore, we construct the objective function by randomizing the parameters of the reduced form policy function using a uniform distribution random number generator and varying the parameters in the 15% interval around the point estimation. We have the following estimates of the parameters of interest.

Table 1: Estimated Parameters of Interest

Parameter	Value	s.d.
Elasticity of Substitution: φ	-0.0639	(0.0126)
Housing consumption share: ξ	0.4888	(0.0018)
Relative risk aversion: ρ	4.0	calibrated
Bequest motive: b	3.0	calibrated
Discount rate: β	0.97	calibrated

The standard errors are computed via bootstraping for 49 times

We can see that the estimated parameters suggest that the European households have very balanced housing consumption as part of their total consumption and the elasticity of

substitution between the housing and non-durable consumption is almost unit, which corresponds to Cobb-Douglas utility function. Notice that our results are significantly different from Bajari et al. (2013); Li et al. (2016), but closer to the results in Flavin and Nakagawa (2008), which employs a similar utility function setup. However, most of the results in the previous papers are estimated using the United States data. It is thus not too surprising that European data shows different housing consumption preference given that Europe has a much lower average homeownership and more stable rental market. The results are, however, sensitive to the discount factor and relative risk aversion parameter calibration due to the limit of the objective function of the method employed in the paper. We will explore more options to estimate the model using backward induction and simulated methods of moments, which we discuss in the technical Appendix A.

6 Counterfactual Simulations and Results

As mentioned in the introduction, we are mainly interested in the regulations that would directly affect households' tenure choice at the micro level: the loan-to-value regulation and the amortization restrictions. These are the popular housing market regulation that targets the mortgage contracts between banks and households. The simple model we build in this paper has already incorporated the channels how those two regulations can affect the households' tenure choice. We now simulate the counterfactual outcomes given different levels of regulations on both fronts to see how effective they are and whether do they cause households substantial welfare loss.

6.1 LTV regulations

We forward simulate the dynamic choices of the young households (age 25 and age 30) to see what are the likely outcome of different LTV regulation policy. For instance, in the baseline estimation, we assume that the banks set the minimum downpayment at 20% on average voluntarily due to foreclosure cost(see Gete and Reher (2016)). According to BIS Financial Stability Policy Indicator, similar LTV regulations have been implemented in many countries around the world such as South Korea, Singapore, China, Hungary, Turkey, Norway, Sweden, and Canada. We look into the possible regulation change that increases the downpayment to 40% to see what are the impacts on household housing tenure choice, housing size choice, and eventually welfare level.

Before we look into the difference that the policy change brings. For the sake of clarity, it is necessary to check the simulated path of those representative young households before the regulation change. In Figure 5, we report the simulated results of the two representative

households in five different countries with an average income in the respective countries. The younger one does not have any wealth, while the older one has accumulated wealth to the average level of households in their 30s. We simulate the same type households for 500 times and calculate the average probability of owning a house and housing size in the different stage of their life cycle. We can see that the households slowly increase their probability of owning a house as they accumulate wealth. It is also evident that households want to live in larger units as they age. Note that we are simulating using the parameters estimated using the subsample of family size 2. The results indicate the life cycle of such households without increase of family size. We acknowledge that it is a very restrictive limitation that we will later address in the later version. However, this shows that even without family size increase, there is also an evident lifecycle of housing tenure and size choice. Moreover, due to different income, housing market and financial market conditions, such lifecycle of housing choices are not homogeneous across western eurozone countries. For instance, Dutch households are more likely to own a house in all stages of life compared with households in Belgium. However, we need to take those results with a grain of salt since we only two waves of panel data to identify many of the time-varying parameters. Therefore, we focus on looking at the difference regulation change brings to the households instead of the levels.

We now look at the changes brought about by the regulation tightening on LTV ratios from 80% to 60%. In Figure 6, we present the effect of the regulation change in housing tenure and size choices. In the upper half o the figure, we can see that the regulation makes it harder for young households to own a house in all stages of life. The difference is more significant among the young wealthless households in Italy than the 30-year-old median wealth level households in Belgium. This is related to the housing price and income process in those countries. On the other hand, the regulation does not have much impact in Cyprus and the Netherlands. Overall, we can see that the regulation tightening can make it harder for the transition from renting to owning for young households. However, it is worth pointing out that the marginal effect on the housing market would be limited: there is only 2% to 5% difference in the probability of owning across all the countries, and the young renters are not likely to be the primary source of housing demand as discussed in the previous empirical section. One of the apparent logic of facing a tighter LTV regulation is to go for a smaller house so that the same amount of saving ensures the minimum requirement of downpayment. The lower panel of Figure 6 confirms such conjecture with a mostly positive difference in the housing size at most stages of the life cycle in most countries with Cyprus being the clear outlier. It is worth noting that as households age, they are much more likely to own a house. This makes the downward pressure of a tighter LTV regulation on housing size more evident.

We also look at the wealth accumulation and welfare level of households when the LTV regulation gets tighter in Figure 7. We can see that by disallowing households to invest in real estate, the tighter regulation costs households significant opportunity cost of wealth accumulation. As indicated by Belgium and young German households, the wealth loss for those households can be as significant as 100k euros in their later stages of life cycle. Finally, we look at the welfare difference in the bottom panel of Figure 7. It is fascinating that even the LTV regulation denies the households entry to the housing market in their early stages of life cycle, it does not necessarily hurt the welfare level largely thanks to the increased non-durable consumptions in the early years, which is rational behavior according to the standard life-cycle model in household finance. Moreover, the higher risk in the housing market, especially in markets like Italy and Germany, makes the forced choice of not entering housing investment rationale and welfare improving.

6.2 LTI regulations

In addition to LTV regulation, LTI regulations are often implemented to ensure that households have sufficient liquidity for the mortgage debt and avoid unnecessary and costly foreclosure. For instance, to secure the financial stability of households and avoid over-indebtedness, the Financial Policy Committee in the United Kingdom has implemented an LTI flow limit Recommendation that restricts the number of mortgages extended at LTI ratios at or above 4.5 to 15% of a lenders new mortgage lending. The Central Bank of Ireland recently renewed such flow restriction that "20% of the value of new mortgage lending to first-time buyers and 10% of the value of new mortgage lending to second and subsequent time buyers can be above the LTI cap of 3.5, effective since January 2018". Norges Bank also temporarily implemented an LTI cap at 5 from 2015 to 2016.

We implement an LTI regulation with the cap at 4.5 on top of the existing LTV regulation at 20% downpayment requirement to investigate the same line of counter-factual results as in the previous section. We focus on the same two types of representative young households. We can see in Figure 8 that some proportion of the households will be blocked from switching to homeownership due to the additional regulation. However, the magnitude is much smaller than the LTV regulation change. There will be almost no difference for the wealthless young households and around 2% of rejected potential owners for average wealth households. It is expected since the younger representative households are more likely to be wealth constrained instead of liquidity constrained. We can also see that the regulation has similar results as in the tighter LTV regulation: tighter regulation forces the households to take smaller housing units to circumvent the limitation imposed by the regulation.

We now look at the wealth and welfare effect of the LTI regulation. In Figure 9, we can see

that LTI regulation also prevents households from accumulating wealth via homeownership. The wealth difference exhibits hump shape along the life cycle, which means that the wealth accumulation difference stabilizes as the households age. It is understandable that households income grows with age and they are much less likely to be blocked from investing in housing by LTI regulation after middle-age. The drastic reverse wealth difference among the younger households without wealth in Cyprus is probably due to the volatile housing prices. The lower panel of Figure 9 shows the welfare difference due to the additional LTI regulation. Our results suggest that the LTI regulation might be welfare improving for the young households. The reason is similar to the previous case, LTI regulation prevents the young households from prematurely investing in housing at their young age with limited labor income and financial savings. Since the households do not have a perfect expectation of the house prices, the LTI may help the households smooth the consumption better by blocking them taking on housing price risk too early.

