Three Essays on the Housing Market and the Macroeconomy

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Für meine Eltern

Dankbar für Ihre beständige Ermutigung und bedingungslose Unterstützung über all diese Jahre

To my parents

for their constant encouragement and unconditional support throughout all these years

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Abstract

This thesis sheds light on certain macroeconomic aspects of the housing market. Chapter 1 explores a novel channel for house price bubble formation: the demand for housing consumption. I argue that the lower the demand for housing consumption, the larger the maximum bubble size, and the larger economies' vulnerability to house price bubbles. In terms of policy implications, I show that a help-to-buy scheme makes the economy more bubble-prone, while rental subsidies are an effective tool to reduce the prevalence of house price bubbles. Using a laboratory experiment, Chapter 2 supports the theoretical and empirical findings of Chapter 1. Chapter 3 investigates whether the persistent cross-country differences in homeownership rates are driven by cultural tastes. Analyzing the homeownership attitudes of second-generation immigrants in the United States leads to robust evidence for this hypothesis.

Resum

Aquesta tesi analitza diferents aspectes macroeconòmics del mercat de l'habitatge. El capítol 1 explora un nou canal per a la formació de bombolles en el preu de l'habitatge: la demanda de consum d'habitatge. Argumento que com més baixa és la demanda de consum d'habitatge, més gran és la mida màxima de la bombolla, i més gran és la vulnerabilitat de l'economia a les bombolles immobiliàries. En termes d'implicacions polítiques, mostro que un programa d'ajuda a la compra d'habitatge fa que l'economia sigui més propensa a generar bombolles, mentre que els subsidis de lloguer són una eina eficaç per reduir la prevalença d'aquestes bombolles immobiliàries. El Capítol 2 presenta un experiment de laboratori que dóna suport als resultats teòrics i empírics del Capítol 1. El Capítol 3 investiga si les diferències persistents entre països en els impostos sobre la propietat d'habitatge estan associades a diferències çulturals". Analitzant les actituds sobre la propietat d'habitatge dels immigrants de segona generació en els Estats Units, presento evidència que recolza aquesta hipòtesi.

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Foreword

The bursting of housing bubbles played an important role in generating the financial crisis that led to the Great recession of the 21^{st} century. This episode has raised interest among policy makers and researchers to understand which economic environments are more prone to produce such house price bubbles. The three self-contained chapters of this thesis contribute to this debate.

Housing is very different to other assets given its dual nature - the consumption and the investment side of a housing asset. The existing literature explores channels for house price bubble formation that work through the investment demand for housing. However, the role housing consumption plays in generating housing bubbles remains underexplored.

Chapter 1, titled ”The Preference for Housing Services and Rational Housing Bubbles”, aims to fill that gap and explores a novel channel for house price bubble formation: the demand for housing consumption. Housing consumption constitutes a large fraction of total consumption, and is measured by the consumption of housing services. A household receives housing services from living in a dwelling independent of whether the dwelling is rented or owned. In particular, I test the hypothesis that housing consumption drives economies' vulnerability to house price bubbles. This chapter addresses this hypothesis from two angles. First, through the lens of a theoretical overlapping generations model (OLG) that disentangles the consumption and investment demand for housing, and second with empirical data analysis.

This chapter highlights two main theoretical results. First, economies characterized by a strong demand for housing consumption, are those economies that are less prone to experience a housing bubble. Second, conditional on bubble existence, economies with strong housing demand face smaller housing bubbles. The mechanism behind the second result is intuitive: strong preferences for housing services (relative to other consumption goods) imply a large demand for housing services, driving high relative prices for housing services. This entails that a large share of the overall consumption expenditure across the economy is spent on housing services. The fundamental value of real estate is given by the expected discounted stream of the price for housing services. Therefore stronger preferences for housing services imply a larger fundamental value of real estate, all else equal. It follows from the economy's resource constraint that the maximum bubble size is smaller in such an environment, as there is simply less room for a large housing bubble. The OLG model offers novel policy implications. While help-to-buy schemes make the economy more bubble-prone, rental subsidies are an effective tool to reduce the prevalence of house price bubbles.

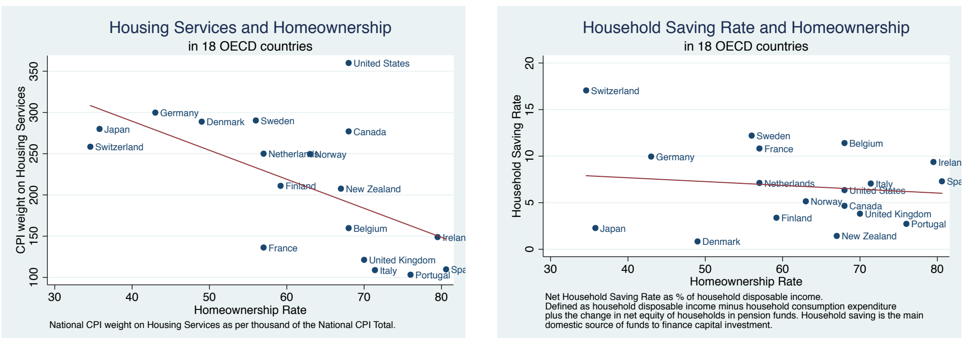
Chapter 1 presents suggestive empirical evidence supporting the theoretical results. Using data on 18 OECD countries, I show that a strong negative cross-country correlation exists between the share of consumption that households spend on housing services and house price bubbles. Countries that spend less on housing services as a share of total consumption experienced significantly more house price booms and busts during the period 1970 - 2014, and the associated housing boom-bust cycles were larger and more volatile.

Chapter 2, titled "The Preference for Housing Services and House Price Bubble Occurrence: A Macro-Experiment", is closely related to the first chapter. It complements the empirical analysis presented in the first chapter by evaluating the theoretical model predictions using a laboratory macro-experiment. In contrast to the empirical analysis, this technique allows to isolate and test the causal effect of the preference for housing services on house price bubbles. The empirical work in the first chapter proxies preferences for housing consumption using consumption expenditure shares for housing. This is an equilibrium outcome of the OLG model. In the experiment, we can induce preferences for housing services directly. The experimental setup allows housing bubbles to be quantified without measurement error. Two treatments are implemented - one with a strong preference for housing services relative to other consumption goods and one with a weak preference for those housing services.

The results of the macro-experiment provide strong support for the model's predictions. In the weak preferences for housing services treatment, larger house price bubbles are consistently observed. This chapter also contributes to the literature on experimental asset markets more generally. The experimental design provides a framework where both a market for a traded asset and a market for the dividend of that traded asset exist. The fundamental value of an asset is determined by the expected flow of future dividends. In the context of the housing market - this dividend is the price for housing services. Hence, the endogeneity of the housing market's dividend is a crucial and novel feature for the analysis of experimental (housing) bubbles. In addition, the work in this chapter provides several further novel design features for bringing OLG models to the laboratory.

Chapter 3, titled "Cross-Country Differences in Homeownership: A Cultural Phenomenon?", is closely related to Chapter 1. It provides supportive empirical evidence for my crucial exogenous model assumption: housing preferences differ across countries. Despite the large attention housing markets have received recently, there are few empirical studies that aim to explain why homeownership rates differ so greatly across countries. Cross-country differences in homeownership rates are large and very persistent over time. Homeownership rates vary from 44% in Switzerland to 83% in Spain. This chapter tests the novel hypothesis that these cross-country differences are driven by cultural tastes. To isolate the effect of culture from the effects of institutions and economic factors, the homeownership decision of second-generation immigrants in the United States is investigated. A second-generation immigrant is defined as an individual that is born, has been raised, and who lives in the United States. All second-generation therefore immigrants face the same markets and institutions. However, they differ in terms of their parents' country of origin and hence in their cultural heritage. A large set of robustness checks reassures that the results are not driven by a systematic difference in second-generation immigrants depending on the country of origin. This chapter shows that large cross-country differences in preferences for homeownership exist and that these differences are persistent over time.

I implement this empirical finding in Chapter 1 by assuming cross-country differences in the preference for housing services. How is this implementation justified? Theoretically speaking, an individual's preference for homeownership depends on his preference for housing consumption (i.e. for housing services) and his preference for housing investment. If the demand for housing investment is equal or larger than the demand for housing consumption, an individual becomes a homeowner, otherwise he becomes a renter. The figure below provides aggregate cross-country data indicating that homeownership rates are highly and negatively correlated with my proxy for the preferences for housing services. There is no correlation with the proxy for the preference for housing investment. I take this as suggestive evidence that cross-country differences in the preference for homeownership are at least partially driven by cross-country differences in the preference for housing services.



(a) Housing Services and Homeownership

(b) Saving rates and Homeownership

Figure 1: Cross-Country Correlations

Chapter 1

PREFERENCE FOR HOUSING SERVICES AND RATIONAL HOUSE PRICE BUBBLES

1.1 Introduction

Large house price bubbles can be devastating for the real economy.[1] The bursting of housing bubbles played an important role in generating the financial crisis that led to the Great Recession of the 21^{st} century. This episode has raised interest among policy makers and researchers to understand which economic environments are more prone to produce such house price bubbles.[2]

This paper explores a novel channel: the demand for housing consumption. In particular, I test the hypothesis that housing consumption drives economies' vulnerability to house price bubbles. The hypothesis is tested from three angles: a theoretical overlapping generations model that disentangles the consumption and investment demand for housing,

[1] Claessens et al. [2012], Claessens et al. [2009] and IMF [2003] show that recessions associated with house price busts are more than twice as long and twice as deep compared to normal recessions or recessions associated with equity busts.

[2] For overviews: Cerutti et al. [2015], Kok et al. [2014] and Claessens et al. [2013].

empirical data analysis, and with a laboratory experiment.

Housing is very different to other assets given its duality - the consumption and investment demand for housing. Empirical studies have shown that times of intensive housing investment are often associated with bubbly episodes.[3] The existing literature explores channels that work through the investment demand for housing.[4] The role housing consumption plays in generating housing bubbles, however, remains unexplored.

This paper aims to fill that gap. Housing consumption constitutes a large fraction of total consumption and is measured by the consumption of housing services. A household receives housing services from living in a house, independent of whether the dwelling is owned or rented. The demand for housing consumption determines the relative price of housing services and hence drives the fundamental value of real estate in the economy. This has important implications for the bubble size and economies' vulnerability to house price bubbles.

This paper highlights two main results. First, if the demand for housing consumption is low, countries are more prone to experience a housing bubble. Second, these countries where housing consumption is low face larger and more volatile housing bubbles.

The first section of this paper explores the implications of housing consumption on house price bubbles through the lens of an overlapping generations model. Crucially, this paper takes a two-dimensional approach to model housing demand - considering the consumption and investment demand for housing separately. This recognition of the duality of housing distinguishes my model from existing papers of house price bubble formation. It therefore allows the specific analysis of the impact of the preference for housing services on house price bubble occurrence.

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[3]Housing investment e.g. measured by turnover rates. The strong relationship between turnover and prices was first illustrated in Stein [1995]. Subsequently, papers by Leung [2004], Andrew and Meen [2003], Hort [2000], and Berkovec and Goodman [1996] have confirmed the results.

[4]The credit channel is widely accepted to play an important role for bubble formation, e.g. Drudi et al. [2009], Agnello and Schuknecht [2011], Schularick and Taylor [2012], Igan and Loungani [2012], Agnello and Schuknecht [2011], Claessens et al. [2009], Borio and Lowe [2002]. Transaction costs are found to matter for bubble formation.

In the model I assume cross-country differences in the preference for housing services relative to *all other* consumption goods. This preference parameter determines the share of consumption spent on housing services as an equilibrium outcome.[5] Assuming cross-country differences in the preference for housing is soundly justified by empirical evidence, as provided in the paper Huber and Schmidt [2017]. In that paper, we show that large cross-country differences in housing preferences exist and that these cross-country differences are persistent over time.[6]

Two main results emerge from the analysis of the model. First, I show that economies characterized by high housing consumption, are those economies that face smaller housing bubbles. The mechanism behind this result is intuitive: strong preferences for housing services (relative to other consumption goods) imply a large demand for housing services, and this drives high relative prices of those housing services. This implies that a large share of the consumption expenditure is spent on housing services.[7] The fundamental value of real estate is given by the expected discounted stream of the price for housing services. Therefore, stronger preferences for housing services imply a larger fundamental value of real

[5]The Log-Specification over composite consumption and housing services is supported by e.g. Davis and Ortalo-Magne [2011], who find that the expenditure share on housing services is constant over time and across cities in the United States. Further, I find that cross-country differences in the expenditure share on housing services are constant over time (for a sample of 18 OECD countries).

[6]Huber and Schmidt [2017] study the impact of cultural preferences on living arrangements, using data on the tenure choice decision of second generation immigrants in the United States - holding constant institutional factors. We find that cultural housing preferences transmitted by parents play an important role in the housing tenure choice of these second generation immigrants. For concreteness, we show that differences in preferences for homeownership exist across countries. In my model, I implement our empirical finding by assuming cross-country differences in preferences for housing services. This is in line with other theoretical papers, e.g. Kaplan et al. [2016] that calibrates the preference for housing services such that it matches homeownership rates in the data.

[7]Empirically, I measure the expenditure share of housing consumption using actual and imputed rents. What are imputed rents? Homeowners do not pay for the consumption of housing services the owned dwelling provides. The imputed rents of these housing services are valued at the estimated rent that a tenant pays for a dwelling of the same size and quality in a comparable location.

estate, all else equal. It follows from the economy's resource constraint that the maximum bubble size is smaller in such an environment, as there is less room left for a large housing bubble.
The second theoretical result shows that economies with strong preferences for housing services are less vulnerable to housing bubbles in the first place. I show that the existence condition for housing bubbles becomes tighter, the larger the demand for housing services. This means that the set of possibilities for bubble occurrence is reduced.

The model is also used to study the impact of two prominent alternative policies aimed at fostering the affordability of housing - rental subsidies and help-to-buy schemes.[8] I focus on analyzing the extent to which each policy impacts on economies' vulnerability to housing bubbles. I find that a proportional rental subsidy is an effective tool to control housing bubbles, while the help-to-buy scheme makes the economy more bubble prone.

The second section of this paper evaluates the extent to which the model's predictions can be reconciled with empirical evidence. To do so, I first provide an empirical characterization of housing cycles, bubbles and housing consumption using a large dataset covering 18 OECD countries during 1970-2014. Interestingly, I find large cross-country differences in both housing consumption (i.e. housing services), and house price bubbles (number, amplitude, volatility) that have occurred during 1970-2014. The number of house price bubbles is interpreted as a measure of the vulnerability of an economy to housing bubbles. Second, the interaction between housing consumption and house price fluctuations is investigated. In line with the model's predictions, two novel empirical regularities are identified across countries: housing consumption is highly negatively correlated with (1) the *frequency* and (2) the *intensity* and *amplitude* of house price bubbles. Thus, countries with a lower share of consumption spent

[8]Rental subsidies are a common policy to promote the affordability of housing in many countries. In e.g. France, the proportion of assisted households is large. According to Laferrere and Blanc [2004], 51.6% of the private sector tenants received a subsidy in 1996. The help-to-buy scheme is most common in English-speaking countries, like the United States and the United Kingdom.

on housing services experienced not only more but also larger and more volatile house price bubbles during 1970-2014.

The paper Huber et al. [2017] complements the empirical analysis with the evaluation of the theoretical model predictions using a laboratory macro experiment. In contrast to the empirical analysis, this technique allows to isolate and test the causal effect of the preference for housing services on house price bubbles. The empirical work proxies these preferences by the expenditure share of housing consumption - an equilibrium outcome of the OLG model. Further, the experimental setup allows quantifying housing bubbles without measurement error. The results of the macro experiment provide strong support for the model's predictions. In the treatment where we induce weak preferences for housing services we consistently observe significantly larger house price bubbles.

The remainder of this paper is organized as follows: Section 1.2 provides a brief review of two strands of literature this paper relates to. Section 1.3 describes the overlapping generation model, emphasizing the existence condition for house price bubble occurrence. Section 1.4 provides comparative statics and shows the impact of the preference for housing services on choice variables, prices, and the housing bubble. Section 1.5 outlines the policy analysis. Section 1.6 describes the methodology used to identify and measure house price bubbles empirically. This section also provides comprehensive descriptive statistics of all housing cycles and housing booms and busts that have occurred during 1970-2014 in 18 OECD countries. Further, this section presents the novel empirical cross-country regularities. Finally, section 1.7 concludes. Appendix A provides a detailed derivation of the model equations. A description of the data used for the empirical analysis can be found in Appendix B.

1.2 Related Literature

This paper is related to a growing theoretical literature on rational bubbles. The model is based on an overlapping generations (OLG) structure, drawing upon seminal work on bubbles by Samuelson [1958] and Tirole [1985]. Most rational bubble models adopt an OLG structure. However, there is a small, but growing literature on rational bubbles using infinite-horizon models.[9] My model is related to Galí [2014] in terms of how I introduce the bubbly asset in the model economy. This paper also relates to the theoretical literature on rational house price bubbles.[10] The closest papers are Arce and López-Salido [2011], Basco [2014], and Basco [2016], who investigate housing bubbles in overlapping generation models. These papers study the interaction between financial market imperfections and rational housing bubbles.

Apart from the different research question, one main difference between existing work and my own lies in how the housing bubble is modeled. In the related literature, the housing bubble is modeled as a shortage of assets in the economy. In my model, the housing bubble is a part of the housing price. A second crucial difference between the existing literature on rational house price bubbles and my own concerns the duality of housing. This paper takes a two-dimensional approach to model housing demand - considering both the demand for consumption and the demand for investment. This recognition of housing duality distinguishes my model from the existing rational housing bubble literature. Likewise, many studies of house prices in standard macroeconomic models without bubbles do not consider simultaneously the two-dimensional aspect of

[9]It is nontrivial to introduce rational bubbles into an infinite-horizon model, due to the transversality conditions (Santos and Woodford [1997]). As Kocherlakota [1992] points out, infinite-horizon models with trading frictions or borrowing constraints can generate bubbles. Kocherlakota [2008] and Hellwig and Lorenzoni [2009] provide infinite-horizon endowment economies with such features.

[10]Brunnermeier and Julliard [2008] and Burnside et al. [2016] present models of housing bubbles based on heterogeneous beliefs or irrational behaviors. There exist many studies of housing prices in the standard macroeconomic models without bubbles, e.g. Iacoviello [2005], Kiyotaki et al. [2011], Liu et al. [2013], among many others.

housing.[11] Notable exception are e.g. Henderson and Ioannides [1983], Piazzesi et al. [2007] and Manuelli and Peralta-Alva [2017].[12]

Given that housing services constitute a large part of total consumption, and its potential to drive bubbles, my model is a useful extension to the literature. My model makes it possible to study housing policy interventions that target either the consumption or investment demand of housing and allows the assessment of their impact on bubble formation.

This paper also contributes to the empirical literature investigating why some countries experience a larger number (and more extreme) house price bubbles than others. While this paper highlights a new channel: housing consumption, the existing literature explores channels that work through the investment demand for housing, such as the credit supply, transaction costs or property taxes. Many studies highlight the credit channel. This channel is widely accepted to play an important role in bubble formation. Drudi et al. [2009] analyze the main developments in housing finance in the euro area over the last decade and evaluate cross-country differences in mortgage markets. This includes relative differences in variable versus fixed rate mortgages, bankruptcy laws, tax regimes, etc. Agnello and Schuknecht [2011] study the credit related determinants of house price booms and busts for a sample of 18 countries over the period 1980-2007. The driving factors this study considers and finds to be important are all credit related: the level of short-term interest rates, credit

[11] Iacoviello [2005]'s seminal paper develops an infinite horizon monetary model and introduces a financial accelerator that works through the housing sector. Housing enters the utility function and the budget constraint. In contrast to my paper, there is no clear distinction between the consumption and investment aspect of a house. Further, housing bubbles are ruled out by a transversality condition. Many papers studying house prices and or policy interventions, use or extend Iacoviello [2005]'s framework without the distinction between investment and consumption demands for housing. Iacoviello and Neri [2010] investigate the nature of the shocks that hit the housing market and access the magnitude of the spillovers resulting from the housing market to the wider economy. Iacoviello and Pavan [2013] study housing and mortgage debt over the cycle. Rubio and Carrasco-Gallego [2014] study how the interaction of macro prudential and monetary policies affect the economy.

[12] Piazzesi et al. [2007] develop a consumption-based asset pricing model with housing and equity, and nonseparable utility over housing services and other consumption.

growth to the private sector, global liquidity growth, and a mortgage market regulation dummy.[13] Housing policies that increase transaction costs are sometimes claimed to reduce speculative behaviour in the housing market. However, Hau [2001] suggests that transaction costs have only a minor impact in preventing asset price bubbles. On the other hand, Andrews et al. [2011] and Catte et al. [2004] find that house price volatility is smaller in countries with greater transaction costs in property markets.[14] Similarly, Ikromov and Abdullah [2012] find that transaction costs reduce the magnitude of experimental asset price bubbles and push prices closer to fundamentals. In the empirical part of this paper, I control for the above-described channels that work through the investment demand for housing. The novel channel of housing consumption remains highly significant and seems to play a large role in driving economies' vulnerability to house price bubbles.

1.3 Model

This paper provides a highly stylized overlapping generations model with housing, without capital and where labor is supplied inelastically. In equilibrium, aggregate employment and output are constant. However, this framework allows to study why countries with a *weaker preference for housing services* experienced significantly larger, and a larger number of house price bubbles over the time period 1970-2014. The model is used as a laboratory for the qualitative analysis of the impact of the preference of housing services on (1) house price bubble occurrence, and (2) the amplitude of those bubbles. Further, I study the impact of two prominent, but very different policies aiming to foster the affordability of housing - *rental subsidies* and *help-to-buy schemes*. Thereby I investigate the potential for

[13]Following the empirical literature, credit related variables perform well in predicting crises in real time, e.g. private sector credit to GDP ratio or credit growth as measures for the leverage of an economy (Schularick and Taylor [2012], Igan and Loungani [2012], Agnello and Schuknecht [2011], Claessens et al. [2009], Borio and Lowe [2002]).

[14]In contrast to stock prices, Hau [2006] studies the French stock market and finds that higher transaction costs should be considered as volatility increasing.

these policies to be used for mitigating house price bubbles occurrence.

1.3.1 Households

I assume an overlapping generations structure where a continuum of households lives for two periods. The size of each generation (young and old) is normalized to unity. After dying, the old generation is replaced by a new, young one. Hence total population remains constant. Households born at time t maximize the expected lifetime utility

$$u(C_{1,t}) + \xi^k v(S_t) + \gamma E_t\{u(C_{2,t+1})\} \tag{1.1}$$

where C_t denotes the non-durable composite consumption good.[15] Consuming housing stock of size S_t yields housing service utility $v(S_t)$. ξ^k denotes the aggregate preference for housing service of country k relative to *all other* consumption $C_{1,t}$ when young. I will use log utility as the functional form for what will follow, i.e. $u(\cdot) = v(\cdot) = log(\cdot)$.[16]

Young households supply their labor service inelastically for a real wage W_t, and allocate their net wealth between consuming the bundle $C_{1,t}$, housing services of size S_t, save/invest in an one period riskless bond of value Z_t and purchasing housing stock of size H_t. The return to saving

[15] $C_{1,t} \equiv \left(\int_0^1 C_{1,t}^{1-\frac{1}{\varepsilon}}(i)di\right)^{\frac{\varepsilon}{\varepsilon-1}}$ and $C_{2,t+1} \equiv \left(\int_0^1 C_{2,t+1}^{1-\frac{1}{\varepsilon}}(i)di\right)^{\frac{\varepsilon}{\varepsilon-1}}$ are the bundles consumed when young and old, respectively. In each period, there exists a continuum of differentiated goods, each produced by a different firm, and with a constant elasticity of substitution denoted by ε. Henceforth I assume $\varepsilon > 1$. Differentiated consumption goods (and the firms producing them) are indexed by $i \in [0, 1]$.

[16] As in Iacoviello [2005], I assume that housing service and *all other* composite consumption are separable. The decision of choosing a log specification over housing service and composite consumption is based e.g. on Davis and Ortalo-Magne [2011], who find that the expenditure share on housing is constant (over time and across U.S. cities). Further, I find that cross-country differences in the expenditure share on housing services are constant over time (for a sample of 18 OECD countries). Bernanke [1984] studies the joint behavior of the consumption of durable and non-durable goods, and finds that a separable log specification is a good approximation. Note the functions $u(\cdot), v(\cdot)$ are continuous and twice differentiable, with $\lim_{C\to 0} u(C) = -\infty$ and $\lim_{C\to 0} u^{'}(C) = \infty$, $\lim_{S\to 0} v(S) = -\infty$ and $\lim_{S\to 0} v^{'}(S) = \infty$.

Z_t is given by the nominal interest rate $(1 + i_t)$. For future reference, I define the real interest rate as

$$R_t \equiv (1 + i_t)E_t \left\{ \frac{P_t}{P_{t+1}} \right\}. \tag{1.2}$$

In this paper, I consider the two-dimensional aspect of housing, the demand for consumption and the investment demand. I disentangle the dual motives of housing behavior by modeling the consumption aspect (consuming housing services) and investment aspect (investing in housing) separately. This assumption distinguishes this model from existing models of rational housing bubbles, and allows the separate analysis of the impact of the demand for housing services on house price bubble occurrence.

For concreteness, when young households buy housing services S_t, they do so by renting housing stock S_t from the old generation. Young households that invest in housing buy housing stock H_t when young from the old generation. The housing asset yields a dividend payment next period - a rental income when old. Before the old household dies, he sells the remaining housing stock to the new young generation.[17]

When born, households are endowed with $\delta \in [0, 1)$ units of housing stock whose price is $Q_{t|t} > 0$. Households can buy and trade houses.[18] Each period, the housing stock depreciates by the fraction δ; it follows that the total housing stock in the economy remains constant.

Young households are endowed with the know-how to set up a new firm producing a differentiated consumption good. That firm only becomes productive after one and for one period only (i.e. when the founder is old), generating profits, D_t, for the owner when old.

[17]As Henderson and Ioannides [1983] argued, "...before the introduction of institutional considerations there is no reason for people to actually owner-occupy their consumption-investment demands, as opposed to being landlords of their asset holdings and renting their consumption demand from some other landlords".

[18]Assuming that housing is a partially bubbly asset, it follows that households are endowed with a partially bubbly asset as in Galí (2014). With the difference that in Galí (2014) households are endowed with a pure bubbly asset, that is intrinsically useless.

Accordingly, the budget constraint of the young household at time t is given by

$$C_{1,t} + \frac{Z_t}{P_t} + \sum_{k=0}^{\infty} q_{t|t-k} H_{t|t-k} + p_t^r S_t \leq W_t + \delta q_{t|t}, \tag{1.3}$$

where P_t is the price of the composite consumption good in period t. The rental and purchasing price of one unit of housing stock is denoted by P_t^r and Q_t, respectively. With prices written in lowercase letters, I define prices relative to the consumption bundle, so $q_t = \frac{Q_t}{P_t}$ and $p_t^r = \frac{P_t^r}{P_t}$. Further, $H_{t|t-k}$ denotes the quantity of the housing stock purchased in t, introduced by the cohort born in period $t-k$, and whose relative current price is $q_{t|t-k}$ for $k = 0, 1, 2, ...$

The budget constraint when old is given by equation (1.4). By purchasing the consumption bundle $C_{2,t+1}$, the old household consumes all his wealth. The household's wealth consists of (1) the rental income from renting his housing stock to the young generation, which is given by $\sum_{k=0}^{\infty} p_{t+1}^r H_{t|t-k}$, (2) the re-selling value of his housing stock[19], (3) the payoff from his maturing bond holding, and (4) real profits generated by his intermediate firm, D_{t+1}. Formally, for each old household we have

$$C_{2,t+1} \leq \frac{(1+i_t)Z_t}{P_{t+1}} + \sum_{k=0}^{\infty} p_{t+1}^r H_{t|t-k} + (1-\delta) \sum_{k=0}^{\infty} q_{t+1|t-k} H_{t|t-k} + D_{t+1}, \tag{1.4}$$

where $H_t = \sum_{k=0}^{\infty} H_{t|t-k}$.

Household Optimality Conditions

The Euler Equation is derived using the FOCs (A1), (A2) and (A5)

$$1 = \gamma(1+i_t) E_t \left\{ \left(\frac{C_{1,t}}{C_{2,t+1}} \right) \left(\frac{P_t}{P_{t+1}} \right) \right\} \tag{1.5}$$

[19] At the end of the period the old household sells his remaining housing stock, i.e. $(1-\delta) \sum_{k=0}^{\infty} q_{t+1|t-k} H_{t|t-k}$, to the young generation.

The intra-temporal Optimality Condition using the FOCs (A1) and (A2),

$$\frac{\xi^k C_{1,t}}{S_t} = p_t^r \tag{1.6}$$

and the optimal saving/investment decision using the FOCs (A3) and (A5)

$$q_{t|t-k} = E_t \left\{ \frac{P_{t+1}}{(1+i_t)P_t} \left(p_{t+1}^r + (1-\delta) q_{t+1|t-k} \right) \right\} \tag{1.7}$$

Using the Euler Equation, the previous equation can be rewritten as

$$q_{t|t-k} = \gamma E_t \left\{ \left(\frac{C_{1,t}}{C_{2,t+1}} \right) \left(p_{t+1}^r + (1-\delta) q_{t+1|t-k} \right) \right\} \tag{1.8}$$

1.3.2 Price of Housing: Definitions and Assumptions

I define the price of the housing asset H as

$$q_t \equiv q_t^F + q_t^B, \tag{1.9}$$

where the *fundamental price component* is defined by the future expected discounted value of rental income the house generates, and is given by

$$q_t^F \equiv E_t \left\{ \sum_{k=1}^{\infty} \prod_{j=0}^{k-1} \frac{1}{R_{t+j}} (1-\delta)^{k-1} p_{r,t+k} \right\}. \tag{1.10}$$

The *bubbly price component* is defined as

$$q_t^B \equiv B_t + U_t^b, \tag{1.11}$$

with $B_t \equiv \delta \sum_{k=1}^{\infty} (1-\delta)^k q_{t|t-k}^B$ and $U_t^b \equiv \delta q_{t|t}^B$, where B_t denotes the value of pre-existing bubbles in the economy and U_t^b the value of the newly introduced bubbles in t. I assume that U_t^b will follow an exogenous *i.i.d.* process with mean U^b.

It can be shown that (1.10) satisfies

$$q^F_{t|t-k} = E_t \left\{ \frac{1}{R_t} \left(p_{r,t+1} + (1-\delta) q^F_{t+1|t-k} \right) \right\}. \tag{1.12}$$

It follows from (1.9), (1.12) and (1.8), that the bubble component satisfies

$$q^B_t \equiv B_t + U^b_t = E_t \left\{ \frac{1}{R_t} B_{t+1} \right\}. \tag{1.13}$$

Hence, an increase in the interest rate will raise the expected growth of the bubble (as long as $U^b > 0$), while the fundamental component of the housing price will be affected negatively by a rise in the interest rate, refer to equation (1.10).

1.3.3 Firms

Final Production Sector

The final consumption good production is perfectly competitive, hence final consumption good producers earn zero profits. Each final consumption good producer has the following production function

$$y_t \equiv \left(\int_0^1 y_t(i)^{\left(\frac{\varepsilon-1}{\varepsilon}\right)} \quad di \right)^{\left(\frac{\varepsilon}{\varepsilon-1}\right)} \qquad with \qquad \varepsilon > 1, \tag{1.14}$$

where $y_t(i)$ is the quantity of the intermediate good i with the demand function

$$y_t(i) = \left(\frac{P_t\,(i)}{P_t} \right)^{-\varepsilon} y_t \qquad \forall i \in [0,1]. \tag{1.15}$$

It follows that the price of the final consumption good is given by

$$P_t \equiv \left(\int_0^1 P_t(i)^{(1-\varepsilon)} \quad di \right)^{\left(\frac{1}{1-\varepsilon}\right)}. \tag{1.16}$$

The optimization problem of the representative final producer is therefore

$$\begin{aligned} \max \qquad & P_t y_t - \left(\int_0^1 P_t(i) y_t(i) \quad di \right) \\ s.t. \qquad & y_t = \left(\int_0^1 y_t(i)^{\left(\frac{\varepsilon-1}{\varepsilon}\right)} \quad di \right)^{\left(\frac{\varepsilon}{\varepsilon-1}\right)} \end{aligned}$$

Intermediate Production Sector

The production function uses labor as the only input and is given by

$$y_t(i) \equiv L_t(i) \qquad \forall i \in [0,1] \tag{1.17}$$

Every firm has monopolistic power in the production of his own variety. The monopolist sets his price $P_t(i)$ to maximize his profits subject to the demand constraint (1.15). The optimization problem of the monopolistic firm is given by

$$\max_{P_t^*} \qquad E_{t-1} \left\{ \Lambda_{t-1,t} \left(\underbrace{P_t^* y_t(i) - \Psi_t\left(y_t(i)\right)}_{profit} \right) \right\} \tag{1.18}$$

$$s.t. \qquad y_t(i) = \left(\frac{P^*}{P_t} \right)^{-\varepsilon} y_{c,t} \tag{1.19}$$

where the price P_t^* is set at the end of $t-1$ (price set in advance), which introduces nominal rigidities in the model. $\Psi_t\left(y_t(i)\right)$ denotes the nominal cost function of firm i. $\Lambda_{t-1,t}$ denotes the discount factor. As households own the intermediate production firms, they will get the profits as a lump-sum payment when old.[20]

[20]Note that households take prices as given, therefore the discount factor used in the firm maximization problem must be slightly different than the one of the household. But as the difference just has to be infinitesimally small, the discount factor can be approximated by the discount factor of the household. So, the relevant discount factor is derived from the Euler Equation and is given by $\Lambda_{t-1,t} \approx \gamma \frac{E_t\left\{u'(C_{2,t})\right\}}{u'(C_{1,t-1})}$.

After some manipulations of the FOC, we derive the optimal pricing condition[21]

$$E_{t-1}\left\{\Lambda_{t-1,t}y_t(i)\left(P_t^* - \frac{\varepsilon}{\varepsilon-1}\Psi_t'\left(y_t(i)\right)\right)\right\} = 0 \tag{1.20}$$

Each firm chooses its new price equal to a fixed markup over its current nominal marginal cost, i.e. $\mathcal{M} = \frac{\varepsilon}{\varepsilon-1}$.

In the *case of flexible prices and or no uncertainty*, the FOC (1.20) is satisfied with

$$P_t^* = \left(\frac{\varepsilon}{\varepsilon-1}\right)\Psi_t'\left(y_t(i)\right) \qquad \Leftrightarrow \qquad P_t^* = \mathcal{M}W_tP_t \tag{1.21}$$

Hence, the real wage is given by $W = \frac{1}{\mathcal{M}}$ and aggregate (real) profits by $D = \left(1 - \frac{1}{\mathcal{M}}\right) = (1 - W)\ \forall t$.[22]

1.3.4 Equilibrium

In this section, I describe the equilibrium of the economy.

Aggregate consumption good market clearing requires[23]

$$Y_t = \left(C_{1,t} + C_{2,t}\right). \tag{1.22}$$

From the income side, I can write

$$Y_t = D_t + W_t. \tag{1.23}$$

[21] The first order condition (FOC) is given by $E_{t-1}\left\{\Lambda_{t-1,t}\left(y_t(i)+P_t^*(-\varepsilon)\left(\frac{P_t^*}{P_t}\right)^{-\varepsilon-1}\frac{y_t}{P_t}-\Psi_t'(y_t(i))(-\varepsilon)\left(\frac{P_t^*}{P_t}\right)^{-\varepsilon-1}\frac{y_t}{P_t}\right)\right\}=0$

[22] $D=\frac{1}{P_t}\left(P_t^*\int_0^1 y_t(i)di-\int_0^1 \Psi_t(y_t(i))di\right)=\frac{1}{P_t}(\mathcal{M}W_tP_t-W_tP_t)=\left(1-\frac{1}{\mathcal{M}}\right) \qquad \forall t.$

[23] Market clearing for each consumption good *i* requires that $Y_t(i)=C_{1,t}(i)+C_{2,t}(i)$ for all t and $i \in [0,1]$. Using the aggreagte output $Y_t=\left(\int_0^1 y_t(i)^{\frac{\varepsilon-1}{\varepsilon}}di\right)^{\frac{\varepsilon}{\varepsilon-1}}$ and the demand functions for each consumption good i, i.e. $C_{1,t}(i)=\left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon}C_{1,t}$ and $C_{2,t+1}(i)=\left(\frac{P_{t+1}(i)}{P_{t+1}}\right)^{-\varepsilon}C_{2,t+1}$, we derive the condition (1.22).

Labor Market Clearing
Given the assumption that only young households supply inelastically one unit of labor it follows that total labor employed is given by[24]

$$L_t = \int_0^1 L_t(i) \quad di = 1. \tag{1.24}$$

Labor market clearing implies

$$L_t = \int_0^1 Y_t(i) \quad di = Y_t = 1. \tag{1.25}$$

The second equality follows because I assume that in a symmetric equilibrium all firms set the same price and produce the same amount.

Housing Market Clearing
Houses exist in fixed supply. The aggregate supply of the housing stock is given by

$$\bar{H}_t = \delta + \delta(1-\delta) + \delta(1-\delta)^2 + ... = \delta \sum_{k=0}^{\infty} (1-\delta)^k = 1 \quad \forall t. \tag{1.26}$$

with $\bar{H}_{t|t-k} = \delta(1-\delta)^k$. The total supply of houses as to equal demand each period. Hence,

$$H_t = 1 \qquad \text{and} \qquad H_{t|t-k} = \delta(1-\delta)^k \quad \forall t. \tag{1.27}$$

Rental Market Clearing
The supply of houses $\bar{H}_t$ is constant and normalized to one. The aggregate supply of the housing stock that is available for rent is given by the aggregate housing stock itself and is denoted by $\bar{S}_t$. Formally,

$$\bar{S}_t = \delta + \delta(1-\delta) + \delta(1-\delta)^2 + ... = \delta \sum_{k=0}^{\infty} (1-\delta)^k = 1 \quad \forall t. \tag{1.28}$$

[24]As $Y_t(i) = L_t(i)$, it follows that $\int_0^1 Y_t(i)di = \int_0^1 L_t(i)di$, hence $Y_t = L_t = 1$.

The supply of rental-homes has to equal the demand each period,

$$S_t = 1 \quad \forall t. \tag{1.29}$$

Bond market Clearing
Market clearing implies that the aggregate value of the bond market must equal zero,

$$Z_t = 0 \quad \forall t. \tag{1.30}$$

Market clearing conditions (1.22), (1.25), (1.27), (1.29), (1.30) and the optimal price setting equation (1.20) together with the optimality conditions of the household (1.5)-(1.8) and the definition of the housing price (1.9) with (1.12) describe the equilibrium of the economy.

Equilibrium Equations[25]

$$
\begin{gathered}
L_t = Y_t = 1 \\
Y_t = (C_{1,t} + C_{2,t}) \\
Y_t = D_t + W_t = 1 \\
S_t = H_t = 1 \\
C_{1,t} = \tfrac{1}{1+\xi}\left(W_t - F_t - B_t\right) \\
p_t^r = \tfrac{\xi}{1+\xi}\left(W_t - F_t - B_t\right) \\
C_{2,t+1} = E_t\left\{D_{t+1} + \tfrac{\xi}{(1+\xi)} W_{t+1} + \tfrac{1}{(1+\xi)}(F_{t+1} + B_{t+1})\right\} \\
q_t = F_t + B_t + U_t \\
q_t^b \equiv B_t + U_t^B = \gamma E_t\left\{\left(\frac{C_{1,t}^j}{C_{2,t+1}^j}\right) B_{t+1}\right\} \\
q_t^f \equiv F_t + U_t^F = \gamma E_t\left\{\left(\frac{C_{1,t}^j}{C_{2,t+1}^j}\right)\left(p_{t+1}^r + (1-\delta) q_{t+1}^f\right)\right\} \\
1 = \gamma(1 + i_t) E_t\left\{\left(\tfrac{C_{1,t}}{C_{2,t+1}}\right)\left(\tfrac{P_t}{P_{t+1}}\right)\right\}
\end{gathered}
$$

[25] The derivation can be found in the Appendix.

1.3.5 Equilibrium Dynamics

Next, I will characterize the dynamics of the deterministic equilibrium for which an exact analytical solution exists. In the deterministic case, it holds that $U_t = U > 0$, $B_t - E_{t-1}\{B_t\} = 0$, and $F_t - E_{t-1}\{F_t\} = 0$ for all t. The optimal price setting equation implies that $W_t = W = (1/\mathcal{M})$, and it follows from the market clearing condition that $D_t = 1 - W$ for all t. Recall that:

$$C_{1,t} = \frac{1}{1+\xi}\left(W_t - F_t - B_t\right) \tag{1.31}$$

$$p_t^r = \frac{\xi}{1+\xi}\left(W_t - F_t - B_t\right) \tag{1.32}$$

$$\begin{aligned} C_{2,t} &= D_t + \frac{\xi}{(1+\xi)}W_t + \frac{1}{(1+\xi)}(F_t + B_t) \\ &= 1 - \frac{1}{(1+\xi)}\left(W_t - F_t - B_t\right) \end{aligned} \tag{1.33}$$

Using the Euler Equation and the consumption levels (1.31) and (1.33), the real interest rate can be expressed as

$$R_t = \frac{(1-W) + \xi + F_{t+1} + B_{t+1}}{\gamma(W - F_t - B_t)} \equiv R(B_t, B_{t+1}, F_t, F_{t+1}) \tag{1.34}$$

The previous conditions determine the deterministic equilibrium allocations given the equilibrium path for the fundamental and the bubble $\{B_t, F_t\}$. The latter two must satisfy the following difference equations:

$$\begin{aligned} B_{t+1} &= \frac{(1-W)(1+\xi)(B+U^B)}{\gamma W - (1+\xi+\gamma)(B_t+F_t) - (1+\xi)U} \\ &\equiv H(B_t, F_t, U) \end{aligned} \tag{1.35}$$

$$\begin{aligned} F_{t+1} &= \frac{(1-W)(F+U^F) + \xi^2(B_t+F_t+U)}{\gamma W - (1+\xi+\gamma)(B_t+F_t) - (1+\xi)U} \\ &+ \frac{\xi\left[\gamma W(B_t+F_t-W) + (B_t+U^B) + (2-W)(F+U^F)\right]}{\gamma W - (1+\xi+\gamma)(B_t+F_t) - (1+\xi)U} \\ &\equiv G(B_t, F_t, U) \end{aligned} \tag{1.36}$$

A deterministic bubbly equilibrium with positive fundamental value is defined by a sequence $\{B_t, F_t\}$ satisfying the two difference equations (1.35) and (1.36), where $B_t \in (W - F_t - \frac{(1+\xi)}{1+(1-\delta)\gamma}, W - F_t - \frac{(1+\xi)}{1+\gamma})$ for all t and a range of $U \in]\underline{u}_{R_1}, \tilde{u_1})$. The aggregate bubble is then given by $Q_t^B = B_t + U^B$. Given the $\{B_t, F_t\}$, we can determine the equilibrium values for all variables. The derivation of all equations in this section is provided in the appendix. On pp. 28-29, I derive the range of U consistent with equilibrium.

Equilibrium Dynamics: Bubbly Steady State with positive Fundamental

Figure (1.1) plots the transition dynamics of $\{B_t, F_t\}$, with $U \in]\underline{u}_{R_1}, \tilde{u_1})$. There exist two sets of bubbly steady states with positive fundamental, one set of stable and one set of unstable steady states.

I define a *steady state* by the triple (B, F, U) such that $B = H(B, U)$ and $F = G(F, U)$ with $B \in (W - F - \frac{(1+\xi)}{1+(1-\delta)\gamma}, W - F - \frac{(1+\xi)}{1+\gamma})$ and $U \in]\underline{u}_{R_1}, \tilde{u_1})$. The steady state (B^s, F^s, U) depicted in figure (1.1) is locally stable. It can be shown numerically that $\partial \left[H(B, F, U) - B\right] / \partial B < 0$ for $B > B^s$ and $\partial \left[G(B, F, U) - F\right] / \partial F < 0$ for $F > F^s$, while $\partial \left[H(B, F, U) - B\right] / \partial B > 0$ for $0 < B < B^s$ and $\partial \left[G(B, F, U) - F\right] / \partial F > 0$ for $0 < F < F^s$. The steady state (B^u, F^u, U) depicted in figure (1.1) is globally unstable. It can be shown numerically that $\partial \left[H(B, F, U) - B\right] / \partial B > 0$ for $B > B^u$ and $\partial \left[G(B, F, U) - F\right] / \partial F > 0$ for $F > F^u$, while $\partial \left[H(B, F, U) - B\right] / \partial B < 0$ for $0 < B < B^u$ and $\partial \left[G(B, F, U) - F\right] / \partial F < 0$ for $0 < F < F^u$.

For each $U \in]\underline{u}_{R_1}, \tilde{u_1})$, the mappings $B_{t+1} = H(B_t, F_t, U)$ and $F_{t+1} = G(B_t, F_t, U)$ have two fixed points, given by (B^s, F^s, U) and (B^u, F^u, U). Given the initial conditions $B_0 \in]0, B^u[$ and $F_0 \in]0, F^u[$, the solutions to $B_{t+1} = H(B_t, F_t, U)$ and $F_{t+1} = G(B_t, F_t, U)$ correspond to a bubbly equilbrium path that converges to (B^s, F^s, U). For any initial condition $\{B_0 > B^u, F_0 > F^u\}$ the constraint (1.38), $B_t < W - F_t$, would be violated in finite time, hence not consistent with equilbrium. For initial conditions $B_0 \in]0, B^u[$ and $F_0 \in]0, F^u[$, the system of two difference equations has a globally stable steady state given by (B^s, F^s, U).

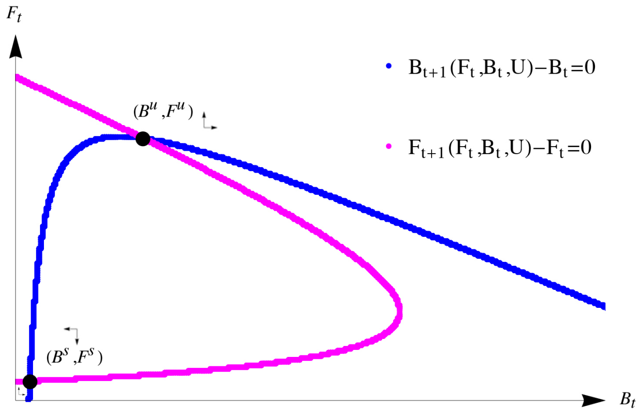

Figure 1.1: Two sets of Bubbly Steady States with positive Fundamental

Equilibrium Dynamics: The Bubbless Steady State

A deterministic bubbleless equilibrium $(B_t = 0)$ with a positive and real fundamental value is defined by a sequence $\{F_t\}$ satisfying the the difference equation (1.37), where $F_t \in (W - \frac{(1+\xi)}{1+(1-\delta)\gamma}, W)$ for all t and a range of $U^F \in]\underline{u}_F, \bar{u_F})$.[26] The aggregate fundamental is given by $Q_t^F = F_t + U^F$. Given $\{F_t\}$, we can determine the equilibrium values for all variables.

$$F_{t+1} = \frac{(1-W)(F+U^F) + \xi^2(F_t+U^F) + \xi\left[\gamma W(F_t - W) + (2-W)(F+U^F)\right]}{\gamma W - (1+\xi+\gamma)F_t - (1+\xi)U^F} \equiv G(F_t, U^F) \tag{1.37}$$

Figure (1.2) plots the transition dynamics of F_t, with $U^F \in]\underline{u}_F, \bar{u_F})$. There exist two sets of bubbleless steady states, one set of stable $F^s = G(F^s, U^F)$ and one set of unstable steady states $F^u = G(F^u, U^F)$. The steady state is stable (unstable) if $\partial G(F, U^F)/\partial F < 1 (> 1)$.[27]

[26] I abstract from complex number solutions that exist for $U^F > \bar{u_F}$.

[27] Functional form of the two sets of steady states: $F_{1,2} = \frac{(\xi+1)U^F - W(1+\gamma+\xi(1-\gamma)) - (1+\xi)^2}{2(\gamma+\xi+1)}$
$\pm \frac{\left[(1+\xi)\sqrt{\xi^2 + (U^F)^2 + + (W(1+\gamma)-1)^2 + 2U^F(W(1+\gamma)-(1+\xi)-2\gamma) + 2\xi(1-W(1-\gamma))}\right]}{2(\gamma+\xi+1)}$

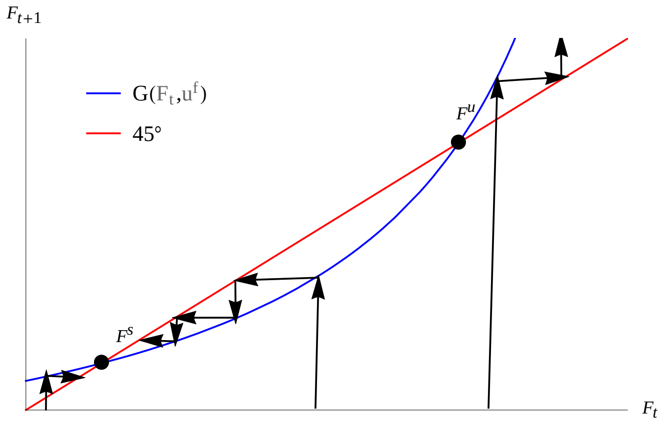

Figure 1.2: Two sets of Bubbleless Steady States

1.3.6 Conditions for the Existence of Bubbles

In this section, I first discuss the conditions for the existence of such bubbly equilibria and steady states with positive fundamental value $(F, B > 0)$ in detail. Second, I will show the restrictions on the real interest rate and the resulting constraints on the bubble size and the size of the fundamental. In the last part of this section, I derive the range of U consistent with such an equilibrium.

Affordability Constraint

The investment in housing has to be affordable. Given that young households are the only agents that buy houses, the affordability constraint is derived from the budget constraint of the young. In a bubbly equilibrium, it must hold that

$$B_t \in [0; W - F_t] \quad \forall \quad t \tag{1.38}$$

Lemma 1.3.1. *The larger the fundamental value of real estate today, the smaller the maximum pre-existing aggregate bubble value today.*
Proof: See Appendix.

Bubbly Equilibrium: Existence Condition

Proposition 1.3.2. *A necessary condition for the existence of a deterministic bubbly steady state with a positive fundamental value is given by*

$$W > F(\underset{+}{\xi^k}, \gamma, \delta) + \left(\frac{1 + \xi^k}{1 + (1 - \delta)\gamma}\right)$$

where $W = \frac{1}{\mathcal{M}}$ is pinned down by the exogenous parameter $\mathcal{M}$.
Proof: See Appendix

Corollary 1.3.3. *The higher ξ^k, i.e. the stronger the population's preference for housing services relative to other consumption in country k, the tighter the inequality - hence, the smaller the set of possibilities that a positive bubble exists (that Proposition 1.3.2. holds).*

A higher ξ^k implies that a larger share of consumption expenditure is spent on housing services as an equilibrium outcome in country k. Hence according to Proposition 1.3.2, countries characterized by a larger share of consumption expenditure spent on housing services, are those countries that are less prone to experience housing bubbles.[28]

Corollary 1.3.4. *The higher the fundamental component of the housing price, the tighter the inequality - hence, the smaller the set of possibilities that a positive bubble exists (that Proposition 1.3.2 holds).*

[28] In section 1.6, I provide empirical cross-country evidence for both model implications. First, I show that countries that have a larger fundamental value of housing experienced smaller housing bubbles. Second, I show that countries that spend a larger share of their consumption expenditure on housing services experienced significantly less housing bubbles over 1970-2014.

Proposition 1.3.5. *A necessary and sufficient condition for the existence of a deterministic pure bubbly steady state without fundamental value is given by* $W > \left(\frac{1}{1+\gamma}\right)$. *Proof: See Appendix.*

Proposition 1.3.6. *A necessary condition for the existence of a deterministic bubbleless steady state with a positive fundamental value is given by* $W > \left(\frac{1+\xi^k}{1+(1-\delta)\gamma}\right)$. *Proof: See Appendix.*

Deterministic Steady State Interest Rate

Case 1: Bubble World & positive Fundamental ($F(u^f) > 0, B(u^b) > 0$)
With $u^b > 0$, it follows from (1.13) that in a bubbly steady state, the interest rate has to be $R(B(u^b), F(u^F)) < 1$. It follows from (1.10) that $R(F(u^f), B(u^b)) > (1 - \delta)$ must hold in any deterministic steady state.[29] Consequently, in a bubbly deterministic steady state with a positive fundamental value, the real interest rate lies between $(1 - \delta) < R(F(u^f), B(u^b)) < 1$.

Case 2: Bubbleless World ($F(u^f) > 0, B(u^b) = 0$)
It follows from (1.10) that $R(F(u^f), B(u^b)) > (1 - \delta)$ must hold in any deterministic steady state Consequently, in a bubbleless deterministic steady state with a positive fundamental value, the real interest rate has to be larger than $(1 - \delta)$, i.e. $R(F(u^f)) > (1 - \delta)$.

Case 3: Pure Bubble World ($\xi = F(u^f) = 0, B(u^b) > 0$)
In a pure bubble world, the model collapses to the economy in Galí [2014]. If $u^b = 0$ and $\xi = f(0) = 0$, the deterministic steady state interest rate is given by $R(0, B(0)) = 1$, the interest rate corresponding to the upper bound of the unstable steady state bubble size. Note if $u^b > 0$ and $\xi = F(u^f) = 0$, it follows from (1.13) that $R(B(u^b)) < 1$.

[29] In the deterministic steady state, the definition of the fundamental price (1.10) becomes $q_t^F \equiv F + u^f = \frac{\xi(W-F-B)}{(1+\xi)(R-(1-\delta))}$. Hence, for the price of the fundamental component to be positive, it must hold $R(F(u^f), B(u^b)) > (1 - \delta)$.

Bubble size and the size of the Fundamental

Using the *deterministic version* of the Euler equation (1.5) and the definition of the real interest rate (1.2), I can write

$$R_t = \frac{(1-W) + \xi^k + F_{t+1} + B_{t+1}}{\gamma(W - F_t - B_t)} \tag{1.39}$$

Using (1.39), the affordability constraint (1.38), and the conditions on the real interest rate derived above (*cases 1-3*), it can be shown that the bubble size and the size of the fundamental are given by

Case 1: Bubble World & positive Fundamental ($F(u^f) > 0, B(u^b) > 0$)

$$B \in \left(W - F - \frac{(1+\xi)}{1+(1-\delta)\gamma}, W - F - \frac{(1+\xi)}{1+\gamma}\right) \tag{1.40}$$

where $(1-\delta) < R < 1$.

Case 2: Bubbleless World ($F(u^f) > 0, B(u^b) = 0$)

$$F \in \left(W - \frac{1+\xi}{1+(1-\delta)\gamma}, W - \frac{(1+\xi)}{1+\gamma}\right) \tag{1.41}$$

where $(1-\delta) < R < 1$.

Case 3: Pure Bubble World ($\xi = F = 0, B(u^b) > 0$)

$$B \in \left(0, W - \frac{1}{(1+\gamma)}\right) \tag{1.42}$$

where $R \leq 1$.

Conditions on the U-Range for the Steady States

We determine the region of compatible U via the steady state expression of the real interest rate. The corresponding derivations can be found in the Appendix.

The continuum of bubbly deterministic steady states with a positive fundamental value (B, F) is described by:

$$\begin{cases} \exists \quad \text{two sets of steady states with} \quad R_1(U) \neq R_2(U) \quad \text{for } U \in]\underline{u}_{R_1}, \tilde{u_1}). \\ \exists \quad \text{one set of steady states with} \quad R_2(U) \quad \text{for } U \in (\underline{u}_{R_2}, \tilde{u_1}). \end{cases}$$

where

$$\underline{u}_{R_1} = \left(\frac{\xi^k + \delta\left[W(1+\gamma) - (1+\xi^k)\right] - W\gamma\delta^2}{\left[1+\gamma(1-\delta)\right](1-\delta)} \right) \qquad \underline{u}_{R_2} = \left(\frac{\xi^k}{1+\gamma} \right)$$

and

$$\tilde{u}_1 \equiv (\gamma + \xi) + (1+\gamma)(1-W) - 2\sqrt{\gamma(1-W)(1+\gamma+\xi)}$$

Proof: see appendix.

Figure (1.3) plots the two sets of steady states with $R_1(U) \neq R_2(U)$ for $U \in]\underline{u}_{R_1}, \tilde{u_1})$. Figure (1.4) plots one set of steady states with $R_2(U)$ for $U \in (\underline{u}_{R_2}, \tilde{u_1})$.

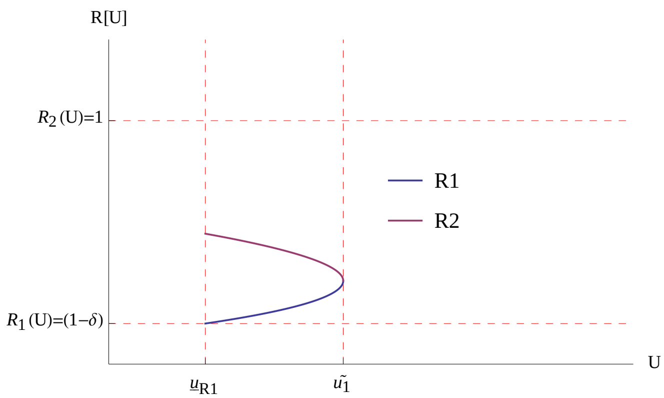

Figure 1.3: Set of Steady State interest rates $R_1(U)$, $R_2(U)$

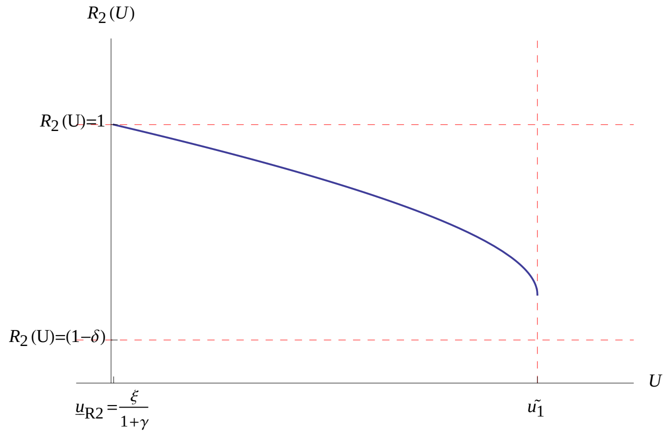

Figure 1.4: Set of Steady State interest rates $R_2(U)$

1.4 Comparative Statics

1.4.1 Impact of the Preference of Housing Services on Steady State Allocations

Figures (1.5)-(1.7) depict the impact of ξ^k, the aggregate preference for housing services of country k, on the set of stable steady state allocations for a given $U \in]\underline{U}, \bar{U})$.

A rise in ξ captures an increase in the preference for housing services relative to *all other* consumption goods when young. It follows that the relative price for housing services (the rental price) increases. This leads to an increase in the fundamental value of real estate, Q^F increases. The fundamental price Q^F is defined as the expected discounted stream of future rental prices. Figure (1.5) shows that the price of houses Q increases, while its bubble component Q^B decreases with the preference for housing services.

Figure (1.6) shows that the price-rent-ratio (PRR) decreases with the preference for housing services ξ. In Figure (1.5) we have seen that the bubble component of the house price Q^B decreases with ξ. In policy debates the PRR is often referred to as a good indicator for the detection of housing bubbles. Likewise in the model economy, a larger PRR indicates larger bubbles.

Figure (1.7) shows that an increase in ξ induces a decrease in all other consumption when young, C_1 decreases. Consumption when old C_2 increases, the larger the preference for housing services ξ.

This analysis of comparative statics implies that countries characterized by a lower aggregate preference for housing services (and hence a lower share of consumption spent on housing services) will experience larger housing bubbles (if any), all else equal. This model implication is investigated empirically in section 1.6.

In addition to the empirical evidence, I evaluate the theoretical model prediction by the means of a laboratory macro-experiment, where we can isolate and directly test the causal effect of the preference of housing services on the size of house price bubbles. We find strong support for the model's prediction. In the treatment where we induce a low preference for housing services, we consistently observe significantly larger house price bubbles. These results are robust to a wide range of robustness checks. The results of the lab-experiment are presented in Chapter 2.

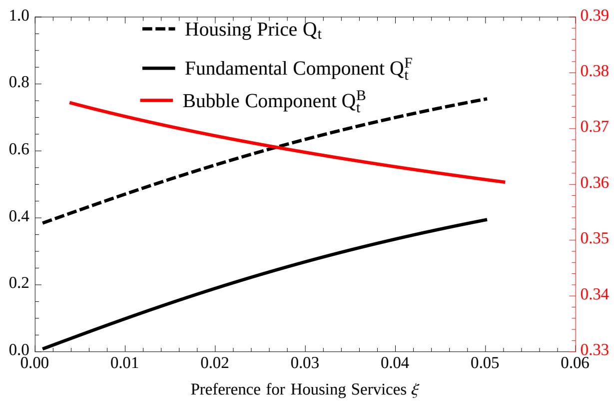

Figure 1.5: Comparative Statics - Price Components: Increase in ξ

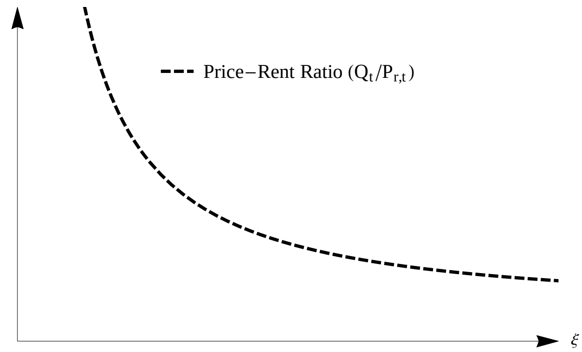

Figure 1.6: Comparative Statics - Price Rent Ratio: Increase in ξ

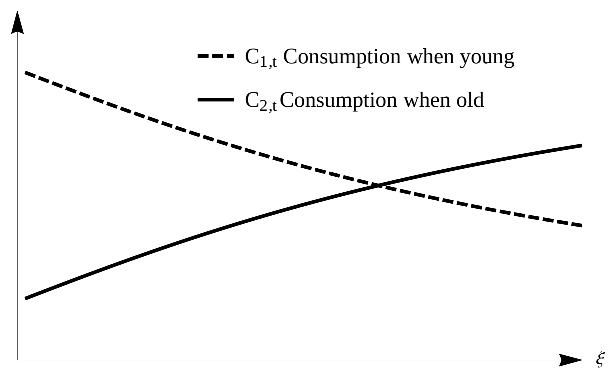

Figure 1.7: Comparative Statics - Consumption: Increase in ξ

1.5 Policy Analysis

Tools aiming to reduce and contain systemic risks are known as macro prudential policies. Many macroprudential tools focus on housing markets. The borrower based regulatory instruments that are most commonly discussed include loan-to-value, debt-service-to-income, and loan-debt-to-income ratios. This paper instead explores tax policies and analyzes their impact on economies' vulnerability to house price bubbles.[30] Many governments are concerned about the affordability of housing. This section discusses two different types of tax policy that both aim to foster the affordability of housing. I study the consequences of these different tax policies on housing bubble occurrence.

First, I study a subsidy fostering the demand for housing consumption (i.e. housing services). Second, I consider the implications of a subsidy promoting the demand for housing investment.

1.5.1 Rental Subsidies

A rental subsidy could be paid proportionally to the rental price or as a flat payment that is independent of the rental price.[31] The impact on bubble occurrence is investigated for a proportional subsidy that is financed by a lump-sum payment of the young.

In France, there is a housing subsidy in place that is proportional to the rental price.[32] The proportion of assisted households in France is large.[33] The subsidy incentivizes households to consume more housing services relative to other consumption goods. In France, the proportional subsidy

[30]According to Hartmann [2015] tax policies fall into the category of macro prudential policies as well.

[31]In the case of a flat payment (independent of the rental price), financed by a lump-sum payment by the young, the existence condition for bubble occurrence is not affected.

[32]In contrast to the United States, in France the rental subsidy is granted independent of the rent or type of house. In the United States, rental subsidy beneficiaries are not eligible for the subsidy if they pay a rent that is above a so-called *fair* market rent.

[33]51.6% of private sector tenants received a subsidy in 1996 (Laferrere and Blanc [2004]).

depends on households' characteristics and is given to the household by a transfer.[34]

Abstracting from the details of the French case, implementing a proportional rental subsidy leads to the following changes in the budget constraint when young:

$$C_{1,t} + \frac{Z_t}{P_t} + \sum_{k=0}^{\infty} q_{t|t-k} H_{t|t-k} + (1-\tau_s) p_t^r S_t \leq W_t + u_t - T_t$$

The government finances the rental subsidy by income taxation (lump-sum of the young), hence $T_t = \tau_w W_t$, leading to the following budget constraint of the government

$$\tau_s p_t^r S_t = \tau_w W_t$$

Does the proportional rental subsidy make the economy more or less prone to housing bubbles? Deriving the corresponding existence condition for housing bubbles yields:

$$W > \underset{+}{q^f(\tau_s)} + \left(\frac{1-\tau_s + \xi}{(1-\tau_s)\left[1+(1-\delta)\gamma\right]} \right) \tag{1.43}$$

where $\frac{\partial \left(\frac{1-\tau_s+\xi}{(1-\tau_s)[1+(1-\delta)\gamma]} \right)}{\partial \tau_s} > 0$ and $\frac{\partial q^f}{\partial \tau_s} > 0$. The larger τ_s, the tighter the existence condition. Hence, the smaller the set of possibilities that a positive bubble exists (that the existence condition is satisfied).

Implementing a proportional rental subsidy makes the economy less prone to housing bubbles. The intuition behind this result is as follows. The subsidy on housing consumption will induce a substitution away from other consumption goods towards housing services. This leads to a higher

[34] A few notes: First, there exists a ceiling for the rent above which the subsidy does not vary, we ignore the ceiling in this theoretical study. Second, I abstract from the fact that the subsidy depends on the geographical region (France is divided into four regions). For details on the computation of individual proportional rental subsidies in France refer to Laferrere and Blanc [2004].

relative price for housing services and therefore to a higher fundamental value of the housing asset in the economy. This has implications for the existence of bubbles and the bubble size. The larger the fundamental value, the less likely that a house price bubble arrives, and the smaller the maximum bubble size.

1.5.2 Help-to-Buy Scheme

The previous section has shown that a subsidy fostering the demand for housing consumption (i.e. housing services) is an effective tool to reduce the prevalence of housing bubbles. Next, I consider the implications of a subsidy that promotes the demand for housing investment. Such investment subsidies are found predominantly in English-speaking countries. The UK Government introduced a *Help-to-Buy* scheme. Help-to-Buy takes two forms: one part offers buyers the opportunity to take an interest-free loan from the government; the other sees the government acting as guarantor for some of a borrower's debt. Alongside Help-to-Buy there is also the newly launched *Help-to-Buy ISA*. The ISA is only available to first-time buyers, who will receive a tax-free bonus from the government to help such first-time buyers in buying a home. It is equivalent to a 25 per cent subsidy for first-time buyers on the savings to pay for the deposit.[35] In the United States, there are a number of Government schemes to increase the affordability of house purchases for first-time buyers. Also, favorable tax treatments are available for homeowners. To name a few, mortgage interest and property tax deductions.[36]

Abstracting from the details in the real world, implementing a proportional housing investment subsidy (financed by lump-sum of the young) leads to the following changes in the budget constraint when young:

$$C_{1,t} + \frac{Z_t}{P_t} + (1 - \tau_h) \sum_{k=0}^{\infty} q_{t|t-k} H_{t|t-k} + p_t^r S_t \leq (1 - \tau_w) W_t + u_t$$

[35] Refer to https://www.gov.uk/affordable-home-ownership-schemes/help-to-buy-isa

[36] Schwartz [2014] provides a detailed overview of the housing policy in the United States.

The budget constraint of the goverment becomes $\tau_h \sum_{k=0}^{\infty} q_{t|t-k} H_{t|t-k} = \tau_w W_t$.

Does the proportional help-to-buy subsidy make the economy more or less prone to housing bubbles? Deriving the corresponding existence condition for housing bubbles yields:

$$W > q^f(\underset{-}{\tau_h}) + \left(\frac{1+\xi}{1+(1-\delta)\gamma}\right) \tag{1.44}$$

where $\frac{\partial q^f}{\partial \tau_h} < 0$. The larger τ_h, the looser the existence condition. Hence, the larger the set of possibilities that a positive bubble exists (that the existence condition is satisfied). Implementing a help-to-buy subsidy makes the economy more prone to housing bubbles.

The mechanism behind the help-to-buy subsidy can be illustrated as follows. The subsidy for housing investment induces an inter-temporal substitution, away from consuming today towards investing for tomorrow. This leads to a higher real interest rate. The real interest rate has a direct impact on the housing price. The housing price consists of its fundamental component and a bubble component. The fundamental component decreases with the real interest rate, given that the fundamental value is defined by the net present value of the price for housing services. The bubble component of the housing price is growing with the interest rate. This is a common feature of OLG generation models with rational bubbles. Hence, implementing a help to buy scheme decreases the fundamental value of real estate in an economy and therefore creates more room for larger bubbles. Given the existence condition for bubbles, the economy also becomes more likely to experience a house price bubble in the first place.

1.6 Empirical Findings

This section is devoted to testing the model's main predictions empirically. Two main results have emerged from the analysis of the model. First, economies characterized by a smaller share of consumption spent for housing services, are those economies that allow for larger housing bubbles. Second, these economies are more vulnerable to housing bubbles in the first place.

This section provides an empirical characterization of housing cycles, bubbles and housing consumption using a large database covering 18 OECD countries during 1970-2014. Interestingly, I find large cross-country differences in both, housing consumption (i.e. housing services), and in the number of house price bubbles that have occurred during 1970-2014. The number of house price bubbles is interpreted as a measure of the vulnerability of an economy to housing bubbles.

Second, the interaction between housing consumption and house price bubbles is investigated.[37] In line with the model's predictions, two novel empirical regularities are identified across countries: housing consumption is highly negatively correlated with (1) the *frequency* and (2) the *intensity* and *amplitude* of house price bubbles. Thus, countries with a lower share of consumption spent on housing services experienced not only more but also larger and more volatile house price bubbles during 1970-2014.

The remainder of this section is organized as follows: In section 1.6.1, I provide a very detailed explanation on how I measured housing cycles and bubbles for 18 OECD countries during 1970 to 2014. Housing bubbles are measured empirically with two indicators, independent housing

[37]Empirically, I proxy the consumption demand for housing by two indicators. First, using national CPI weights on housing services, this is a good measure for the relative importance of housing services in the total consumption basket. And second by household spending on housing services (% of disposable income). In my sample of 18 OECD countries, the national CPI weights on housing services vary from around 10.3% in Portugal to around 29% in Denmark. Both indicators include actual and imputed rents. Household spending on housing (% of disposable income) varies from 14% in Portugal to 30% in Denmark.

booms, and boom-bust cycles. Section 1.6.2 provides the corresponding descriptive statistics. And section 1.6.3 presents thenovel empirical cross-country regularities.[38]

1.6.1 Methodology

This section provides a detailed explanation of how housing cycles, house price booms and busts are identified in this paper. Defining and thus measuring a housing bubble proves to be more challenging. This section discusses my choice of independent housing booms and boom-bust cycles as potential indicators for housing bubbles.

Methodology: Identifying House Price Cycles

Housing cycles are identified with a method that falls into the category of *classical* approaches. Cycles are identified in the level of the reference variable.[39] An alternative concept of measuring housing cycles is that of growth cycles, fluctuations in economic activity around a long-run trend. For this study, the classical approach is more suitable in order to achieve the desired objectives - as it offers the following advantages: (1) turning points are robust to the inclusion of newly available data, in contrast to methods that require detrending (where the inclusion of new data can affect the estimated trend and hence the identification of a cycle); and most importantly (2) detrending involves an arbitrary distinction between trend and cycle, where there is no clear consensus on the best method for this distinction[40], and (3) turning point analysis does not require a pre-specified frequency range at which the house price cycle is assumed to

[38] Appendix B provides a description of the data used for this part of the analysis.

[39] Cycles are identified by changes in the level of economic activity and hence describe absolute increases and declines.

[40] See King et al. [1991] among others. The identification of cycles does clearly depend on the detrending method (parametric assumptions) chosen. As a result, key growth cycle characteristics depend on the detrending method employed, see Canova [1998].

operate.[41] Since this paper predominately aims to uncover novel cross-country empirical regularities between house price fluctuations and housing services, I want to avoid restrictive parametric assumptions and chose to look at cycles in the level of real house prices.

Harding and Pagan [2002]'s BBQ algorithm is used to detect turning points in quarterly house price data.[42] This algorithm belongs to the strand of pattern-recognition methods pioneered by Burns and Mitchell [1946] in their work on business cycles for the National Bureau of Economic Research (NBER), and later formalized by Bry and Boschan [1971]. The dating procedure consists in finding a series of local maxima and minima that allow a segmentation of the series into expansions and contractions. In order to date housing cycles, this procedure was employed among others by Bordo and Landon-Lane [2014], Bracke [2013], Igan and Loungani [2012], Claessens et al. [2012], Claessens et al. [2011], Andre [2010], Girouard et al. [2006] and Borio and McGuire [2004]. Pagan and Sossounov [2003] meanwhile applied this method to identify bulls and bear markets in stock prices.

As well illustrated in Bracke [2013], the algorithm requires the implementation of the following three steps on a quarterly series:

1. Identification rule. Identification of points which are higher or lower than a window of surrounding observations. Using a window of j quarters on each side, a local maximum q_t^{max} is defined as an observation of the house price series such that $(q_{t-j}, ..., q_{t-1}) < q_t^{max} > (q_{t+1}, ..., q_{t+j})$. Symmetrically, a local minimum q_t^{min} satisfies $(q_{t-j}, ..., q_{t-1}) > q_t^{min} < (q_{t+1}, ..., q_{t+j})$.

2. Alternation rule. A local maximum must be followed by a local minimum, and vice versa. In the case of two consecutive maxima

[41]Growth cycles require this pre-specified frequency range and are therefore not suited for the analysis and comparison of empirical regularities across countries, as research has shown that characteristics of financial cycles (e.g. duration) are indeed very different across countries, see Hiebert et al. [2015].

[42]Following Bracke [2013] "The algorithm is denominated BBQ because it is a quarterly (Q) application of the Bry and Boschan [1971] algorithm designed to find business cycles in monthly data."

(minima), the highest (lowest) q_t is chosen.

3. Censoring rule. The distance between two turning points has to be at least x quarters, where x is chosen by the analyst in order to retrieve only the significant series movements and avoid some of the series noise.[43]

As housing cycles are longer than GDP cycles, the threshold parameter for the identification and censoring rule should be set higher to avoid spurious cycles. For housing cycles, Borio and McGuire [2004] suggest a rolling window of 13 quarters to be appropriate, which implies $j = 6$. For the censoring rule, I follow Girouard et al. [2006]. The distance between two turning points has to be at least six quarters, i.e. $x = 6$.[44] The decisions over the length of the rolling window (j) and the minimum phase duration (q) correspond to the choices made by Bracke [2013].

Methodology: Identifying Housing Bubbles

There is no clean or accepted definition of the term asset price bubble in the literature. Researchers often focus on a single specific aspect of a vague concept: rapid and substantial price increases[45], unrealistic expectations of future price increases[46], the departure of prices from fundamentals[47], or large drops in prices after the bubble pops[48].

The empirical literature measuring housing bubbles can be decomposed into two main strands. Firstly, the *fundamental analysis* tries to explicitly measure the departure of the housing price from fundamental values that are inferred from the residual of an error-correction framework with real house prices regressed on fundamental variables.[49] The

[43] Harding and Pagan [2002] choose $x = 2$ for U.S. GDP.

[44] It follows that a housing cycle has a minimum duration of 3 years.

[45] Baker [2002].

[46] Case and Shiller [2003].

[47] Garber [2000] and Lansing [2006].

[48] Siegel [2003], p.3.

[49] Theoretically, researchers would need to quantify the unobserved expected future values of fundamentals on which the fundamental asset price depends.

selection of variables that are seen as fundamental to housing prices is subjective and varies significantly across studies.[50] The selection of fundamental variables is crucial when measuring housing bubbles with this approach. This is very problematic, and I will therefore not follow this route.[51]

The second strand of literature that identifies housing bubbles empirically uses the *technical analysis*, which has a strong descriptive character. This method is intuitive and has the important advantage that fundamental factors do not need to be chosen. Researchers simply need to have data on the evolution of housing prices to identify housing bubbles. According to this method, a necessary feature of a housing bubble is a ”dramatic price increase”, the literature calls this phenomenon an asset price boom.[52] An obvious criticism follows from the fact that a rapid price increase could also result from a pure change in fundamentals.[53] Given this criticism, researchers extended the concept to boom-bust cycles, i.e. a rapid price increase has to be directly followed by a dramatic bust.[54] However, for the identification of a housing bubble, many researchers do not require booms to be followed by busts. Allowing booms to be disconnected from busts is appropriate from a theoretical perspective as well, as bubbles do not need to burst. Despite the debates concerning the measurement of

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[50]Examples for fundamental variables included in empirical studies are (1) short-run factors like current real GDP per capita, construction costs, the real interest rate, investment demand, (2) long run factors like population and economic growth and (3) institutional factors as the supply of land, taxes, financial deregulations (...).

[51]The selection of fundamental factors will determine the unexplained residual of the regression and hence the bubble size.

[52]Detken and Smets [2004], pp.9. However, it should be noted that from a theoretical perspective, bubbles do not have to involve rising prices in the past.

[53]Case and Shiller [2003]: ”The mere fact of rapid price increases is not itself conclusive evidence of a bubble.” Helbling [2005]: ”However, large price increases - which will be referred to as booms - are only a sufficient but not a necessary condition for bubbles.”

[54]Following Garber [2000] the general criticism also applies to the boom-bust cycle, it is still just ”an empirical statement about the pattern of prices.” This aspect is also highlighted by Haines and Rosen [2007] : ”Thus, what appears to be a bubble in some markets might just be a reflection of normally high volatility in those markets”.

housing bubbles, there is a widespread consensus that many boom-bust cycles in housing prices were accompanied by financial instabilities and recessions. Moreover, it is widely accepted that recessions associated with house price busts are not only longer but at least twice as deep as *normal* recessions or recessions that are associated with other types of asset price busts.[55] This study will use both concepts to identify housing bubbles; independent booms, and boom-bust cycles.

In summary, the technical analysis can only provide indications for housing bubbles. Nevertheless, advantages of this method include that (1) it is clearly defined and economically intuitive concept, (2) it has a low requirement for information, and (3) it allows exact dating of housing bubbles. I conclude that its advantages outweigh its disadvantages - and I, therefore, choose to proceed using this method.

House Price Booms and Busts: An Indictor for Housing Bubbles

The identification of housing booms and busts requires two steps. The first step, the determination of housing price cycles, was described in detail in the previous section.[56] The second step, the identification of house price booms and busts, involves the choice of a cut-off value for a house price increase (decrease) to be considered as large enough to denote a boom (bust). Such a threshold for the identification of booms and busts is clearly rather arbitrary and varies across studies.[57] This analysis will, therefore, consider four different cut-off values, leading to four different

[55]Refer to e.g. Claessens et al. [2009], and Claessens et al. [2011], IMF [2003].

[56]The described dating procedure was employed among others by Bordo and Landon-Lane [2014], Bracke [2013], Igan and Loungani [2012], Claessens et al. [2011], Andre [2010], Girouard et al. [2006] and Borio and McGuire [2004].

[57]E.g. Girouard et al. [2006] identifies booms and busts episodes when a real house price change exceeds 15%. Claessens et al. [2011], Helbling [2005], IMF [2003] chose the quartile as cutoff value. Bordo and Landon-Lane [2014] define an upturn as a boom if the house price increase is at least 10% within 2 years. IMF [2009] choses a methodology similar to Bordo and Jeanne [2002] where turning points are not determined. Busts (booms) are defined as periods when the four-quarter trailing moving average of the annual growth rate of the housing price, in real terms, falls below (above) 5%, equivalent to an accumulated (decrease) increase of 20%.

bubble identification methods. A housing price boom (bust) is defined as an upturn (downturn) that is accompanied by at least a 10%, 15%, 20% or 80% price increase (decrease). The stylized facts presented in this study remain robust across these threshold options.[58]

Recall that independent booms are the first measure for housing bubbles. The second approach (boom-bust cycles) considers only those booms that are followed by busts. The empirical regularities are robust to both types of housing bubble measurements.