7 Conclusion

In this paper, we investigate the homeownership transition for households in 6 Countries in the EU, right after the financial crisis of 2007. Through a similar conceptual, theoretical framework with the one of Campbell and Cocco (2003) we identify three different factors which might have a potential impact on the homeownership decision, namely a preference shock, background risk, and the future expectation. We then, empirically test these factors in a more organized econometric setting that tests the previous findings of the literature on the transition to homeownership. Moreover, we build a parsimonious partial equilibrium model on housing demand to structurally estimate the housing preference of the European households. We find that Europeans have significantly different housing preferences compared with American households. Finally, we investigate the possible change of a tighter LTV and LTI regulation and find that it does have a significant effect on households' choice of housing tenure and housing size. It limits the entry to the housing market and slows the wealth accumulation. However, the welfare level computed using the empirical utility estimated from the structural model suggests that such regulation tightening may be welfare improving. However, our results heavily rely on the identification power of an extremely short panel data. We do not make any strong normative policy suggestion. Instead, we show in this paper that given ample survey panel data, we can credibly estimate the housing tenure and size choice and then evaluate policy change at a micro level using simple partial equilibrium models.

References

Bajari, P., C. L. Benkard, and J. Levin (2007). Estimating dynamic models of imperfect competition. *Econometrica 75*(5), 1331–1370.

Bajari, P., P. Chan, D. Krueger, and D. Miller (2013). A dynamic model of housing demand: Estimation and policy implications. *International Economic Review 54*(2), 409–442.

Battu, H., A. Ma, and E. Phimister (2008). Housing tenure, job mobility and unemployment in the uk. *The Economic Journal 118*(527), 311–328.

Blickle, K. and M. Brown (2016). Borrowing constraints and home ownership.

Brown, S., K. Taylor, and S. W. Price (2005). Debt and distress: Evaluating the psychological cost of credit. *Journal of Economic Psychology 26*(5), 642–663.

Cameron, S. and J. Tracy (1997). The transition to homeownership: The importance of early career concerns. *General Information 84*(2), 151–163.

Campbell, J. Y. and J. F. Cocco (2003). Household risk management and optimal mortgage choice. *The Quarterly Journal of Economics 118*(4), 1449–1494.

Campbell, J. Y. and J. F. Cocco (2015). A model of mortgage default. *The Journal of Finance 70*(4), 1495–1554.

Chambers, M. S., C. Garriga, and D. Schlagenhauf (2009). The loan structure and housing tenure decisions in an equilibrium model of mortgage choice. *Review of Economic Dynamics 12*(3), 444–468.

Chetty, R., L. Sándor, and A. Szeidl (2017). The effect of housing on portfolio choice. *The Journal of Finance 72*(3), 1171–1212.

Clapham, D., P. Mackie, S. Orford, K. Buckley, and I. Thomas (2012). Housing options and solutions for young people in 2020. *population 16*, 19.

Cocco, J. F. (2004). Portfolio choice in the presence of housing. *The Review of Financial Studies 18*(2), 535–567.

Corradin, S. (2014). Household leverage. *Journal of Money, Credit and Banking 46*(4), 567–613.

Davidoff, T. (2006). Labor income, housing prices, and homeownership. *Journal of urban Economics 59*(2), 209–235.

Di, Z. X. and X. Liu (2007). The importance of wealth and income in the transition to homeownership. *Cityscape*, 137–151.

Díaz, A. and M. J. Luengo-Prado (2008). On the user cost and homeownership. *Review of Economic Dynamics 11*(3), 584–613.

Flavin, M. and S. Nakagawa (2008). A model of housing in the presence of adjustment costs: A structural interpretation of habit persistence. *American Economic Review 98*(1), 474–95.

Flavin, M. and T. Yamashita (2002). Owner-occupied housing and the composition of the household portfolio. *The American Economic Review 92*(1), 345–362.

Fuster, A. and B. Zafar (2016). To buy or not to buy: Consumer constraints in the housing market. *The American Economic Review 106*(5), 636–640.

Gathergood, J. (2012). Debt and depression: causal links and social norm effects. *The Economic Journal 122*(563), 1094–1114.

Gete, P. and M. Reher (2016). Two extensive margins of credit and loan-to-value policies. *Journal of Money, Credit and Banking 48*(7), 1397–1438.

Grossman, S. and G. Larogue (1990). Asset pricing and optimal portfolio choice in the presence of illiquid durable consumption goods. *Econometrica 58*(1), 25–31.

Han, L. (2010). The effects of price risk on housing demand: empirical evidence from us markets. *The Review of Financial Studies 23*(11), 3889–3928.

Henderson, J. V. and Y. M. Ioannides (1983). A model of housing tenure choice. *American Economic Review 73*(1), 98–113.

Holmlund, B. (1984). Income prospects and job mobility: the case of sweden. *European Economic Review 24*(3), 383–400.

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

Landvoigt, T. (2017). Housing demand during the boom: The role of expectations and credit constraints. *The Review of Financial Studies 30*(6), 1865–1902.

Lauster, N. T. and U. Fransson (2006). Of marriages and mortgages: The second demographic transition and the relationship between marriage and homeownership in sweden. *Housing Studies 21*(6), 909–927.

Li, W., H. Liu, F. Yang, and R. Yao (2016). Housing over time and over the life cycle: a structural estimation. *International Economic Review 57*(4), 1237–1260.

Mitra, M. S. et al. (2015). *LTV and DTI limitsGoing granular*. Number 15-154. International Monetary Fund.

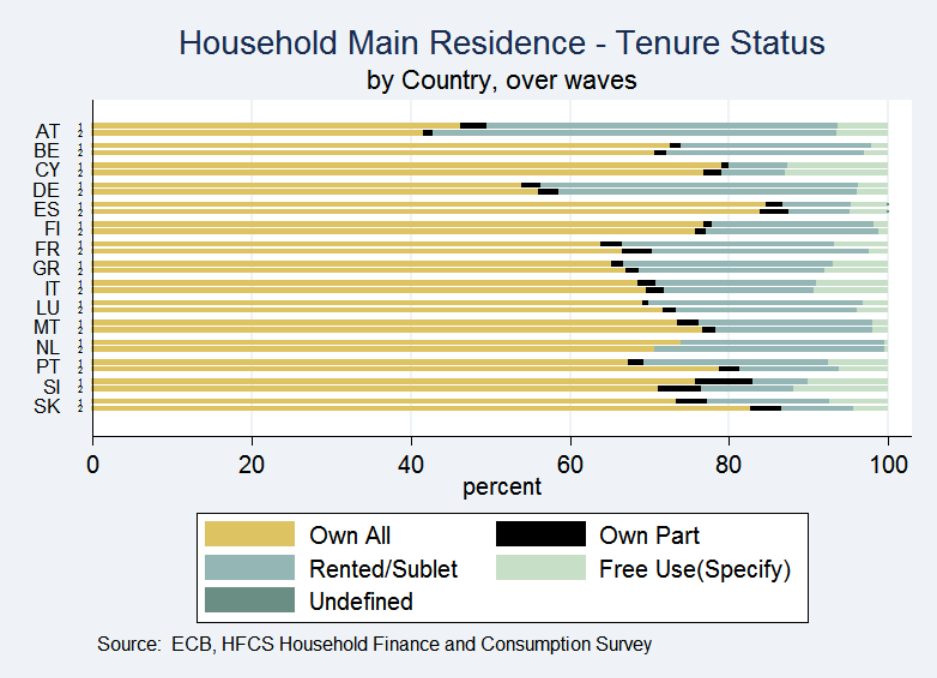
Poterba, J. M. (1984). Tax subsidies to owner-occupied housing: an asset-market approach. *The quarterly journal of economics 99*(4), 729–752.

Tauchen, G. (1986). Finite state markov-chain approximations to univariate and vector autoregressions. *Economics letters 20*(2), 177–181.