1.6.2 Descriptive Statistics: Housing Cycles, Booms and Busts, and Housing Services

This section provides descriptive statistics of the cross-country differences in the consumption of housing service. Second, this section provides a descriptive analysis of housing cycles, booms, and busts, that have occurred between 1970:1-2013:4 for 18 OECD countries in the sample. For the descriptive part of the housing cycles and bubble indicators, I focus on four main characteristics: (1) the *frequency*, (2) the *amplitude*, (3) the *duration*, and (4) the *intensity*. However, in the analysis that will follow, special emphasis is placed on the *frequency* and the *amplitude*. Frequency is measured by the number of completed up- and downturns (booms, busts) in the sample. Amplitude is measured by the change in real house prices from peak (trough) to trough (peak), expressed in %. Duration is measured in quarters. Intensity is a good proxy for the violence of an episode and is given by the amplitude divided by duration.

A comprehensive summary of all real house price peaks and troughs for all OECD countries is given in Table (1.11) in the appendix. For each housing up- and downturn in the sample, the four characteristics (frequency, amplitude, duration, and intensity) are listed separately. Figure (1.10) plots the house price indices and shows the peaks and troughs for

[58]This two-step procedure does not require booms to be followed by busts, as these two events are determined independently. Bordo and Jeanne [2002] and Helbling [2005] among others also use a procedure whereby booms and busts are determined independently.

each country. The gray shaded areas show downturns (peak to trough) and the white areas symbolize upturns (trough to peak).

The structure of the dataset is such that it has an on-going upturn or downturn at the time of the last observation (2013q4). I will compute the statistics and analysis without those right-censored phases. Left-censored phases are excluded as well.[59]

House Price Cycles:
Table (1.1) gives an overview of the frequency, duration, amplitude and intensity of all up- and downturns in the sample. The dataset contains 55 completed downturns and 50 completed upturns.[60]

I find that housing cycles are on average 11.7 years long with notable dispersions across countries.[61] Table (1.1) shows that on average, upturns last longer and display more duration variability (measured by the standard deviation) than downturns.

The amplitude of upturns is larger on average and displays a much larger variability than the amplitude of downturns. These findings are in line with e.g. Claessens et al. [2011], Drehmann et al. [2012], Igan and Loungani [2012] and Bracke [2013]. This related literature does not consider the intensity measure. The intensity and its variability (measured by the standard deviation) of housing cycles are considerably larger for upturns than for downturns. In summary and on average, upturns are larger, longer, more violent and more volatile than downturns.

[59]Phases for which the starting date precedes 1970q1 and is unknown.

[60]The dataset contains additionally 7 right-censored downturns and 10 right-censored upturns. Including these, does not alter the statistics much. The average upturns are slightly shorter and larger. While downturns become slightly shorter and are of smaller magnitude (on average).

[61]The average housing cycle length is in line with e.g. Schueler et al. [2015], Bracke [2013] and Drehmann et al. [2012]. Bracke [2013] finds that the average house price cycle lasts 10.6 years, while Drehmann et al. [2012] finds an average duration of 10.5 years. Schueler et al. [2015] find an average financial cycle length of 12 years, using 13 European countries, a time period spanning over 1970-2013, and a novel spectral approach to identify financial cycles.

House Price Booms and Busts

Table (1.2) provides descriptive statistics for independent house price booms and boom-bust cycles. House price booms that are followed by a bust are on average shorter than upturns, while independent house price booms tend to be longer than upturns. Since independent house price booms last longer than booms that are followed by busts, it is not surprising that the amplitude of independent booms is larger than the amplitude of booms that are followed by busts.

Interestingly, the intensity of booms that are followed by busts (measured by amplitude divided by duration) is larger than the intensity of independent booms. This reinforces the point that the intensity of house price increases might inherit more valuable information on future house price busts compared to the amplitude of house price increases.[62] This intensity measure of house price booms is not yet widely used in the literature. However, policy makers might want to keep track of the intensity measure as a warning signal.

Table (1.3) gives a detailed overview on how many completed independent booms and boom-bust cycles each country experienced during 1970:1 to 2013:4.[63] While table (1.10) in the appendix provides the average amplitude (and the standard deviation) of all individual house price booms and boom-bust cycles for each country seperately.

The cross-country variation in the number of house price booms (as well as the cross-country variation in the average amplitude) is substantial.

[62] How many booms end in a bust? I find that 80.9% $(74.4\%, 69.2\%, 25\%)$ of all booms that involve at least a 10% $(15\%, 20\%, 80\%)$ price increase are followed by a bust.

[63] The corresponding table listing for each country the number of completed *and* ongoing housing booms and boom-bust cycles is shown in the Appendix, table (1.9).

	Frequency	**Duration**		**Amplitude**		**Intensity**	
	Number	Mean	StDev	Mean	StDev	Mean	StDev
Completed upturns	50	27.89	20.14	72.54	49.18	2.30	1.22
Completed downturns	55	19.08	6.62	-22.96	10.62	1.25	0.55

Frequency is measured by the number of quarters from peak (trough) to trough (peak). Amplitude measured by real house prices $\%-$change from peak (trough) to trough (peak). Duration is measured in quarters from peak (trough) to trough (peak). Intensity is obtained by $I_i = \frac{Amplitude_i}{Duration_i}$. 18 OECD countries.

Table 1.1: Descriptive Statistics of Housing Cycles

	Upturns	**Booms**				**Boom-Buster**		
		$> 10\%$	$> 15\%$	$> 20\%$	$> 80\%$	$> 10\%$	$> 15\%$	$> 20\%$
F	50	47	39	39	12	38	29	27
A	72.5	75.9	85.1	85.1	146.8	53.5	61.2	63.28
D	27.9	32.3	33.9	33.9	48.4	20.7	20.7	20.4
I	2.3	2.4	2.8	2.8	3.1	2.6	3.0	3.1

F stands for the number of upturns, independent booms and boom-busters. A for the amplitude, D for duration and I for intensity. Frequency is measured by the number of quarters from peak (trough) to trough (peak). Amplitude measured by real house prices $\%-$change from peak (trough) to trough (peak). Duration is measured in quarters from peak (trough) to trough (peak). Intensity is obtained by $I_i = \frac{Amplitude_i}{Duration_i}$. 18 OECD countries.

Table 1.2: Descriptive Statistics of Housing Booms

	Independent Booms				Boom-Bust Cycles			
	$> 10\%$	$> 15\%$	$> 20\%$	$> 80\%$	$> 10\%$	$> 15\%$	$> 20\%$	$> 80\%$
Australia	4	3	3	0	3	2	2	0
Belgium	2	2	2	1	1	1	1	0
Canada	1	1	1	0	1	1	1	0
Denmark	3	2	2	1	3	2	2	1
Finland	6	5	5	0	5	4	3	0
France	2	2	2	1	2	2	2	0
Germany	2	0	0	0	2	0	0	0
Ireland	3	3	3	1	1	1	1	0
Italy	3	3	3	1	2	2	2	1
Japan	1	1	1	1	0	0	0	0
Netherlands	1	1	1	1	0	0	0	0
New Zealand	5	4	4	1	5	3	2	0
Norway	2	1	1	0	2	1	1	0
Spain	3	3	3	2	2	2	2	0
Sweden	2	2	2	0	2	2	2	0
Switzerland	1	1	1	0	1	1	1	0
United Kingdom	3	3	3	2	3	3	3	1
United States	3	2	2	0	3	2	2	0
SUM	47	39	39	12	38	29	27	3

Table 1.3: Number of completed Housing Booms and Busts per country

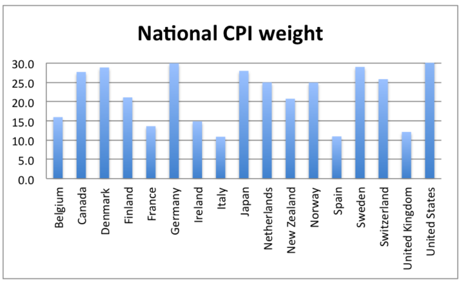
The Preference for Housing Services

In the model, the preference for housing services implies the share of consumption spent on housing services as an equilibrium outcome. Empirically, housing services constitute a large fraction of total consumption. I use two indicators to measure the preference for housing services empirically. The first indicator is the *national consumer price index (CPI) weight* on housing services. This indicator is a good measure for the relative importance of housing services in the total consumption basket. The CPI weight on housing services varies from 11% in Spain to 29% in Denmark.[64] As a second indicator, I use *spending on housing services as %*

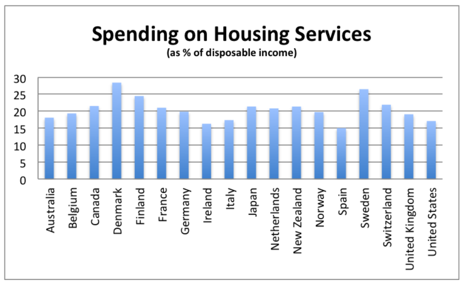
[64]The indicator includes (Housing, Electricity, Gas and other Fuels). Annual frequency over time period 1992 to 2013 for 17 countries. Measured as per thousand of National CPI total. Source: OECD.stat.

of disposable income.[65] This measure varies from 15% in Spain to 28% in Denmark. The variation of both indicators across countries is large and is shown in Figure (1.8). The cross-country differences in expenditure shares spent on housing services are not only large but also persistent over time.[66]

Importantly, both indicators include imputed rents. What are imputed rents? Homeowners do not pay for the consumption of housing services the owned dwelling provides. The imputed rents of these housing services are valued at the estimated rent that a tenant pays for a dwelling of the same size and quality in a comparable location with similar neighborhood amenities.[67] In the model, I do not distinguish between homeowners and renters. Therefore the expenditure shares spent on housing services includes imputed and actual rents. Hence, it is important that the empirical indicators for the preference for housing services include imputed and actual rents as well.



(a) CPI weight on housing services



(b) Fraction of disposable income

Figure 1.8: Indicators for the Preference for Housing Services

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[65]Point estimates for the years 1995 and 2005 for 18 OECD countries available. Source: OECD Outlook No. 86 and OECD National Accounts.

[66]Appendix B, figure (1.9). Appendix B also provides information on the data sources.

[67]When markets for rented accommodation are virtually non-existent or unrepresentative, the value of imputed rents is derived by some other objective procedure such as the user-cost method. Refer to the OECD glossary of statistical terms, imputed rents.

1.6.3 Empirical Cross-Country Regularities

This paper highlights two novel empirical regularities identified across countries: First, the consumption of housing services is highly and negatively correlated with the number of independent house price booms and the number of boom-bust cycles. For instance, the number of completed independent house price booms (boom-bust cycles) that are associated with at least a 80% price increase, displays a cross-country correlation with the share of consumption spent on housing services of -0.72 (-0.30).[68]

Second, I find that the consumption of housing services is highly and negatively correlated with the amplitude and especially with the intensity of independent house price booms and boom-bust cycles across countries.[69]

Thus, countries with a lower share of consumption spent on housing services experienced not only more frequent but also larger and more violent independent house price booms as well as boom-bust cycles. And therefore potentially more frequent, larger and more violent house price bubbles during 1970 to 2014.[70]

The Frequency of Housing Bubbles

In this section, I analyze the cross-country relationship between housing services and the frequency of house price bubble occurrence during 1970-2014. I find that the share of consumption spent on housing services is highly and negatively correlated with the number of independent house price booms and the number of boom-bust cycles. Table (1.4) presents these cross-country correlations.

OLS regressions show that housing services inherit a high explanatory power for the frequency of independent house price booms, see regression

[68] Please refer to table (1.4).

[69] Please refer to table (1.7).

[70] The results shown in this section use the national CPI weight on housing services as a proxy for the preference for housing services. The corresponding results using the fraction of disposable income spent on housing services are available upon request.

table (1.5). How important is the impact of housing services quantitatively? An increase in the level of the CPI weight on housing services by one standard deviation (across countries) is associated with a decrease in the average number of independent booms (associated with a price increase of at least 20%) by 0.66 which accounts for 52% of the variation of the number of such independent house price booms across countries.[71] This is remarkable.

Adding more control variables to the regression does not alter the results - countries with a lower consumption share spent on housing services experienced more frequent independent house price booms and boom-bust cycles. Table (1.6) illustrates the regression results including measures for cross-country differences in the taxation of properties, transaction costs, the percentage of the population living in urban areas and the typical loan-to-value (LTV) ratio. For very large independent house price booms (associated with a price increase of at least 80%), the controls transaction costs, the percentage of the population living in urban areas and the LTV ratio are statistically significant. As expected, countries with lower transaction costs, higher urban density, and easier access to credit (higher LTV ratios), experienced more frequent independent house price booms during 1970-2014. However and in comparison, the explanatory variable housing services is not only the most significant regressor, but the quantitative impact is also largest.[72]

In summary and in line with the theoretical model's prediction, cross-country differences in housing services pick up a large part of the cross-country variation in house price bubble occurrence over the time period 1970-2014.

[71] The increase in the level of the CPI weight on housing services by one standard deviation (across countries) is associated with a decrease in the average number of booms (associated with a price increase of at least 80%) by 0.50 which accounts for 72% of the variation of the number of booms per country. The regression results for independent housing booms defined by a different threshold are very similar. The results are henceforth robust to various housing bubble identification rules.

[72] An alternative set of control variables is used to account for cross-country differences in mortgage markets and institutions, unemployment and income. Table (1.12) provides the regression results in the appendix.

Number of Booms (price rise larger)	CPI weight (on housing services)	Number of Boom-Busters (price rise larger)	CPI weight (on housing services)
$> 80\%$	-0.72	$> 80\%$	-0.30
$> 20\%$	-0.52	$> 20\%$	-0.37
$> 15\%$	-0.52	$> 15\%$	-0.31
$> 10\%$	-0.26	$> 10\%$	-0.06

Table 1.4: Cross-country correlations - CPI weight on housing services and number of Booms (Boom-Busters)

Dependent variable: Number of independent Booms				
	$> 80\%$	$> 20\%$	$> 15\%$	$> 10\%$
	(1)	(2)	(3)	(4)
CPI weight	-0.0636****	-0.0854***	-0.0854***	-0.0469*
(on housing services)	(-4.30)	(-3.43)	(-3.43)	(-1.83)
Constant	2.111****	4.006****	4.006****	3.567****
	(5.98)	(7.33)	(7.33)	(5.92)
N	17	17	17	17
R^2	0.515	0.272	0.272	0.070
adj. R^2	0.483	0.223	0.223	0.008

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$. Booms denoted by $> x\%$ involve real house price changes (trough to peak) larger than $x\%$.

Table 1.5: OLS - Number of independent Housing Booms

	Booms				Boom-Busts	
	$> 80\%$	$> 20\%$	$> 15\%$	$> 10\%$	$> 20\%$	$> 15\%$
	(1)	(2)	(3)	(4)	(5)	(6)
CPI weight	-0.0898****	-0.131***	-0.131***	-0.0918*	-0.0698*	-0.0940*
	(-6.50)	(-3.59)	(-3.59)	(-1.82)	(-1.82)	(-2.08)
typical LTV	0.0183*	0.0383	0.0383	0.0188	0.0104	0.0303
	(1.97)	(1.13)	(1.13)	(0.50)	(0.50)	(0.98)
Urban population	0.00882*	-0.0234	-0.0234	-0.0211	-0.0224*	-0.0268
	(2.12)	(-1.33)	(-1.33)	(-1.10)	(-1.85)	(-1.73)
Transaction cost	-0.0747**	-0.0517	-0.0517	-0.101	-0.0257	-0.0568
	(-2.21)	(-0.64)	(-0.64)	(-1.11)	(-0.35)	(-0.74)
Property tax	0.0331	0.0364	0.0364	-0.0472	0.0746	0.0673
	(1.16)	(0.39)	(0.39)	(-0.39)	(1.01)	(0.81)
Constant	1.286*	3.434*	3.434*	5.208**	3.016	2.747
	(1.98)	(1.80)	(1.80)	(2.29)	(1.41)	(1.22)
N	17	17	17	17	17	17
R^2	0.779	0.432	0.432	0.259	0.368	0.310
adj. R^2	0.678	0.174	0.174	-0.077	0.080	-0.004

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$. Booms denoted by $> x\%$ are those booms that involve real house price changes (trough to peak) larger than $x\%$. The variable of interest is the *national consumer price index (CPI) weight* on housing services. This indicator is a good measure for the relative importance of housing services in the total consumption basket. *Urban Pop*: % of national population living in urban regions, 2012. *Typical LTV* for 1992 and 2002, taken from Calza et al. [2013], Catte et al. [2004]. *Transcation costs* measured as a percentage of property value, 2009. It includes notary fees, typical real estate agent fees, legal fees, registration fees, and transfer taxes. *Property tax*, (%) of GDP. Defined as recurrent and non-recurrent taxes on the use, ownership or transfer of property. These include taxes on immovable property or net wealth, taxes on the change of ownership of property through inheritance or gift and taxes on financial and capital transactions. This indicator relates to government as a whole (all government levels) and is measured in percentage of total taxation. Macro variables: averages 1970-2013, if not noted otherwise.

Table 1.6: OLS - Number of independent Booms and Boom-Bust Cycles

The Amplitude, Intensity, and Duration of House Price Bubbles

In this section, I analyze the relationship between housing services and house price bubble characteristics, such as the amplitude, intensity, and duration of house price booms and busts. Table (1.7) illustrates the cross-country correlations between these bubble characteristics and the preference for housing services (measured by the CPI weight on housing services).

I find that the cross-country correlations are negative for the amplitude and exceptionally large (and negative) for the intensity of house price bubbles. Countries with a lower CPI share on housing services experienced larger independent housing booms as well as boom-bust cycles. Further, these independent booms and boom-bust cycles have been shorter, the amplitude of the price increase (decrease) has been reached faster in these countries. It follows that these countries lived larger and more violent independent house price booms and boom-bust cycles.[73]

For the regression analysis, I include measures for cross-country differences in the taxation of properties, transaction costs, the percentage of the population living in urban areas and the typical loan-to-value (LTV) ratio. To account for cross-country differences in income, I include GDP per capita. The fraction of the population in the working age is also included as an additional measure of housing demand. The OLS regression analysis shows that our proxy for the preference for housing services (CPI weight on housing services) has a substantial and significant explanatory power for both the intensity and amplitude of moderate independent housing booms and boom-bust cycles that involve a price increase of at least 10%. In line with the empirical literature, the larger the LTV ratio, the

[73] For policy makers, the intensity (violence) of housing bubbles might be more important than the amplitude, as the impact of a housing boom (bust) on the macroeconomy will depend on the speed of the price increase (decrease). A smooth build up (drop) in house prices can be managed by macro-prudential policy makers - as this will provide time to put policies in place to mitigate risks to the real economy. More violent booms (busts) are more dangerous - as policymakers have less time to effectively mitigate risks, and it is, therefore, more likely that risks spillover from the housing market into the financial sector and into the rest of the economy.

larger the independent booms. Interestingly, the LTV ratio has no explanatory power for the intensity of booms nor boom-bust cycles. Table (1.8) shows the regression output.

How large is the impact of the preference for housing services on the amplitude of housing bubbles? An increase in the CPI weight on housing services by one standard deviation (across countries) is associated with a decrease in the amplitude of independent booms ($> 10\%$) by 27.98, which accounts for 58 percent of the cross-country variation in the amplitude of such booms. This impact is remarkable.

How large is the impact on the intensity? An increase in the CPI by one standard deviation (across countries) is associated with a decrease in the intensity of independent booms ($> 10\%$) by 0.94, which accounts for 99 percent of the cross-country variation in the intensity of such booms.[74] The impact is very large.

In summary, cross-country differences in housing services pick up a large part of the cross-country variation in the amplitude and intensity of house price bubbles that have occurred during the time period 1970-2013. This is in line with the theoretical model's prediction.

[74] An increase in the CPI by one standard deviation (across countries) is associated with a decrease in the intensity of boom-bust cycles ($> 10\%$) by 1.08, which accounts for 95 percent of the cross-country variation in the intensity of such boom-bust cycles.

	Amplitude	Intensity	Duration
Independent Booms			
Boom ($> 10\%$)	-0.34	-0.51	0.02
Boom ($> 15\%$)	-0.20	-0.28	0.10
Boom ($> 20\%$)	-0.20	-0.28	0.10
Boom ($> 80\%$)	0.06	-0.53	0.50
Boom Phase of Boom-Buster			
Boom-Bust ($> 10\%$)	-0.44	-0.50	0.10
Boom-Bust ($> 15\%$)	-0.11	-0.28	0.10
Boom-Bust ($> 20\%$)	-0.11	-0.25	0.16
Bust Phase of Boom-Buster			
Boom-Bust ($> 10\%$)	0.03	-0.43	0.28
Boom-Bust ($> 15\%$)	-0.14	-0.38	0.30
Boom-Bust ($> 20\%$)	0.03	-0.41	0.30

Booms denoted by $> x\%$ are those booms that involve real house price changes (trough to peak) larger than $x\%$. To qualify for a boom-buster of $> x\%$, the amplitude of the boom (trough to peak) has to be larger than $x\%$, the treshold for qualifying as a subsequent bust is chosen such that the bust falls into the same percentile than the booms that have larger price increases than $> x\%$. Amplitude is measured by the change in real house prices from peak (trough) to trough (peak), expressed in $\%$. Duration is measured in quarters. Intensity is is a good proxy for the violence of an episode and is given by the amplitude divided by duration. Intensity is measured from through (peak) to peak (through) by $I_i = \frac{amplitude_i}{duration_i}$.

Table 1.7: Correlations: Amplitude, Intensity, Duration of Bubbles indicators with CPI weight on housing services

	Amplitude		Intensity	
	indep. Boom	Boom-Buster	indep. Boom	Boom-Buster
	(1)	(2)	(3)	(4)
CPI weight	-3.613**	-0.941	-0.121***	-0.140***
(of housing services)	(-2.47)	(-0.78)	(-4.10)	(-3.92)
Urban population	1.088**	-0.381	-0.00804	-0.00730
	(2.31)	(-0.88)	(-1.06)	(-0.61)
Working population	13.73	1.081	0.747	1.296
	(0.68)	(0.08)	(1.40)	(1.76)
GDP (head, PPP)	-0.00364	0.000862	0.0000107	-0.0000324
	(-1.66)	(0.43)	(0.32)	(-0.53)
Property tax	1.498	1.206	-0.0134	-0.0157
	(0.46)	(0.34)	(-0.17)	(-0.17)
Transaction cost	-1.015	2.065	-0.0862	-0.127
	(-0.31)	(0.71)	(-1.10)	(-1.55)
Typical LTV	2.183**	-0.119	0.0320	0.0170
	(2.46)	(-0.11)	(1.72)	(0.63)
Constant	-22.00	49.66	0.314	1.073
	(-0.24)	(0.59)	(0.12)	(0.32)
N	17	15	17	15
R^2	0.733	0.309	0.602	0.726
adj. R^2	0.526	-0.383	0.293	0.453

t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *GDP* measure per head, constant prices, constant PPPs, OECD base year. *Urban Pop*: % of national population living in urban regions, 2012. *Working population* measured by the ratio working age (20-64) per pension age (+65). Typical LTV for 1992 and 2002, taken from Calza et al. [2013], Catte et al. [2004]. *Transcation costs* measured as a percentage of property value, 2009. It includes notary fees, typical real estate agent fees, legal fees, registration fees, and transfer taxes. *Property tax*, (%) of GDP. Defined as recurrent and non-recurrent taxes on the use, ownership or transfer of property. These include taxes on immovable property or net wealth, taxes on the change of ownership of property through inheritance or gift and taxes on financial and capital transactions. This indicator relates to government as a whole (all government levels) and is measured in percentage both of GDP and of total taxation. Macro variables: averages 1970-2013, if not noted otherwise.

Table 1.8: OLS - Amplitude and Intensity of Housing Booms including macro variables

1.7 Conclusion

Housing is very different to other assets given its duality - the consumption and investment demand for housing. Housing consumption constitutes a large fraction of total consumption and is measured by the consumption of housing services. However, the role housing consumption plays in generating housing bubbles was until now not explored in the literature.

The present paper should be viewed as part of an effort to enhance our understanding of the relation between housing consumption and housing bubbles. In particular, I tested the hypothesis that housing consumption drives economies' vulnerability to housing bubbles from three angles: a theoretical overlapping generation model, empirical data analysis, and with a laboratory experiment.

The first part of this paper explored the implications of housing consumption on house price bubbles through the lens of an OLG model. I disentangle the dual motives of housing demand by modeling the consumption aspect (consuming housing services) and investment aspect (investing in housing) independently. In the model, I assume cross-country differences in the preference for housing services relative to *all other* consumption goods. Assuming cross-country differences in the preference for housing is soundly justified by empirical evidence, as provided in my paper Huber and Schmidt [2017].[75]

Two main results emerged from the analysis of the model. First, if the demand for housing consumption is low, countries are more prone to housing bubbles. Second, these countries where housing consumption is low face larger and more volatile housing bubbles.

The second part of this paper evaluated the extent to which the model's predictions can be reconciled with empirical evidence. In line with the

[75] Huber and Schmidt [2017] study the impact of culture on living arrangements, using data on the tenure choice decision of second generation immigrants in the United States - holding constant institutional factors. We find that cultural housing preferences transmitted by parents play an important role in the housing tenure choice of these second generation immigrants.

model's predictions, novel empirical regularities are identified across countries: countries spending a lower share of consumption on housing services experienced more frequent housing bubbles during 1970-2014. These bubbles have been larger and more volatile.

The companion paper Huber et al. [2017] complements the empirical analysis with the evaluation of the OLG model's predictions using a laboratory macro experiment. In contrast to the empirical analysis, this technique allows to isolate and directly test the causal effect of the preference for housing services on house price bubbles. The empirical work proxies these preferences by the expenditure share of housing consumption - an equilibrium outcome of the OLG model. Further, the experimental setup allows quantifying housing bubbles without measurement error. The results of the macro experiment provide strong support for the model's predictions. In the treatment where we induce a weak preference for housing services, we consistently observe significantly larger house price bubbles.

Finally, the model was used to study the impact of two prominent alternative policies aimed at fostering the affordability of housing - *rental subsidies* and *help-to-buy schemes*. I found that a proportional rental subsidy is an effective tool to control housing bubbles, while the help-to-buy scheme makes the economy more prone to housing bubbles. The results arising from the model should not be used unadulterated as the basis for designing housing policy in the real world, as certain elements of the policy-making balancing act are not directly considered in the analysis. In particular, the model above abstracts from distributional consequences, hence inequality concerns. Nonetheless, the undertaken policy analysis may provide some relevant insight on the relative merits of alternative policies for enhancing house-affordability from the perspective of their different consequences for the vulnerability of the economy to housing bubbles.

More generally, the paper should be viewed as an effort to enhance our understanding of the relationship between housing consumption and rational house price bubbles. This topic has been underexplored to this point. For policy makers, this paper provides a new perspective on how to reduce the economy's vulnerability to house price bubbles. Vulnerability to house price bubbles can potentially be reduced by incentivising households to increase their housing consumption (housing services) relative to other consumption goods. Such an increase in housing consumption could be achieved in various ways. For example, the government could subsidize the renovation of owner-occupied dwellings or provide incentives to landlords to improve the quality of their properties.[76] These interventions would increase the amount of housing services provided by one unit of housing stock.[77] Alternatively, governments could seek to impose reforms to improve the efficiency of housing service production - thereby resulting in more housing services being provided to the economy per unit of housing stock.[78]

[76]Germany provides examples of such subsidies. Subsidies are given to homeowners that improve the quality of their dwelling, e.g. improvements of insolation. Renovation of dwellings that have been originally built before the Second World War is also subsidized. Landlords that improve the quality of their real estate can subtract all costs from their income subject to taxation.

[77]In the model, this could be captured by an increase in the parameter ξ.

[78]In the model, a unit of housing stock S provides housing services $\xi u(S)$. The relative preference parameter ξ can also be interpreted as an efficiency parameter in transforming housing stock into housing services. A proxy for many things, e.g. the ability of the legal framework to enforce and hence promote rental contracts.

1.8 Appendix A: Model Derivations

1.8.1 Lagrangian and First Order Conditions (FOCs)

$$\max_{C_{1,t},C_{2,t+1}H_t,S_t} \left\{ \begin{array}{l} u(C_{1,t}) + \xi v(S_t) + \gamma E_t\{log(C_{2,t+1})\} \\ -\lambda_t \left(C_{1,t} + \frac{Z_t}{P_t} + \sum_{k=0}^{\infty} q_{t|t-k} H_{t|t-k} + p_t^r S_t - W_t - \delta q_{t|t} \right) \\ -\phi_t \left(E_t\{C_{2,t+1}\} - \frac{(1+i_t)Z_t}{E_t\{P_{t+1}\}} - \sum_{k=0}^{\infty} E_t \left\{ \left(p_{t+1}^r + (1-\delta) q_{t+1|t-k} \right) H_{t|t-k} - D_{t+1} \right\} \right) \\ +\mu_t C_{1,t} \\ +\gamma_t C_{2,t+1} \\ +\kappa_t H_t \\ +\varphi_t S_t \\ +\psi_t Z_t \end{array} \right\}$$

The households first order conditions (FOCs) and complementary slackness conditions (CSCs) are given by

$$C_{1,t}: \quad u'(C_{1,t}) - \lambda_t + \mu_t = 0 \tag{A1}$$
$$\text{with} \quad \mu_t, C_{1,t} \geq 0 \quad \text{and} \quad \mu_t C_{1,t} = 0$$
$$C_{2,t+1}: \quad \gamma E_t\{u'(C_{2,t+1})\} - \phi_t + \gamma_t = 0 \tag{A2}$$
$$\text{with} \quad \gamma_t, C_{2,t+1} \geq 0 \quad \text{and} \quad \gamma_t C_{2,t+1} = 0$$
$$H_{t|t-k}: \quad -\lambda_t q_{t|t-k} + \phi_t(1-\delta)E_t\{q_{t+1|t-k}\} + \phi_t E_t\{p_{t+1}^r\} + \kappa_t = 0 \tag{A3}$$
$$\text{with} \quad \kappa_t, H_{t|t-k} \geq 0 \quad \text{and} \quad \kappa_t H_{t|t-k} = 0$$
$$S_t: \quad \xi v'(S_t) - \lambda_t p_t^r + \varphi_t = 0 \tag{A4}$$
$$\text{with} \quad \varphi_t, S_t \geq 0 \quad \text{and} \quad \varphi_t S_t = 0$$
$$Z_t: \quad -\frac{\lambda_t}{P_t} + \phi_t \frac{(1+i_t)}{E_t\{P_{t+1}\}} + \psi_t = 0$$
$$\Leftrightarrow \lambda_t = \phi_t(1+i_t)\frac{P_t}{E_t\{P_{t+1}\}} + \psi_t \tag{A5}$$
$$\text{with} \quad \psi_t, Z_t \geq 0 \quad \text{and} \quad \psi_t Z_t = 0$$

Note: I focus on the case where consumption is positive in both periods of life, i.e. $C_{1,t}, C_{2,t+1} > 0$, this is a realistic assumption as it is empirically motivated. One time period corresponds to around 35 years. Hence, $\mu_t = \gamma_t = 0$. Further I assume that the constraints on H_t, S_t, Z_t are not binding, i.e. $\kappa = \varphi_t = \psi_t = 0$.

1.8.2 Equilibrium Dynamics

In the deterministic case, where $U_t = U > 0$, and $B_t - E_{t-1}\{B_t\} = 0$, and $F_t - E_{t-1}\{F_t\} = 0$ for all t. The optimal price setting equation implies that $W_t = W = (1/\mathcal{M})$, and it follows from market clearing condition that $D_t = 1 - W$ for all t. Recall that:

$$C_{1,t} = \frac{1}{1+\xi}\left(W_t - F_t - B_t\right) \tag{A6}$$

$$p_t^r = \frac{\xi}{1+\xi}\left(W_t - F_t - B_t\right) \tag{A7}$$

$$\begin{aligned} C_{2,t} &= D_t + \frac{\xi}{(1+\xi)}W_t + \frac{1}{(1+\xi)}(F_t + B_t) \qquad \text{(A8)} \\ &= 1 - \frac{1}{(1+\xi)}\left(W_t - F_t - B_t\right) \end{aligned}$$

Using the Euler Equation and (A6) and (A8), we get

$$R_t = \frac{(1 - W_{t+1}) + \xi + F_{t+1} + B_{t+1}}{\gamma(W - F_t - B_t)} \equiv R(B_t, B_{t+1}, F_t, F_{t+1}) \tag{A9}$$

The latter must satisfy the deterministic version of the intertemporal optimality condition, which was given by:[79]

$$q_t \equiv F_t + B_t + U_t = \frac{p_{r,t+1} + B_{t+1} + F_{t+1}}{R_t} \tag{A10}$$

Plugging (A7) in the latter equation and solving for R_t gives

$$R_t = \frac{\xi W_{t+1} + F_{t+1} + B_{t+1}}{(1+\xi)(F_t + B_t + U_t)} \equiv R(B_t, B_{t+1}, F_t, F_{t+1}) \tag{A11}$$

Setting (A9) equal to (A11), and solving for F_{t+1} gives

$$F_{t+1}(B_t, B_{t+1}, F_t) = -\frac{\frac{B_{t+1}+\xi W}{(\xi+1)(B_t+F_t+U)} + \frac{B_{t+1}+\xi-W+1}{\gamma(B_t+F_t-W)}}{\frac{1}{(\xi+1)(B_t+F_t+U)} + \frac{1}{\gamma(B_t+F_t-W)}} \tag{A12}$$

[79] The deterministic version of the intertemporal optimality condition is given by $q_t \equiv F_t + B_t + U_t = \frac{p_{r,t+1}+(1-\delta)q_{t+1|t-k}}{R_t}$. Multiplying this equation by $\delta\sum_{k=0}^{\infty}(1-\delta)^k$ and recalling that $q_t = \delta\sum_{k=0}^{\infty}(1-\delta)^k q_{t|t-k}$ yields (A10).

Recall that the intertemporal optimality condition was given by:

$$q_{t|t-k} = \frac{p_{r,t+1}}{R_t} + \frac{(1-\delta)}{R_t} q_{t+1|t-k}$$

Solving forward gives

$$\begin{aligned} q_{t|t-k} &= \frac{p_{r,t+1}}{R_t} + \frac{(1-\delta)p_{r,t+2}}{R_t R_{t+1}} + \frac{(1-\delta)^2 p_{r,t+3}}{R_t R_{t+1} R_{t+2}} + (\ldots) \\ &= \underbrace{\sum_{k=1}^{\infty} \prod_{j=0}^{k-1} \frac{1}{R_{t+j}} (1-\delta)^{k-1} p_{r,t+k}}_{\equiv q^F_{t|t-k}} + \underbrace{lim_{m\to\infty} \left(\prod_{j=0}^{m-1} \frac{1}{R_{t+j}} (1-\delta)^m q_{t+m|t-k} \right)}_{\equiv q^B_{t|t-k}} \end{aligned}$$

Rewriting $q^F_{t|t-k}$ gives

$$\begin{aligned} q^F_{t|t-k} &= \frac{p_{r,t+1}}{R_t} + \sum_{k=2}^{\infty} \prod_{j=0}^{k-1} \frac{1}{R_{t+j}} (1-\delta)^{k-1} p_{r,t+k} \\ &= \frac{p_{r,t+1}}{R_t} + \sum_{k=1}^{\infty} \prod_{j=0}^{k} \frac{1}{R_{t+j}} (1-\delta)^{k} p_{r,t+1+k} \\ &= \frac{p_{r,t+1}}{R_t} + (1-\delta) \sum_{k=1}^{\infty} \prod_{j=0}^{k} \frac{1}{R_{t+j}} (1-\delta)^{k-1} p_{r,t+1+k} \\ &= \frac{p_{r,t+1}}{R_t} + \frac{(1-\delta)}{R_t} \underbrace{\sum_{k=1}^{\infty} \prod_{j=0}^{k-1} \frac{1}{R_{t+1+j}} (1-\delta)^{k-1} p_{r,t+1+k}}_{\equiv q^F_{t+1|t-k}} \end{aligned} \tag{A13}$$

Recall that $q_t = \delta \sum_{k=0}^{\infty}(1-\delta)^k q_{t|t-k}$. Multiplying (A13) with $\delta \sum_{k=0}^{\infty}(1-\delta)^k$ gives

$$
\begin{aligned}
q_t^F &= \frac{p_{r,t+1}}{R_t} + \frac{1}{R_t}\delta \sum_{k=0}^{\infty}(1-\delta)^{k+1} q_{t+1|t-k}^F \\
&= \frac{p_{r,t+1}}{R_t} + \frac{1}{R_t}\underbrace{\delta \sum_{k=1}^{\infty}(1-\delta)^{k} q_{t+1|t+1-k}^F}_{\equiv F_{t+1}} \qquad \text{(A14)}
\end{aligned}
$$

Recall the definition $q_t^F = F_t + u_t^F$. Plug (A7) in (A14) and solve for R_t:

$$
R_t = \frac{\frac{\xi}{(1+\xi)}\left(W - F_{t+1} - B_{t+1}\right) + F_{t+1}}{F_t + u^F} \qquad \text{(A15)}
$$

Substracting from (A10), (A14) gives

$$
\begin{aligned}
q_t - q_t^F &= \frac{(p_{r,t+1} + F_{t+1} + B_{t+1}) - (p_{r,t+1} + F_{t+1})}{R_t} \\
\Leftrightarrow \quad q_t^B &\equiv B_t + U^B = \frac{B_{t+1}}{R_t} \\
\Leftrightarrow \quad R_t &= \frac{B_{t+1}}{B_t + U^B} \qquad \text{(A16)}
\end{aligned}
$$

Setting (A16) equal to (A15) and solving for B_{t+1} gives

$$
\begin{aligned}
B_{t+1} &= \frac{(1-W)(1+\xi)(B+U^B)}{\gamma W - (1+\xi+\gamma)(B_t+F_t) - (1+\xi)U} \\
&\equiv H(B_t, F_t, U) \qquad \text{(A17)}
\end{aligned}
$$

Now plugging (A17) into (A12) gives

$$
\begin{aligned}
F_{t+1} &= \frac{(1-W)(F+U^F) + \xi^2(B_t+F_t+U)}{\gamma W - (1+\xi+\gamma)(B_t+F_t) - (1+\xi)U} \\
&+ \frac{\xi\left[\gamma W(B_t+F_t-W) + (B_t+U^B) + (2-W)(F+U^F)\right]}{\gamma W - (1+\xi+\gamma)(B_t+F_t) - (1+\xi)U} \\
&\equiv G(B_t, F_t, U) \qquad \text{(A18)}
\end{aligned}
$$

A deterministic bubbly equilibrium with positive fundamental value is defined by a sequence $\{B_t, F_t\}$ satisfying the two difference equations (A17) and (A18), where $B_t \in (W - F_t - \frac{(1+\xi)}{1+(1-\delta)\gamma}, W - F_t - \frac{(1+\xi)}{1+\gamma})$ for all t and a range of $U \in]\underline{u}_{R_1}, \tilde{u_1})$. The aggreagte bubble is then given by $Q_t^B = B_t + U^B$. Given the $\{B_t, F_t\}$, we can determine the equilbrium values for all variables.

1.8.3 Existence Conditions

Derivation of Lemma 1.3.1
The investment in housing has to be affordable. Given that young households are the only agents that buy houses, the affordability constraint is derived from the budget constraint of the young. Using the budget constraint when young, and $q_t \equiv \delta \sum_{k=1}^{\infty} (1-\delta)^k q_{t|t-k}$ and $H_{t|t-k} = \delta(1-\delta)^k \quad \forall t$, leads to the Affordability constraint (1.38) in the text. Lemma 1.3.1 follows directly.

Derivation of Proposition 1.3.2:
Using the *deterministic versions* of the Euler equation (1.5), the definition of the real interest rate (1.2), the equilbrium equations for the consumption levels, $C_{1,t} = \frac{1}{1+\xi}(W_t - F_t - B_t)$ and $C_{2,t+1} = D_{t+1} + \frac{\xi}{(1+\xi)} W_{t+1} + \frac{1}{(1+\xi)}(F_{t+1} + B_{t+1})$, the fact that in the flexible price equibrium we have $D_t = 1 - W_t$, as well as the necessary condition that the real interest rate has to be larger than $(1-\delta)$, one can show that for the existence of a deterministic bubbly steady state with a positive fundamental and bubble the following inequality has to hold: $W > F(\xi^k, \gamma, \delta) + \left(\frac{1+\xi^k}{1+(1-\delta)\gamma}\right)$. Given the necessity that the real interest rate has to be smaller than one, we derive the restriction $W > F(\xi^k, \gamma, \delta) + \left(\frac{1+\xi}{1+\gamma}\right)$. Hence, the existence condition for a deterministic bubbly steady state with a positive fundamental and bubble is given by

$$W > F(\xi^k, \gamma, \delta) + \left(\frac{1+\xi^k}{1+(1-\delta)\gamma}\right)$$

Derivation of Proposition 1.3.5:
The derivation follows the one of Proposition 1.3.2, with the difference that $\xi = 0$ and hence no housing services S enter the utiliy function.

Derivation of Proposition 1.3.6:
The derivation follows the one of Proposition 1.3.2, with the difference that the bubble component $q^B(u^b = 0) = 0$.

1.8.4 Conditions on the U-Range for Steady States

The steady state interest rate solves the equation[80]

$$R^2 + \underbrace{\frac{(1-\gamma)W + U - (1+\xi)}{\gamma(W+U)}}_{\equiv Z} R + \underbrace{\frac{(1-W)}{\gamma(W+U)}}_{\equiv X} = 0 \tag{A19}$$

where W is a constant. Solving for R gives

$$R_{1,2}(U) = \frac{(1+\xi) - U - W(1-\gamma) + \mp\sqrt{-4\gamma(1-W)(U+W) + [U + (1-\gamma)W - (1+\xi)]^2}}{2\gamma(U+W)}$$

Solving if $Z^2 - 4X = 0$ for U gives

$$\tilde{u}_{1,2} \equiv (\gamma + \xi) + (1+\gamma)(1-W) \mp 2\sqrt{\gamma(1-W)(1+\gamma+\xi)} \tag{A20}$$

Resulting in two real solutions $R_1(\tilde{u_1}) = R_2(\tilde{u_1})$ and $R_1(\tilde{u_2}) = R_2(\tilde{u_2})$.[81]
In the following we focus on the range $U \in (0, \tilde{u_1})$.

Bubbly deterministic steady state with a positive fundamental value:

$$\begin{cases} \exists \quad \text{two sets of steady states with} \quad R_1(U) \neq R_2(U) \quad \text{for } U \in]\underline{u}_{R_1}, \tilde{u_1}). \\ \exists \quad \text{one set of steady states with} \quad R_2(U) \quad \text{for } U \in (\underline{u}_{R_2}, \tilde{u_1}). \end{cases}$$

[80]Solving the deterministic version of the Euler Equation (1.5) for R yields this quadratic equation.

[81]For $U > \tilde{u_2}$, two real, non-positive solutions $R_1(U) \neq R_2(U)$. For $\tilde{u_1} < U < \tilde{u_2}$, two complex solutions $R_1(U) \neq R_2(U)$. For $U < \tilde{u_1}$, two real, positive solutions $R_1(U) \neq R_2(U)$.

where

$$\underline{u}_{R_1} = \left(\frac{\xi^k + \delta \left[W(1+\gamma) - (1+\xi^k) \right] - W\gamma\delta^2}{\left[1+\gamma(1-\delta)\right](1-\delta)} \right) \qquad \underline{u}_{R_2} = \left(\frac{\xi^k}{1+\gamma} \right)$$

Proof 1: Existence of two sets of steady states with $R_1(U) \neq R_2(U)$ for $U \in]\underline{u}_{R_1}, \tilde{u_1})$

$R_2(U) > R_1(U)$ and $\frac{\partial R_1}{\partial U} > 0$ and $\frac{\partial R_2}{\partial U} < 0$ for $U < \tilde{u_1}$. Given the restriction that $(1-\delta) < R(U) \leq 1$, recall (1.40), the lower bound on U for both real interest rates can be derived and is given by $R_1(\underline{u}_{R_1}) = (1-\delta)$ and $R_2(\underline{u}_{R_2}) = 1$. Hence, $\underline{u} = max\{\underline{u}_{R_1}, \underline{u}_{R_2}, 0\}$ where $\underline{u}_{R_1} = \left(\frac{\xi^k + \delta \left[W(1+\gamma) - (1+\xi^k) \right] - W\gamma\delta^2}{\left[1+\gamma(1-\delta)\right](1-\delta)} \right)$, $\underline{u}_{R_2} = \left(\frac{\xi^k}{1+\gamma} \right)$. Using the necessary condition (Proposition 1.2.) for the existence of a deterministic bubbly steady state with positive fundamental, it can be shown that $\underline{u}_{R_1} > \underline{u}_{R_2}$ and hence $\underline{u} = \underline{u}_{R_1}$.[82]

Proof 2: Existence of one set of steady states with $R_2(U)$ for $U \in (\underline{u}_{R_2}, \tilde{u_1})$ $R_2(U)$ is decreasing in U, hence a sufficient condition is $R_2(\tilde{u_1}) - (1-\delta) > 0$. The solution set, where all parameter restrictions and the existence condition (Proposition 1.3.2) hold is given by the explicit representation of the following region: $0 < \delta < 1 \quad \wedge \quad 0 < \gamma < 1 \quad \wedge \quad 0 < \xi < -\frac{\gamma(\delta-1)\delta}{\gamma(\delta^2-3\delta+2)+1} \quad \wedge \quad \frac{\xi+1}{\gamma(-\delta)+\gamma+1} < W < \frac{1-\gamma(\delta-1)(\delta\xi+\delta-\xi+1)}{(\gamma(\delta-1)-1)^2}$.

[82]This follows from Proposition 1.2. and the fact that $\frac{\partial \underline{u}_{R_1}}{\partial W} = \frac{\delta}{1-\delta} > 0$.

1.8.5 Proportional Rental Subsidy

Budget constraint when young:

$$C_{1,t} + \frac{Z_t}{P_t} + \sum_{k=0}^{\infty} q_{t|t-k} H_{t|t-k} + (1-\tau_s) p_t^r S_t \leq (1-\tau_w) W_t + u_t \quad \text{(A21)}$$

Budget constraint when old:

$$C_{2,t+1} \leq \frac{(1+i_t)Z_t}{P_{t+1}} + \sum_{k=0}^{\infty} \left(p_{t+1}^r + (1-\delta) q_{t+1|t-k}\right) H_{t|t-k} + D_{t+1} \quad \text{(A22)}$$

where $H_t = \sum_{k=0}^{\infty} H_{t|t-k}$. The inter-temporal budget constraint (IBC) is thus given by

$$\begin{aligned} & C_{1,t} + \sum_{k=0}^{\infty} q_{t|t-k} H_{t|t-k} + (1-\tau_s) p_t^r S_t \\ & + \frac{1}{R_t} \left(C_{2,t+1} - \sum_{k=0}^{\infty} \left(p_{t+1}^r + (1-\delta) q_{t+1|t-k}\right) H_{t|t-k}^j \right) \\ & \leq \quad (1-\tau_w) W_t + \delta q_{t|t} + \frac{D_{t+1}}{R_t} \end{aligned} \quad \text{(A23)}$$

Financed by income taxation (lump-sum of the young)
Budget constraint of the goverment

$$\tau_s p_t^r S_t = \tau_w W_t \quad \text{(A24)}$$

The steady state interest rate solves the following quadratic equation

$$R^2 + \underbrace{\frac{(1+\tau_w \xi - \gamma(1-\tau_w)(1-\tau_s) - \tau_s(1+\xi))W + (1-\tau_s(1+\xi))U - (1+\xi)(1-\tau_s)}{\gamma(1-\tau_s)((1-\tau_w)W + U)}}_{\equiv Z_1} R$$

$$+ \underbrace{\frac{(1-\tau_s(1+\xi))(1-W)}{\gamma(1-\tau_s)((1-\tau_w)W + U)}}_{\equiv F_1} = 0$$

where W, ξ, γ, τ_w and τ_s are constants. Solving for R gives

$$R_{1,2}(U) = \frac{(1+\xi) - U - W(1-\gamma) + \tau_s(1+\xi)(U+W) - W(\tau_w\gamma(1-\tau_s) + \gamma\tau_s + \tau_w\xi)}{2\gamma((1-\tau_s)U + (1-\tau_s-(1-\tau_s)\tau_w)W)}$$
$$\mp \frac{\sqrt{-4\gamma\left[(1-W) - \tau_s(1+\xi) + \tau_s(1+\xi)W\right]\left[(U+W) - \tau_s(W+U) - \tau_w(1-\tau_s)W\right]}}{2\gamma((1-\tau_s)U + (1-\tau_s-(1-\tau_s)\tau_w)W)}$$
$$\mp \frac{\sqrt{\left[U + (1-\gamma)W - (1+\xi) + \tau_s(1+\xi) - \tau_s(1+\xi)(W+U) + W(\tau_w(\xi+\gamma) - \tau_s(\tau_w\gamma-\gamma)\right]^2}}{2\gamma((1-\tau_s)U + (1-\tau_s-(1-\tau_s)\tau_w)W)}$$

Solving if $Z_1^2 - 4F_1 = 0$ for u gives

$$\begin{aligned}\tilde{u}_{1,2} \equiv & \frac{(1+\xi) + \tau_s^2(\xi^2+2\xi+1) - \tau_s(\xi^2+3\xi+2)}{((1+\xi)\tau_s-1)^2} \\ & - \frac{W(1-\tau_s(1+\xi))(1-\gamma(1+\tau_w) + \tau_w\xi - \tau_s(1+\xi))}{((1+\xi)\tau_s-1)^2} \\ & \mp 2\frac{\sqrt{\gamma(\tau_s-1)^2(1-W)(\gamma+\xi+1)(\tau_s(1+\xi)-1)^2(1-\tau_w W)}}{((1+\xi)\tau_s-1)^2}\end{aligned}$$

Resulting in two real solutions $R_1(\tilde{u_1}) = R_2(\tilde{u_1})$ and $R_1(\tilde{u_2}) = R_2(\tilde{u_2})$.[83]
In the following we focus on the range $U \in (0, \tilde{u_1})$.

Bubbly deterministic steady state with a positivie fundamental value:

$$\begin{cases} \exists \quad \text{two sets of steady states with} \quad R_1(U) \neq R_2(U) \quad \text{for } U \in]\underline{u}_{R_1}, \tilde{u_1}). \\ \exists \quad \text{one set of steady states with} \quad R_2(U) \quad \text{for } U \in (\underline{u}_{R_2}, \tilde{u_1}). \end{cases}$$

where

$$\begin{aligned}\underline{u}_{R_1} = & \frac{(1-\tau_w W)\xi + \delta\left[W(1+\tau_w\xi + \gamma(1-\tau_w)(1-\tau_s) - (1+\xi)\right]}{\left[1+\gamma(1-\delta)(1-\tau_s) + (1+\xi)\tau_s\right](1-\delta)} \\ & - \frac{W\gamma\delta^2(1-\tau_w)(1-\tau_s)}{\left[1+\gamma(1-\delta)(1-\tau_s) + (1+\xi)\tau_s\right](1-\delta)} \\ \underline{u}_{R_2} = & \frac{\xi(1-\tau_w W)}{1+\gamma(1-\tau_s) - \tau_s(1+\xi)}\end{aligned}$$

[83]For $U > \tilde{u_2}$, two real, non-positive solutions $R_1(U) \neq R_2(U)$. For $\tilde{u_1} < U < \tilde{u_2}$, two complex solutions $R_1(U) \neq R_2(U)$. For $U < \tilde{u_1}$, two real, positive solutions $R_1(U) \neq R_2(U)$.

Note that these expressions boil down to those in the baseline scenario, when setting $\tau_s = \tau_w = 0$.

1.8.6 Proportional Buying Subsidy

Budget constraint when young:

$$C_{1,t} + \frac{Z_t}{P_t} + (1-\tau_h)\sum_{k=0}^{\infty} q_{t|t-k}H_{t|t-k} + p_t^r S_t \leq (1-\tau_w)W_t + u_t \tag{A25}$$

Budget constraint when old:

$$C_{2,t+1} \leq \frac{(1+i_t)Z_t}{P_{t+1}} + \sum_{k=0}^{\infty}\left(p_{t+1}^r + (1-\delta)q_{t+1|t-k}\right)H_{t|t-k} + D_{t+1} \tag{A26}$$

Budget constraint of the goverment

$$\tau_h \sum_{k=0}^{\infty} q_{t|t-k}H_{t|t-k} = \tau_w W_t \tag{A27}$$

The steady state interest rate solves the following quadratic equation

$$R^2 + \underbrace{\frac{\left[(1+\tau_w\xi)(1-\tau_h) - \gamma(1-\tau_w)\right]W + \left[1-\tau_h(1+\gamma)\right]U - (1+\xi)(1-\tau_h)}{\gamma(1-\tau_h)((1-\tau_w)W + U)}}_{\equiv Z_2} R$$
$$+ \underbrace{\frac{(1+\tau_h\xi)(1-W)}{\gamma(1-\tau_h)((1-\tau_w)W+U)}}_{\equiv F_2} = 0$$

where W, ξ, γ, τ_w and τ_h are constants. Solving for R gives

$$R_{1,2}(U) = \frac{(U+W)\left[(1-\tau_h)(1+\xi) - U(1-\tau_h(1+\gamma)) - W\left[(1-\tau_w\xi)(1-\tau_h) - \gamma(1+\tau_w)\right]\right]}{2\gamma(1-\tau_h)(U+W)(U+(1-\tau_w)W)}$$
$$\mp \frac{\sqrt{(U+W)\left[-4\gamma(1-W)(U+(1-\tau_w)W)^2(-1+\tau_h)^2\right]}}{2\gamma(1-\tau_h)(U+W)(U+(1-\tau_w)W)}$$
$$\mp \frac{\sqrt{(U+W)\left[-(1-(1+\gamma)\tau_h)U - (1-\gamma(1-\tau_w) + \tau_w\xi(1-\tau_h) + \tau_h)W + (1+\xi)(1-\tau_h)\right]^2}}{2\gamma(1-\tau_h)(U+W)(U+(1-\tau_w)W)}$$

$$\tilde{u}_{1,2} \equiv \frac{(1-\tau_h)(1+\xi)+\gamma(2-\tau_h(1+3\xi))}{((1+\xi)\tau_h-1)^2}$$
$$-\frac{W\left[\gamma^2(1-\tau_w)\tau_h+\gamma(1-\tau_h)(1+\tau_w-(1+\xi(2-\tau_w))\tau_h+(1-\tau_w\xi)(-1+\tau_h)^2\right]}{((1+\xi)\tau_h-1)^2}$$
$$\mp 2\frac{\sqrt{\gamma(1-W)(\tau_h-1)^2(1-\xi\tau_h)X}}{((1+\xi)\tau_h-1)^2}$$

where $X = (1-\tau_h)(1-\tau_w(1-\xi)W+\xi)-\tau_h(1-\tau_w)\gamma^2 W+\gamma(1-\tau_h(1+2\xi)-W(\tau_w(1-2\tau_h)+(1+\xi(\tau_w-1))\tau_h)$.

Resulting in two real solutions $R_1(\tilde{u_1}) = R_2(\tilde{u_1})$ and $R_1(\tilde{u_2}) = R_2(\tilde{u_2})$.[84] In the following we focus on the range $U \in (0, \tilde{u_1})$.

Bubbly deterministic steady state with a positivie fundamental value:

$$\begin{cases} \exists \quad \text{two sets of steady states with} \quad R_1(U) \neq R_2(U) \quad \text{for } U \in]\underline{u}_{R_1}, \tilde{u_1}). \\ \exists \quad \text{one set of steady states with} \quad R_2(U) \quad \text{for } U \in (\underline{u}_{R_2}, \tilde{u_1}). \end{cases}$$

[84]For $U > \tilde{u_2}$, two real, non-positive solutions $R_1(U) \neq R_2(U)$. For $\tilde{u_1} < U < \tilde{u_2}$, two complex solutions $R_1(U) \neq R_2(U)$. For $U < \tilde{u_1}$, two real, positive solutions $R_1(U) \neq R_2(U)$.

1.9 Appendix B: Empirical Work

1.9.1 Data Sources and Descriptive Statistics

This section outlines the data sources and provides a short descriptive statistics of the data used in the analysis of this paper.

House Price Data
The dataset consists of 22 OECD countries and contains real and nominal prices for housing markets, and are reported from national statistical sources. It includes Australia, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, the United Kingdom, Greece, Ireland, Israel, Italy, Japan, Korea, Portugal, the Netherlands, Norway, New Zealand, Sweden, and the United States. The series are provided on a quarterly basis, are seasonally adjusted, and the average of the observations in 2010 is indexed to 100. Most of the series contain observations from 1970Q1 to 2013Q4 except for five countries that have later starting points.[85] Due to the much shorter sample sizes I discard Greece, Israel, Korea and Portugal from the analysis. Spain is included, thereby leaving a total of 18 OECD countries.

Preference for Housing Services is measured with two proxies:

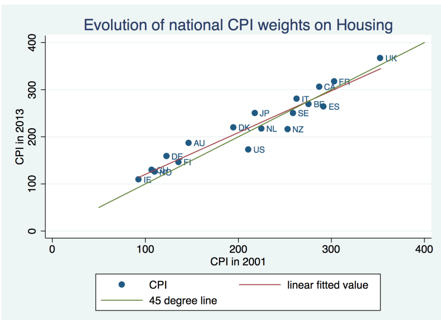
- National CPI weights
  (Housing, Water, Electricity, Gas and other Fuels)
  Per thousand of the National CPI Total. Annual frequency over the time period 1992 to 2013 (if available) for 17 countries, data for Australia is missing. Source: OECD.stat

- Household spending on housing (as % of disposable income)
  Point estimate for the years 1995 and 2005 for 18 OECD countries. Source: OECD Outlook No. 86 and OECD National Accounts.

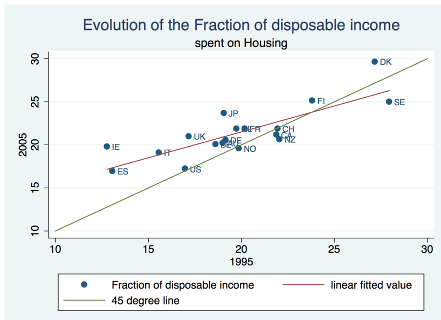
[85]These are Spain (1971Q1), Greece (1997Q1), Israel (1994Q1), Portugal (1988Q1) and Korea (1986Q1). I thank Natalie Girouard (OECD) for providing me with the house price data.

Figure (1.9) shows the evolution of the two proxies for the preference for housing services over time and across countries. The preference for housing services differs significantly across countries.

Figure (1.9a) plots for a sample of 17 OECD countries the initial observation of the CPI weight for housing services (the year 2001) against the last observation available (the year 2013). The fitted line is slightly above and close to being parallel to the 45-degree line. Hence, the CPI weights increased slightly over time. However, the cross-country differences in the CPI weights for housing services remained constant over time. Figure (1.9b) plots for 18 OECD countries the initial observation of fraction of income spent on housing services (the year 1995) against the last observation available (the year 2005). Cross-country differences in the preference for housing services are persistent over time.



(a) Evolution of CPI weights



(b) Evolution of fraction of disposable income

Figure 1.9: Evolution of the Preference for Housing Services

Descriptive Statistics of Housing Cycles

	Independent Booms				Boom-Bust Cycles			
	$> 10\%$	$> 15\%$	$> 20\%$	$> 80\%$	$> 10\%$	$> 15\%$	$> 20\%$	$> 80\%$
Australia	5	3	3	0	3	2	2	0
Belgium	2	2	2	1	1	1	1	0
Canada	2	2	2	1	1	1	1	0
Denmark	3	2	2	1	3	2	2	1
Finland	6	5	5	0	5	4	3	0
France	2	2	2	1	2	2	2	0
Germany	3	0	0	0	2	0	0	0
Ireland	3	3	3	1	2	2	2	1
Italy	3	3	3	1	3	3	3	1
Japan	1	1	1	1	1	1	1	1
Netherlands	1	1	1	1	1	1	1	1
New Zealand	6	5	4	1	5	3	2	0
Norway	3	2	2	1	2	1	1	0
Spain	3	3	3	2	3	3	3	1
Sweden	3	3	3	1	2	2	2	0
Switzerland	2	2	2	0	1	1	1	0
United Kingdom	3	3	3	2	3	3	3	1
United States	4	2	2	0	3	2	2	0
SUM	55	44	43	15	43	34	32	7

Table 1.9: Number of completed and ongoing Housing Booms and Busts for each OECD Country

	Downturn				Upturn			
	Completed		Ongoing		Completed		Ongoing	
country	Average	StdD	Average	StdD	Average	StdD	Average	StdD
Australia	-0.08	0.05	-0.08	0.05	0.34	0.31	0.29	0.30
Belgium	-0.38		-0.20	0.26	1.30	0.97	1.30	0.97
Canada	-0.14	0.06	-0.14	0.06	0.36	0.45	0.56	0.47
Denmark	-0.26	0.14	-0.26	0.14	0.84	0.84	0.63	0.80
Finland	-0.19	0.19	-0.17	0.18	0.36	0.19	0.36	0.19
France	-0.15	0.05	-0.13	0.06	0.53	0.55	0.53	0.55
Germany	-0.15	0.08	-0.15	0.08	0.14	0.14	0.15	0.01
Ireland	-0.11	0.15	-0.20	0.21	1.12	1.24	1.12	1.24
Italy	-0.26	0.12	-0.25	0.10	0.76	0.28	0.76	0.28
Japan	-0.29		-0.38	0.13	0.83		0.83	
Netherlands	-0.50		-0.38	0.17	2.21		2.21	
New Zealand	-0.15	0.15	-0.15	0.15	0.53	0.34	0.48	0.34
Norway	-0.25	0.20	-0.25	0.20	0.35	0.32	1.00	1.16
Spain	-0.21	0.13	-0.25	0.13	0.98	0.62	0.98	0.62
Sweden	-0.33	0.03	-0.33	0.03	0.32	0.12	0.68	0.63
Switzerland	-0.34	0.06	-0.34	0.06	0.74		0.59	0.21
United Kingdom	-0.23	0.10	-0.23	0.10	1.01	0.71	0.77	0.25
United States	-0.11	0.11	-0.11	0.11	0.33	0.27	0.28	0.25
Portugal	-0.12	0.03	-0.11	0.02	0.11	0.08	0.11	0.08
Korea	-0.21	0.29	-0.17	0.26	0.14	0.10	0.14	0.10

Table 1.10: Amplitude of Housing Cycles for each OECD Country

Note: Prices in 2010 are normalized to 100

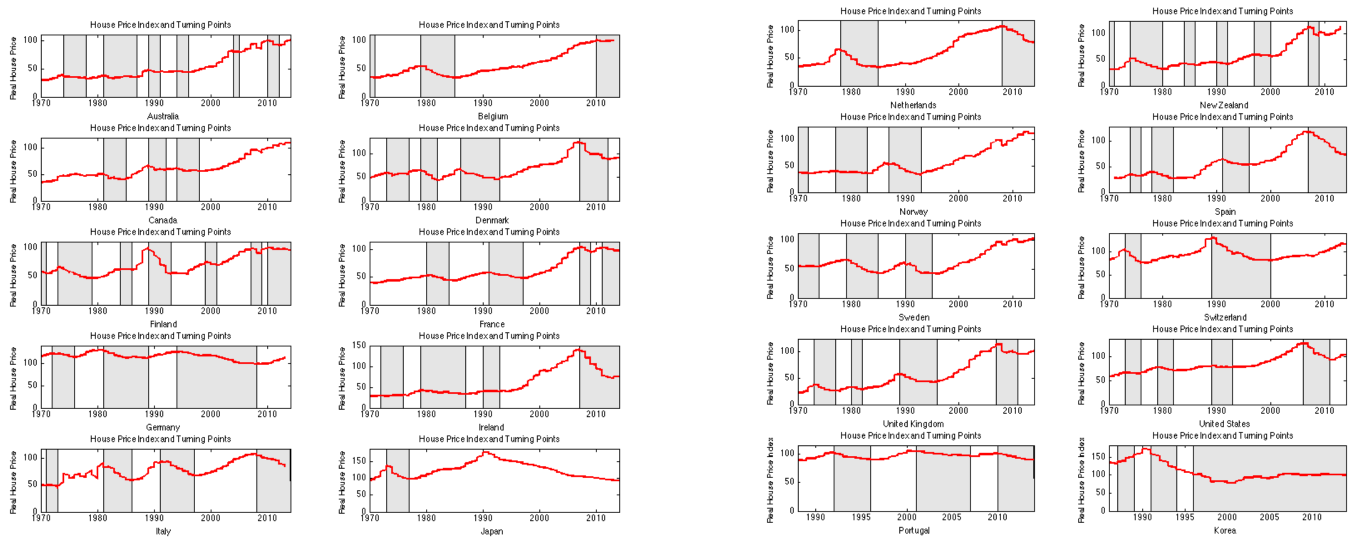


Figure 1.10: House Price Indices and Turning Points

Country	Peak	Trough	Downturn Duration	Downturn Amplitude	Downturn Number	Downturn Intensity	Upturn Duration	Upturn Amplitude	Upturn Number	Upturn Intensity
Australia	1974q1	1978q4	19	-16.60	6	-0.87	12	14.82	5	1.23
	1981q4	1987q1	13	-5.94		-0.46	9	36.73		4.08
	1989q2	1991q1	7	-8.30		-1.19	14	4.58		0.33
	1994q3	1996q1	6	-4.06		-0.68	32	85.4		2.67
	2004q1	2005q3	6	-2.85		-0.48	19	27.42		1.44
	2010q2	2012q3	9	-9.31		-1.03		7.95*		1.59*
Belgium		1971q3			1		32	61.38	2	1.92
	1979q3	1985q2	23	-38.14		-1.16	62	198.68		3.20
	2010q4			-1.34*		-0.11*				
Canada	1981q3	1985q1	14	-20.68	3	-1.48	16	68.05	2	4.25
	1989q1	1992q1	12	-13.53		-1.13	8	4.55		0.57
	1994q1	1998q3	21	-9.28		-0.44		95.91*		4.57*
Denmark	1973q3	1977q1	14	-5.82	4	-0.42	9	14.47	3	1.61
	1979q2	1982q3	13	-34.74		-2.67	15	58.74		3.92
	1986q2	1993q2	28	-34.04		-1.22	55	177.39		3.23
	2007q1	2012q2	21	-29.05		-1.38		3.05*		0.51*
Finland		1971q4			5		8	20.46	6	2.56
	1973q4	1979q1	21	-29.59		-1.41	22	36.31		1.65
	1984q3	1986q2	7	-4.46		-0.64	12	65.96		5.50
	1989q2	1993q2	16	-47.64		-2.98	26	42.14		1.62
	1999q4	2001q4	8	-6.80		-0.85	23	40.81		1.77
	2007q3	2009q1	6	-8.81		-1.47	6	11.60		1.93
	2010q3			-3.13*		-0.24*				

Notes: Turning points of real housing price cycles are based on the cycle-dating procedure of Harding and Pagan [2002] with the minimum duration between two turning points being set to six quarters. Duration is the number of quarters from peak (trough) to trough (peak). Amplitude is the change in real house prices from peak (trough) to trough (peak) and expressed in %.
* : On-going upturn (downturn), no peak (trough) identified, amplitude calculated from last trough (peak) to 2013q4.

Table 1.11: House Price Cycles by Country - Turning Points

			Downturn				**Upturn**			
Country	Peak	Trough	Duration	Amplitude	Number	Intensity	Duration	Amplitude	Number	Intensity
France	1980q4	1984q3	15	-18.39	3	-1.23	27	33.03	3	1.22
	1991q2	1997q1	23	-17.62		-0.77	43	115.38		2.68
	2007q4	2009q2	6	-8.62		-1.44	9	9.84		1.09
	2011q3			-5.76*		-0.64*				
Germany	1972q2	1976q3	17	-7.06	3	-0.42	19	14.49	2	0.76
	1981q2	1989q2	32	-14.61		-0.46	21	14.41		0.69
	1994q3	2008q3	56	-22.29		-0.40		16.28*		0.78*
Irland	1972q2	1976q3	17	-1.09	3	-0.06	11	54.95	3	5.00
	1979q2	1987q2	32	-27.85		-0.87	12	26.47		2.21
	1990q2	1993q3	13	-3.25		-0.25	54	253.72		4.70
	2007q1			-45.83*		-1.70*				
Italy	1971q4	1973q3	7	-13.40	3	-1.34	31	109.10	3	3.52
	1981q2	1986q2	20	-36.10		-1.81	22	59.94		2.72
	1991q4	1997q3	23	-28.49		-1.24	42	59.59		1.42
	2008q1			-21.83*		-0.95*				
Japan	1973q4	1977q3	15	-29.29	1	-1.95	54	82.64	1	1.53
	1991q1			-47.43*		-0.93*				

Notes: Turning points of real housing price cycles are based on the cycle-dating procedure of Harding and Pagan [2002] with the minimum duration between two turning points being set to six quarters. Duration is the number of quarters from peak (trough) to trough (peak). Amplitude is the change in real house prices from peak (trough) to trough (peak) and expressed in %.
* : On-going upturn (downturn), no peak (trough) identified, amplitude calculated from last trough (peak) to 2013q4.

Table 1.11: House Price Cycles by Country - Turning Points (cont.)

			Downturn				Upturn			
Country	Peak	Trough	Duration	Amplitude	Number	Intensity	Duration	Amplitude	Number	Intensity
Netherlands	1978q2	1985q1	27	-49.91	1	-1.85	95	221.28	1	2.33
	2008q4			-25.99*		-1.30*				
New Zealand		1971q4			5		11	74.04	5	6.73
	1974q3	1980q2	23	-40.71		-1.77	16	34.22		2.14
	1984q2	1986q4	10	-6.97		-0.70	13	13.87		1.07
	1990q1	1992q1	15	-7.31		-0.49	21	43.74		2.08
	1997q2	2000q4	14	-6.28		-0.45	27	100.84		3.73
	2007q3	2009q1	6	-15.07		-2.51		18.57*		0.98*
Norway		1972q4			2		17	11.83	2	0.70
	1977q1	1983q4	27	-11.09		-0.41	14	57.66		4.12
	1987q2	1993q1	23	-39.69		-1.73		231.91*		2.79*
Spain	1974q3	1976q2	7	-10.58	3	-1.51	8	27.90	3	3.49
	1978q2	1982q2	16	-35.06		-2.19	38	145.33		3.82
	1991q4	1996q3	19	-18.03		-0.95	44	120.94		2.75
	2007q3			-37.27*		-1.49*				
Sweden		1974q2			2		20	24.03	2	1.20
	1979q2	1985q3	25	-34.98		-1.40	18	40.53		2.25
	1990q1	1995q4	23	-30.5		-1.33		140.16*		1.95*

Notes: Turning points of real housing price cycles are based on the cycle-dating procedure of Harding and Pagan [2002] with the minimum duration between two turning points being set to six quarters. Duration is the number of quarters from peak (trough) to trough (peak). Amplitude is the change in real house prices from peak (trough) to trough (peak) and expressed in %.
* : On-going upturn (downturn), no peak (trough) identified, amplitude calculated from last trough (peak) to 2013q4.

Table 1.11: House Price Cycles by Country - Turning Points (cont.)

			Downturn				Upturn			
Country	Peak	Trough	Duration	Amplitude	Number	Intensity	Duration	Amplitude	Number	Intensity
Switzerland	1973q1	1976q3	14	-29.54	2	-2.11	53	74.20	1	1.40
	1989q4	2000q1	41	-37.75		-0.92		44.50*		0.81*
United Kingdom	1973q3	1977q3	16	-33.29	4	-2.08	12	29.05	3	2.42
	1980q3	1982q1	6	-12.43		-2.07	30	102.87		3.43
	1989q3	1996q2	27	-27.73		-1.03	46	171.64		3.73
	2007q4	2011q4	16	-16.81		-1.05		3.72*		0.47*
United States	1973q4	1976q1	9	-3.78	4	-0.4	13	20.26	3	1.56
	1979q2	1982q3	13	-9.39		-0.72	29	14.43		0.50
	1989q4	1993q1	13	-4.5		-0.35	55	64.42		1.17
	2006q4	2011q4	20	-26.95		-1.35		11.69*		1.46*
Korea	1990q4	2001q1	41	-55.02	3	-1.34	10	23.91	3	2.39
	2003q3	2005q1	6	-5.36		-0.89	8	13.79		1.72
	2007q1	2010q3	15	-4.1		-0.34		3.39		0.42
	2012q1			-1.97		-0.28				
Portugal	1992q2	1996q3	17	-13.63	2	-0.80	19	16.87	2	0.89
	2001q2	2007q4	26	-9.39		-0.36		5.82		0.65
	2010q1			-10.58		-0.71				

Notes: Turning points of real housing price cycles are based on the cycle-dating procedure of Harding and Pagan [2002] with the minimum duration between two turning points being set to six quarters. Duration is the number of quarters from peak (trough) to trough (peak). Amplitude is the change in real house prices from peak (trough) to trough (peak) and expressed in %.
* : On-going upturn (downturn), no peak (trough) identified, amplitude calculated from last trough (peak) to 2013q4.

Table 1.11: House Price Cycles by Country - Turning Points (cont.)

1.9.2 Additional empirical results

	Booms			Boom-Busts	
	$> 80\%$	$> 20\%$	$> 15\%$	$> 20\%$	$> 15\%$
	(1)	(2)	(3)	(4)	(5)
CPI weight	-0.0791*	-0.0924*	-0.0924*	-0.0702*	-0.0684*
	(-3.23)	(-2.44)	(-2.44)	(-2.71)	(-2.32)
IMF Mortgage Index	1.684	4.382*	4.382*	4.099**	4.249**
	(2.07)	(2.96)	(2.96)	(3.68)	(3.52)
typical LTV	0.0170	-0.0310	-0.0310	-0.0645	-0.0625
	(1.30)	(-1.10)	(-1.10)	(-1.89)	(-1.73)
maximum LTV	-0.00690	0.00151	0.00151	0.0239	0.0253
	(-0.45)	(0.08)	(0.08)	(0.88)	(0.86)
unemployment rate	-0.0207	-0.0429	-0.0429	-0.0967	-0.113
	(-0.29)	(-0.42)	(-0.42)	(-1.54)	(-1.39)
GDP (head, PPP)	-0.0000802	-0.000175	-0.000175	-0.0000927	-0.000125
	(-1.30)	(-1.44)	(-1.44)	(-1.26)	(-1.12)
Constant	3.178	8.989*	8.989*	6.904*	7.568
	(1.59)	(2.86)	(2.86)	(2.55)	(2.24)
N	15	15	15	15	15
R^2	0.691	0.586	0.586	0.633	0.516
adj. R^2	0.460	0.275	0.275	0.357	0.153

t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Booms denoted by $> x\%$ are those booms that involve real house price changes (trough to peak) larger than $x\%$. The variable of interest is the *national consumer price index (CPI) weight* on housing services. This indicator is a good measure for the relative importance of housing services in the total consumption basket. *Typical LTV* for 1992 and 2002, taken from Calza et al. [2013], Catte et al. [2004]. *Maximum LTV* taken from Heitor et al. [2006]. *GDP* measure per head, constant prices, constant PPPs, OECD base year. *IMF Mortgage Index* is taken from World Economic Outlook, April 2008: Housing and the Business Cycle. The index includes: typical refinancing option, mortgage equity withdrawal option (yes, no), typical LTV, covered bond issues (% of residential loans outstanding), mortgage backed security issues (% of residential loans outstanding). Index not available for New Zealand and Switzerland. Macro variables: averages 1970-2013, if not noted otherwise.

Table 1.12: Frequency of independent Booms, Boom-Bust Cycles (2)

Chapter 2

PREFERENCES FOR HOUSING SERVICE AND HOUSE PRICE BUBBLES: A MACRO-EXPERIMENT

(written jointly with Christina Rott)

2.1 Introduction

Housing market fluctuations have a strong impact on overall economic performance. Empirical studies show that recessions associated with house price busts are not only longer but also much deeper compared to normal recessions or recessions associated with equity price busts.[1] Therefore, understanding the conditions under which large house price bubbles occur is fundamental.

[1]Recessions that are associated with house price busts (four years) are much longer than recessions associated with equity busts (two and a half years). According to e.g. Claessens et al. [2012], Claessens, Kose, and Terrones [2009], IMF [2003], house price busts have larger effects on consumption, investment and therefore GDP. GDP drops by 8% on average when house prices burst compared to 4% when equity prices burst.

Housing is very different to other assets given its dual nature - the consumption and investment demand for housing. Empirical studies have shown that times of intensive housing investment are often associated with bubbly episodes.[2] The existing empirical and experimental literature explores channels that work through the investment demand for housing. The role housing consumption plays in generating housing bubbles, however, remains underexplored.

We shed new light on this issue in a laboratory setting by exploring the relevance of preferences for housing services as a potential driver for house price bubbles. We find that endowing subjects with a weaker preference for housing services generates larger house price bubbles. This experimental result is in line with the empirical cross-country regularities found in Huber [2017a]. The first chapter of this Thesis shows that countries characterized by a weaker preference for housing services experienced significantly larger, more volatile, and a larger number of independent housing booms (and boom-bust cycles) during 1970-2014.[3] However, conclusions on the causal effect cannot be easily drawn. Huber [2017a] proposes a theoretical overlapping generation (OLG) model that provides an explanation for why the preference for housing services might determine the vulnerability of an economy to housing bubbles.

The proposed model mechanism is tested in a laboratory experiment. The model allows for rational bubbles, given its overlapping generation structure. The strong assumption of rationality is removed in the laboratory, and the theoretical mechanism is tested without it. Households live for two periods and decide how much *housing services* and how much of *all other* consumption goods to consume, how much to invest in the asset

[2]Housing investment e.g. measured by turnover rates. The strong relationship between turnover and prices was first illustrated in Stein [1995]. Subsequently, papers by Leung [2004], Andrew and Meen [2003], Hort [2000], and Berkovec and Goodman [1996] have confirmed the results.

[3]The preference for housing services relative to other consumption goods is measured empirically by (1) the CPI weight on housing services, and (2) by the expenditure for housing services as a share of disposable income. Both measures include imputed rents. In the model, the preference for housing services determines the consumption expenditure share for housing services.

house, and how much to save in riskless bonds. The dividend from investing into the asset house is given by the rental income a house generates.[4]

Two treatments are implemented - one with a weak and one with a strong preference for housing services. The results show that housing bubbles are substantially larger in the treatment with weak preferences for housing service. This results holds for a wide range of bubble measures, as well as for established experimental bubble indicators: the absolute bubble size, the bubble size relative to the fundamental value, the relative absolute deviation (RAD), the relative deviation (RD), the price amplitude (PA), the total dispersion (TD), and for the average bias (AB). Further, the difference in the magnitude of housing bubbles across treatments is robust to adjusting realized trading prices for endogenously resulting differences in the cash-to-asset ratio. Since the weak and strong preferences for housing services are randomly induced across sessions, we can conclude that the preference for housing services causally and negatively affects the size of housing bubbles in our setup.

The present paper's contribution to the existing literature on experimental asset markets is twofold.

First, this study highlights a new channel that determines the size of house price bubbles: the preference for housing services. The existing literature shows that the magnitude and duration of experimental bubbles vary with market conditions that affect the investment demand for housing. Ikromov and Yavas [2012], for instance, show experimentally that asset and market characteristics such as transaction costs, short selling restrictions and divisibility of the asset affect the magnitude of the boom and bust cycles. The role housing consumption plays in generating experimental housing bubbles has not been explored. This paper aims to fill this gap. Second, this paper - one of the first laboratory experiments on housing markets - contributes to the existing literature on experimental asset markets also methodologically.[5] We implement several novel design

[4]Rental income is determined by young generation's demand for housing services.

[5]To our knowledge, Ikromov and Yavas [2012] and Bao and Hommes [2015] are the only experimental studies that analyze housing market features and their impact on house price bubbles.

features for OLG market experiments and believe that the experimental design provides a good starting point for the study of policy interventions in an OLG environment.

First, our design provides a framework where both a market for the traded asset and a market for the dividend of that traded asset exist. In the related literature, most experiments assume an exogenous dividend for the traded asset, e.g., Marimon and Sunder [1993], Noussair et al. [2001] or Ikromov and Yavas [2012]. In contrast, in our design, the dividend of the bubbly asset is determined endogenously by the choices of the market participants. As mentioned before housing is a special asset given its dual nature. The fundamental value of a real estate asset is determined by the expected flow of future dividends that the asset generates. The dividend is given by the price for housing services. Hence, the demand for housing consumption determines the fundamental value of the real estate asset. It is, therefore, important to consider both the demand for housing consumption and the demand for housing investment simultaneously. The endogeneity of the dividend in the housing market is a crucial and novel feature for the analysis of experimental (housing) bubbles on asset markets.

Second, we provide new design features concerning the assignment of subjects to markets. In comparison to the existing literature, our assignment keeps the design close to the model structure and has the advantage of gathering more observations, providing the participants with experience, and simplifying the complex setup.