Turner, T. M. and D. Seo (2007). Investment risk and the transition into homeownership. *Journal of Regional Science 47*(2), 229–253.

8 Figures

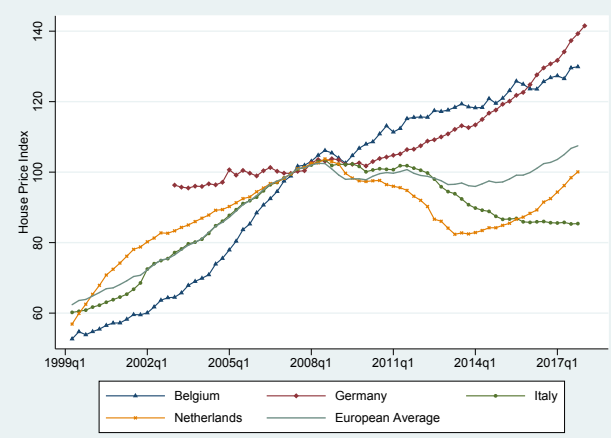
Figure 1: Housing Tenure Status over Country and Wave of the Survey



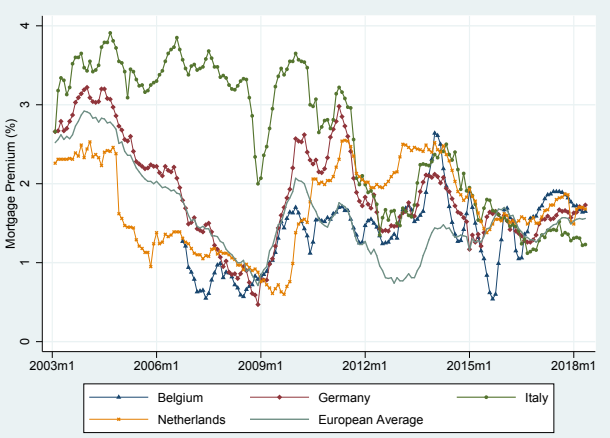
We present housing tenure profile of all the participating countries of HFCS in Europe. For each country, we show the profile of the average tenure choice at both waves of the survey. Tenure choices are categorized in the following five types: complete ownership (own all), partial ownership (own part), renting (rented/sublet), Free use and undefined

Figure 2: Housing Price Index and Mortgage Rates

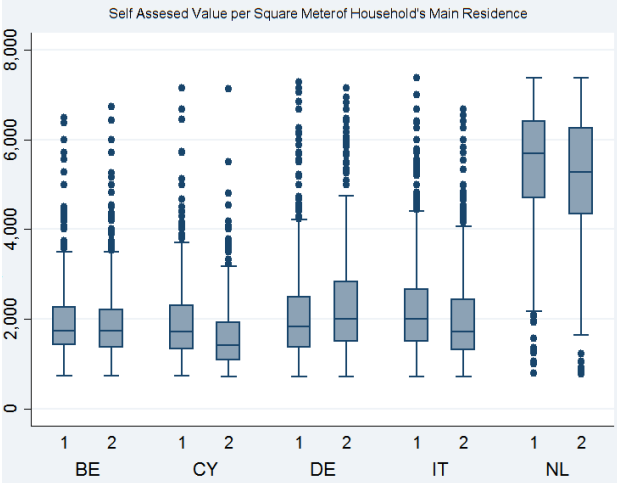
(a) Housing Price Index in Selected Countries



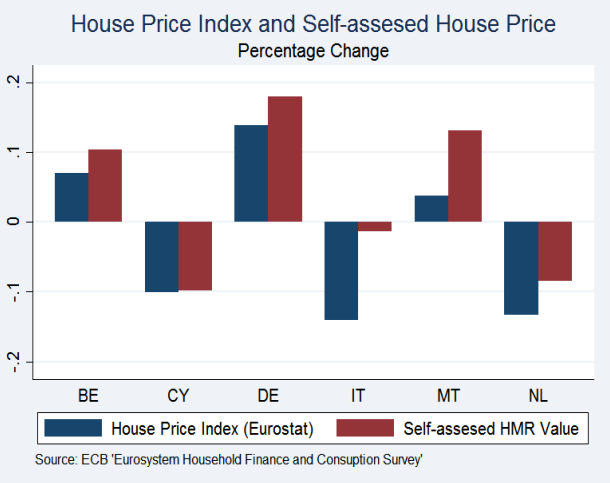
(b) Mortgage Premium in Selected Countries