Third, our incentive structure is novel and important for overlapping generations market experiments. As is common in the literature, subjects play several life-cycles in the experiment. However, in the theoretical model subjects live one lifecycle only. To address this issue in the experiment, only one lifecycle is chosen randomly and paid out.[6] This design feature prevents subjects from hedging risk by playing different strategies

[6]Duffy and Lafky [2016] explore the effect of fixed versus dynamic group membership on a public good provision in an OLG setup. They also chose one lifecycle randomly for payment. However, their study does not fall into the category of experimental OLG asset markets.

in different life-cycles. We also find very stable patterns over the different life-cycles of a subject - which indicates that our incentive structure is aligned with the theoretical setup.

The remainder of the paper is structured as follows: Section 2.2 provides an overview of the related experimental literature. Section 2.3 describes the experimental design and implementation of the lab experiment. Section 2.4 explains carefully how we measure experimental bubbles and presents the experimental results. In section 2.5 we address alternative explanations and provide corresponding robustness checks. Section 2.6 concludes. Refer to the first chapter for a detailed presentation of the overlapping generation model, and the empirical cross-country regularities.

2.2 Related Experimental Literature

Our paper is related to the literature that studies the occurrences and underlying causes of experimental bubble formation. This literature is large. However, most of the experimental designs are very different to ours. In contrast to our design, most experimental papers assume an exogenous and finite dividend process. The seminal paper of Smith et al. [1988] (hereafter SSW) assumes a four-state iid. dividend process that is public knowledge. As the fundamental value (FV) of an asset is assumed to be its expected future dividend stream, it follows that the FV is deterministically declining. SSW find that experimental asset prices deviate strongly from fundamental values.

This setting was replicated and modified by many researchers, studying different treatments in similarly designed experiments as SSW. Examples include experiments that study the impact of experience, short selling restrictions, constant fundamental values, transaction costs, and the divisibility of assets on bubble formation, e.g. Porter and Smith [1995], Noussair et al. [2001], Dufwenberg et al. [2005], Haruvy and Noussair [2006], Lei and Vesely [2009], Kirchler et al. [2012], Ikromov and Yavas [2012]. These studies have in common that they design a tradable asset that has a finite lifetime. The asset pays a common-knowledge dividend distribution every period, which is the only source of value.[7]

One main difference to our design is that all aforementioned papers assume a finite horizon (declining fundamental value). By contrast, our design captures an infinite horizon OLG model to allow for rational bubbles. The seminal paper of an OLG laboratory experiment is Marimon and Sunder [1993]. Marimon and Sunder [1993]'s experimental design consists of assigning a fixed number of subjects to each session. Each subject plays during two periods (i.e. a lifecycle) as young and old in the first and second period respectively. After playing in the second period (old) subjects are randomly assigned to restart as a young participant or waiting until being reassigned. Marimon and Sunder [1993] constructed this experimental environment to address questions of equilibrium selection and sunspots in the presence of multiple equilibria. Following Marimon and Sunder [1993], Lim et al. [1994] implemented an OLG model with money in a laboratory setting with the objective of studying price dynamics and the use of money as a store of value. Bernasconi and Kirchkamp [2000] use a slightly different environment to Marimon and Sunder [1993] to

[7] Porter and Smith [1995] study whether bubbles are less likely or smaller if the dividend is certain compared to an uncertain dividend. The authors do not find significant differences between the two treatments. A further result is that future markets help reduce the magnitude of bubbles but cannot eliminate them. Noussair et al. [2001] study whether bubbles are eliminated when the fundamental value is constant over the finite lifetime of the asset (instead of decreasing as in SSW). They find that bubbles are not eliminated. This finding is in line with Vernon L. Smith [2000]. Dufwenberg et al. [2005] find that bubbles are reduced when the assets are traded by experienced traders, while Lei and Vesely [2009] show that bubble formation is reduced when the dividend process is explained very thoroughly to the participating subjects. Kirchler et al. [2012] show that confusion about the fundamental value plays a crucial role in experimental bubble formation. Haruvy and Noussair [2006] analyze the impact of short selling restrictions on bubble formation. They find that trading prices are reduced when short selling restrictions are relaxed, however negative bubbles persist. Ikromov and Yavas [2012] investigates the impact of transaction costs, short selling restrictions and the divisibility of assets on bubble formation. They find that transaction costs, as well as an increase in the divisibility of assets, reduce the magnitude of bubbles. Short-selling restrictions lead to prolonged bubbles. For a review of the literature see chapters 29 and 30 in Plott and Smith [2008].

investigate how inflation is determined by monetary policy and by the amount of average saving within each period. Camera et al. [2003] use an OLG environment built on Marimon and Sunder [1993] with the difference of adopting a double auction environment instead of a supply schedule as the market institution to determine prices and quantities. They investigate how fiat money is used in transactions when an identically marketable, dividend-bearing asset, is also present.

Our OLG environment is based on Marimon and Sunder [1993], however, it differs in three aspects. First and as in Camera et al. (2003), we use a continuous double auction environment. Second, we use a different way to construct 'generations' as we opted for pooling subjects randomly after each life-cycle instead of having them waiting to be reassigned. This different assignment strategy has two advantages. First, it allows us to gather more observations. Second, we manage to stay closer to the theoretical model by mixing over a larger pool of subjects to reassign subjects to new generations. Recall that in the model a pair of subjects meets just once for a transaction. A further difference is the incentive structure. Our subjects know that only one lifecycle will be paid out, this lifecycle is chosen randomly. This design feature helps us to prevent subjects from hedging risk by playing different extremes in different lifecycles. We think this incentive structure is very important to align the experiment with the theoretical model, where subjects live for one lifecycle only. To implement an infinite horizon environment in the laboratory, we follow Crockett and Duffy [2015] by implementing an indefinite horizon by assuming a constant probability of continuation each period.

2.3 Experimental Design

This section outlines the experimental design using overlapping generations. First, we explain the decisions that subjects take in a lifecycle. Second, we describe the assignment to groups (= markets) and the overall structure of the experiment. Third, we present the treatments and the parameters (chosen based on the theoretical model) and, finally, the procedure and the subject pool. The instructions are provided in the appendix. Our objective to run a macro lab experiment was two-fold: First, we focus in the lab-experiment on the novel empirical stylized fact identified across 18 OECD countries. Countries that spent a lower share of consumption expenditure on housing services experienced larger house price bubbles during 1970-2014. However, conclusions on the causal effect cannot be easily drawn given data availability issues, potential measurement errors especially for the bubble and the preference for housing services, and the problem of reversed causality. As conclusions on the causal effect of the preference of housing services on housing bubbles cannot be drawn from the empirical data, Huber [2017a] develops a theoretical model that provides a causal link, an explanation why the preference for housing services might determine the vulnerability of an economy to housing bubbles. The proposed model mechanism is tested in a laboratory setting.

Second, this paper contributes to the literature on experimental asset markets more generally. It provides an experimental framework where also a market for the dividend of a traded asset exists. Most experiments in the related literature assume exogenously a dividend for the traded asset. Our design is one of the first where a market for the dividend of a bubbly asset exists and where the dividend is determined endogenously in the laboratory setting by the choices of the market participants. Furthermore, we implement novel design features with respect to the assignment to markets, and the incentive structure in an OLG setup. These features will be discussed in more detail in the next sections.

2.3.1 Decisions in a lifecycle (young and old)

As mentioned earlier, we implement an experimental design using overlapping generations. For feasibility reasons, subjects play several lifecycles, but only one completed lifecycle (chosen randomly) forms the basis for the payment. We decided to pay only one completed lifecycle because it most closely aligns incentives with the idea of independent overlapping generations. Figure (2.1) shows the timing of the decisions subjects take within each lifecycle.

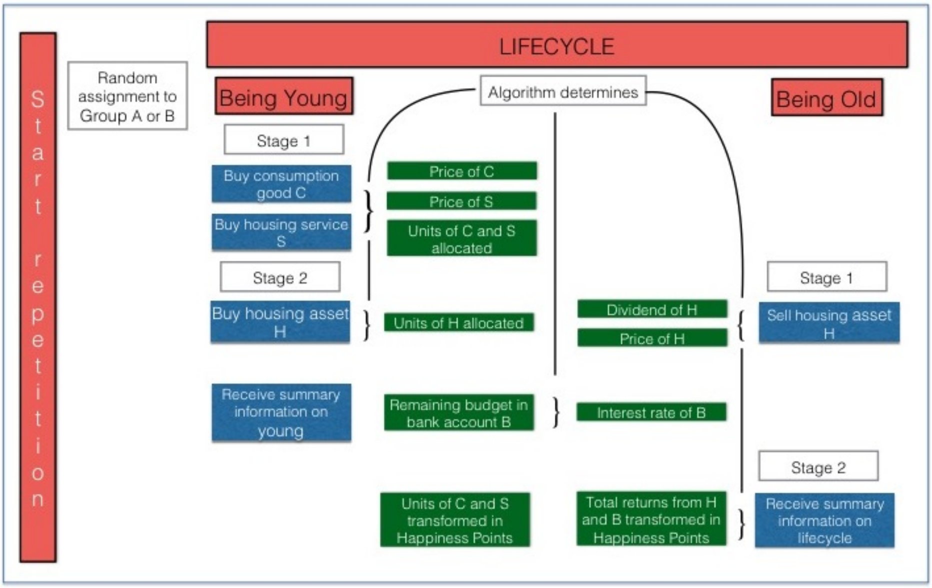


Figure 2.1: Lifecycle and decisions when young and old

A lifecycle consists of two periods: In the first period of a lifecycle, subjects take decisions as a *young* household. In the second period of a lifecycle, subjects take decisions as an *old* household and receive payments that are based on their decisions when young and old, as well as aggregate outcomes. The decision screens of a lifecycle can be found in the appendix.

Each period (*young* and *old*) is divided into two stages. In the theoretical model, young households make decisions on the consumption good C, housing services S, the housing asset H and the riskless bond B simultaneously. For practical reasons (screen overload, remaining budget calculation, dividend calculation), this is not feasible in the lab. We, therefore, split decisions into two stages. At the beginning of a lifecycle, subjects receive an endowment (= budget) that they can spend on the consumption good C, housing service S, the housing asset H, and the riskless bond B.

When *young*, subjects first decide how many units of the consumption good C and how many units of housing service S they want to purchase (young, stage 1). They do so by clicking on a combination of C and S in a graph on the decision screen. Next to the graph where they make their choices, a colored heat map is displayed on the screen. The colors go from red to yellow to green. The greener the color the more happiness points (utility) subjects receive for the specific combination of C and S. The price for one unit of C is set to the numeraire (and equal to one). The (relative) price for one unit of S, p_t^r, depends on all young's purchases of C and S in the market. The price p_t^r can only be calculated once all young in the group have submitted their purchase decisions (subject to budget constraints and available supply of C and S). We therefore provide a graph on which subjects can simulate the purchase decision of C and S of other young subjects in the group. Together with the own chosen combination of C and S, the relative price for one unit of S, p_t^r, is calculated and displayed on the screen. Subjects can try as many combinations as they wish (without time restriction). Once they decide for a combination of C and S, they press a "Submit" button, and their decision is submitted. We tell subjects to submit the very maximum number of units of C and S they want to purchase. Once all young in the group have submitted their demands, the algorithm checks for availability of the demanded number of units. In the case of excess demand, each young subject's demanded units are reduced proportionally to the requested amounts.

In the second stage when *young*, subjects purchase units of housing asset H in a double auction from the current *old* in the group (young, stage 2). Before the *young* subjects get to the double auction, they learn how the dividend of the housing investment H will be determined. They understand that the dividend will depend on the choices of C and S by the *future young*. They can simulate the average purchase of C and S by the future *young* on a graph.[8] The dividend resulting from each simulated combination of C and S is calculated and displayed on the screen. We implement a standard experimental double auction with the only excep-

[8] As a helping device, the same heat map as in stage 1 when *young* is depicted because the future *young* will make the exactly same decision on purchasing C and S as the current *young* generation.

tion that *young* subjects can only *purchase* and *old* subjects can only *sell* housing assets H. Currently *young* subjects can initiate a purchase of an asset by submitting an offer to buy (a price for which they want to buy one unit of housing asset H) or by accepting an offer to sell submitted by *old* subjects (a price for one unit of housing asset H). The duration of the double auction is three minutes. After the double auction, the remaining budget is automatically invested into a riskless bond B (= remains in the bank account) and earns a fixed interest payment.

When *old*, subjects learn about their investment return in asset H. They receive a dividend payment for each housing asset H they bought when young. The *old* subjects enter a double auction, where they can sell housing assets H to the current *young* generation in the group (old, stage 1). Currently *old* subjects can initiate a sale of an asset by submitting an offer to sell (a price for which they want to sell one unit of housing asset H) or by accepting an offer to buy from the *young* subjects (a price for one unit of housing asset H). The duration of the double auction is three minutes. The stock of housing assets H has to remain constant from generation to generation, we assume no depreciation of the housing stock. Unsold units of the housing asset H are assigned randomly to the current *young* in the group at a punishment price. The punishment price is lower than the median trading price for the current *old* and it is higher for the current *young* in the group. This incentivizes subjects to trade the existing housing stock H, such that the market clears.

At the end of a lifecycle, subjects receive summary information on their decisions in the corresponding lifecycle: the number of units C and S purchased in that lifecycle and the respective prices, units of H purchased, and the median price of H of all sold assets H. Furthermore, subjects receive information on the dividend of each purchased housing asset H, the price for which they sold the purchased assets H, the return from the riskless bond B, and the total lifecycle utility.

To facilitate decisions and ensure that decisions are as well-informed as possible, subjects can get to a history screen from any decision screen or feedback screen (and back to the decision or feedback screen). On the history screen, they find a summary of their decisions on C, S, H, and

B as well as the corresponding utility in all previous periods of the experiment. Furthermore, the history table shows the median price for all traded housing assets H and the average dividend per housing asset H in all previous periods of the experiment.

2.3.2 Markets Assignment and Experimental Structure

In the beginning of the experiment, 50% of all subjects are randomly assigned to Cohort I and the remaining 50% of subjects to Cohort II. All subjects are informed that they will remain in the assigned cohort for all periods of the experiment.

In the beginning of period 1, four members of each cohort are randomly assigned to Market A and the other four members to Market B. Cohort I (II) starts as a *young* (*old*) generation in period 1 and subjects make decisions accordingly. Figure (2.2) summarizes the assignment to Cohorts and Markets.

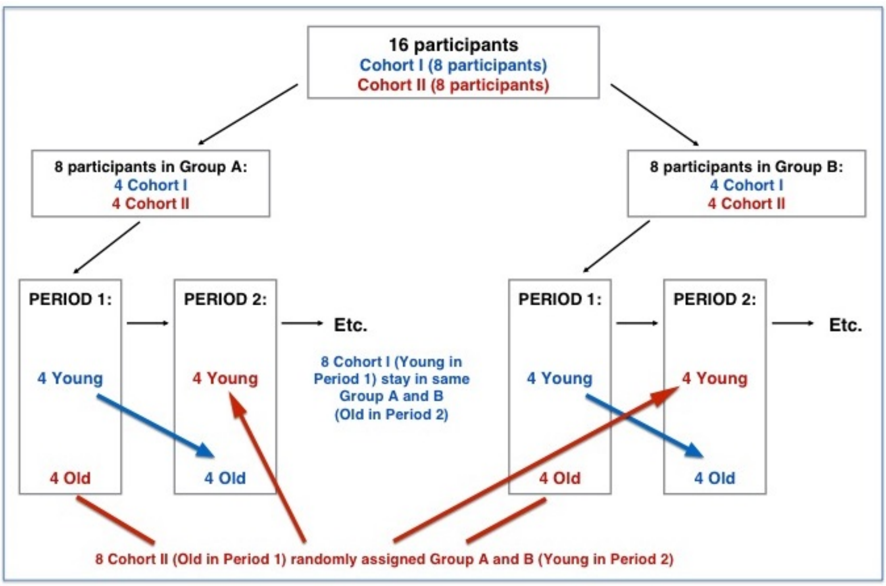


Figure 2.2: Assignment of subjects to Market A and B

From period 2 onwards, cohorts switch between generation in each period. That means that Cohort I (II) takes the role of the *old* (*young*) generation in period 2, the role of *young* (*old*) generation in period 3, etc. As an important design feature, the *old* subjects remain in the *same* Market as in the previous period (when they were *young*), while the *young* subjects are *randomly* assigned to either Market A or Market B. Through this assignment, we control for colluding behavior in small markets and repeatedly interacting agents.

Cohort I's lifecycle 1 consists of periods 1 and 2, lifecycle 2 consists of periods 3 and 4, etc. Cohort II's lifecycle 1 consists of periods 2 and 3, lifecycle 2 consists of periods 4 and 5, etc. Figure (2.3) presents an overview over each cohort's lifecycles. As mentioned earlier, one completed lifecycle is chosen randomly and paid out at the end of the experiment. If a cohort is *old* (*young*) in the last period of the experiment that lifecycle is complete (incomplete) and enters (does not enter) the lottery of the randomly selected lifecycle for payment.

Period		1	2	3	4	5	6	7	
Cohort I (8 subjects)		young	old	young	old	young	old	young	
	Lifecycle	1		2		3		....	
	Group	A or B (random)		A or B (random)		A or B (random)		....	Etc...
Cohort II (8 subjects)		old	young	old	young	old	young	old	
	Lifecycle		1		2		3		
	Group	A or B	A or B (random)		A or B (random)		A or B (random)		

Figure 2.3: Chronological order of the experiment

To implement an infinite horizon environment in the lab, we follow Crockett and Duffy [2015] and implement an indefinite horizon by assuming a constant probability of continuation each period. This probability is set to

80%. Before running the sessions, we threw a ten-sided dice to determine the number of periods. Thus the length of each session is the same and equal to nine periods. Before the experiment starts, subjects have four trial periods to get familiar with the experiment and the decisions they are expected to make.

Conservatively, we consider each session as an independent observation because subjects go back and forth between the two Markets A and B. We thus interpret one session as a "super-Market" and the aggregate behavior in one session as the behavior in a "super-Market."

2.3.3 Treatments and Parameter Choices

The treatments are derived from Huber [2017a]'s theoretical model. We implement the following two treatments in a between-subject design:

- Treatment *"Weak preference for housing service"*: subjects have a weak preference for housing services (low ξ), the utility from consuming housing services S relative to the consumption good C is low.

- Treatment *"Strong preference for housing service"*: subjects have a strong preference for housing services (high ξ), the utility from consuming housing services S relative to the consumption good C is high.

The main hypothesis concerning the effect of preference for housing service on the size of housing bubbles on the housing asset market is:

> *Housing Bubbles are larger in the treatment "Weak preference for housing service" with low ξ compared to the treatment "Strong preference for housing service" with high ξ. We expect the deviation of the asset price from the fundamental value to be larger in treatment "Weak preference for housing service" compared to the treatment "Strong preference for housing service".*

The treatment variable ξ takes the following values: $\xi = 2$ in the treatment *"Weak preference for housing service"* and $\xi = 6$ in the treatment *"Strong preference for housing service"*. In the treatment Strong preference for housing service the relative preference parameter is 300% larger.

We calibrated these values to match cross-country stylized facts presented in Chapter 1. More concretely, for the sample of 18 OECD countries, the lowest share of total consumption spent on housing services is around 11%, while the largest is slightly above 30%. In the model, data on the aggregate consumption expenditure share spent on housing services pins down the model parameter ξ for each country uniquely. We match the distance between the lowest and largest ξ implied by the aggregate consumption expenditure shares spent on housing services across countries.

The remaining parameter choice are derived from the theoretical model and are summarized below

- 16 subjects in each session (8 in Cohort I, and 8 in Cohort II)
- Four trial periods and nine periods in the experiment (number of periods determined by throwing a ten-sided dice before the sessions started)
- Supply: In each market (A and B), 20 units of consumption good C, housing service S, and housing asset H, respectively
- Excess demand for S and/or H:
  proportional cut of the demand for all *young* subjects until demands equals supply
- Endowment at the beginning of each lifecycle (when being *young*): 250 EURUX
- Endowment of initial Cohort II members in period 1 (*old subjects*): five units of housing asset H and 50 EURUX invested in bond B.
- Price for one unit of C: numeraire and equal to one

- Price for one unit of S: relative price $p^r = \xi * \frac{C^{demanded}}{S^{demanded}}$
- Price for one unit of H: determined in a double auction
- Punishment price for unsold H: 0.5 of median price in the respective market for sellers (currently *old*); 1.5 of median price in the respective market for buyers (currently *young*).
- In each period, the dividend of the Housing asset H is determined by the current *young* and given by p^r if $S^{demand} = S^{supply}$; Dividend $= p^r * \frac{S^{demand}}{S^{supply}}$ if $S^{demand} < S^{supply}$
- After purchase of C, S, and H, remaining budget invested in riskless bond B at an interest rate of 5%.
- Happiness Points (from C and S) = $log(C) + \xi log(S)$
- Happiness Points (from H and B) = log(return from selling the previously purchased H + divided per purchased H + 1.05*investment in bond B)

2.3.4 Procedure and Subject Pool

At the beginning of each experimental session, the instructions, illustrating screenshots, graphs, and tables are handed out to the subjects on paper and then read aloud by one of the experimenters. The material handed out to the subjects can be found in the appendix. The instructions and materials are the same for treatment *"Weak preference for housing service"* and treatment *"Strong preference for housing service"* with two exceptions: First, the formula for the utility from C and S differs depending on the treatment ("Happiness Points (from C and S) $= log(C) + 2 * log(S)$" for treatment *"Weak preference for housing service"*; "Happiness Points (from C and S) $= log(C) + 6 * log(S)$" for treatment *"Strong preference for housing service"*). Second, the heat map and screenshots are adjusted accordingly. The beginning of the trail sequence, as well as the start of the main sequence, are announced aloud by one of the experimenters.

The experimental sessions were conducted at the BEElab at Maastricht University in April and May 2016 and the programming was done with the experimental software z-Tree, Fischbacher [2007]. Participants were mainly undergraduate students from Maastricht University and were recruited using the online recruitment system ORSEE, Greiner et al. [2004]. We sent invitations only to students from the following fields of study: Econometrics and Operations Research, Economics and Business Economics, Fiscal Economics as well as International Business.

In total 256 subjects took part in 16 experimental sessions (eight sessions per treatment) composed by 53% women and 47% men (the share of women per session varied between 37.5% and 62.5%). Eckel and Füllbrunn [2015] show that asset markets with a higher share of male participants produce larger price bubbles. To control to some extend for the gender composition, we invited the same number of male and female students to each session. The average age was 21 years. The conversion rate was 1 Happiness Point (= utility) to 3 Euro and the average earnings per subject were 27.27 Euro (including a show-up fee of 5.00 Euro and a finishing fee of 5.00 Euro). The average duration of a session was 2 hours 30 minutes. After the experiment had finished, subjects were asked to fill out a questionnaire and were paid their earnings in private.

2.4 Data Analysis and Main Results

In this section, we first explain how we measure house price bubbles. As in the model, we define a bubble as the difference between the realized median trading price q and the fundamental value q^F. For robustness purposes, we measure the expected fundamental value by four alternative methods, leading to four different bubble measures. For each alternative, we show the difference and similarities of the raw data in the trading price, fundamental value and bubble formation across treatments. Our results are robust to these variations.
Second, we employ and describe a wide range of indicators for measuring experimental bubbles. These indicators are widely used in the exper-

imental asset price literature, and we study their differences across the two treatments (strong versus weak preference of housing services). All employed indicators reveal the same pictures; bubbles are significantly larger in the treatment *"Weak preference for housing service"*.

In addition, we provide statistical inference. Conservatively, we consider a session as an independent observation (resulting in 16 independent observations) and use the non-parametric Mann-Whitney U test to test the difference in the distribution of housing bubbles between the two treatments. Complementary regression analysis allows controlling for the gender composition in a session, age, and a time trend.

2.4.1 Experimental Bubble Measures

As in the model, the experimental bubble is computed by $q_t^B = q_t - q_t^F$, where q_t denotes the realized trading price in the experiment in period t, and q_t^F the fundamental value, i.e. the discounted stream of expected dividends. Next, we assume four different expectation formations, leading to four different measures for the fundamental value, and hence bubble sizes.

Fundamental Value
Each period ends with a probability $x = 20\%$. In our baseline, we assume *sophisticated traders*. We assume that they recognize all realized dividends of the past and update their beliefs accordingly. Hence, in period one sophisticated traders expect all future dividends to be equal to the current and first realization. In all future periods, sophisticated traders update their belief and expect that all future dividends will be equal to the average of all up to date realized dividends. The sophisticated traders

calculate and expect the following fundamental value:

$$q^F_{t=1,sophisticated} = \left(\frac{1-x}{R}\right) p^r_1$$

$$q^F_{t=2,sophisticated} = \left(\frac{1-x}{R}\right)^2 \frac{p^r_1 + p^r_2}{2}$$

$$\dots$$

$$q^F_{t,sophisticated} \equiv E_t \left\{ \sum_{j=1}^{\infty} \left(\frac{1-x}{R}\right)^j \sum_{k=1}^{t} \frac{p^r_k}{t} \right\} \tag{2.1}$$

For robustness purposes, we measure the expected fundamental value by alternative methods. Our results are robust to these variations.

The first alternative we call *naive traders*. We assume that naive traders expect the dividend to be constant and equal to the first realization. The naive traders calculate and expect the following fundamental value:

$$\begin{aligned} q^F_{t,naive} &\equiv E_t \left\{ \sum_{k=1}^{\infty} \left(\frac{1-x}{R}\right)^k p^r_{t=1} \right\} \\ &= \frac{1}{R}(1-x)p^r_{t=1} + \frac{1}{R^2}(1-x)^2 p^r_{t=1} + \frac{1}{R^3}(1-x)^3 p^r_{t=1} + \dots \\ &= p^r_{t=1} \left(\frac{1-x}{R-(1-x)}\right) \quad \forall \quad t \end{aligned} \tag{2.2}$$

The second alternative we call *myopic traders*. For myopic traders we assume that they observe the dividend payment in each period and expect all future dividends to be equal to the current realization. In all periods, myopic traders update their belief and expect that all future dividends will be equal to current realized dividend. The myopic traders calculate and expect the following fundamental value:

$$q^F_{t,myopic} \equiv E_t \left\{ \sum_{k=1}^{\infty} \left(\frac{x}{R}\right)^k p^r_t \right\} \tag{2.3}$$

The third alternative assumes *omniscient traders*, they forecast the dividend process correctly:

$$q^F_{t=1,omniscient} = \left(\frac{1-x}{R}\right)p^r_1 + \left(\frac{1-x}{R}\right)^2 p^r_2 + ... + \left(\frac{1-x}{R}\right)^8 p^r_9$$
$$+ E_t\left\{\sum_{j=1}^{\infty}\left(\frac{1-x}{R}\right)^j p^r_9\right\}$$
$$q^F_{t=2,omniscient} = \left(\frac{1-x}{R}\right)p^r_2 + \left(\frac{1-x}{R}\right)^2 p^r_3 + ... + \left(\frac{1-x}{R}\right)^7 p^r_9$$
$$+ E_t\left\{\sum_{j=1}^{\infty}\left(\frac{1-x}{R}\right)^j p^r_9\right\}$$
$$...$$
$$q^F_{t,omniscient} \equiv \sum_{j=t}^{9}\left(\frac{1-x}{R}\right)^{j-t+1} p^r_j + E_t\left\{\sum_{j=1}^{\infty}\left(\frac{1-x}{R}\right)^j p^r_9\right\} \quad (2.4)$$

Bubble Indicators

In the experimental asset price literature, there are five well established indicators for measuring bubbles. Table (2.1) shows these indicators for all sessions and compares the averages for both treatments.

Price Amplitude (PA)

$$PA_{King} = \frac{max_t(Q_t - q^F_t) - min_t(Q_t - q^F_t)}{q^F_1} \quad (2.5)$$

is defined as the difference between the peak and the trough of the period house price relative to the fundamental value, normalized by the initial fundamental value in period 1. A high Price Amplitude suggests large price swings relative to fundamental value, and is evidence that prices have departed from fundamental values. This measure was first proposed by King et al. [1991].

Total Dispersion (TD)

$$TD = \sum_t |Q_t - q_t^F| \tag{2.6}$$

is the sum of all period absolute deviations of median prices from the fundamental value and thus a measure of the magnitude of overall mispricing. This deviation measure is similar to the amplitude measures and measures the difference between the trading price and the fundamental value. However, this deviation measure is more complete in the sense that it does not only measure the difference between the maximum and minimum deviation from fundamental value. Total Dispersion (TD) was first introduced by Haruvy and Noussair [2006].

Average Bias (AB)

$$AB = \frac{\sum_t (Q_t - q_t^F)}{T} \tag{2.7}$$

was first introduced by Haruvy and Noussair [2006] and is calculated by the sum of all period absolute deviations of median prices from fundamental value, normalized by the total number of periods T. Hence, it is an indicator of the average per-period deviation of prices from fundamental value.

Relative Absolute Deviation (RAD)

$$RAD = \frac{1}{T} \sum_{t=1}^{T} \frac{|Q_t - q_t^F|}{|\bar{q}^F|} \tag{2.8}$$

was proposed by Stöckl et al. [2010] and measures the average level of mispricing. It is similar to the TD measure, but has two important advantages: The measure is independent of (1) the number of periods, and (2) the absolute level of the fundamental value. The *Relative Absolute Deviation (RAD)* is shown in the fourth column of table (2.1) and is calculated by averaging the absolute differences between the mean price and the fundamental across all periods and is normalized by the absolute value of the fundamental value of the market $\bar{q}^F$. T denotes the total number of periods in the asset market.

Relative Deviation (RD)

$$RD = \frac{1}{T}\sum_{t=1}^{T}\frac{(Q_t - q_t^F)}{|\bar{q}^F|} \tag{2.9}$$

was proposed by Stöckl et al. [2010]. The fifth column in table (2.1) shows the *Relative Deviation (RD)* measure that is very similar to RAD. While RAD averages the absolute difference between the mean price and the fundamental value, RD averages just the difference between the mean price and the fundamental value. Hence, positive and negative deviations from FV offset each other. When RAD and RD deliver the same number, the mean trading price has never been below the fundamental value, e.g. there has never been a negative bubble.

2.4.2 Descriptive Statistics and Statistical Inference

Bubble Relative to Fundamental Value

Figure (2.4) shows the average median trading price for the housing asset (green line) and its fundamental value FV (blue line). The fundamental value is computed as the average over all sessions assuming sophisticated traders. The black doted lines indicate the range of a reduced (increased) FV by 60%, respectively. The red dotted lines indicate the maximally feasible average trading price. This measure will be discussed in a later section. The left column shows the sessions with the treatment *Weak preference for housing service* and in the right column the treatment *Strong preference for housing service*.

As it can be seen in figure (2.4), the housing asset is on average overvalued in both treatments: The average median trading price Q is similar for both treatments and equals 28.58 for $\xi = 2$ and 28.85 for $\xi = 6$ ($z = 0.000, p = 1.0000, n = 16$, two-sided Mann-Whitney U test). The average median trading price is relatively constant over time for the treatment Strong preference for housing service. For the treatment Weak preference for housing service, the average median trading price seems to slightly decrease over time. Figure (2.7) in the Appendix shows that this slight decrease is driven by one outlier (session 12).

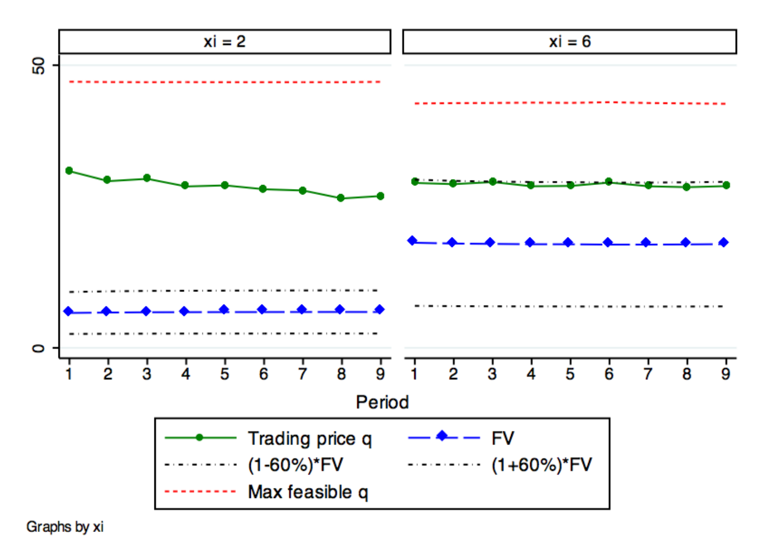


Figure 2.4: Average Median Trading Price and FV (by Treatment)

The FV is substantially larger in the treatment with a strong preference for housing services (18.60) compared to in the treatment with a weak preference for housing services (6.18). The black dotted lines visualize that, for the treatment Weak preference for housing service, the average median trading price is fare outside of the range $((1-60\%)\cdot FV, (1+60\%)\cdot FV)$. The trading price is substantially larger than $1.60 \cdot FV$ while, for the treatment Strong preference for housing service, the trading price lies in between the bounds $((1-60\%)\cdot FV, (1+60\%)\cdot FV)$.

The absolute bubble size is defined as the difference between the median trading price and the corresponding fundamental value. The absolute bubble size is on average 22.26 in the treatment Weak preference for housing service with $\xi = 2$ and 10.48 in the treatment Strong preference for housing service with $\xi = 6$. The distributions are statistically significantly different ($z = 2.626, p = 0.0087, n = 16$, two-sided Mann-Whitney U test).

Figure (2.5) shows the average bubble relative to the fundamental value $\frac{q_t^B}{q_t^F}$. On the left (right) side of the figure, the relative bubble sizes for the weak (strong) preference for housing services $\xi = 2$ ($\xi = 6$) are displayed for each session. On average, the relative bubble size is 3.53 (0.57) in the treatment with a weak (strong) preference for housing service. It is evident that the relative bubble size is significantly larger in the treatment Weak preference for housing service, i.e. for $\xi = 2$ - the left graph ($z = 3.361, p = 0.0008$, two-sided Mann-Whitney U test). Note that the average bubble relative to the fundamental value is relatively constant over time for both treatments.

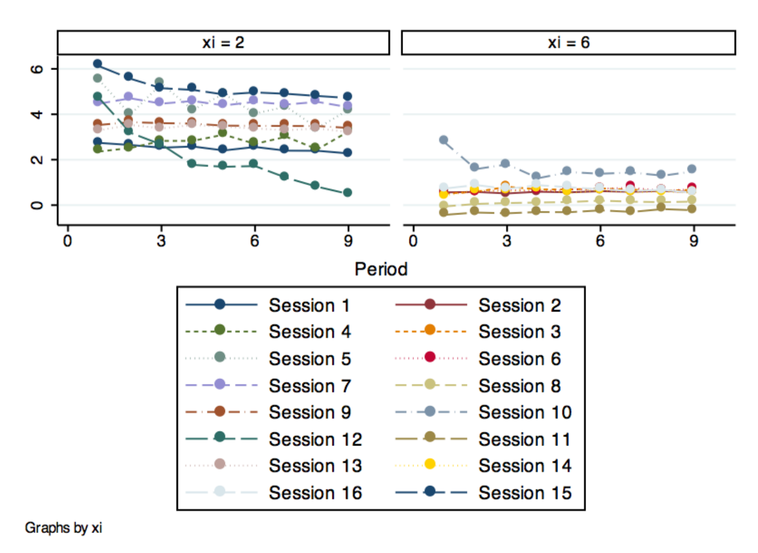


Figure 2.5: Bubble Relative to FV (by Treatment and Session)

Experimental Bubble Indicators

The experimental asset price literature offers five well-established indicators for measuring bubbles. Table (2.1) shows these indicators for all sessions and compares the averages for both treatments. For a detailed explanation and calculation of the five bubble measures, we refer to the previous subsection.

The first column of table (2.1) shows the *Price Amplitude (PA)*. According to this measure, the bubble in the treatment with a weak preference for housing services is on average three times as large.

The second column of table (2.1) shows the *Total Dispersion (TD)* measured by the sum of all period absolute deviations of median trading prices from the FV. It is a measure of the magnitude of mispricing. According to this measure, the bubble is significantly larger in the treatment with a weak preference for housings services.

The third column of table (2.1) shows the measure *Average Bias (AB)*, it averages the sum of all median price deviations from the FV. This measure is substantially larger for the treatment with a weak preference for housings services.

The *Relative Absolute Deviation (RAD)* is shown in the forth column of table (2.1) and is easy to interpret. The value 3.49 for the treatment with a weak preference for housing services means that on average prices per period differ 349% from the average FV in the market. This compares to 65% for the treatment with a strong preference for housing services - a large difference.

The fifth column shows the *Relative Deviation (RD)* measure that is very similar to RAD. For the treatment weak preferences for housing services the two indicators RAD and RD are identical for each session. The market on average overvalues the housing asset by 349%. For the treatment with a strong preferences for housing services, RAD and RD differ in the session 11. On average, the housing asset has been undervalued in this session. Considering all session, according to RD, on average the housing asset is overvalued by 58%, while according to RAD the housing asset is overvalued by 65% on average.

In summary, all indicators considered paint the same pictures. Bubbles are substantially larger in a world with weak preferences for housing services, i.e. in the treatment with $\xi = 2$.

Session	PA	TD	AB	RAD	RD
S1 Average	0.48	140.34	15.59	2.49	2.49
S4 Average	1.82	159.42	17.71	2.55	2.55
S5 Average	2.41	252.50	28.06	4.41	4.41
S7 Average	0.59	258.90	28.77	4.48	4.48
S9 Average	0.42	200.99	22.33	3.49	3.49
S12 Average	4.21	114.72	12.75	2.10	2.10
S13 Average	0.64	194.90	21.66	3.36	3.36
S16 Average	0.96	281.23	31.25	5.07	5.07
Treatment $\xi = 2$ Average	**1.44**	**200.38**	**22.26**	**3.49**	**3.49**
S2 Average	0.31	99.99	11.11	0.60	0.60
S3 Average	0.38	113.89	12.65	0.68	0.68
S6 Average	0.37	103.05	11.45	0.64	0.64
S8 Average	0.27	18.16	2.02	0.14	0.11
S10 Average	1.29	252.76	28.08	1.58	1.58
S11 Average	0.47	-48.62	-5.40	0.27	-0.26
S14 Average	0.36	92.29	10.25	0.59	0.59
S15 Average	0.46	122.79	13.64	0.71	0.71
Treatment $\xi = 6$ Average	**0.49**	**94.29**	**10.48**	**0.65**	**0.58**

PA (Price Amplitude)= $max(Q_t - FV_t)/FV_1 - min(Q_t - FV_t)/FV_1$ (Porter, Smith 1995). TD (Total Dispersion)= $\sum_{t=1}^{N} \mid Q_t^m - FV_t \mid$ (Haruvy, Noussair 2006). AB (Average Bias)= $\frac{1}{N}\sum_{t=1}^{N}(Q_t^m - FV_t)$ (Haruvy, Noussair 2006). RAD (Relative Absolute Deviation)= $\frac{1}{N}\sum_{t=1}^{N} \mid Q_t - FV_t \mid \ / \mid \bar{FV} \mid$ (Stoeckel et al. 2010). RD (Relative Deviation)= $\frac{1}{N}\sum_{t=1}^{N}(Q_t - FV_t) \ / \mid \bar{FV} \mid$ (Stoeckel et al. 2010). Q_t denotes the mean trading price and Q_t^m the median trading price.

Table 2.1: Indicators for Experimental Bubbles

To test the differences between the two treatments (strong preference versus weak preference for housing services) we conduct Mann-Whitney-U-Tests and OLS regression analysis for each experimental bubble indicator. For the Mann-Whitney-U-Test, we consider conservatively one session as an independent observation. Table (2.2) shows that aggregate markets with a weak preference for housing services are characterized by strong mispricing compared to markets where the aggregate preference for housing services is strong. The difference in the bubble size across the two treatments is statistically significant. The Z-value is highly significant for all mispricing indicators.

Table (2.3) shows the OLS regression results. The coefficient of the treatment parameter, the preference for housing services ξ is negative, highly significant, and explains a large part of the variation in the mispricing indicators across treatments. An increase in the preference for housing services by one standard deviation (across treatments), is associated with a decrease of the RAD ratio by 1.44, which is about 82.58% of the variation in RAD.

	RAD	RD	PA	TD	AB	B/FV
Δ mean (median)	2.84***	2.91***	0.95***	106.09***	11.79***	2.96***
Z	3.361	3.361	2.731	2.626	2.626	3.361

Notes: The values represent the difference in means (medians) of the two treatments and Z-values from a Mann-Whitney-U-Test (Z). * Significant at the 10 percent level. ** Significant at the 5 percent level, *** Significant at the 1 percent level. RAD (Relative Absolute Deviation)= $\frac{1}{N}\sum_{t=1}^{N} \mid Q_t - FV_t \mid \ / \mid \bar{FV} \mid$. RD (Relative Deviation)= $\frac{1}{N}\sum_{t=1}^{N} (Q_t - FV_t) \ / \mid \bar{FV} \mid$. PA (Price Amplitude)= $max(Q_t - FV_t)/FV_1 - min(Q_t - FV_t)/FV_1$. TD (Total Dispersion)= $\sum_{t=1}^{N} \mid Q_t^m - FV_t \mid$. AB (Average Bias)= $\frac{1}{N}\sum_{t=1}^{N} (Q_t^m - FV_t)$. B/FV= $\frac{1}{N}\sum_{t=1}^{N}(Q_t - FV_t)/FV_t$. Q_t denotes the mean trading price and Q_t^m the median trading price.

Table 2.2: Means across Treatments: Differences in Distribution (Mann-Whitney-U-Test (1))

	RAD	RD	PA	TD	AB
	(1)	(2)	(3)	(4)	(5)
ξ	-0.711***	-0.728***	-0.238*	-26.52**	-2.947**
	(-6.92)	(-6.85)	(-1.97)	(-2.84)	(-2.84)
Constant	4.915***	4.950***	1.915**	253.4***	28.16***
	(8.50)	(8.52)	(2.72)	(7.16)	(7.16)
N	16	16	16	16	16
R^2	0.774	0.770	0.217	0.366	0.366
adj. R^2	0.757	0.754	0.161	0.321	0.321

t statistics in parentheses. * p<0.1, ** p<0.05, *** p<0.01. Std. Errors adjusted for 16 clusters in Session. Adding additional controls (age, ratio of female subjects, and reported risk aversion) does not alter the size of the coefficient of interest ξ.

Table 2.3: Impact of ξ on Bubble Size Indicators (OLS)

2.5 Robustness Checks

We have shown in the previous section that the housing bubble in absolute terms (and relative to the FV) is significantly larger in the treatment with weaker preferences for housing services.[9] The same result holds for the experimental bubble indicators (RAD, RD, PA, TD and AB).

In this section we discuss four potential concerns the reader might have, and address them with corresponding robustness checks. In particular, we test alternative explanations for the obtained trading price Q and the resulting bubble sizes.

Upper Endowment Bound

As it can be seen in figure (2.4), the average median trading price Q is similar in both treatments, 28.58 for $\xi = 2$ and 28.85 for $\xi = 6$. A valid concern is that this trading price is obtained because of an upper endowment bound. It could be that in both treatments participants spend all remaining budget (after purchasing the consumption good C and housing services S) on housing assets H. In this case, the market price would be obtained by the endowment upper-bound in the economy. The difference

[9]This result is robust to three alternative measurements for the fundamental value q_t^F.

in the bubble size across treatments would then simply be obtained by construction, i.e. because the endogenously realized fundamental value in both treatments is different. The red doted line in figure (2.4) shows the maximum possible trading price Q^{max} for both treatments. This upper bound, Q^{max}, is significantly higher than the actual trading price Q for both treatments.

We compute maximum possible trading price Q^{max} as follows: After subtracting aggregate spending on C (= 20) and S (= $p^r \cdot 20$) from the endowment in the market (= 4·250), the participants could spend maximally 47.02 and 43.32 experimental currency units per unit of housing asset H, in treatment $\xi = 2$ and $\xi = 6$, respectively. The difference between the upper bound Q^{max} and the realized market price for H amounts to 18 and 14 experimental currency units in the case of treatment $\xi = 2$ and $\xi = 6$, respectively. This corresponds to a difference between the upper bound Q^{max} and the realized trading price Q of at least 30%. This gap is to large for being considered a constraint for the realized trading price Q.

Reaction to the Treatment Parameter ξ

Related to the previous concern, the reader might wonder whether participants react to the treatment parameter or whether the similar trading prices Q result from pure randomness. Indeed, the trading prices Q are not significantly different across treatments (z = 0.000 and p = 1.0000, two-sided Mann-Whitney U test). However, the purchase decisions for the consumption good C, and thus the ratio of housing services over consumption S/C differ significantly. As the model predicts, participants purchase significantly fewer units of C in the treatment with a strong preference for housing services (z = 3.123 and p = 0.0018, two-sided Mann-Whitney U test). On average, the purchased amount of C is 19.90 with $\xi = 2$ and 19.13 with $\xi = 6$, a small yet statistically significant difference. The difference in the ratio housing services over consumption S/C across treatments is significant (z = -3.123, p = 0.0018, two-sided Mann-Whitney U test). Recall that the price of C is the numeraire and is set equal to one. The relative price of housing services S is determined endogenously by the relative consumption choices C and S of the subjects, and determines in turn the dividend of housing asset H (the steady state model prediction is $p^r = 2$ in case of $\xi = 2$, and $p^r = 6$ for the treatment $\xi = 6$). Our experimental data is very close to the model's predictions, the realized relative price for housing services $p^r_{\xi=2} = 1.99$ and $p^r_{\xi=6} = 5.74$. The relative price for housing services p^r is significantly different across treatments (z = 3.363 and p = 0.0008, two-sided Mann-Whitney U test). Therefore, we conclude that the participants react to the treatment parameter ξ.

The stable Bubble Size

A third potential concern the reader might have, is the stable bubble size B over time for both treatments, refer to figure (2.5). The bubble size as well as the trading price Q do not display any boom-bust cycles over time. Empirical work is often measuring bubbles in asset prices by boom-bust cycles. If a price increase is larger than a certain threshold during an upturn, this episode is considered as an asset price boom and is used as an indicator for a bubbly episode. Many experimental asset markets display boom-bust cycles as well. However, these experiments are based on infinite horizon models - in contrast to our two-period overlapping generation model. The households live for two periods only, they only buy and sell the asset H once in their lifetime. In the experiment, subjects play several lifecycles but are incentivized to treat the lifecycles as independent lifecycles. To stay as closely to the model, the subjects are informed that only one lifecycle is chosen randomly and is paid out. This avoids potential design problems, where results might be driven by e.g. risk hedging (in one lifecycle the subject tries one extreme, in the next the opposite extreme). If subjects are correctly incentivized (they live for one lifecycle only), then one should not expect any boom-bust cycles in the trading price or the bubble size. Subjects would decide what the optimal decision is and replay this decision every lifecycle.[10]

[10]If we would extend the two-period overlapping generation model to an overlapping generation model where agents live for many periods, the extended model would allow for boom-bust cycles in the price Q of the asset house H over the lifetime of a specific household.

The Cash to Asset Ratio
A fourth potential objection concerns the cash-asset ratio. Haruvy and Noussair [2006], Caginalp et al. [2001] and Caginalp et al. [1998] report that high initial cash-to-asset ratios drive bubble formation. Kirchler et al. [2012] show that bubbles emerge when a decreasing fundamental value is coupled with an increasing cash-to-asset ratio. In contrast, when fundamentals follow a constant time trajectory, Kirchler et al. [2012] find that the levels of cash holdings of traders do not affect asset prices. However, Noussair and Tucker [2016] replicate the findings of Kirchler et al. [2012] and include a new treatment, in which cash holdings are at high levels early in the life of the asset. In this treatment, Noussair and Tucker [2016] observe overpricing and asset bubbles, indicating that greater cash levels are indeed associated with higher prices, even when fundamental values are constant over time. As indicated earlier, the youngs' remaining budget after purchasing C and S, and before entering the double auction of H is different in both treatments. With $\xi = 2$, the endogenously determined steady state price for one unit of S is 2, and it is 6 with $\xi = 6$. Since all parameters and the experimental setup are otherwise identical, the remaining budget when entering the double auction of H differs by $(6 - 2) \cdot 20 = 80$ experimental currency units in the two treatments. This corresponds to a potential price difference of 4 experimental currency units per unit of asset H.

Ideally, we would like to control for the cash-to-asset ratio in the regression analysis. However, the cash-to-asset ratio is highly correlated with the treatment variable ξ.[11] Therefore, we cannot perform joint regressions. We propose the following adjustment to address the concern that the different bubble sizes might be driven by endogenously resulting different endowments across treatments. We adjust the trading price in treatment $\xi = 2$ for the difference in the cash-to-asset ratio. We do so by reducing the realized trading price Q in the treatment with weak preferences for housing services ($\xi = 2$) by $0.674 \cdot (4$ experimental currency units$)$. 67.4% corresponds to the share of the endowment (after purchas-

[11]The correlation coefficient is equal to -0.99.

ing C and S) that the participants invest in H in the treatment with strong preferences for housing services ($\xi = 6$). Alternatively, we could have taken the share of the endowment invested in H under treatment $\xi = 2$ (60.3%), but we decided for the more conservative robustness test.

Tables (2.4) and (2.5) present the same tests for the bubble indicators as in the previous section, but calculated with the adjusted trading price Q^a for the treatment $\xi = 2$. As it can be seen from the non-parametric test results in table (2.4) and the OLS regression results in table (2.5), some tests become marginally less significant (for the measures PA, TD, and AB), however the main bubble indicators RAD and RD remain significantly different across treatments at the 1% level.

Summarizing our results, we find laboratory evidence for the model mechanism and for the empirical regularity that countries characterized with stronger preferences for housing services (relative to other consumption goods) are less prone to experience large house price bubbles. We find high mispricing in treatments with a weak preference for housing services, while over-evaluation is significantly smaller when the preference for housing services is strong.

	Robustness check: Adjusted trading price for treatment $\xi = 2$					
	RAD^a	RD^a	PA^a	TD^a	AB^a	(B^a/FV)
Δ mean (median)	2.51***	2.62***	0.94**	104.74**	11.64**	2.53***
Z	3.361	3.361	2.415	2.521	2.521	3.361

Notes: The values represent the difference in means (medians) of the two treatments and Z-values from a Mann-Whitney-U-Test (Z). * Significant at the 10 percent level. ** Significant at the 5 percent level, *** Significant at the 1 percent level. P^A (Price Amplitude)= $max(Q_t^a - FV_t)/FV_1 - min(Q_t^a - FV_t)/FV_1$. TD^a (Total Dispersion)= $\sum_{t=1}^{N} \mid Q_t^{m,a} - FV_t \mid$. AB^a (Average Bias)= $\frac{1}{N}\sum_{t=1}^{N}(Q_t^{m,a} - FV_t)$. RAD^a (Relative Absolute Deviation)= $\frac{1}{N}\sum_{t=1}^{N} \mid Q_t^a - FV_t \mid / \mid \bar{FV} \mid$. RD^a (Relative Deviation)= $\frac{1}{N}\sum_{t=1}^{N}(Q_t^a - FV_t) / \mid \bar{FV} \mid$. B/FV= $\frac{1}{N}\sum_{t=1}^{N}(Q_t^a - FV_t)/FV_t$. Q_t^a denotes the adjusted mean trading price and $Q_t^{m,a}$ the adjusted median trading price. We adjust the realized trading price of treatment $\xi = 2$ by subtracting $(4 * 0.674)$.

Table 2.4: Differences in Distributions (Mann-Whitney-U-Test (2))

	RAD^a	RD^a	PA^a	TD^a	AB^a
	(1)	(2)	(3)	(4)	(5)
ξ	-0.628***	-0.656***	-0.235*	-26.18**	-2.909**
	(-6.19)	(-6.18)	(-1.95)	(-2.81)	(-2.81)
Constant	4.323***	4.378***	1.910**	228.5***	25.39***
	(7.50)	(7.55)	(2.71)	(6.46)	(6.46)
N	16	16	16	16	16
R^2	0.733	0.732	0.214	0.360	0.360
adj. R^2	0.714	0.713	0.157	0.314	0.314

t statistics in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$. Std. Errors adjusted for 16 clusters in Session. Adding additional controls (age, ratio of female subjects, and reported risk aversion) does not alter the significance level or size of the coefficient of interest ξ.

Table 2.5: Impact of ξ on Adjusted Bubble Indicators (OLS)

2.6 Conclusion

The laboratory experiment in this paper tests the theoretical prediction in Huber [2017a] that economies characterized with weaker preferences for housing services (relative to other consumption goods) tend to experience larger house price bubbles. The hypothesis is tested in an overlapping generation lab experiment where two relative preference levels for housing services are assigned in a between-session design.

Huber [2017a] shows empirically that economies with a lower share of consumption spent on housing services experienced larger housing bubbles during 1970-2014. However, conclusions on the causal effect cannot be easily drawn due to data availability issues, potential measurement errors regarding housing bubbles and preferences for housing services, and the problem of reversed causality. In the absence of econometric clarity on causality, this experiment seeks to provide an alternative basis to test the causal effects.

Consistent with empirical data and the model's predictions we find that a lower share of consumption is spent on housing services in the treatment with a weaker preference for housing services. We find that the bubble size (both absolute and relative) and the price-rent ratio are larger in the treatment with weaker preferences for housing services. This result is robust to calculating the absolute and relative bubble size with four different fundamental values.[12] Five well established experimental bubble indicators (RAD, RD, PA, TD and AB) draw the same conclusions.

This paper adds to the evidence that preferences for housing services (relative to other consumption goods) are an important driver for an economy's vulnerability to house price bubbles. The results suggest that policy makers might want to keep track of indicators for preferences for housing services (e.g. expenditure shares on housing services). Being aware of the environment in which policy makers have to make decisions concerning the housing market seems to be crucial. Depending on the environment, more or less far-reaching policy interventions might be necessary to reduce the likelihood of housing bubble occurrence and size as well as the negative consequences they bring with them.

This paper also contributes a carefully developed experimental design for OLG models. This provides a basis for several potential extensions. Including for example the analysis of competing approaches to policy intervention on the housing market to manage bubbles. Follow-up work could also study the relative merits of potential policy interventions aiming to foster the affordability of housing services e.g. rental subsidies, rental caps or help-to-buy schemes. It would be interesting to study the potentially different implications of these tools on economies' vulnerability to bubbles. The proposed experiment provides a good starting point for follow-up studies because it provides novel OLG design features.

Our experimental design provides a framework where a market for the traded asset and a market for the dividend of the traded asset exists. In the related literature, most experiments assume an exogenous dividend for the traded asset. In contrast, in our design, the dividend of the bubbly asset is determined endogenously by the choices of the market participants.

[12] The absolute bubble size is measured by the difference of the realized trading price from its fundamental value. The relative bubble size is measured by the ratio of realized trading price over fundamental value. We use as a robustness check three additional alternative measurements for the fundamental value.

Furthermore, our novel assignment to markets has the advantages of gathering more observations, simplifying the structure for the participants and giving them the chance to get as much experience as possible. Finally, our incentive structure is novel and important in a world with overlapping generations. From the played lifecycles we select one randomly and pay the participants for their decisions in that lifecycle rather than summing up each participant's earnings over the entire experiment. As discussed previously, we find very stable patterns over the different lifecycles of a subject, which indicates that our incentive structure is closely in line with the theoretical OLG model.

2.7 Appendix A: Individual Market Results

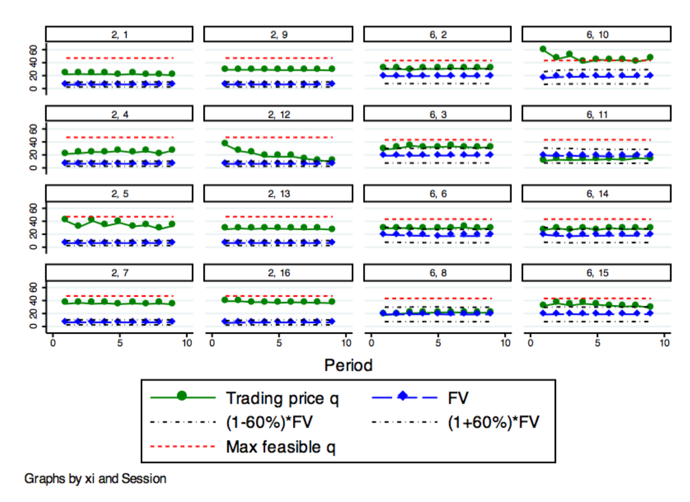


Figure 2.6: Trading Price and Fundamental Value (Group Averages)

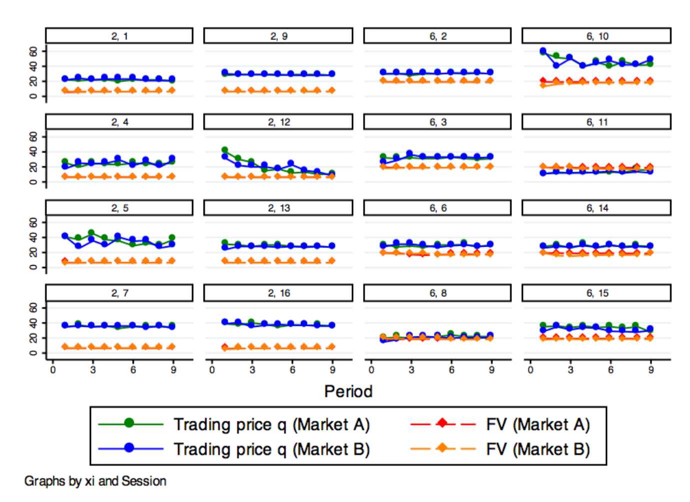


Figure 2.7: Trading Price and Fundamental Value (Session and Group)

Session	PA	TD	AB	RAD	RD
S1- Group A	0.52	138.11	15.35	2.52	2.52
S2 - Group B	0.47	142.58	15.84	2.48	2.48
S4 - Group A	0.78	156.90	17.43	2.72	2.72
S4 - Group B	1.74	161.94	17.99	2.84	2.84
S5 - Group A	2.47	264.94	29.44	4.53	4.53
S5 - Group B	2.34	240.06	26.67	4.30	4.30
S7 - Group A	0.53	258.90	28.77	4.45	4.45
S7 - Group B	0.64	258.90	28.77	4.51	4.51
S9 - Group A	0.43	200.40	22.27	3.43	3.43
S9 - Group B	0.41	201.58	22.40	3.54	3.54
S12 - Group A	4.88	117.18	13.02	2.14	2.14
S12 - Group B	3.54	112.25	12.47	2.06	2.06
S13 - Group A	1.01	202.4	22.49	3.43	3.43
S13 - Group B	0.29	187.4	20.82	3.30	3.30
S16 - Group A	1.27	281.39	31.27	5.06	5.06
S16 - Group B	0.65	281.07	31.23	5.06	5.06
Treatment $\xi = 2$ Average	**1.56**	**187.81**	**20.87**	**3.29**	**3.29**
S2 - Group A	0.17	98.78	10.98	0.58	0.58
S2 - Group B	0.05	101.20	11.24	0.59	0.59
S3 - Group A	0.16	111.06	12.34	0.65	0.65
S3 - Group B	0.59	116.72	12.97	0.69	0.69
S6 - Group A	0.45	102.51	11.39	0.66	0.66
S6 - Group B	0.29	103.58	11.51	0.62	0.62
S8 - Group A	0.19	25.10	2.79	0.16	0.16
S8 - Group B	0.35	11.22	1.25	0.12	0.06
S10 - Group A	1.01	244.74	27.19	1.46	1.46
S10 - Group B	1.56	260.78	28.98	1.70	1.70
S11 - Group A	0.42	-51.16	-5.68	0.24	-0.24
S11 - Group B	0.52	-46.07	-5.12	0.30	-0.28
S14 - Group A	0.33	85.07	9.45	0.47	0.47
S14 - Group B	0.38	99.51	11.06	0.70	0.70
S15 - Group A	0.44	133.2	14.8	0.73	0.73
S15 - Group B	0.48	112.38	12.49	0.69	0.69
Treatment $\xi = 6$ Average	**0.48**	**89.87**	**9.99**	**0.65**	**0.55**

PA (Price Amplitude)= $max(Q_t - FV_t)/FV_1 - min(Q_t - FV_t)/FV_1$ (Porter, Smith 1995). TD (Total Dispersion)= $\sum_{t=1}^{N} \mid Q_t^m - FV_t \mid$ (Haruvy, Noussair 2006). AB (Average Bias)= $\frac{1}{N}\sum_{t=1}^{N}(Q_t^m - FV_t)$ (Haruvy, Noussair 2006). RAD (Relative Absolute Deviation)= $\frac{1}{N}\sum_{t=1}^{N} \mid Q_t - FV_t \mid \; / \mid \bar{FV} \mid$ (Stoeckel et al. 2010). RD (Relative Deviation)= $\frac{1}{N}\sum_{t=1}^{N}(Q_t - FV_t) \; / \mid \bar{FV} \mid$ (Stoeckel et al. 2010).
Q_t denotes the mean trading price and Q_t^m the median trading price.

Table 2.6: Indicators for experimental Bubbles (individual sessions and groups)

2.8 Appendix B: Instructions & Screenshots

2.8.1 Written Instructions (printed on A4)

Welcome and General Instructions

Thank you for participating in this experiment. You are taking part in an experiment involving decisions on experimental groups.

Please read these instructions carefully; they will help you make appropriate decisions. You will receive 5 Euro for participating in this experiment and another 5 Euro for finishing the experiment. Furthermore, you will earn money depending on your decisions and the decisions of other participants during the experiment. Depending on your own and other participants' decisions you may earn a considerable amount of money.

At the end of the experiment, your earnings will be immediately paid out in cash.

Questions

Please feel free to raise your hand and ask the experimenter(s) any question you may have at any time during the experiment.

Please do not talk to other participants until the experiment is over. During the experiment, the use of cell phones is prohibited.

Overview over the Experiment

In this experiment, you will play several "**lifecycles**." A lifecycle consists of two periods: In the **first period** of a lifecycle, you are "**Young**." In the **second period** of a lifecycle, you are "**Old**."

In each lifecycle, you can earn Happiness Points, which will depend on your consumption and investment decisions when ”Young” and ”Old” as well as on other participants’ decisions.

You will play several **independent** lifecycles. In each lifecycle, the decisions when ”Young” and ”Old” will be the same.

Objective in each lifecycle

Your **objective in each lifecycle** is to earn **as many Happiness Points as possible** with your available budget. You earn Happiness Points by purchasing consumption good C and housing service S. Your final budget at the end of the lifecycle will also be transformed into Happiness Points. The number of Happiness Points will be transformed into EURO at the exchange rate of 1 Happiness Point = 3 Euro.

When ”Young,” you can use your budget to purchase consumption good C and housing service S. You can also invest in the housing asset H. In case you do not spend all your money on S, C and H, your remaining budget will remain in your bank account B and receive automatically an interest rate payment. Your purchase of consumption good C and housing service S gives you immediately Happiness Points.

When ”Old,” your housing asset H (you bought when ”young”) provides a dividend (= return) and a potential profit from reselling it at a higher price to the next young generation. The remaining budget in your bank account B provides a fixed interest. After the period of being ”Old,” your total returns from housing asset H and bank account B will be transformed into Happiness Points.

Decisions in a lifecycle

Remember: A **lifecycle** consists of two periods: In the **first period** of a lifecycle, you are ”**Young**.” In the **second period** of a lifecycle, you are ”**Old**.” **Each period** is split into **two stages**, respectively.

When you are ”Young”: In stage (1), you decide how many units of consumption good C and how many units of housing service S you want to purchase. In stage (2), you can ask for units of the housing assets H with the remaining budget in a double auction.

When you are ”Old”: In stage (1), you can sell your purchased units of the housing assets H (if you have purchased any) in a double auction to the new ”Young.” In stage (2), you will be informed on your total returns from housing assets H and the bank account B and you will receive a summary of your lifecycle decisions and the corresponding Happiness Points.

Decisions when being ”Young”

You will receive a budget of 250 EURUX that will be deposited in your bank account. You can use this money for buying consumption good C, housing services S and housing assets H.

Stage (1) when young

At the top of the screen you'll see a **graph** with the different combinations of consumption good C (x-axis) and housing service S (y-axis) that you can buy. The graph shows different colors for each combination of consumption C and housing services S chosen. The color map goes from red to yellow to green. The **greener the color** the **more Happiness Points** you receive for the specific **combination of C and S**. The more red the area, the fewer Happiness Points you receive for the corresponding combination of C and S. The formula behind it is: **Happiness Points (from C and S) = log(C) + 2*log(S)**.

You can move the red point in the upper graph to the left. The red point represents your choice of C and S. On the right, you see how many Happiness Points you would receive for this particular combination of C and S. You can try any combination of C and S units and as many combinations as you wish.

The price for one unit of C is fix and equal to 1 EURUX. Each of the different **combinations of C and S** defines a **price for housing service S**. The price will depend on the combination-choice of all ”Young” participants in your group.

The graph with the blue point on the left of the screen helps you to understand what the relative price of housing services might be. The blue point represents the (simulated!) average choice by the other ”Young” participants in your group. Note that this is just a simulation and not the final choice of the other ”Young” in your group. The simulated price will be displayed on the right side of the screen. Notice that this information is only a potential (simulated) price. The actual price will be computed based on all group member’s choices.

You will receive information on the total number of Happiness Points and your remaining bank account balance for the chosen combination of C and S units.

Once you have decided for a combination of C and S units on the graph, you submit your final decision by clicking on the button ”Submit.”

Note that, for **all Young** in your group, **the total available amount of C and S is 20 units, respectively**. You will input the very maximum amount you would like to purchase. You may end up purchasing less than your desired amount. If the total demand for consumption good C and housing service S in the group is in excess of what is available, you may find yourself able to purchase only a fraction of the units you requested. Each Young?s purchased units of C and S will be reduced proportionally to the requested amounts.

After all participants have submitted their consumption and housing service decisions, the price for S will be computed. Spending on C and S will be debited from your bank account.

The computer will check that every Young is able to pay the purchased units of C and S at the calculated price of C and S. Once everybody is set, you continue with Stage (2).

Stage (2) when young

In Stage (2) when "Young," you have to decide how many assets H you want to buy. The dividend will depend on the future "Youngs" purchase of C and S, i.e. the "Young" when you will be "Old." Before buying the housing assets H when "Young," you will find a screen where you can choose different combinations of C and S to simulate the choice by the future "Young" and its implication for the dividend. The graph will help you get an idea about the dividend.

You can buy as many housing assets H as you wish and as your available budget allows you. Your available bank account balance (after having purchased C and S) will be displayed on the upper part of the screen. Below that information, you will see the current number of housing assets H that you hold. Both are instantly updated each time you buy an asset. You will have 3 minutes for buying the assets H.

When you are "Young," you will only be able to **buy** assets H. You will not be able to sell them. You can buy assets H from the current "Old" in your group. You will be able to do so in two ways.

First, you can **initiate a purchase** of an asset by **submitting an offer to buy (a price for which you want to buy a unit of asset H)**. If you have money (EURUX) in your bank account and would like to buy an asset, you can initiate the purchase by submitting an offer to buy. Note that the offer cannot be larger than your available budget.

After writing a number in the text area "Enter offer to buy" press the red button labeled ”Submit offer to buy.” Immediately in the column labeled ”Offers to buy” you will see a list of numbers ranked from low to high. These numbers are the prices at which all ”Young” in your group are willing to buy a asset in this period. The offers to buy will be executed once they are accepted by one of the current ”Old” in your group.

On the trading screen, your own offers are marked in blue; others? offers are in black. If you want to buy more assets H - repeat this process.

Second, you can **realize a purchase** of assets by **accepting an offer to sell (accepting a price for one unit of H)** submitted by a participant who is currently ”Old.”

If you have enough money in your bank account, you can buy an asset at one of the prices listed in the ”Offers to sell” column which contain all the offers submitted by participants in the Old role. You buy an asset by selecting one of the others’ offers and then clicking on the red button ”Buy.” The best offer is highlighted in deep blue.

Whenever an offer is accepted, a transaction is executed. Immediately when you accept an offer to sell, you realize a purchase and the number of EURUX in your bank account goes down by the trading price. At the same time, your trading partner realizes a sale and the balance in his/her bank account increases by the trading price. Similarly, your number of assets H goes up by one unit and your trading partner’s number of assets H goes down by one unit.

In each group, there will be **20 units of housing assets H** (owned by the ”Old” in your group). Assets not sold in the double auction are distributed equally among all ”Young” in your group (or until the budget of all ”Young” is zero) at a punishment price that equals 1.5 times the median price. To calculate the median price in your group you order all sale prices from lowest to highest and pick the price that is in the middle.

Your remaining bank account balance, i.e. the budget that you did not spend on consumption good C, housing service S, and housing asset H will stay on your bank account B and you will receive an interest rate payment of 5%.

Decision when being ”Old”

At the beginning of the ”Old” phase of the lifecycle, you receive the interest rate payment on your bank account B; it will be deposited in your bank account.

You will receive a dividend for the housing assets H that you bought when ”Young” (if any) and the selling price for your housing assets H. How the dividend and the selling price for H are determined is explained below.

Stage (1) when old

When you are ”Old,” you will only be able to **sell** the assets H that you purchased when you were ”Young” in the same lifecycle. You can sell assets H to the current ”Young” in your group. Note that you can only sell as many assets H as you hold. You will have 3 minutes to sell all your assets H. Note that you should sell all your assets H, otherwise you will be punished. You will be able to sell assets H in two ways:

First, you can **initiate a sale** of assets by **submitting an offer to sell (you propose a price for which you want to sell one unit of asset H)**.

You can write a number (integer) in the text area labeled ”Enter offer to sell” in the first column and then click on the button ”Submit offer to sell.” A set of numbers will appear in the column labeled ”Offers to sell.” Each number corresponds to an offer from one of the participants who is currently ”Old” in your group. Your own offers are shown in blue; others' offers are shown in black. The offers to sell are ranked from high to low. Each offer introduced corresponds to **one single asset**. Note that by submitting an offer to sell, you initiate a sale, but the sale will not be executed until someone accepts it.

If you want to sell more of your assets H, repeat this process.

Second, you can **realize a sale** of an asset H by **accepting an offer to buy (accepting a price a "Young" is willing to buy an asset H for)**.

The highest (best) price currently listed in the column of "Offers to buy" is highlighted in deep blue.

Again, a transaction is executed whenever an offer to buy is accepted. If you accept an offer to buy posted by others, you realize a sale and as a result, the amount of EURUX in your bank account increases by the trading price. At the same time, your trading partner realizes a purchase and the balance in his/her bank account decreases by the trading price. Similarly, your number of assets H goes down by one unit and your trading partner's number of assets H goes up by one unit.

For all housing assets H that you do not sell you will be punished for. You loose your unsold assets H and you will only receive 50% of the median price that was realized during this period in your group. To calculate the median price you order all sale prices from lowest to highest and pick the price in the middle.

Stage (2) when old

Your total budget when being "Old" includes the remaining bank account balance B plus interest payments, as well as the dividend for your housing assets H and the price at which you sell the housing assets H that you had purchased when being "Young."

Summary of the Lifecycle

You will see a summary of your decisions in the corresponding lifecycle on the screen:

- How many units of C and S you bought in that lifecycle and the respective prices,
- How many units of H you bought
- The median price of housing asset H of all sold H,
- The dividend of asset H you received when ”Old”
- The price for which you have sold the purchased assets H
- The return on your bank account B
- The number of Happiness Points you received for this lifecycle.

From this information, your **final budget when ”Old”** will be calculated (in EURUX) and transformed into Happiness Points at the following exchange rate **Happiness Points (from H and B) = log (EURUX)**.

History screen

To help you with the decisions, you find on the decision screens when ”Young” a button labeled ”History.” If you click on the button, you get to the respective screen and can get back anytime to the decision screen. You will find a summary over your decisions on C, S, H, and B as well as the corresponding Happiness Points you received in all previous periods of this experiment. Furthermore, you find a summary of the median price per housing asset H and the average dividend per housing asset H in all previous periods of this experiment.

Assignment to group A and B

In total, 16 participants participate in this experiment including yourself. All 16 participants will be assigned randomly to Cohort I and Cohort II at the beginning of the experiment, i.e. before period 1 starts. You will be informed whether you belong to Cohort I or Cohort II. All participants will remain in the assigned cohort for the entire experiment. 8 participants will form Cohort I and 8 participants will form Cohort II.

At the beginning of period 1, 4 members of each cohort will be randomly assigned to Group A and the other 4 members of each cohort will be assigned to Group B.

In period 1, Cohort I will be ”Young” and Cohort II will be ”Old” and make decisions accordingly. To start, each member of Cohort II will be endowed with 5 units of housing assets H and 50 EURUX on the bank account.

In period 2, Cohort I will be ”Old” and Cohort II will be ”Young.” Cohort I will remain in the *same* group (A or B) as in period 1. 4 members of Cohort II will be randomly assigned to Group A and the other 4 members will be assigned to Group B.

In period 3, Cohort I will be ”Young” and Cohort II will be ”Old.” Cohort II will remain in the *same* group (A or B) as in period 2. 4 members of Cohort I will be randomly assigned to Group A and the other 4 members will be assigned to Group B.

Etc.

Chronological order of the experiment

Remember that one lifecycle will be chosen randomly and you will be paid according to your Happiness Points in **that** lifecycle. Cohort I's lifecycle 1 consists of periods 1 and 2, lifecycle 2 consists of periods 3 and 4, etc. Cohort II's lifecycle 1 consists of periods 2 and 3, lifecycle 2 consists of periods 4 and 5, etc.

If a cohort is ”Old” in the last period of the experiment, that lifecycle is complete and enters the lottery of the randomly selected lifecycle for payment. If a cohort is ?Young? in the last period of the experiment, that lifecycle is not complete and does not enter the lottery of the randomly selected lifecycle for payment.

In the graphs and tables attached, you find a summary of the experiment.

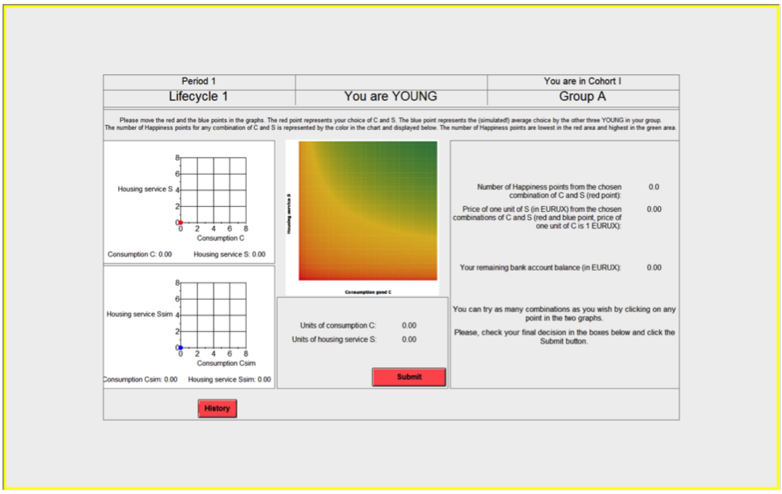
There will be two sequences of the just described experiment: One trial sequence with four periods, which does not enter the lottery for the payment. It is there to help you get familiar with the experiment. Then there will be a sequence out of which one lifecycle will be chosen randomly at the end of the experiment and paid out.

The experiment ends after each period with a probability of 20%. We have thrown a ten-sided dice to determine the number of periods, whereby the numbers 0 and 1 indicated ending the experiment and the numbers 2 through 9 indicated continuing the experiment.

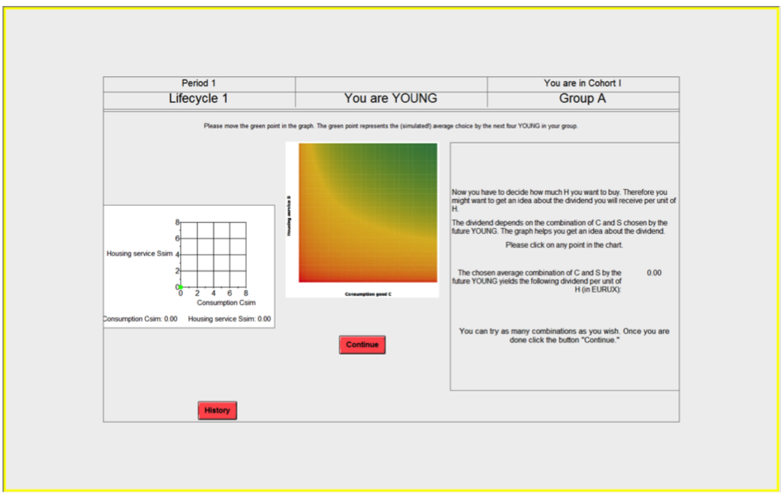
2.8.2 Screenshots

Screens when "Young"

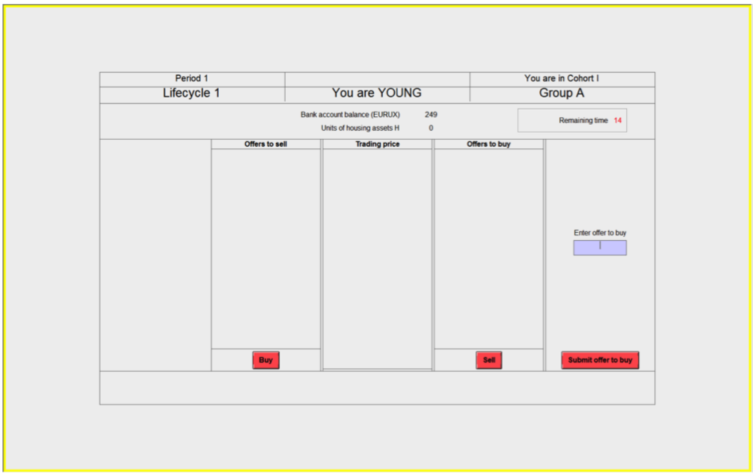
Stage 1 (consumption C and housing service S)



Stage 2 (Simulation of dividend)

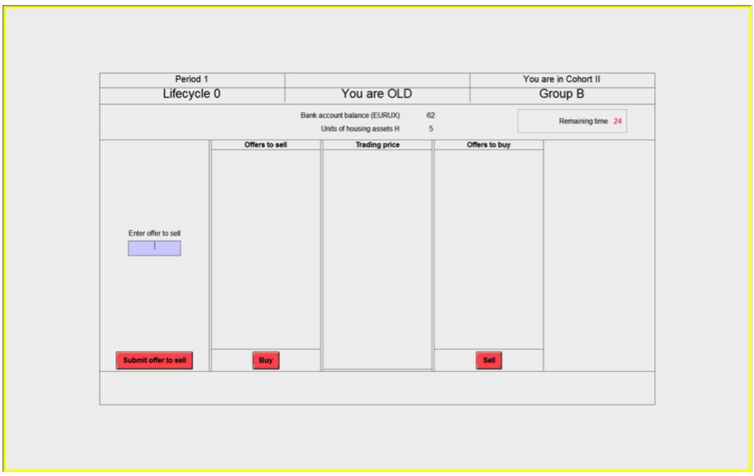


Stage 2 (Housing asset H)



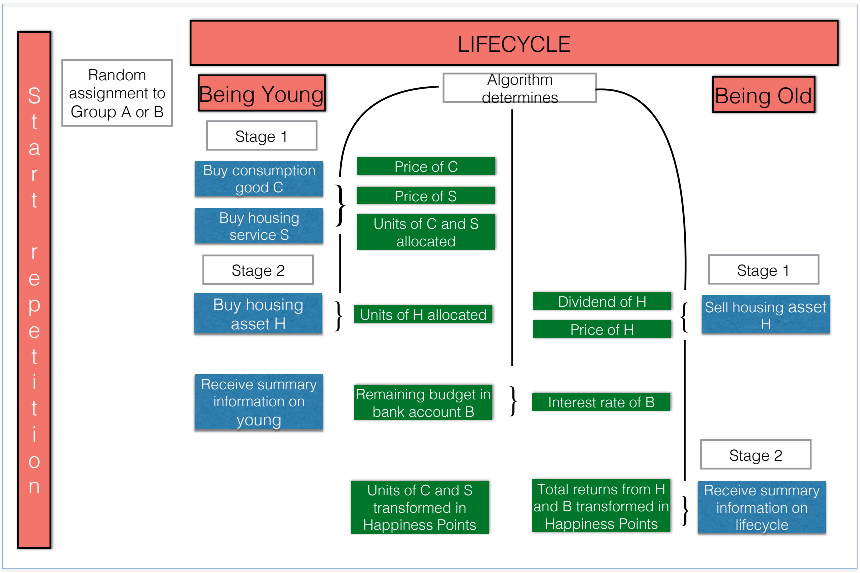
<u>Decision screens when "Old"</u>

Stage 1 (Housing asset H)

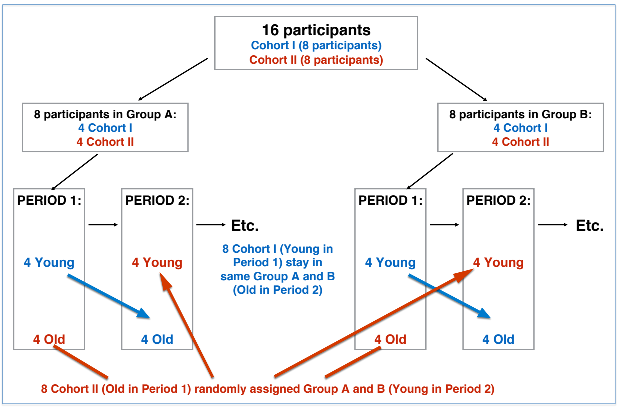


2.8.3 Handouts: Graphs and Tables

Decisions in a lifecycle



Assignment and chronological order



Period		1	2	3	4	5	6	7	
Cohort I (8 subjects)		young	old	young	old	young	old	young	
	Lifecycle	1		2		3		....	
	Group	A or B (random)		A or B (random)		A or B (random)		....	Etc.
Cohort II (8 subjects)		old	young	old	young	old	young	old	
	Lifecycle		1		2		3		
	Group	A or B	A or B (random)		A or B (random)		A or B (random)		

Chapter 3

CROSS-COUNTRY DIFFERENCES IN HOMEOWNERSHIP: A CULTURAL PHENOMENON?