(c) Self-Evaluated Prices

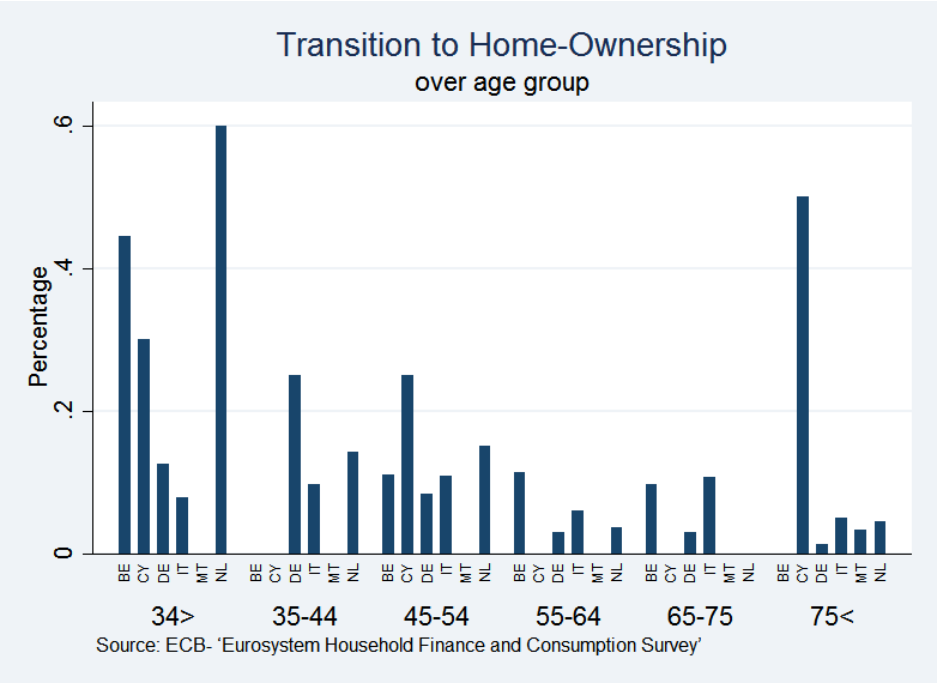


(d) House Price Index v.s. Self-Evaluated Price



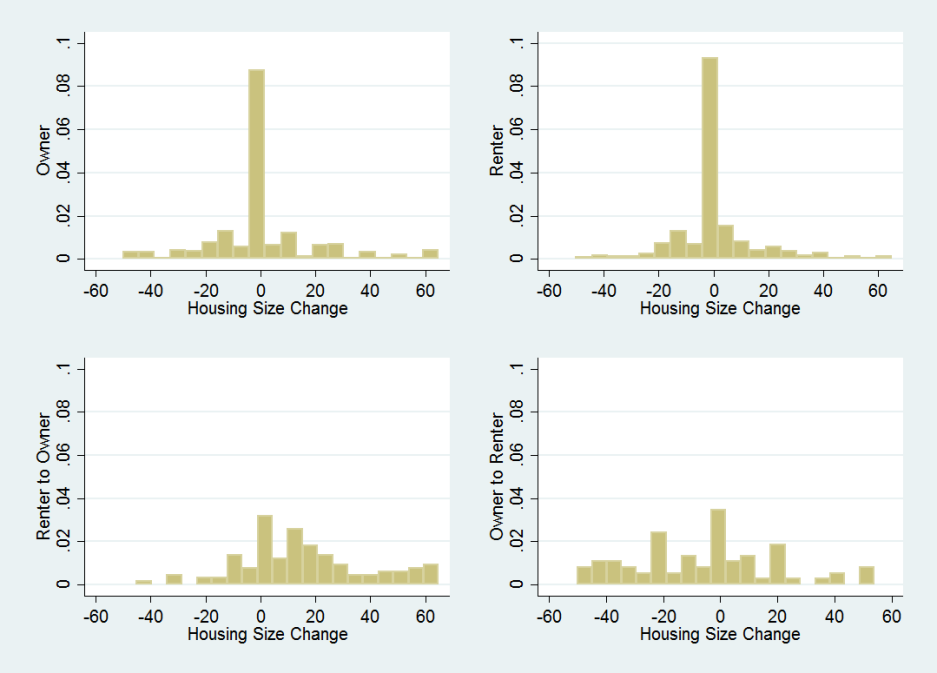
We present the macroeconomic and housing market conditions in this figure. Panel (a) plots the housing price index in recent history of the selected countries according to the Eurostat database; panel (b) plots the average mortgage premium in the selected countries at a monthly frequency according to the Eurostat database; panel (c) depcits the price difference of the average self-reported housing prices in the selected countries in the two waves of HFCS; panel (d) shows the difference between the average housing index price and the self-reported housing price.

Figure 3: Percentage transtition to homeownership over Country and age group



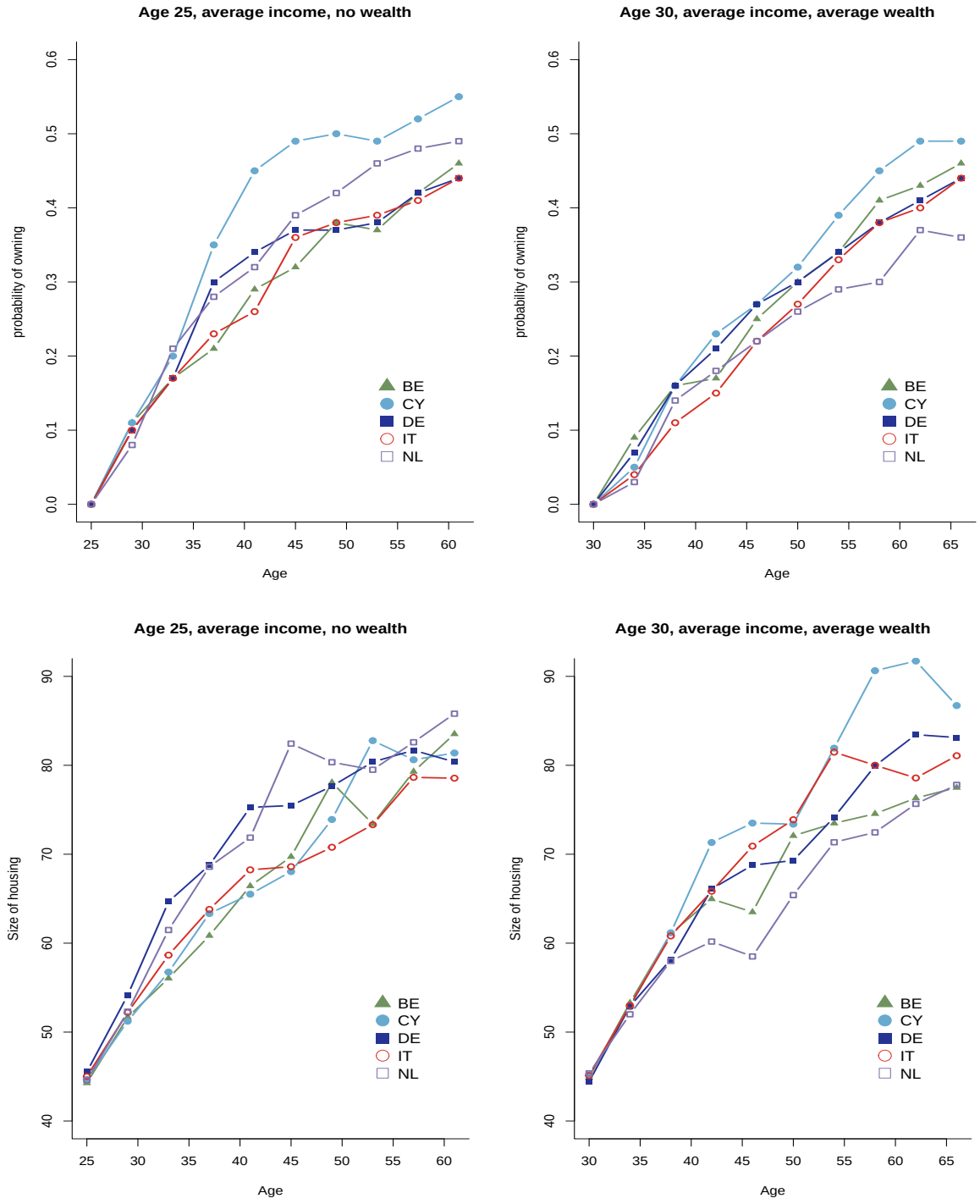
This figure plots the share of tenure transition with respect to different age groups and in different countries.

Figure 4: Housing Size Change



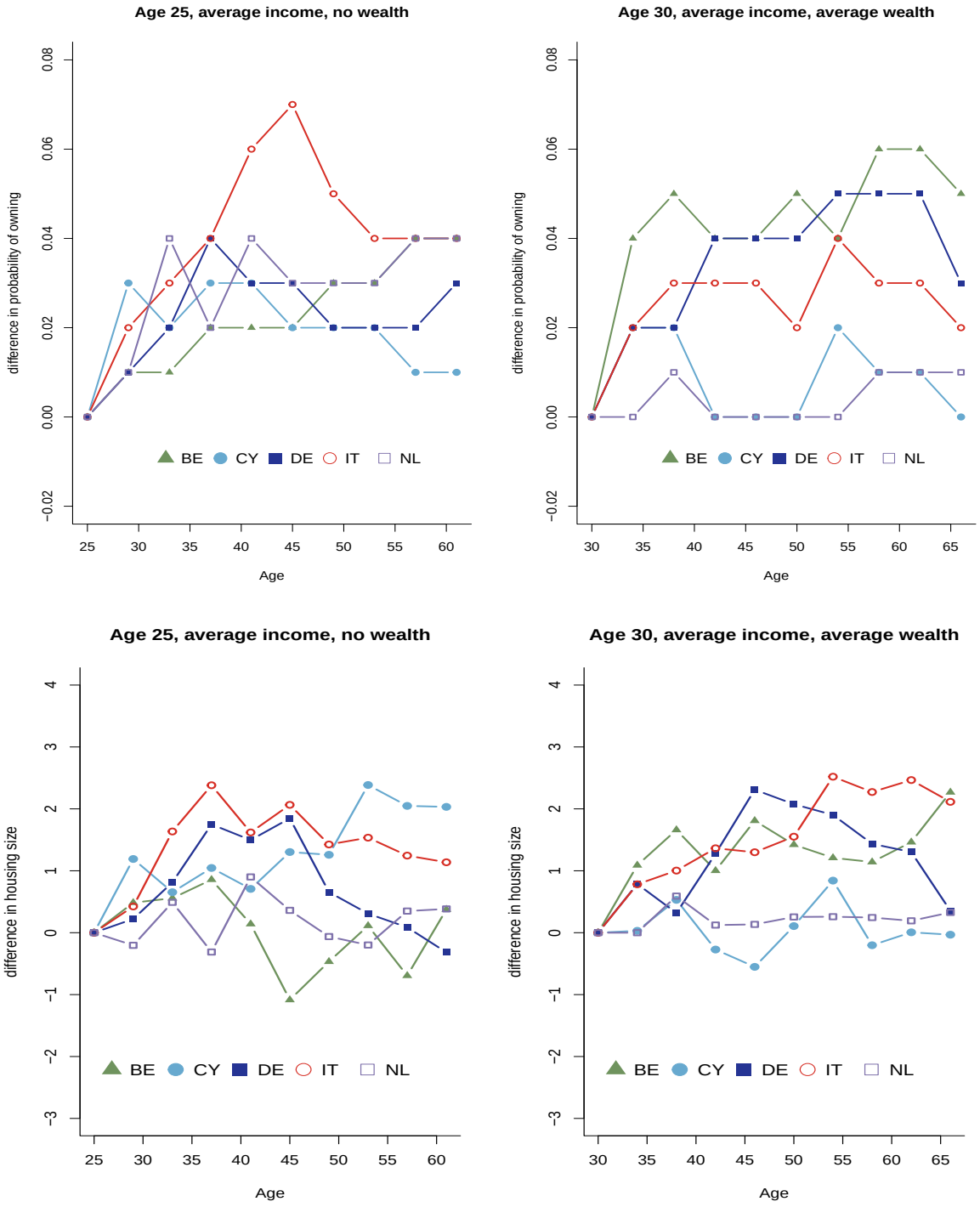
This figure plots the density of housing size adjustment with respect to four housing tenure groups: owner at both waves (top left), renter at both waves (top right), renter to owner transition (bottom left), and owner to renter transition (bottom right); source: ECB – "Eurosystem Household Finance and Consumption Survey"

Figure 5: Simulated Housing Choice: Ownership (up) and Size (down)



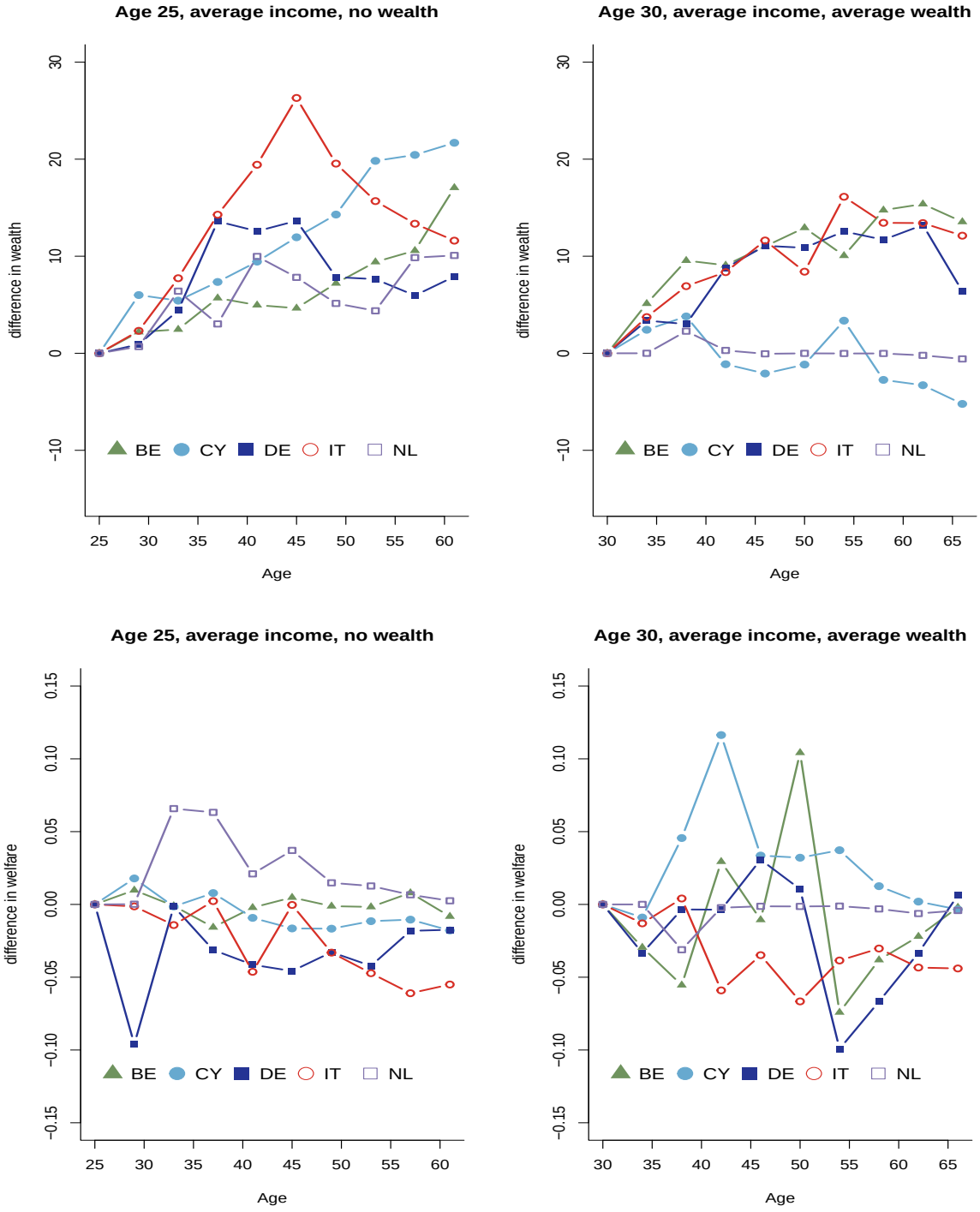
This figure plots the simulated housing tenure (upper panel) and size choices (lower panel) of two types of representative young households: 25-year-old average income household without wealth (lefthand side) and 30-year-old average income household with average wealth (righthand side). We plot the life cycle of housing choices are country specific due to different income growth, financial market conditions and housing market evolution. We present the results in five countries: Belgium(BE), Cyprus(CY), Germany(DE), Italy(IT), and the Netherlands(NL).

Figure 6: Effect of LTV Regulation – 80% to 60%: Ownership (up) and Size (down)