(written jointly with Tobias Schmidt)

3.1 Introduction

Despite the large attention housing markets have received recently, there are few empirical studies that aim to explain why homeownership rates differ so greatly across countries. Cross-country differences in homeownership rates are large and persistent over time. Homeownership rates vary from 44% in Switzerland to 83% in Spain. In this project we test the novel hypothesis that these cross-country differences are driven by cultural tastes.[1]

[1] According to Alesina and Giuliano [2015] most empirical papers define culture as "*those customary beliefs and values that ethnic, religious, and social groups transmit fairly unchanged from generation to generation*." We follow this definition, which was originally adopted by Guiso et al. [2006].

To isolate the effect of culture from the effects of institutions and economic factors, we employ the epidemiological approach - we investigate the homeownership decision of second generation immigrants in the United States. A second generation immigrant is defined as an individual that is born, has been raised and who lives in the United States. All second generation immigrants in our sample face therefore the same markets and institutions. However, they differ in terms of their parents' country of origin and hence in their cultural heritage.

We employ a quantitative proxy for culture, we proxy cultural preferences for homeownership of second generation immigrants by aggregate homeownership rates in the country of origin.[2] Aggregate homeownership rates capture aggregate preferences for homeownership and will depend on the distribution of these preferences. These distributions may vary across countries. It is evident that markets and institutions also shape aggregate homeownership rates. However, only the cultural component of aggregate homeownership rates in the father's country of origin can be relevant and have explanatory power for the homeownership decision of a second generation immigrant who was born, raised and lives in the United States.

It is clearly important to assure that our results are not driven by a systematic difference in second generation immigrants depending on the country of origin. We therefore control for many individual characteristics that are known to be important for the tenure choice decision. In particular, we control for educational attainment, income, race, age, marital status, and gender. Further, we control for location and time to account for house price effects in a specific year and metropolitan area of the second-generation immigrant's residence.[3]

[2]Our empirical strategy is similar to Fernández and Fogli [2009], who show that the female labor force participation and fertility in the country of origin replicates the fertility and labor participation rate of second generation immigrant women in the United States. They employ a quantitative proxy for cultural preferences, preferences for labor force participation (children) are measured by aggregate female labor force participation rate (aggregate fertility rate) in the country of origin.

[3]Metropolitan areas are defined as specific counties or groups of counties centering on a substantial urban area. House price cycles vary systematically across regions in the

Our first finding shows that our cultural proxy, the aggregate homeownership rate in the country of origin, has a significant impact on homeownership decisions by second generation immigrants. The quantitative impact of culture on homeownership decisions is sizeable. The impact of culture is considerably larger in magnitude than the impact of moving from the lowest to the highest education category. Further, it is comparable to the effect of moving from the first to the third income decile.

We suspect the quantitative impact of the baseline estimate to be a lower bound for the effect of cultural preferences on the homeownership decision. There might be heterogeneity in the cultural preferences of second generation immigrants for several reasons. First, parents are not the only transmitter of culture - as the friendships of the second generation immigrant, and the institutions in their country of residence may also shape their preferences and beliefs. Second, the impact of the culture of one's ancestors may diminish over time. Third, the cultural preferences of the parents of second-generation immigrants may differ from the average of those preferences observed in the country of origin. Hence, our cultural proxy might not represent accurately the preferences of those parents.

To unravel these effects and thereby explore the extent of the cultural impact on the homeownership decision, we split the group of second-generation immigrants further into more homogenous subgroups. The first hypothesis is that singles can preserve their cultural heritage more than married couples that do not share the same cultural background. The second hypothesis tested is that married couples sharing the same cultural background conserve their cultural preferences more in comparison to singles or couples where each partner is from a different cultural background. As mentioned before, the impact of the culture of origin might

United States, see Sinai [2012]. Therefore it is particularly important to include this large set of location dummies, as well as time dummies to account for house price effects in a specific year and location of residence. Appendix B shows alternative regression specifications to account for price effects within a given location and year. One specification includes the interaction term metropolitan area x year. Another specification uses the interaction term of metropolitan central city status per year dummies.

diminish over time. The third hypothesis therefore tested is that the effect of culture is larger for first generation married couples sharing the same cultural background than for second generation couples with the same background.

We find that the effect of culture is significantly and approximately 125% larger for single household heads compared to married couples that do not share the same cultural background.[4]

We also find evidence for the second hypothesis. For second generation married household heads sharing the same cultural background with their spouse, we find that our cultural proxy is significant and approximately 205% (587%) larger than for singles (married to spouse from different cultural background). The quantitative impact of culture is large for married household heads sharing the same cultural background with their spouse. The impact of cultural preferences for homeownership is significantly larger compared to the impact of moving from the lowest to the highest income decile.

Finally, we present evidence for the third hypothesis. The effect of culture diminishes in our sample over time. The effect of culture is 37% larger for first generation married couples sharing the same cultural background than for second generation couples sharing the same background. Therefore, we conclude that the quantitative impact of cultural preferences on the homeownership decisions is substantial.

The findings are robust to a number of alternative explanations. In the paper, we address potential concerns such as the systematic selection of immigrants before emigration (the parents of our subjects of study), and omitted variables. In addition, we provide a wide range of robustness checks concerning the estimation technique, the measurement of culture, and the sample size. We also the address the potential concern of a systematic difference in second generation immigrant groups depending on the country of parent's origin. We find that second-generation immigrants

[4] For second generation married household heads who have a spouse from a different cultural background, their own cultural background has a much smaller impact on their homeownership decision compared to the baseline estimation. The effect of culture is only significant at the 10% level.

are not systematically different in the observed individual characteristics. To control for a systematic clustering of second generation immigrants within the United States, we provide several alternative specifications for the control of the location of residence.

Our main data source is the March supplement of the Current Population Surveys (CPS) from 1994 to 2014. The individual data is augmented with aggregate homeownership rates for 38 countries. Our main sample includes second generation immigrant household heads that are at least twenty years old, and whose parents immigrated from one of the 38 countries for which homeownership rates are available.

This paper not only provides a novel explanation for the observed large and persistent cross-country differences in homeownership rates, it also contributes to the literature that studies the impact of culture on economic outcomes. Our results are relevant for policy. Huber [2017b] shows for a sample of 18 OECD countries, that countries with larger homeownership rates are more vulnerable to housing bubbles, and generally characterized by more volatile housing markets. To develop effective macro-prudential policy tools for the control of European housing markets, country heterogeneity needs to be taken into account.[5] Therefore, it seems to be important to understand where the large and persistent cross-country differences in homeownership rates originate from.

The remainder of this paper is organized as follows. Section 3.2 provides a brief review of two strands of literature this paper relates to. Section 3.3 outlines our empirical strategy, describes the data and sample selection. Section 3.4 presents our baseline results. Section 3.5 provides additional evidence for the hypothesis that cultural preferences matter. Section 3.6 discusses the robustness of our findings. Section 3.7 analyses the implied aggregate homeownership rates of ethnic groups in the United States and relates them to the homeownership rates in the country of origin. Section 3.8 concludes. Appendix A gives a detailed overview of the data of our cultural proxy and provides summary and descriptive statistics. Appendix B provides a wide range of robustness checks.

[5] The necessity of considering country heterogeneity was pointed out e.g. by Hartmann [2015].

3.2 Related Literature

Although our paper combines ideas about homeownership and culture in a novel way, it follows a large literature on related topics.

The first strand of related literature investigates the transmission of cultural values, preferences or beliefs, and studies the impact of culture on economic outcomes. This literature is relatively new in economics, and the applied empirical methodology is often referred to as the epidemiological approach.[6] This empirical methodology isolates the effects of culture from those of markets and institutions by studying the individual behavior of immigrants from different cultural backgrounds in one host country - hence holding constant the institutional and economic environment. This approach mainly involves capturing cultural preferences of immigrants by an average value of a continuous variable assigned to the country of origin. The seminal paper in this area is Carroll et al. [1994] that studies the impact of culture on saving rates.[7] This methodology has been used to study a variety of topics.

Regarding the research question, our paper is most related to Giuliano [2007]. Her study evaluates why Southern Europeans chose to stay longer at their parents' homes compared to young adults in the North of Europe by studying the behavior of second generation immigrants in the United States. Giuliano [2007] finds that these behavioral differences between Southern and Northern Europeans are also visible for second generation immigrants in the United States and cannot be explained by income differences or the like. Giuliano [2007] concludes that cultural preferences are the most relevant factor.

Our empirical strategy is similar to that of Fernández and Fogli [2009],

[6]In addition, the methodologies of natural experiments (e.g. Botticini and Eckstein [2005]) and laboratory experiments (e.g. Henrich et al. [2001]) have been used to provide evidence that culture matters. Fernández [2010] provides a detailed literature overview.

[7]Carroll et al. [1994] investigate the saving behavior of first generation immigrants in Canada and find that cross-country differences in saving rates cannot be explained by culture. However, their results need to be taken with care, as the analysis is subject to large data restrictions.

Alesina and Giuliano [2010], and Fernández et al. [2004] who show that the labor force participation and fertility rates of U.S. immigrant women is influenced by the female labor participation and fertility rates of the country of origin of their mothers.

In a similar vein, Algan and Cahuc [2005] use inherited family values of U.S. immigrants as an instrument for family values in the source country to explain cross-country employment heterogeneity. Algan and Cahuc [2010] and Guiso et al. [2006] show that the level of trust of U.S. immigrants depends on and is highly correlated with the average trust level in their country of origin. Osili and Paulson [2008] study the investment behavior of first generation U.S. immigrants and find that immigrants from countries with institutions that more effectively protect private property are more likely to own financial stocks in the United States. They conclude that the effect of home institutions is absorbed early in life and is persistent after emigrating. Osili and Paulson [2008] show that the cultural background matters more when the immigrants live in areas with many other immigrants from the same country of origin. One important difference between their work and ours is that we study the behavior of second, not first generation immigrants. Ichino and Maggi [2000] find that the place of birth explains the largest part of the south-north shirking on the job differential in Italy, the place of birth is seen as a proxy for the cultural background. Kosse and Jansen [2013] study first and second generation immigrants in the Netherlands and find that culture affects the choice between payment instruments.[8] In a recent study, Atkin [2016] shows that substantial and persistent differences in food preferences exist across social groups in India. He shows that migrants bring and keep their origin-state food preferences and that these differences in food preferences can explain the differences in the intake of calories per Rupee of food expenditure across social groups. Luttmer and Singhal [2011] shows that culture is an important determinant of preferences for redistribution.

The main conclusion from this first strand of literature is that values

[8]Kosse and Jansen [2013] show that first generation immigrants are affected by their cultural background, while second generation immigrants behave as their Dutch counterparts. Payment behavior is not passed from one generation to the next.

and preferences, summarized as culture, differ across countries and that culture influences economic outcomes.

The second strand of related literature analyses the determinants of homeownership rates within or across countries. Although there is still little consensus on why homeownership rates differ so greatly across OECD countries, surprisingly few empirical cross-country analyses of homeownership determinants have been published so far. Chiuri and Jappelli [2003]'s dataset consists of 14 OECD countries over a 30 year period. They find that down-payment requirements on mortgage loans only have a negative impact on homeownership for young households.[9] Georgarakos et al. [2010] find that homeownership rates in Europe do not correlate with the breadth of mortgage markets. This result matches that of Earley [2004], who finds for a sample of 15 European countries that the highest homeownership countries are among those with the lowest levels of mortgage-to-GDP ratios. Hilber [2007] analyzes homeownership rates in 15 European countries and finds that demographic factors are highly significant determinants of individual tenure choice. Homeownership is larger for married couples, increases with age and the number of children.[10] However, Hilber [2007] finds that country differences in the socio-economic composition cannot explain cross-country differences in homeownership rates. This is in line with Davis [2012], who finds that homeownership rates are not correlated with cross-country standards of living. This finding is consistent with earlier cross-country studies, e.g. Oxley [1984] and the more recent study of Fisher and Jafee [2003], who find that income-differences across countries have no explanatory power regarding homeownership rates. Fisher and Jafee [2003] discover that the percentage of a country's population living in urban areas has a significant and negative impact on aggregate homeownership rates. According to Hilber [2007] most of the cross-country differences can be explained by

[9]This result corresponds to Andrews and Sanchez [2011]'s finding that a decrease in the down-payment has a positive impact on homeownership for young households that are in the second income quartile.

[10]For the United States, Bourassa et al. [2014] finds a negative relationship between homeownership and the number of children living in the household.

landlord efficiency and certain specific tax policies. The non-taxation of imputed rents has a strong positive effect on homeownership. Notably, the deductibility of mortgage interest (tax relief on mortgage-debt-financing) plays only a minor role.[11] Hilber [2007]'s result that non-taxation of imputed rents is an explanation for cross-country differences in homeownership rates should be handled with care. Only 2 out of the 15 countries in his sample have a taxation of imputed rents in place. Andrews and Sanchez [2011] estimate a Probit Model and find that rental market regulations influence tenure choice. Higher rent controls and lower security of tenure are associated with a higher probability of homeownership.

The main conclusions from this strand of the literature is that there is a consensus on factors that cannot explain cross-country difference in homeownership rates - namely cross-country differences in income or the breath of the mortgage market. On the other hand, the fundamental causes for the large differences remain an open question.

3.3 Estimation Strategy and Data

3.3.1 Data and Sample Selection

Individual Data

The main dataset consists of the March supplement of the Current Population Surveys (CPS) from 1994 to 2014.[12] The March CPS includes questions about the birthplace of each individual and his or her parents. In the literature, "second generation" immigrants are generally defined as

[11] This is in line with the results of Andrews and Sanchez [2011], who suggest that tax relief on mortgage-debt-financing has only a very small effect on aggregate homeownership rates and that the effect might even be negative if these tax reliefs are factored into real housing prices, see Andrews [2010], and therefore make homeownership less affordable for lower-income households, see Bourassa and Yin [2007]. In a recent paper Hilber and Turner [2010] finds that tax relief on mortgage-debt-financing is an inefficient policy in promoting homeownership rates.

[12] IPUMS-CPS is conducted jointly by the U.S. Census Bureau and the Bureau of Labor Statistics.

individuals with immigrant fathers.[13] We follow this definition.

Our main sample includes second generation immigrant household heads that are at least twenty years old and whose fathers immigrated from one of the 38 countries for which homeownership rates are available. Most countries are European (28 countries).[14] We also include a few countries in Asia (Japan, South Korea, Singapore), in Australasia (Australia and New Zealand), in America (Mexico, Canada, Chile), and in the Middle East (Israel, Turkey).[15]

The sample consists of 29,214 female and 31,512 male household heads, who are born, raised, and live in the United States, and whose fathers immigrated from one of the countries in our sample.[16] The average second generation immigrant in our sample is 59 years old, and the homeownership rate of second generation immigrants is 73%. This compares to a homeownership rate of 67.3% for the household-heads whose fathers were born in the United States. Table (3.6) in the Appendix provides summary statistics for the sample of second generation immigrants at the level of fathers' country of origin, while Table (3.7) provides detailed characteristics for first generation immigrants at the level of the country of origin.

For the baseline sample, we impose the restriction that the number of observations must be larger than fifteen for each country of origin. Relaxing this restriction does not alter the results.[17] Figure (3.3) shows the baseline sample's distribution of all observations across U.S. states. While Figure (3.4) illustrates the distribution of all observations across

[13]See Card et al. [1998], Giuliano [2007], Fernández and Fogli [2009].

[14]The sample includes: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Spain, Sweden, Switzerland, the United Kingdom.

[15]This set of countries has been chosen as this sample corresponds to the largest collection of aggregate homeownership rates from a single source.

[16]This compares to 759,209 female and 650,809 male household heads, born and living in the United States, and whose fathers was born in the United States.

[17]Refer to the robustness check in Appendix B, Table (3.13).

metropolitan statistical areas (MSAs) in the United States.[18] For first generation immigrants these distributions are shown in Tables (3.5) and (3.6) respectively.

Country Level Data: The individual data is augmented with aggregate homeownership rates for 38 countries. The data is provided by the PEW Research Center. Table (3.5), in Appendix A, gives an overview of the data, followed by descriptive statistics. Homeownership rates are defined by the fraction of the households living in an owner-occupied dwelling.

3.3.2 Estimation Strategy

As discussed previously, this paper uses the epidemiological approach. To isolate the effect of culture from those of markets and institutions, we study the homeownership decision of individuals who were born, raised, and reside in the United States, and whose parents were born in a foreign country. Using second generation immigrants rather than first generation immigrants is advantageous. The potential problem of a systematic selection of immigrants depending on the country of origin is less prominent when studying second-generation immigrants. For first generation immigrants the reasons for emigration might vary in a systematic fashion depending on the country of origin (e.g. some countries might be in war). There might also exist systematic differences in the difficulty of assimilation to the United States, e.g. learning the language of the host country.

The epidemiological approach mainly involves capturing cultural preferences of immigrants by an average value of a continuous variable assigned to the country of origin. The outcome of the immigrants' choices' is regressed on the same outcome variable (average) prevailing in the country of origin.

We use homeownership rates in the country of origin as our cultural proxy for cultural preference regarding homeownership. The optimal decade from which to take these numbers is not clear. We study sec-

[18] The second generation immigrants are distributed across 415 different MSAs in our baseline sample.

ond generation immigrants from 1994 to 2014, who are older than 20 years, and were born in the United States. Hence, their parents must have arrived in the United States by 1974-1994 at the latest. Hence, one can argue that values for the cultural proxy from 1974-1994 would best reflect the culture of the country of origin, as this is the most likely time window when the parents emigrated and took their cultural preferences with them. On the other hand, as argued by Fernández and Fogli [2009], cultural values transmitted by parents are best reflected by what the counterparts of the individuals in the country of origin are doing during the same period, i.e. 1994-2014. Data limitations, do not allow to use homeownership rates from 1974-1994 - as prior to 1990 homeownership rates exist for six countries only. Therefore, we use homeownership rates for the year 2011 as our cultural benchmark proxy.[19]

For the analysis to be meaningful, the proxy for culture should evolve slowly over time. Otherwise, the cultural values/preferences transmitted by the parents to children would not be captured by past or future values. This is not a concern and will be discussed in detail in the next section. Aggregate homeownership rates and especially cross-country differences are very persistent over time.

Persistent Cross-Country Differences in Homeownership Rates

Comparable homeownership rates over time and across countries are scarce. Neither time series nor data points for year-pairs are available for our full sample of countries. The full sample is shown in Table (3.5).

We therefore reduce the sample to study the evolution of cross-country

[19] The critical reader might question whether immigrants' preferences can be proxied by an average value in their country of origin. Here, it should be noted that this factor will bias the test of the hypothesis towards not finding any effect of culture on the homeownership decision of the second generation immigrant. More generally, the reader may suspect that aggregate homeownership rates might not only capture preferences but may also capture institutions, differences in taxation, etc. This is definitely true. The beauty of this approach is that only the cultural component (of homeownership rates in the country of father's origin) can have explanatory power for the tenure decision of individuals born and raised in the United States.

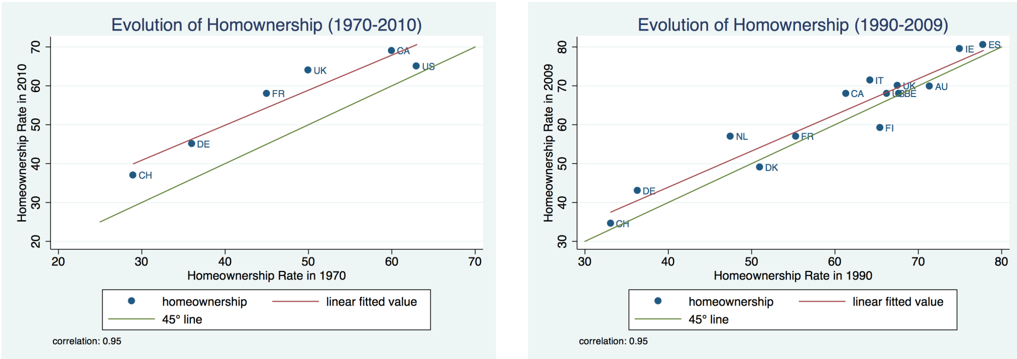
differences in homeownership rates over time. Table (3.1) shows the cross-country correlations of homeownership rates for selected year pairs. The correlations are large and positive. For a sample of six OECD countries, Figure (3.1a) plots the initial observation of the homeownership rate (year 1970) against the last observation available (year 2010). The fitted line is above and close to parallel to the 45°line. Hence, homeownership rates rose proportionally in these OECD countries - over the 40 years considered. The cross-country correlation of homeownership rates for the year pairs 1970 and 2010 amounts to 0.95. Figure (3.1b) plots the initial observation of the homeownership rate (year 1990) against the last observation available (year 2009) for 18 OECD countries. The fitted line is above and parallel to the 45°line. The cross-country correlation of homeownership rates for the year pairs 1990 and 2009 equals 0.95.

We conclude that homeownership rates rose proportionally in many OECD countries over time. Therefore the cross-country differences remained.[20] Cross-country differences in homeownership rates are constant, and very persistent over time.

Homeownership Rates					
	1970	1990	2004	2009	2010
1970	1.00				
1990	0.90	1.00			
2004	0.92	0.98	1.00		
2009	0.93	0.95	0.98	1.00	
2010	0.95	0.95	0.97	0.98	1.00

Table 3.1: Cross-country correlations for selected year pairs

[20]For 1970, homeownership rates are available for six countries. In this sample, homeownership rates rose by 9.2% points from 1970 to 2010. For the year pairs 1990 and 2009, the sample consists of 18 countries. On average, homeownership rates rose by 2.53 % points from 1990 to 2009.



(a) Evolution of Homeownership, 6 countries (b) Evolution of Homeownership, 18 countries

Figure 3.1: Evolution of Homeownership rates

3.4 Estimation and Results

3.4.1 Baseline Model

We estimate the following model:

$$HO_{imo} = \beta_0 + \beta_1' X_i + \beta_2 \tilde{Z}_o + F_m + F_t + \varepsilon_{imo} \qquad (3.1)$$

HO_{imo} denotes the homeownership status of the second generation immigrant i, who resides in the metropolitan area m and who's father immigrated from country of origin o. This indicator is equal to one if the individual is a homeowner and zero otherwise. X_i denotes a vector of controls for individual i, which varies with the specification considered.[21] $\tilde{Z}_o$ is our variable of interest, the proxy for cultural preferences towards homeownership assigned to the parents' birthplace: the aggregate homeownership rate prevailing in 2011 in the country of father's origin. F_m and F_t stand for a large set of metropolitan area and time dummies, respectively. These dummies capture house price effects within the metropolitan

[21]The individual characteristics include: age, age (squared), gender, marital status, income deciles, categories for race and education. These controls account for sources of heterogeneity across second generation immigrant other than their cultural preferences.

area of residence in a particular year.[22] The error term is denoted by ε_{imo}. Throughout the paper, the analysis utilizes probit models to understand, at a micro level, the relationship between homeownership status of second generation immigrants and their cultural preferences, while controlling for other factors that are known to impact the tenure choice. As a robustness check, we repeat all regressions using a linear probability model. The OLS coefficients are very similar to the marginal effects, and the estimation results can be found in Appendix B.[23]

Table (3.2) shows the marginal effects for the main probit regression of the model in (3.1). In the first column, the homeownership status of second generation immigrant i is regressed on the cultural proxy for the preference towards homeownership and on a full set of metropolitan area and time dummies corresponding to individuals' residence. The coefficient is strongly significant and positive, indicating that second generation immigrants with fathers that emigrated from a country with high homeownership rates are more likely to be a homeowner themselves.

In the second column, we include individual characteristics - in particular age and age squared, as well as race categories, gender, marital status, and income deciles. As expected, individuals that have more income, are married and live together, and those that are older, are more likely to be homeowners. The direct effect of culture remains positive and significant, although slightly smaller in magnitude.

The full specification is shown in the last column, where we add three categories of education.[24] As expected, education has a positive and significant impact on homeownership. The direct effect of culture remains positive and significant, although slightly larger in magnitude than in specification (2), indicating that education and homeownership rates in the country of origin are negatively correlated. The coefficients of income

[22]We include 415 different metropolitan area dummies. For robustness check purpose, appendix B shows three alternative regression specifications to account for price effects within a given location and year. One specification includes the interaction term metropolitan area x year (robustness check 11). Another specification uses the interaction term of metropolitan central city status x year dummies (robustness check 12).

[23]The estimations are performed using pooled datasets.

[24]The education categories: High School or less, college without degree, college +.

remain significant, although slightly smaller in magnitude compared to specification (2), suggesting that income and education are positively correlated.

We conclude that cultural preferences concerning homeownership play a significant role in home buying decisions. The results are robust to changes in the estimation technique, to changes in the sample criteria (changes in the sample of countries of origin)[25], to alternative variables as cultural proxy, to clustered standard errors, and to different specifications to control for house price effects in a particular year and location.

The quantitative impact of culture on homeownership decisions is sizeable. The impact of culture is much larger in magnitude than the impact of moving from the lowest to the highest education category. Further, it is comparable to the effect of moving from the first to the third income decile.[26] An increase in the homeownership rate in the country of father's origin by one standard deviation (across countries) is associated with a probability increase of the second generation immigrant to be a homeowner in the United States, which accounts around 8% of the variation in the homeownership rate across immigrant groups within the US.

We suspect the quantitative impact of the baseline estimate to be a lower bound for the general effect of culture on the homeownership decision. There might be heterogeneity in the cultural preferences of second generation immigrants for several reasons. First, parents are not the only transmitter of culture - as the friendships of the second generation immigrant and the institutions in their country of residence (i.e. the United States) may also shape their preferences and beliefs. Second, the impact of the culture of one's ancestors may diminish over time. Third, the cultural preferences of the parents of second-generation immigrants may differ from the average of those preferences observed in the country of

[25]We show seven sample size variations in Appendix B. We exclude e.g. countries of origin for which we have less than 100 observations, or the country of origin that has most observations, i.e. Mexico. Additional tests exclude countries of origin that might have been systematically different and therefore induced systematically different types of emigrants (i.e. the parents of our subjects of study), refer to robustness checks 6-9.

[26]The impact of reaching the highest income decile (relative to the first income decile) is approximately 3.5 as large as the economic impact of culture.

origin. Hence, our cultural proxy might not represent accurately the preferences of those parents.

To unravel these effects and thereby explore the extent of the cultural impact on the homeownership decision, we split the group of second-generation immigrants further into more homogenous subgroups.

The first hypothesis is that singles can preserve their cultural heritage more than married couples that do not share the same cultural background. Hence, we expect that the effect of cultural preferences toward homeownership for a single non-married household head to be significantly larger. The second hypothesis is that married couples sharing the same cultural background conserve their cultural preferences more in comparison to singles or couples where each partner is from a different cultural background. Hence we expect that if both spouses share the same cultural background, the effect of our cultural proxy on behavior will be larger. As mentioned before, the impact of culture might diminish over time. The third hypothesis tests whether the effect of culture is larger for first-generation married couples sharing the same cultural background compared to second-generation couples with the same background. The results are shown in the next section.

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i	(1)	(2)	(3)
HO_{origin}	0.0649***	0.0658***	0.0691***
	(0.0224)	(0.0237)	(0.0238)
male (dummy)		-0.0135****	-0.0137****
		(0.00407)	(0.00407)
marital status (dummy)		0.178****	0.180****
		(0.00421)	(0.00421)
age		0.0223****	0.0219****
		(0.000669)	(0.000674)
age squared		-0.000134****	-0.000130****
		(0.00000610)	(0.00000615)
eduction categories	✓	✓	✓
income categories	✓	✓	✓
race categories	✓	✓	✓
metropolitan area	✓	✓	✓
year (dummy)	✓	✓	✓
N	60726	60726	60726
pseudo R^2	0.043	0.227	0.228

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$.

Table 3.2: Main Probit Regression - Culture and Homeownership

3.5 Cultural Transmission

This section provides additional evidence for our hypothesis that cultural preferences matter for the homeownership decision. We investigate cultural transmission and show that when individuals are more exposed to their cultural inheritance in the United States, the effect of culture on the homeownership decision is significantly stronger.

3.5.1 Married Couples

In this section, we study the effect of the composition of married couples in cultural transmission. The spouse might play an important role in preserving the beliefs and preferences. The first hypothesis is that singles can preserve their cultural heritage more than married couples that do not share the same cultural background. The second hypothesis is that married couples sharing the same cultural background conserve their cultural preferences more in comparison to singles or couples where each partner has a different cultural background. As mentioned before, the impact of culture might diminish over time. Therefore, the third hypothesis tests whether the effect of cultural preferences towards homeownership is larger for first-generation compared to second-generation married couples sharing the same cultural background. We run the baseline regression in (3.1) for more homogenous subsets of our sample. The estimation results are presented in Table (3.3). Column 1 shows the baseline regression. In column 2 we run the regression for second generation immigrant singles only. The third column presents the estimation results for the subset of married household heads, who's spouse is from a different background. In column 4 we only include married household heads sharing the same cultural background with their spouse.

We find that the effect of culture is significantly and approximately 125% larger for single household heads compared to married couples that do not share the same cultural background.[27]

[27]For second-generation married household heads having a spouse from a different cultural background, their own cultural background has a much smaller impact on their

We also find evidence for the second hypothesis. The effect of culture is largest for married household heads sharing the same cultural background with their spouse. Table (3.3) shows the estimation results in column 4. We find that our cultural proxy is significant and approximately 205% larger than for singles (compared to column 2), while 587% larger compared to household heads that are married to a spouse from different cultural background (compared to column 3). The quantitative impact of culture is large for married household heads sharing the same cultural background with their spouse. The impact is larger than the effect of moving from the lowest to the highest income decile.

Next, we explore whether the effect of cultural preferences towards homeownership is larger for first generation married immigrants. As mentioned before, the impact of culture might diminish over time in our sample. Column 3 in Table (3.4) shows the estimation results. Married first generation household heads that are older, better educated and who have a higher income are more likely to be a homeowner. The cultural proxy is highly significant, and the coefficient is 37% larger for first-generation married couples sharing the same cultural background compared to second-generation couples sharing the same background. The quantitative impact of culture is larger than the effect of moving from the lowest to the highest income decile. These effects are not only significant but quantitatively large.

We conclude that the spouse's cultural background matters for preserving culture as well as for its transmission. The results of this section indicate that the quantitative impact of cultural preferences on the homeownership decisions is substantial. Further, this section provides evidence that the quantitative impact found in the baseline specification is indeed a lower bound for the general effect of cultural preferences towards homeownership on the actual homeownership decision.

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homeownership decision compared to the baseline estimation. The effect of culture is only significant at the 10% level.

	Dependent Variable: Homeownership status of immigrant i			
	2nd generation			
	all (baseline) (1)	single (2)	married $\neq$ background (3)	married same background (4)
HO_{origin}	0.0691***	0.0943**	0.0418*	0.287**
	(0.0238)	(0.0367)	(0.0238)	(0.135)
male (dummy)	-0.0137****	-0.0339****	-0.00133	-0.0130
	(0.00407)	(0.00657)	(0.00453)	(0.0108)
marital status (dummy)	0.180****			
	(0.00421)			
age	0.0219****	0.0224****	0.0169****	0.0242****
	(0.000674)	(0.00100)	(0.000848)	(0.00196)
age squared	-0.000130****	-0.000122****	-0.000116****	-0.000144****
	(0.00000615)	(0.00000904)	(0.00000786)	(0.0000187)
eduction categories	✓	✓	✓	✓
income categories	✓	✓	✓	✓
race categories	✓	✓	✓	✓
metropolitan area	✓	✓	✓	✓
year (dummy)	✓	✓	✓	✓
N	60726	31019	20634	7419
pseudo R^2	0.228	0.152	0.215	0.267

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the homeownership rate in the country of origin in 2011 and is $\in (0, 1)$.

Table 3.3: Married - Does the Partners Background matter?

	Dependent Variable: Homeownership status of immigrant i		
	2nd generation		1st generation
	all (baseline)	married same background	married same background
	(1)	(2)	(3)
HO_{origin}	0.0691***	0.287**	0.394****
	(0.0238)	(0.135)	(0.0780)
male (dummy)	-0.0137****	-0.0130	-0.00346
	(0.00407)	(0.0108)	(0.00665)
marital status (dummy)	0.180****		
	(0.00421)		
age	0.0219****	0.0242****	0.0322****
	(0.000674)	(0.00196)	(0.00142)
age squared	-0.000130****	-0.000144****	-0.000185****
	(0.00000615)	(0.0000187)	(0.0000145)
race categories	✓	✓	✓
income categories	✓	✓	✓
education categories	✓	✓	✓
year (dummy)	✓	✓	✓
metropolitan area (dummy)	✓	✓	✓
N	60726	7419	33471
pseudo R^2	0.228	0.267	0.206

Marginal effects. * p¡0.1, ** p¡0.05, *** p¡0.01, **** p¡0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category *High School or less* is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the homeownership rate in the country of origin in 2011 and is $\in (0, 1)$.

Table 3.4: Married - Does the Partners Background matter? (2)

3.6 Robustness of our Findings

This section is dedicated to exploring the robustness of our findings. For robustness purposes, we run a linear probability model estimation of (3.1). Our cultural variable of interest remains highly significant, and the OLS estimates correspond to the marginal effects. We propose seven sample size variations and three alternative regression specifications to account for house price effects in a particular year and location. We present one robustness check where we use an alternative proxy for cultural preferences towards homeownership. Two robustness checks consist of using clustered standard errors instead of the robust (Huber-White-sandwich) standard errors. All robustness checks are presented in Appendix B.

Next, we discuss potential concerns as the systematic selection of immigrants, omitted variables, as well as our measurement of cultural preferences towards homeownership.

Systematic Selection of Immigrants: This is an important empirical issue when studying the behavior of immigrants. Immigrants may not be representatives of their home country and might be systematically different depending on the country of origin. The reasons for emigration might be different depending on the country of origin. Further, one might be concerned that the difficulty of assimilation into the United States (e.g. learning the language of the host country) might vary in a systematic fashion depending on the country of origin.

We address the systematic selection concern by studying second generation immigrants instead of first generation immigrants. A second generation immigrant has been born, raised and lives in the United States, and possesses the U.S. nationality. The potential concern of a systematic selection is less prominent when studying second generation immigrants.

In addition, we show in the Appendix B seven sample size variations, where we exclude countries of origin that might have been systematically different and therefore induced systematically different types of emigrants (i.e. the parents of our subjects of study). We exclude countries-of-origin that have experienced a war during 1945-1994.[28] In other robustness checks we exclude countries that have been post-soviet states, or countries that have experienced dictatorships during 1945-1994. Our baseline results are very robust to these sample size variations.

Further, we study the characteristics of first generation immigrants - the generation the parents of our subjects of study belong to. Table (3.7) in Appendix A shows that first generation immigrant's characteristics (income, education levels, age, etc.) are not significantly correlated with homeownership rates prevailing in the country of origin.

Omitted variables: Omitted variables are always a serious concern when employing the epidemiological approach. In our specific case, the most likely candidate for an omitted variable is unobserved parental income of the second generation immigrant. Our estimate could be biased if the parental income varies in a systematic fashion across countries of origin and if parents are a source of financial help to become a homeowner. If our positive coefficient of our cultural proxy is driven by this omitted variable, then parents from high homeownership countries would need to be systematically richer compared to parents from low homeownership countries. It is highly unlikely that parents from higher homeownership countries were systematically richer before emigrating, as it is widely accepted in the literature that homeownership rates and income are negatively correlated across countries. On average, countries with larger homeownership rates, are characterized with a lower GDP per capita.[29]

[28]This time window corresponds to the time when the parents emigrated to the United States.

[29]Cross-country studies have shown that countries with lower homeownership rates, are typically the richer countries; see e.g. Oxley [1984], Fisher and Jafee [2003] or Davis [2012]. These negative cross-country correlations between homeownership rates and income hold irrespective of measuring income by (1) real GDP per capita or (2) real GDP per capita, adjusted for purchasing power parity. Assuming for now that this cross-country pattern persists after emigrating, then omitting parental income would lead to an underestimation of the cultural effect. As immigrants from richer countries (on average richer), are those emigrating from countries with lower homeownership rates. The coefficient of HO_o would pickup the effect of this omitted variable and would be biased downwards.

We do not have the data on parental income nor wealth, but we study the characteristics of first generation immigrants - the generation the parents of our subjects of study belong to. Table (3.7) in Appendix A shows that first generation immigrant's income is not significantly correlated with homeownership rates prevailing in the country of origin.[30] Therefore, there is no evidence for the theory that immigrants to the United States are systematically richer if they emigrate from poorer countries (i.e. high homeownership countries) compared to immigrants emigrating from richer countries (i.e. low homeownership countries).

Measurement of culture: The critical reader might raise the concern that parents of second-generation immigrants are not a random sample of the distribution of beliefs and preferences in the country of origin. Hence, the cultural values transmitted to the second generation immigrant may not reflect the culture of the country of origin. This is not a major concern as this factor would bias the test of the hypothesis against finding any effect of culture on the homeownership decision of the second generation immigrant. More generally, the reader may suspect that aggregate homeownership rates might not only capture preferences but may also capture institutions, differences in taxation, etc. This is definitely true. However, only the cultural component of homeownership rates prevailing in the country of origin can have explanatory power for the tenure decision of individuals born and raised in the United States.

Our baseline results are robust to an alternative proxy for cultural preferences towards homeownership. Instead of using the quantitative continuous variable *aggregate homeownership rates in the country of origin*, we construct a dummy variable that is equal to one if the homeownership rate in the country of origin is larger than 70 % (median value) and zero otherwise.[31] The estimation results are shown in appendix B.

[30]The correlation b/w the homeownership rate in the country of origin and income of the corresponding first generation immigrant group is equal to -0.14. If we take this small correlation seriously, we would conclude that first generation immigrants from high homeownership countries are slightly poorer. This would lead to a downward bias.

[31]The countries having homeownership rate above the median are: Romania, Lithuania, Croatia, Hungary, Slovakia, Norway, Spain, Poland, Latvia, Malta, Czech Republic, Greece, Portugal, Finland, Italy, Belgium, Mexico, Ireland.

3.7 Aggregates

We compute aggregate homeownership rates H_{i_o} for all second generation immigrants i with a father born in country of origin o. Figure (3.2) plots the aggregate homeownership rates HO_{i_o} against our cultural proxy, i.e. the aggregate homeownership rates of the country of father's origin. The correlation is positive and equal to 0.33. Higher homeownership countries are associated with higher homeownership rates of their descendants living in the United States. We run a corresponding (and basic) OLS regression:

$$H_{i_o} = \beta_0 + \beta_1 HO_{origin} + \varepsilon_{io}$$

The results can be found in Table (3.8). Our proxy for cultural preferences towards homeownership is significant, positive and large. An increase in the homeownership rate in the country of the father's origin o by one standard deviation (across countries) is associated with an increase of in the homeownership rate of the corresponding second generation immigrant group in the United States by 3.35 %-points, which is about 27.22% of the variation in the homeownership rate across immigrant groups within the United States. We take these results as additional evidence that cultural preferences matter when it comes to the homeownership decision.

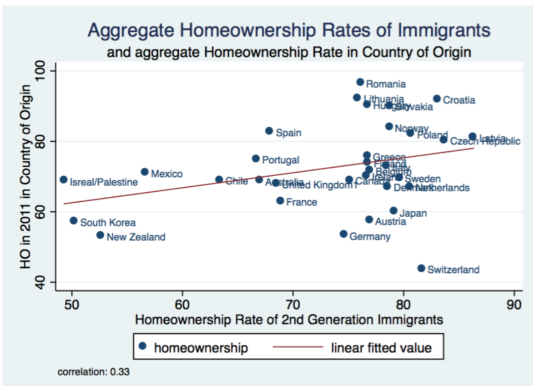

Figure 3.2: Aggregate Homeownership Rates

3.8 Conclusion

This paper argues that cross-country differences in cultural preferences are an important explanatory factor for the large and persistent cross-country differences in homeownership rates that we observe in the data.