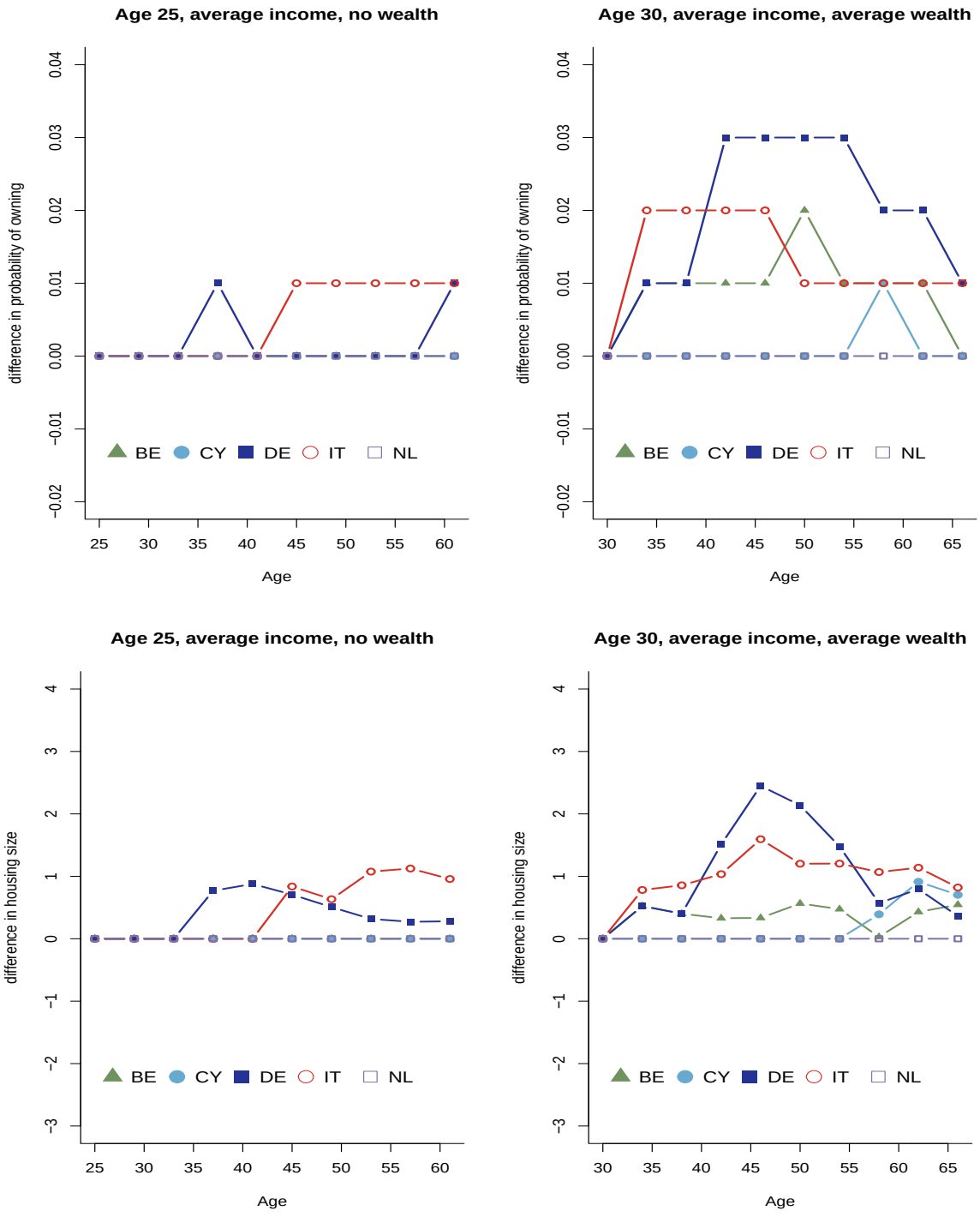
This figure plots the simulated effect of LTV regulation (80% to 60%) on housing tenure (upper panel) and size choices (lower panel) of two types of representative young households: 25-year-old average income household without wealth (lefthand side) and 30-year-old average income household with average wealth (righthand side). We plot the life cycle of housing choices are country specific due to different income growth, financial market conditions and housing market evolution. We present the results in five countries: Belgium(BE), Cyprus(CY), Germany(DE), Italy(IT), and the Netherlands(NL).

Figure 7: Effect of LTV Regulation – 80% to 60%: Wealth (up) and Welfare (down)



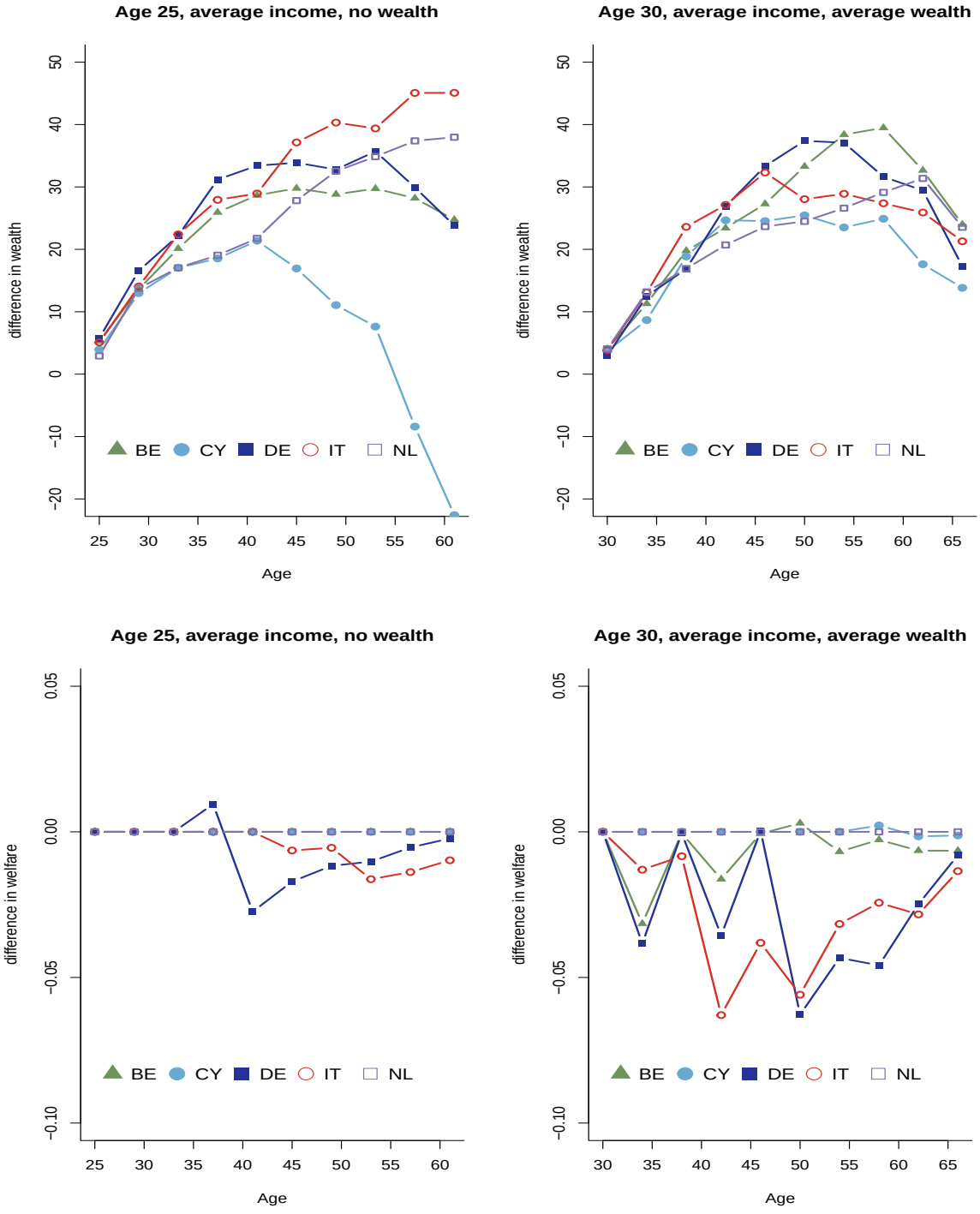
This figure plots the simulated effect of LTV regulation (80% to 60%) on wealth accumulation (upper panel) and welfare (lower panel) of two types of representative young households: 25-year-old average income household without wealth (lefthand side) and 30-year-old average income household with average wealth (righthand side). We plot the life cycle of housing choices are country specific due to different income growth, financial market conditions and housing market evolution. We present the results in five countries: Belgium(BE), Cyprus(CY), Germany(DE), Italy(IT), and the Netherlands(NL).

Figure 8: Effect of LTI Regulation – 4.5 cap: Ownership (up) and Size (down)



This figure plots the simulated effect of LTI regulation (4.5 to annual income) on housing tenure (upper panel) and housing size (lower panel) of two types of representative young households: 25-year-old average income household without wealth (lefthand side) and 30-year-old average income household with average wealth (righthand side). We plot the life cycle of housing choices are country specific due to different income growth, financial market conditions and housing market evolution. We present the results in five countries: Belgium(BE), Cyprus(CY), Germany(DE), Italy(IT), and the Netherlands(NL).

Figure 9: Effect of LTI Regulation – 4.5 cap: Wealth (up) and Welfare (down)



This figure plots the simulated effect of LTI regulation (4.5 to annual income) on wealth accumulation (upper panel) and welfare (lower panel) of two types of representative young households: 25-year-old average income household without wealth (lefthand side) and 30-year-old average income household with average wealth (righthand side). We plot the life cycle of housing choices are country specific due to different income growth, financial market conditions and housing market evolution. We present the results in five countries: Belgium(BE), Cyprus(CY), Germany(DE), Italy(IT), and the Netherlands(NL).

9 Tables

Table 2: Sample Summary Statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Renter-to-Owner	0.088	0.283	0	1	1775
Gross income	39543.3	49397.7	0	740400	1761
Net wealth	90093.2	306315.1	-452500	4957000	1762
Household Demographics					
Male	0.514	0.5	0	1	1775
Age	55.7	15.7	22	85	1643
Tertiary Educ.	0.246	0.431	0	1	1775
Working	0.457	0.498	0	1	1775
Married	0.491	0.5	0	1	1775
Preference Shocks					
Employment Shock	0.038	0.0192	0	1	1039
Marriage Shock	0.067	0.250	0	1	968
Family Size Increase	0.069	0.254	0	1	1775
Background Risks					
Income Growth	1.0483	1.278	-66.0	148.53	1539
Income Expectations	1.278	1.244	0	1	1775
Housing Market					
House Price Growth 1st Wave	1.838	2.300	0.2	7.225	4970
House Price Growth 2nd Wave	-0.493	2.848	-3.475	3.3	7449
House Price Volatility 1st Wave	31.560	41.693	2.82	125.0358	4970
House Price Volatility 2nd Wave	4.872	4.032	0.0533	12.409	7449

Source: **ECB – "Eurosystem Household Finance and Consumption Survey"**
The Gross income and net wealth are aggregated at the household level instead of individuals. The household contols, preference shocks and background risk variables are the personal characteristics of the reported head of the household. The preference shocks report the status change between the two waves of the survey. On the bottom part of the table, we report the moving average of the housing market history in the past 10 years.

Table 3: Homeownership Rates in the HFCS

Country	2010 (%)	2014 (%)	Δ
Austria	46.4	41.7	-4.7%
Belgium	72.7	70.8	-1.9%
Cyprus	79.1	76.9	-2.2%
Germany	54.0	56.1	+2.1%
Spain	84.9	84.0	-0.9%
Finland	77.0	75.9	-1.1%
France	64.0	66.6	+2.6%
Greece	65.3	67.1	+1.8%
Italy	68.7	69.7	+1.0%
Luxembourg	69.3	71.8	+2.5%
Malta	43.5	76.8	+33.3%
Netherlands	74.1	70.8	-3.3%
Portugal	67.4	78.9	+11.5%
Slovenia	75.8	71.2	-4.6%
Slovakia	73.4	82.9	+9.5%
EU(Average)	69.4	70.9	+1.5%

Source: **ECB – "Eurosystem Household Finance and Consumption Survey"**
This table reports the percentage of homeowners in all countries surveyed in the HFCS in two waves and the change of ownership percentage in four years.

Table 4: Housing Tenure Transition Matrix

Tenure	**Renters (2nd)**	**Owners (2nd)**	**Total (2nd)**
Renters (1st)	1.619 91.21%	156 8.79%	1775 100.00%
Owners (1st)	97 1.71%	5577 98.29%	5674 100.00%
Total (1st)	1716 23.04%	5733 76.96%	7449 100.00%

Source: **ECB – "Eurosystem Household Finance and Consumption Survey"**
This table details the housing tenure transition from the first wave to the second wave of the survey. The first wave housing tenure status is reported in the column, and the second wave is reported in the row.

Table 5: Characteristics of Movers and Stayers

	2010		2014		Owner-to-Owner		Renter-to-Renter	
	Movers	Stayers	Movers	Stayers	Movers	Stayers	Movers	Stayers
Fraction of households								
aged ≤ 35	-	-	5.9%	3.5%	65.2%	34.8%	73.2%	26.8%
aged > 35	-	-	94.1%	96.5%	60.1%	39.9%	58.1%	41.9%
Median income (EU thousands)								
aged ≤ 35	36.1	42.0	40.1	39.1	43.7	50.0	32.7	31.2
aged > 35	39.5	38.0	35.1	42.6	38.1	46.2	26.1	30.9
Median wealth (EU thousands)								
aged ≤ 35	62.0	147.7	92.5	68.1	191.0	214.0	17.3	9.2
aged > 35	186.0	252.5	233.4	240.9	288.2	291.2	18.6	26.4

Source: **ECB – "Eurosystem Household Finance and Consumption Survey"**
Notes: This table reports summary statistics for stayer and mover households in the HFCS panel component for the 1st and 2nd wave of the data. The table has two age bins for household heads; aged 35 and younger, older than 35 years as in Landvoigt (2015). For both income and wealth statistics we have dropped outliers below the 5th and above the 95th percentile. Total income and total household wealth are reported.

Table 6: Housing Consumption Shifts across Housing Tenure Groups

	Full Sample			Own One Property Only		
	Trade-Down	No Diff	Trade-Up	Trade-Down	No Diff	Trade-Up
Owners	26.21%	39.70%	34.09%	25.48%	42.23%	32.29%
Renters	25.39%	40.27%	34.34%	-	-	-
Renters-to-Owners	16.67%	12.82%	70.51%	-	-	-
Owners-to-Renters	55.67%	12.37%	31.96%	52.63%	13.16%	34.21%

Source: **ECB – "Eurosystem Household Finance and Consumption Survey"**
Notes: This table reports the percentage of households who adjust their housing consumption in term of residence size with respect to their housing tenure status in two waves of the panel data between 2010 and 2014. The left part titled "full sample" reports all observations, while the right panel reports the owners in the first wave with only one property.

Table 7: Mortgage Contract Types and Mortgage Rates

Country	Wave	Population Shares (%)		Average Rates (%)			Tenure Transition
		Adjustable Rate	Fixed Rate	Adjustable Rate	Fixed Rate	Yield	(From Renter to Owner)
BE	**1**	36.5	63.5	3.85	4.52	-0.67	10.34%
	2	36.8	63.2	3.00	3.70	-0.70	
CY	**1**	64.7	35.3	4.79	4.70	0.09	13.04%
	2	51.4	48.6	5.38	5.03	0.35	
DE	**1**	14.7	85,3	4.44	4.45	-0.01	9.67%
	2	9.7	90.3	3.71	3.76	-0.05	
IT	**1**	46.7	53.3	3.39	4.80	-1.41	8.67%
	2	55.8	44.2	3.43	4.50	-1.07	
MT	**1**	69.5	30.5	4.33	4.07	0.26	3.36%
	2	23.5	76.5	3.01	4.54	-1.53	
NL	**1**	79.9	20.1	4.71	5.11	-0.4	7.01%
	2	75.0	25.0	4.35	4.89	-0.54	
Total	**1**	48.4	51.4	4.49	4.62	-0.13	8.79%
	2	43.4	56.6	4.23	4.19	-0.04	

Source: **ECB – "Eurosystem Household Finance and Consumption Survey"**
This table reports the self-reported mortgage type and imputed mortgage rates based on their monthly interest payment. The summary statistics are both in both waves and all countries in the sample.