By studying second-generation immigrants, we credibly disentangle the effect of cultural preferences from the effects of markets and institutions. We robustly show that the aggregate homeownership rate in the father's country of origin has a significant and sizeable impact on the homeownership decisions of second generation immigrants living in the United States. The results hold after controlling for a large set of individual characteristics that are known to affect the tenure choice. By including a large set of location and time dummies, we account in particular for house price effects in a specific year and metropolitan area of the second-generation immigrant's residence. Our results provide an interesting new perspective on the drivers of differing homeownership rates across countries.

We explored whether the quantitative impact of cultural preferences on the homeownership decision is a lower bound in our baseline specification. We study the impact of cultural preferences for more homogenous subgroups. We find that when individuals are more exposed to their cultural heritage while living in the United States, the effect of cultural preferences on the homeownership decision is significantly stronger. For single household heads, the impact of cultural preferences is 125% larger compared to household heads that are married to a spouse of a different background. For married household heads sharing the same cultural background with their spouse, the impact of cultural preferences is 205% (587%) larger compared to household heads that are singles (married to a spouse of a different cultural background).

The results are also relevant for policy. Huber [2017b] shows for a sample of 18 OECD countries, that countries characterized by larger homeownership rates, are those countries that are more vulnerable to housing bubbles, and generally characterized by more volatile housing markets. To develop an effective macro-prudential policy for the control of European housing markets, country heterogeneity needs to be taken into account. Therefore it is helpful to understand where the large and persistent cross-country differences in homeownership rates originate from. The impact and the effectiveness of the transmission of macro-prudential tools and monetary policy into the economy will be influenced both by homeownership rates and by the underlying reasons that drive these cross-country differences.

3.9 Appendix A: Summary and Descriptive Stats

Country	year	Homeownership
Romania	2011	96.6
Lithuania	2011	92.3
Croatia	2011	92.1
Hungary	2012	90.5
Slovakia	2011	90.2
Singapore	2012	90.1
Bulgaria	2011	87.2
Norway	2011	84.0
Estonia	2011	83.5
Spain	2011	82.7
Poland	2011	82.1
Latvia	2012	81.2
Malta	2011	80.8
Czech Republic	2012	80.4
Iceland	2011	77.9
Slovenia	2011	77.5
Greece	2011	75.9
Portugal	2011	75.0
Finland	2012	73.9
Cyprus	2011	73.8
Italy	2011	72.9
Belgium	2011	71.8
Mexico	2011	71.1
Ireland	2011	70.2
Sweden	2011	69.7
Canada	2006	69.0
Chile	2006	69.0
Australia	2010	68.8
Israel	2008	68.8
Luxembourg	2011	68.2
United Kingdom	2011	67.9
Denmark	2011	67.1
Netherlands	2011	67.1
France	2011	63.1
Japan	2010	60.0
Turkey	2011	59.6
Austria	2011	57.5
South Korea	2005	57.3
Germany	2011	53.4
New Zealand	2006	53.2
Switzerland	2011	43.8

Source: PEW Research Center. Based on: Eurostat; US Census Bureau; Turkish Statistical Institute; Statistics Canada; Singapore Department of Statistics; Australien Bureau of Statistics; Statistics New Zealand; Housing Finance Information Network.

Table 3.5: Aggregate Homeownership Rates in %

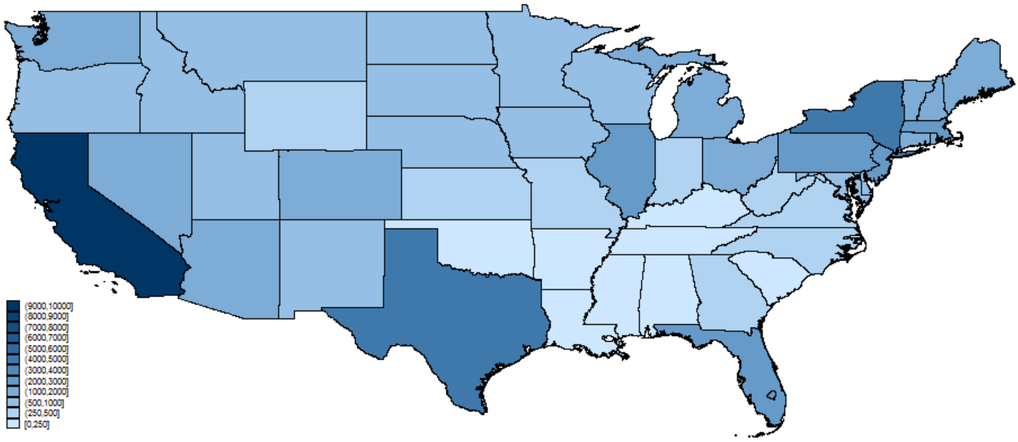

Figure 3.3: Distribution of 2^{nd} generation immigrants across U.S. States

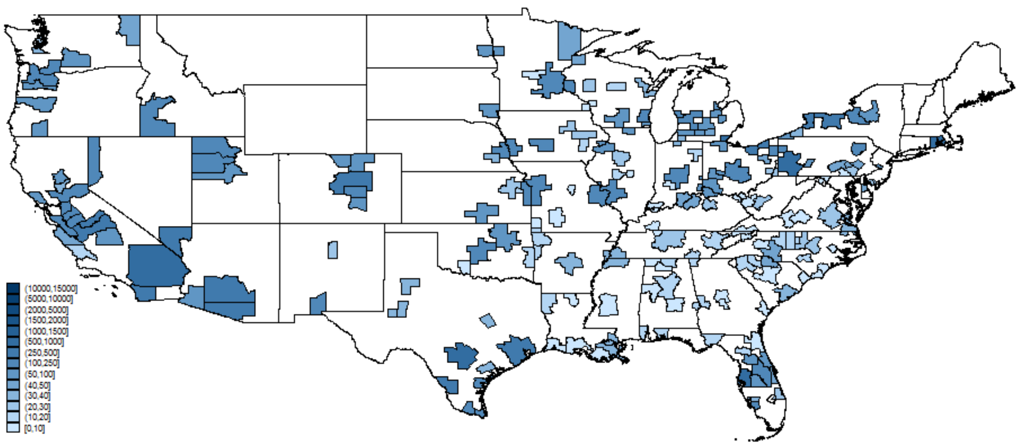

Figure 3.4: Distribution of 2^{nd} generation immigrants across MSAs

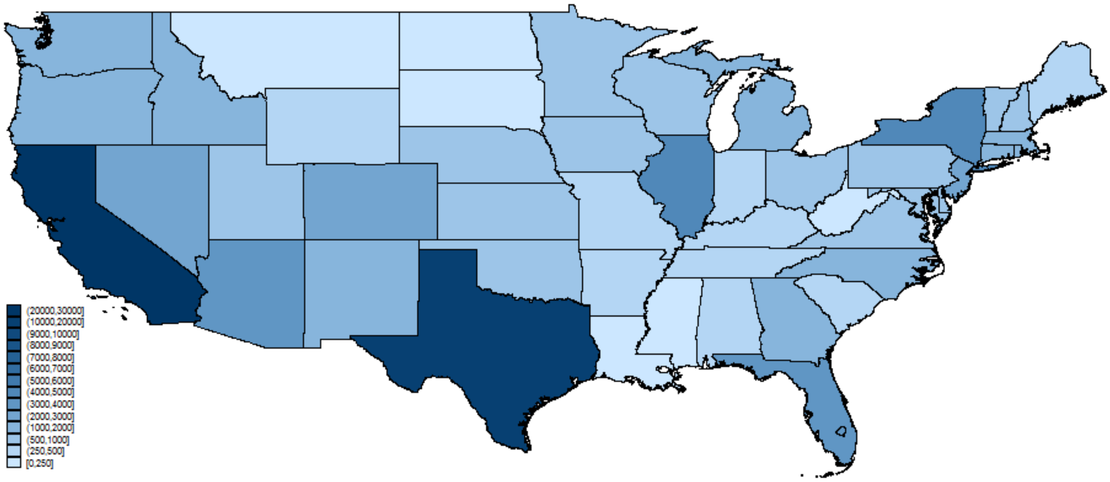

Figure 3.5: Distribution of 1^{st} generation immigrants across U.S. States

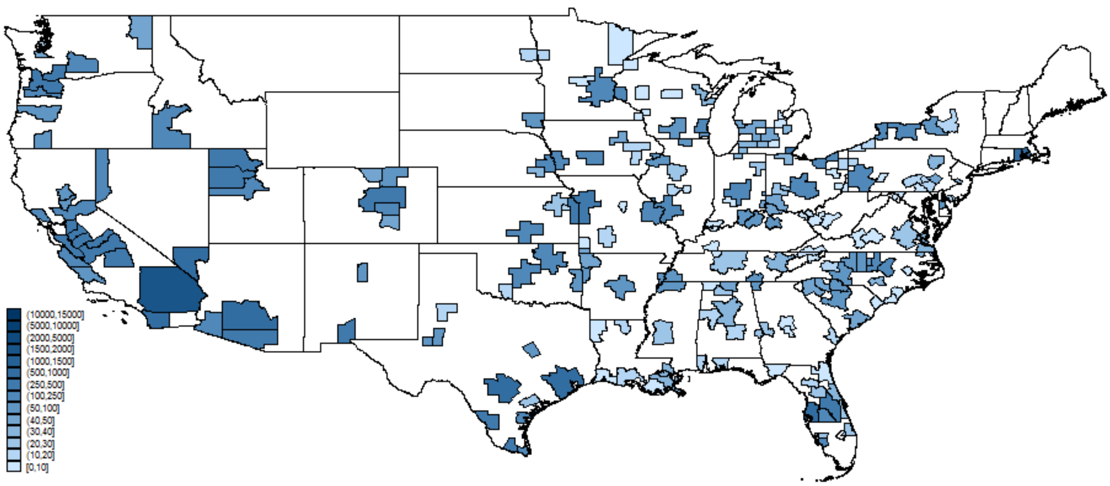

Figure 3.6: Distribution of 1^{st} generation immigrants across MSAs

Second Generation Immigrants: Summary Statistics I									
Father's birthplace	Age	Male	Income	High School (or less)	College w/o degree	College degree	Marital status	Nobs	HO_{im}
Australia	57.1	0.5	78645.25	0.29	0.25	0.45	0.43	106	67
Austria	70.1	0.47	49335.5	0.52	0.14	0.33	0.42	950	76
Belgium	61.7	0.53	62409.08	0.48	0.18	0.34	0.57	194	76
Canada	58.5	0.55	59086.89	0.46	0.18	0.36	0.53	5988	75
Chile	38.2	0.6	66177.2	0.24	0.24	0.53	0.39	110	63
Croatia	58.9	0.48	88990.8	0.29	0.12	0.58	0.46	65	83
Czech Republic	69.1	0.45	48831.8	0.54	0.13	0.33	0.45	204	83
Denmark	69.8	0.53	49370.13	0.48	0.20	0.32	0.46	446	78
England	60.4	0.54	58405.4	0.40	0.19	0.41	0.50	2071	75
Finland	70.8	0.46	43871.2	0.54	0.15	0.30	0.43	215	77
France	54.6	0.51	58408.4	0.37	0.18	0.45	0.46	490	68
Germany	59.9	0.54	59003.1	0.46	0.17	0.38	0.50	4808	74
Greece	55.3	0.51	73180.8	0.34	0.19	0.47	0.49	1028	77
Hungary	64.2	0.50	60415.6	0.50	0.16	0.34	0.47	1249	77
Ireland	61.9	0.53	64845.8	0.38	0.18	0.44	0.49	2344	77
Isreal/Palestine	38.1	0.47	84899.6	0.3	0.14	0.56	0.56	140	49
Italy	65.4	0.53	50580.3	0.59	0.14	0.26	0.49	10059	78
Japan	69.8	0.55	56549.6	0.53	0.14	0.34	0.49	1991	79
Latvia	55.8	0.47	81149.1	0.12	0.18	0.70	0.57	134	88
Lithuania	68.3	0.43	52829.5	0.47	0.17	0.36	0.41	521	76
Mexico	42.7	0.51	49156.5	0.59	0.20	0.20	0.49	15994	57
Netherlands	58.3	0.59	68013.3	0.50	0.13	0.40	0.60	776	81
New Zealand	41.3	0.53	62510.8	0.32	0.37	0.32	0.16	19	53
Norway	68.4	0.49	50615.6	0.51	0.17	0.32	0.49	1069	78
Poland	68.1	0.49	51813.1	0.54	0.14	0.32	0.44	4470	81
Portugal	53.9	0.47	54026.3	0.57	0.16	0.28	0.47	860	66
Romania	64.8	0.51	63174.8	0.36	0.21	0.44	0.52	329	76
Scotland	61.1	0.52	63020.1	0.37	0.19	0.43	0.56	879	81
Slovakia	69.2	0.47	40135.0	0.65	0.13	0.22	0.42	648	79
South Korea	36.1	0.56	72755.4	0.22	0.19	0.59	0.32	203	50
Spain	55.8	0.56	58687.1	0.39	0.19	0.42	0.48	603	68
Sweden	69.5	0.49	47107.4	0.47	0.21	0.32	0.43	1013	80
Switzerland	64.5	0.50	58121.9	0.41	0.25	0.34	0.47	296	81
Turkey	60.4	0.47	60443.86	0.34	0.17	0.49	0.43	181	77
United Kingdom	52.1	0.51	69001.71	0.32	0.15	0.53	0.48	255	68
Wales	70.6	0.44	66704.5	0.39	0.56	0.06	0.33	18	56
Average	59.6	0.51	60618.7	0.42	0.19	0.39	0.46	1686.83	73
Std. deviation	9.79	0.04	11188.5	0.12	0.08	0.12	0.08	3149.43	0.1
Correlation w/ HO_{origin}	0.27	-0.31	-0.02	0.16	-0.27	0.02	0.22	-0.04	0.30

Table 3.6: Characteristics of 2^{nd} generation immigrants

First Generation Immigrants: Summary Statistics II								
Birthplace	Nobs.	Age	Income	High school (or less)	College w/o degree	College degree	HO_{origin}	HO_{im}
Australia	273	46.3	105183	0.227	0.172	0.601	0.69	0.62
Austria	323	62.6	63881	0.35	0.152	0.498	0.58	0.77
Belgium	144	51.8	93975	0.243	0.125	0.632	0.72	0.76
Canada	3,664	53	75569	0.377	0.175	0.447	0.69	0.73
Chile	673	46.3	58157	0.327	0.134	0.539	0.69	0.47
Croatia	83	51	100648	0.458	0.084	0.458	0.92	0.71
Czech Republic	155	50.4	59579	0.4	0.09	0.51	0.80	0.64
Denmark	149	57.8	71938	0.228	0.154	0.617	0.67	0.69
England	2,637	53.9	78884	0.331	0.167	0.502	0.68	0.74
Finland	102	54.5	75844	0.304	0.137	0.559	0.74	0.63
France	762	51.2	76780	0.268	0.121	0.612	0.63	0.62
Germany	3,086	58.1	61181	0.366	0.165	0.469	0.53	0.76
Greece	891	55.1	61798	0.568	0.116	0.316	0.76	0.75
Hungary	558	57.7	58615	0.369	0.134	0.496	0.91	0.72
Ireland	1,017	55.9	70347	0.446	0.151	0.402	0.70	0.67
Isreal/Palestine	341	41	77594	0.355	0.097	0.548	0.69	0.55
Italy	2,774	59.1	61246	0.623	0.098	0.279	0.73	0.77
Japan	1,939	49	61155	0.286	0.124	0.59	0.60	0.47
Latvia	94	62.4	56119	0.149	0.223	0.628	0.81	0.80
Lithuania	217	55.6	65448	0.249	0.175	0.576	0.92	0.63
Mexico	54,476	40.8	39429	0.846	0.074	0.08	0.71	0.45
Netherlands	512	55.9	90637	0.277	0.184	0.539	0.67	0.80
New Zealand	103	44.9	101618	0.184	0.155	0.66	0.53	0.61
Norway	214	63	66687	0.36	0.201	0.439	0.84	0.77
Poland	2,630	53	61695	0.438	0.161	0.401	0.82	0.67
Portugal	1,290	50.7	59129	0.752	0.095	0.153	0.75	0.70
Romania	579	47.8	85307	0.333	0.121	0.546	0.97	0.66
Scotland	605	57.8	72291	0.395	0.218	0.387	0.68	0.71
Slovakia	226	57.2	54747	0.429	0.115	0.456	0.90	0.73
South Korea	2,443	45.3	59280	0.325	0.123	0.551	0.57	0.43
Spain	1,103	56.5	61234	0.396	0.139	0.465	0.83	0.63
Sweden	213	55.9	72073	0.249	0.141	0.61	0.70	0.69
Switzerland	225	56.2	85198	0.227	0.102	0.671	0.44	0.76
Turkey	535	47.2	69388	0.355	0.108	0.536	0.60	0.49
United Kingdom	463	51.5	113851	0.201	0.134	0.665	0.68	0.75
Wales	12	73.8	46196	0.25	0.167	0.583	0.68	0.67
Average	2375	53.62	71464	0.36	0.14	0.50	0.72	0.67
Standard Devitation	8987	6.58	16736	0.15	0.04	0.13	0.12	0.10
Correlation w. Ho_origin		0.11	-0.14	0.22	-0.01	-0.24	1	0.17
Correlation w. Ho_im		0.66	0.25	-0.12	0.38	0.03	0.17	1.00

Table 3.7: Characteristics of 1^{st} generation immigrants

Dependent variable: Aggregate Homeownership Rate of 2^{nd} generation immigrants groups H_{i_o}		
	(1)	(2)
HO_{origin}	0.270*	0.266*
	(1.96)	(1.88)
Average aggregate income		-0.000176
		(-1.06)
constant	53.12***	63.97***
	(4.93)	(4.13)
Number of countries	38	38
R^2	0.102	0.140
adj. R^2	0.077	0.091

t statistics in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table 3.8: OLS - Culture and Homeownership - Aggregates

3.10 Appendix B: Robustness Checks

Robustness Check 1: Alternative (OLS) Estimation Methods
Robustness Check 1a: Baseline
We estimate the model in (3.1) with a OLS regression. The estimation results are shown in Table (3.9). The cultural proxy remains highly significant and the marginal effects correspond to the OLS estimates.
Robustness Check 1b: Married Couples
The corresponding OLS results of Table (3.3) are shown in Table (3.10).
Robustness Check 1c: Married Couples (2)
The corresponding OLS results of Table (3.4) are shown in Table (3.11).

Robustness Check 2: Alternative Proxy for Cultural Preferences
Robustness Check 2: Dummy High Homeownership country
We estimate the model in (3.1) with an alternative proxy for cultural preferences. The alternative proxy is a dummy variable and equal to one if the homeownership rate in the country of origin is larger than 70 % (median value) and zero otherwise. The estimation results are shown in Table (3.12). Our new cultural variable of interest remains highly significant.

Robustness Checks 3-9: Varying Sample Sizes
Robustness Check 3: Larger Sample
We estimate (3.1) for all available countries in the sample. The sample includes 5 more countries-of-origin in comparison to our baseline sample.[32] The estimation results are very similar. The cultural proxy stays significant, and the quantitative impact of the cultural proxy is basically identical. Table (3.13) shows the regression results.
Robustness Check 4: Excluding countries < 100 *observations*
We estimate (3.1) for a smaller sample of countries. We exclude all countries of origin listed in Table (3.5) that have less than 100 observations. The estimation results are very similar. Table (3.14) shows the results.

[32] The included countries are Bulgaria, Cyprus, Estonia, Iceland, and Singapore. In the baseline, we exclude these countries as the number of observations is below ten for these countries of origin.

Robustness Check 5: Excluding Mexico
(country of origin with most observations)
We estimate (3.1) for a smaller sample of countries. We exclude Mexico. We lose 26% of the baseline observations. The cultural proxy stays significant, and the quantitative impact of the cultural proxy is basically identical. Table (3.15) shows the regression results.

Robustness Check 6: Excluding "war countries"
We estimate (3.1) for a smaller sample of countries. We exclude all countries of origin listed in Table (3.5) that might have been affected by wars between 1945-1994. We exclude Israel/Palestine, Croatia, and South Korea. The cultural proxy stays significant; the quantitative impact is basically identical. Table (3.16) shows the regression results.

Robustness Check 7: Excluding "dictatorship countries"
We estimate (3.1) for a smaller sample of countries. We exclude all countries of origin from the baseline sample that had a dictatorship at some point between 1945-1994. We exclude Portugal, Spain, and Greece. The estimation results are very similar. The cultural proxy stays significant, and the quantitative impact is basically identical. Refer to Table (3.17).

Robustness Check 8: Excluding Post-Soviet States
We estimate (3.1) for a smaller sample of countries. We exclude all countries of origin from the baseline sample that are Post-Soviet States (Lithuania, Estonia, and Latvia). The estimation results are very similar. The cultural proxy stays significant, and the quantitative impact is basically identical. Table (3.18) shows the regression results.

Robustness Check 9: Excluding Outliers
We estimate (3.1) for a smaller sample of countries. We exclude all countries of origin from the baseline sample that are outliers in Figure (1), we exclude Lithuania, Estonia, and Latvia. The estimation results are very similar. Table (3.19) shows the regression results.

Robustness Check 10-12: Varying Location-Time Dummies

Robustness Check 10: Without metropolitan area and year dummies
We estimate (3.1) without F_m and F_t, the large sets of metropolitan area and time dummies. The estimation results are very similar. The cultural proxy stays significant, and the quantitative impact of the cultural proxy is basically identical. Table (3.20) shows the regression results.

Robustness Check 11: Metropolitan area per year dummies (instead of metropolitan area and year dummies)
We estimate (3.1) without F_m and F_t, the large sets of metropolitan area and time dummies. Instead, we include F_{m_t}, a set of metropolitan area per year dummies. The estimation results are very similar. The cultural proxy stays significant, and the quantitative impact of the cultural proxy is basically identical. Table (3.21) shows the regression results.

Robustness Check 12: Metropolitan central city status per year dummies
We estimate (3.1) without F_m and F_t, the large sets of metropolitan area and time dummies. Instead, we include F_{c_t}, a set of metropolitan central city status per year dummies. For households within metropolitan areas, the metropolitan central city status specifies whether the household is located inside or outside the metropolitan central city of the metropolitan area. The cultural proxy stays significant, and the quantitative impact of the cultural proxy is basically identical. Table (3.22) shows the regression results.

Robustness Check 13: Varying Standard Errors

Robustness Check 13: Clustered Standard Errors
We estimate (3.1) with clustered standard errors at the metropolitan area level and the country of origin level, respectively. The cultural proxy stays significant. Table (3.23) shows the regression results.

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i			
	(1)	(2)	(3)
HO_{origin}	0.0585***	0.0426**	0.0446**
	(0.0209)	(0.0192)	(0.0192)
male (dummy)		-0.0187****	-0.0191****
		(0.00356)	(0.00356)
marital status (dummy)		0.157****	0.159****
		(0.00387)	(0.00387)
age		0.0232****	0.0228****
		(0.000619)	(0.000621)
age squared		-0.000144****	-0.000141****
		(0.00000564)	(0.00000566)
Income Categories			
2nd income decile		0.0741****	0.0734****
		(0.00752)	(0.00751)
10th income decile		0.379****	0.363****
		(0.00805)	(0.00831)
Education Categories			
college without degree			0.00902*
			(0.00465)
college +			0.0304****
			(0.00406)
race categories		✓	✓
metropolitan area (dummy)	✓	✓	✓
year (dummy)	✓	✓	✓
N	60726	60726	60726
R^2	0.051	0.251	0.251
adj. R^2	0.045	0.245	0.246

* p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$.

Table 3.9: Robustness Check (1a) - Baseline OLS Regression

	Dependent Variable: Homeownership status of immigrant i			
	2nd generation			
	all (baseline) (1)	single (2)	married $\neq$ background (3)	married same background (4)
HO_{origin}	0.0446**	0.0778**	0.0259	0.156*
	(0.0192)	(0.0313)	(0.0231)	(0.0913)
male (dummy)	-0.0191****	-0.0290****	-0.00467	-0.0151
	(0.00356)	(0.00557)	(0.00520)	(0.0101)
marital status (dummy)	0.159****			
	(0.00387)			
age	0.0228****	0.0200****	0.0276****	0.0283****
	(0.000621)	(0.000837)	(0.00113)	(0.00173)
age squared	-0.000141****	-0.000111****	-0.000197****	-0.000183****
	(0.00000566)	(0.00000768)	(0.0000100)	(0.0000161)
Income Categories				
2nd income decile	0.0734****	0.0778****	0.0334	-0.0243
	(0.00751)	(0.00855)	(0.0215)	(0.0268)
10th income decile	0.363****	0.399****	0.244****	0.289****
	(0.00831)	(0.0151)	(0.0194)	(0.0277)
Education Categories				
college without degree	0.00902*	0.00961	0.000557	0.0313**
	(0.00465)	(0.00718)	(0.00665)	(0.0131)
college +	0.0304****	0.0143**	0.0329****	0.0809****
	(0.00406)	(0.00675)	(0.00543)	(0.0116)
race categories	✓	✓	✓	✓
metropolitan area (dummy)	✓	✓	✓	✓
year (dummy)	✓	✓	✓	✓
N	60726	31019	20634	7419
R^2	0.251	0.189	0.186	0.281
adj. R^2	0.246	0.178	0.173	0.259

* p<0.1, ** p<0.05, *** p<0.01. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the homeownership rate in the country of origin in 2011 and is $\in (0, 1)$.

Table 3.10: Robustness Check (1b): OLS - Married

	Dependent Variable: Homeownership status of immigrant i		
	2nd generation		1st generation
	all (baseline) (1)	married same background (2)	married same background (3)
HO_{origin}	0.0446**	0.156*	0.284****
	(0.0192)	(0.0913)	(0.0546)
male (dummy)	-0.0191****	-0.0151	-0.00293
	(0.00356)	(0.0101)	(0.00531)
marital status (dummy)	0.159****		
	(0.00387)		
age	0.0228****	0.0283****	0.0277****
	(0.000621)	(0.00173)	(0.00105)
age squared	-0.000141****	-0.000183****	-0.000165****
	(0.00000566)	(0.0000161)	(0.0000106)
Income Categories			
2nd income decile	0.0734****	-0.0243	0.0188
	(0.00751)	(0.0268)	(0.0115)
10th income decile	0.363****	0.289****	0.419****
	(0.00831)	(0.0277)	(0.0142)
Education Categories			
college without degree	0.00902*	0.0313**	0.0754****
	(0.00465)	(0.0131)	(0.00949)
college +	0.0304****	0.0809****	0.0112
	(0.00406)	(0.0116)	(0.00767)
race categories	✓	✓	✓
metropolitan area (dummy)	✓	✓	✓
year (dummy)	✓	✓	✓
N	60726	7419	33471
R^2	0.251	0.281	0.252
adj. R^2	0.246	0.259	0.244

* p¡0.1, ** p¡0.05, *** p¡0.01, **** p¡0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category *High School or less* is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the homeownership rate in the country of origin in 2011 and is $\in (0, 1)$.

Table 3.11: Robustness Check (1c): OLS - Married (2)

	Dependent Variable: Homeownership status of immigarnt i
$HO_{high-low}$	0.0141***
	(0.00446)
age	0.0220****
	(0.000675)
age squared	-0.000130****
	(0.00000616)
male (dummy)	-0.0137****
	(0.00407)
marital status (dummy)	0.180****
	(0.00422)
income categories	✓
education categories	✓
race categories	✓
metropolitan area (dummy)	✓
year (dummy)	✓
N	60726
pseudo R^2	0.228

* p¡0.1, ** p¡0.05, *** p¡0.01, **** p¡0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category *High School or less* is the reference category. Number of metropolitan area categories: 415. $HO_{high-low}$ is equal to one if the homeownership rate in the country of origin in 2011 is larger than the median and zero otherwise.

Table 3.12: Robustness Check (2): Alternative Proxy Cultural Preferences

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i	(1)	(2)	(3)
HO_{origin}	0.0634***	0.0653***	0.0686***
	(0.0224)	(0.0237)	(0.0238)
male (dummy)		-0.0135****	-0.0137****
		(0.00407)	(0.00407)
marital status (dummy)		0.178****	0.180****
		(0.00421)	(0.00421)
age		0.0223****	0.0219****
		(0.000669)	(0.000673)
age squared		-0.000134****	-0.000130****
		(0.00000610)	(0.00000615)
Income Categories			
2nd income decile		0.0589****	0.0581****
		(0.00619)	(0.00619)
10th income decile		0.256****	0.252****
		(0.00296)	(0.00316)
Education Categories			
college without degree			0.0127**
			(0.00524)
college +			0.0358****
			(0.00477)
race categories		✓	✓
metropolitan area	✓	✓	✓
year (dummy)	✓	✓	✓
N	60756	60756	60756
pseudo R^2	0.043	0.227	0.228

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$. Include all countries of origin without any restrictions.

Table 3.13: Robustness Check (3): Varying Sample Size 1

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i	(1)	(2)	(3)
HO_{origin}	0.0617***	0.0632***	0.0667***
	(0.0225)	(0.0238)	(0.0239)
male (dummy)		-0.0136****	-0.0138****
		(0.00407)	(0.00407)
marital status (dummy)		0.178****	0.180****
		(0.00421)	(0.00422)
age		0.0223****	0.0219****
		(0.000670)	(0.000674)
age squared		-0.000134****	-0.000130****
		(0.00000611)	(0.00000616)
Income Categories			
2nd income decile		0.0591****	0.0582****
		(0.00619)	(0.00620)
10th income decile		0.256****	0.251****
		(0.00297)	(0.00317)
Education Categories			
college without degree			0.0129**
			(0.00524)
college +			0.0357****
			(0.00478)
race categories		✓	✓
metropolitan area	✓	✓	✓
year (dummy)	✓	✓	✓
N	60661	60661	60661
pseudo R^2	0.043	0.227	0.228

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$. Include all countries of origin that have more than 100 observations.

Table 3.14: Robustness Check (4): Varying Sample Size 2

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i			
	(1)	(2)	(3)
HO_{origin}	0.0998****	0.0608***	0.0614***
	(0.0212)	(0.0209)	(0.0209)
male (dummy)		-0.0184****	-0.0188****
		(0.00432)	(0.00431)
marital status (dummy)		0.179****	0.180****
		(0.00458)	(0.00458)
age		0.0228****	0.0227****
		(0.000781)	(0.000783)
age squared		-0.000152****	-0.000150****
		(0.00000679)	(0.00000682)
Income Categories			
2nd income decile		0.0610****	0.0606****
		(0.00572)	(0.00573)
10th income decile		0.202****	0.199****
		(0.00320)	(0.00337)
Education Categories			
college without degree			0.00892
			(0.00567)
college +			0.0270****
			(0.00498)
race categories		✓	✓
metropolitan area	✓	✓	✓
year (dummy)	✓	✓	✓
N	44565	44565	44565
pseudo R^2	0.038	0.204	0.205

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$. We exclude Mexico from the baseline sample.

Table 3.15: Robustness Check (5): Varying Sample Size 3

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i			
	(1)	(2)	(3)
HO_{origin}	0.0445**	0.0621***	0.0655***
	(0.0225)	(0.0238)	(0.0239)
male (dummy)		-0.0133***	-0.0134****
		(0.00408)	(0.00407)
marital status (dummy)		0.178****	0.180****
		(0.00422)	(0.00422)
age		0.0222****	0.0217****
		(0.000670)	(0.000675)
age squared		-0.000133****	-0.000129****
		(0.00000610)	(0.00000616)
Income Categories			
2nd income decile		0.0593****	0.0584****
		(0.00618)	(0.00618)
10th income decile		0.256****	0.251****
		(0.00297)	(0.00317)
Education Categories			
college without degree			0.0126**
			(0.00524)
college +			0.0365****
			(0.00477)
race categories		✓	✓
metropolitan area	✓	✓	✓
year (dummy)	✓	✓	✓
N	60488	60488	60488
pseudo R^2	0.043	0.227	0.227

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$. War countries excluded from baseline sample.

Table 3.16: Robustness Check (6): Varying Sample Size 4

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i			
	(1)	(2)	(3)
HO_{origin}	0.0671***	0.0670***	0.0710***
	(0.0227)	(0.0241)	(0.0242)
male (dummy)		-0.0134***	-0.0136***
		(0.00416)	(0.00416)
marital status (dummy)		0.178****	0.180****
		(0.00431)	(0.00431)
age		0.0226****	0.0221****
		(0.000684)	(0.000688)
age squared		-0.000137****	-0.000132****
		(0.00000623)	(0.00000628)
Income Categories			
2nd income decile		0.0596****	0.0588****
		(0.00629)	(0.00630)
10th income decile		0.255****	0.250****
		(0.00302)	(0.00321)
Education Categories			
college without degree			0.0125**
			(0.00534)
college +			0.0352****
			(0.00487)
race categories		✓	✓
metropolitan area	✓	✓	✓
year (dummy)	✓	✓	✓
N	58147	58147	58147
pseudo R^2	0.045	0.229	0.229

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$. Excluding countries of origin from baseline sample that experienced a dictatorship.

Table 3.17: Robustness Check (7): Varying Sample Size 5

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i			
	(1)	(2)	(3)
HO_{origin}	0.0551**	0.0696***	0.0743***
	(0.0230)	(0.0245)	(0.0245)
male (dummy)		-0.0132***	-0.0134***
		(0.00410)	(0.00410)
marital status (dummy)		0.178****	0.180****
		(0.00423)	(0.00424)
age		0.0222****	0.0217****
		(0.000673)	(0.000677)
age squared		-0.000133****	-0.000128****
		(0.00000614)	(0.00000619)
Income Categories			
2nd income decile		0.0592****	0.0584****
		(0.00624)	(0.00624)
10th income decile		0.257****	0.252****
		(0.00299)	(0.00319)
Education Categories			
college without degree			0.0129**
			(0.00527)
college +			0.0366****
			(0.00480)
race categories		✓	✓
metropolitan area	✓	✓	✓
year (dummy)	✓	✓	✓
N	60098	60098	60098
pseudo R^2	0.044	0.228	0.228

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$. Excluding countries of origin from baseline sample that are Post-Soviet States.

Table 3.18: Robustness Check (8): Varying Sample Size 6

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i	(1)	(2)	(3)
HO_{origin}	0.0807****	0.0604***	0.0610***
	(0.0212)	(0.0209)	(0.0209)
male (dummy)		-0.0179****	-0.0183****
		(0.00432)	(0.00431)
marital status (dummy)		0.179****	0.180****
		(0.00459)	(0.00459)
age		0.0226****	0.0226****
		(0.000784)	(0.000786)
age squared		-0.000150****	-0.000149****
		(0.00000681)	(0.00000684)
Income Categories			
2nd income decile		0.0610****	0.0606****
		(0.00570)	(0.00570)
10th income decile		0.201****	0.197****
		(0.00320)	(0.00337)
Education Categories			
college without degree			0.00879
			(0.00565)
college +			0.0280****
			(0.00497)
race categories		✓	✓
metropolitan area	✓	✓	✓
year (dummy)	✓	✓	✓
N	44345	44345	44345
pseudo R^2	0.037	0.203	0.203

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$. Excluding countries of origin from baseline sample that are outliers in Figure (3.2).

Table 3.19: Robustness Check (9): Varying Sample Size 7

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i	(1)	(2)	(3)
HO_{origin}	0.0824****	0.0504**	0.0530**
	(0.0202)	(0.0222)	(0.0223)
male (dummy)		-0.00845**	-0.00846**
		(0.00396)	(0.00396)
marital status (dummy)		0.185****	0.187****
		(0.00408)	(0.00409)
age		0.0236****	0.0233****
		(0.000647)	(0.000650)
age squared		-0.000145****	-0.000142****
		(0.00000591)	(0.00000595)
Income Categories			
2nd income decile		0.0604****	0.0597****
		(0.00600)	(0.00601)
10th income decile		0.250****	0.246****
		(0.00318)	(0.00341)
Education Categories			
college without degree			0.0105**
			(0.00510)
college +			0.0254****
			(0.00464)
race categories		✓	✓
N	63564	63564	63564
pseudo R^2	0.000	0.197	0.197

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$. Difference to baseline: No metropolitan area nor year dummies.

Table 3.20: Robustness Check (10): Varying Location-Time Dummies 1

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i			
	(1)	(2)	(3)
HO_{origin}	0.0632***	0.0650**	0.0680***
	(0.0240)	(0.0257)	(0.0257)
male (dummy)		-0.0112**	-0.0114***
		(0.00436)	(0.00436)
marital status (dummy)		0.189****	0.191****
		(0.00449)	(0.00449)
age		0.0239****	0.0234****
		(0.000722)	(0.000726)
age squared		-0.000144****	-0.000140****
		(0.00000656)	(0.00000662)
Income Categories			
2nd income decile		0.0646****	0.0636****
		(0.00660)	(0.00661)
10th income decile		0.269****	0.264****
		(0.00306)	(0.00326)
Education Categories			
college without degree			0.0171***
			(0.00559)
college +			0.0371****
			(0.00514)
race categories		✓	✓
year per metropolitan area (dummy)	✓	✓	✓
N	56948	56948	56948
pseudo R^2	0.062	0.248	0.249

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0, 1)$. Difference to baseline: No separate year and metropolitan area dummies. We include a large set of 4339 year per metropolitan area dummies.

Table 3.21: Robustness Check (11): Varying Location-Time Dummies 2

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i	(1)	(2)	(3)
HO_{origin}	0.0708****	0.0671***	0.0705***
	(0.0207)	(0.0225)	(0.0226)
male (dummy)		-0.00836**	-0.00846**
		(0.00397)	(0.00397)
marital status (dummy)		0.176****	0.178****
		(0.00411)	(0.00412)
age		0.0225****	0.0221****
		(0.000653)	(0.000657)
age squared		-0.000137****	-0.000134****
		(0.00000595)	(0.00000600)
Income Categories			
2nd income decile		0.0613****	0.0606****
		(0.00603)	(0.00604)
10 income decile		0.253****	0.248****
		(0.00308)	(0.00330)
Education Categories			
college without degree			0.0119**
			(0.00511)
college +			0.0287****
			(0.00465)
race categories		✓	✓
year per metro city (dummy)	✓	✓	✓
N	63161	63161	63161
pseudo R^2	0.023	0.208	0.209

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0,1)$. Difference to baseline: No metropolitan area nor year dummies. We include instead a set of metropolitan central city status *per* year dummies. For households within metropolitan areas, metropolitan central city status specifies whether the housing unit is inside or outside the central city of the metropolitan area.

Table 3.22: Robustness Check (12): Varying Location-Time Dummies 3

Dependent Variable: Homeownership status of 2^{nd} generation immigrant i		
	Clustered standard errors at	
	MSA	country of origin
HO_{origin}	0.0691**	0.0691*
	(0.0291)	(0.0410)
male (dummy)	-0.0137**	-0.0137**
	(0.00636)	(0.00616)
marital status (dummy)	0.180****	0.180****
	(0.00668)	(0.0175)
age	0.0219****	0.0219****
	(0.00114)	(0.00307)
age squared	-0.000130****	-0.000130****
	(0.0000109)	(0.0000312)
Income Categories		
2nd income decile	0.0580****	0.0580****
	(0.00834)	(0.0127)
10th income decile	0.252****	0.252****
	(0.00407)	(0.0112)
Education Categories		
college without degree	0.0128*	0.0128**
	(0.00698)	(0.00612)
college +	0.0357****	0.0357****
	(0.00823)	(0.00553)
race categories	✓	✓
metropolitan area	✓	✓
year (dummy)	✓	✓
N	60726	60726
pseudo R^2	0.228	0.228

Marginal effects. * p<0.1, ** p<0.05, *** p<0.01, **** p<0.001. Standard errors in parentheses. Dependent variable: Equal to one if 2^{nd} the generation immigrant is a homeowner, 0 otherwise. Marital status dummy: equal to one if married and living with partner. Number of race categories: 21. Number of income categories (income deciles) is 10. The first decile is the reference category. The education categories are: High School or less, college without degree, college +. The first category 'High School or less' is the reference category. Number of metropolitan area categories: 415. HO_{origin} denotes the aggregate homeownership rate in the country of origin in 2011 and is $\in (0,1)$. Difference to baseline: In column 1, we include Clustered Standard Errors at metropolitan area of the second immigrant's residence. In column 2, we include Clustered Standard Errors at the country of origin level of the second immigrant.

Table 3.23: Robustness Check (13): Clustered Standard Errors

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