Table 8: House Price Volatility in the sample Countries

Country	**Standard Deviation**	
	Wave 1	**Wave 2**
Belgium	5.83	3.56
Cyprus	14.87	6.45
Germany	1.60	3.59
Italy	3.18	3.80
Malta	11.76	2.78
Netherlands	2.87	5.94
Total	8.16	8.71

Source: **Eurostat Database**
Notes: The volatilities are calculated from the four years prior to the survey. In Wave 1 in all countries except from Italy survey fieldwork started in 2010 (Italy 2011), therefore the volatility is calculated from 2006q1 to 2009q4 (2007q1-2010q4). For the second wave, in all countries fieldwork started in 2014 (2010q1-2013q4). Since the extracted data from the ECB statistical warehouse are a housing index 2007=100, then the recorded s.d. is in percentage points

Table 9: Logistic Regression, Dependent Variable is Binary Rent-to-Owner

Household Characteristics	Column I	Column II	Column III	Column IV
Income (2nd Tertile)	0.169	0.015	0.569	0.563
	(0.699)	(0.974)	(0.203)	(0.214)
Income (3rd Tertile)	0.857 *	0.732	1.566***	1.480***
	(0.094)	(0.188)	(0.003)	(0.005)
Wealth (2nd Tertile)	2.984***	3.102***	2.275***	2.605***
	(0.000)	(0.000)	(0.000)	(0.000)
Wealth (3rd Tertile)	1.941***	1.988***	1.408**	1.714**
	(0.000)	(0.000)	(0.009)	(0.004)
Preference Shock				
Marriage		1.287**	1.386***	1.466***
		(0.023)	(0.010)	(0.009)
Employment		-0.400	-0.421	-0.352
		(0.567)	(0.495)	(0.581)
Family Size Growth		0.975 *	0.884	0.947 *
		(0.087)	(0.106)	(0.087)
Wealth/Gift Transfer		1.442	1.555**	1.679**
		(0.054)	(0.037)	(0.034)
Background Risk				
Net Wealth Growth			0.005	0.003
			(0.313)	(0.498)
Income Growth			-0.377	-0.266
			(0.363)	(0.528)
Positive Income Expectations			-0.106	-0.062
			(0.849)	(0.914)
Investment Motives				
House Price Growth				-0.436***
				(0.007)
House Price Volatility				-0.184 *
				(0.072)
Demographic Controls	YES	YES	YES	YES
Country Effects	YES	YES	NO	NO
Observations	1430	1430	1430	1430
F	5.985	6.723	5.997	7.478
Prob>F	0	0	0	0

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This table reports the results of logistic regression of housing tenure status switch from renter to owner on explanatory variables conditional on households being renter at the first wave. The investment motive variables are country specific and taken from the "Eurostat Database".

Table 10: Logistic Regression of Tenure Transition: Marginal Effect

Household Characteristics	Column I	Column II	Column III	Column IV
Income (2nd Tertile)	0.007	0.000	0.022	0.022
	(0.696)	(0.974)	(0.192)	(0.205)
Income (3rd Tertile)	0.049	0.040	0.087***	0.078**
	(0.111)	(0.207)	(0.010)	(0.013)
Wealth (2nd Tertile)	0.252***	0.248***	0.154***	0.177***
	(0.000)	(0.000)	(0.000)	(0.000)
Wealth (3rd Tertile)	0.111**	0.107**	0.069	0.086**
	(0.021)	(0.017)	(0.057)	(0.041)
Preference Shock				
Marriage		0.082	0.088**	0.092**
		(0.074)	(0.047)	(0.043)
Employment		-0.017	-0.017	-0.014
		(0.530)	(0.455)	(0.552)
Family Size Growth		0.057	0.049	0.052
		(0.160)	(0.177)	(0.153)
Wealth/Gift Transfer		0.097	0.105	0.113
		(0.157)	(0.137)	(0.133)
Background Risk				
Net Wealth Growth			0.000	0.000
			(0.315)	(0.500)
Income Growth			-0.017	-0.012
			(0.361)	(0.527)
Positive Income Expectations			-0.010	-0.008
			(0.705)	(0.771)
Investment Motives				
House Price Growth				-0.019***
				(0.006)
House Price Volatility				-0.008 *
				(0.071)
Demographic Controls	YES	YES	YES	YES
Country Effects	YES	YES	NO	NO
Observations	1430	1430	1430	1430
F	5.985	6.723	5.997	7.478
Prob>F	0.000	0.000	0.000	0.000

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This table reports the marginal results of logistic regression of housing tenure status switch from renter to owner on explanatory variables conditional on households being renter at the first wave. The investment motive variables are country specific and taken from the "Eurostat Database".

Table 11: OLS Regression of Housing Ajustment for Owners

Household Characteristics	Column I	Column II	Column III
Log Income	6.055	5.597	5.726
	(1.282)***	(1.372)***	(1.423)***
Log Wealth	11.489	11.963	10.733
	(1.176)***	(1.209)***	(1.185)***
Preference Shock			
Marriage		4.024	3.385
		(2.672)	(2.581)
Family Size		-0.176	0.585
		(0.952)	(0.949)
Wealth/Gift Transfer		3.057	2.575
		(10.905)	(10.587)
Income Expectation		1.771	1.684
		(1.046)*	(1.034)*
Financial Market Conditions			
House Price Growth			49.726
			(5.189)***
House Price Volatility			36.618
			(3.126)***
Average Mortgage rate			7.476
			(3.438)**
Real deposit rate			-61.487
			(6.412)***
Demographic Controls	YES	YES	YES
Country Effects	YES	YES	NO
Observations	1430	1430	1430
F	5.985	5.997	7.478
Prob>F	0.000	0.000	0.000

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
This table reports the results of OLS regression of housing size change on explanatory variables conditional on households being owner in both waves. Financial market conditions are country specific and taken from the "Eurostat Database".

A An Alternative Numerical Solution of the Model

We can also use an alternative numerical solution that follows the classic dynamic programming approach. The model proposes a finite horizon model with mixed endogenous variables: tenure choice, housing consumption, and net debt position, among which the first one is discrete, and the other two are continuous. We use the Tauchen (1986) to discretize

the continuous endogenous variables. We construct a fine grid for both housing size H_t and outstanding net debt position X_t to run the backward induction. We construct the grid range broad enough to ensure that all the results of the policy function lie within the grid range.

For the stochastic process of the house price and labor income growth, we use Gaussian quadrature numerical integration method to construct the expected continuation value EV. For the baseline model, we use a two-dimensional quadrature with seven nodes for each dimension, and we assume zero covariance between the house price shock and labor income shock. However, we can introduce covariance to the process if it is later proven necessary.

It is worth noting that with mixed type endogenous variables, using multivariate interpolation to update the value function through the iteration is computationally complicated and burdensome. However, if we use the exact grid point to grid point projection, the difficulty arises for the points that do not fall on grid points. Therefore, we circumvent this issue by constructing the wealth at the beginning of period as the single endogenous variable that dictates the optimal continuation value. We then use the univariate interpolation to approximate the value function of wealth wt. For the baseline model, we use a spline interpolation with 30 nodes and the order of three. According to John Rust 2006, this is sufficient to capture most of the curvature of the function and deliver global maximum.

The exogenous state variable evolutions in the model, the labor income, moving shock and house prices, are computed using the real world data we have obtained from the HFCS. Labor income is age and household characteristic dependent. We, therefore, run a simple OLS regression of total non-financial income of the households on their age cohort and personal characteristics. Then we use the regression results to compute the deterministic part of the permanent labor income part of the households at a different period. For instance, at period t= 20, the household's age is 40 and has 40 periods left until the final period. We thus have the labor income equal to the average labor income at the age of 40: $L_20 = L(40) + shock$. For the house price, we look at the average housing purchase price per square meter at 2010 in Europe as our benchmark price. We do not have the details of the housing; thus we ignore the granular difference between rural and urban housing, locational difference, the construction quality and the garden space. We only use the price per sqm as the indication of the housing price. We finally look at the households who move between 4 years to construct the likelihood of receiving a moving shock. However, it is more complicated because households also voluntarily move without receiving the shock. We assume that among all the households who move, half of them receive moving shock. We would like to construct a more accurate measure of the moving shock given more information.

Once we obtain the numerical solution of the model, we move on to simulate the moments

of interests, i.e., tenure choice transition, average housing consumption, the average debt outstanding, the loan to value ratio, the loan to income ratio and so on. We take the wave of 2010 as the given state variable and then simulate the stochastic shocks, combined with the observed decision choices, we can predict the state variable for the next period, and their choices as well. We then simulate for four periods to obtain the simulated moments at the year 2014. Given the parameter of interest in the numerical solution as an input, we can construct the simulated methods of moments as $m(\theta, \theta_K)$. We then construct the corresponding moments in the data $\hat{m}$. the minimum distance estimator of $min(m(\theta) - (\hat{m}))$ will give us the estimation of the parameters of interest.