Universidad de Navarra

Facultad de Ciencias Económicas y Empresariales

Working Paper nº 24/12

Portfolio Choice with Indivisible and Illiquid Housing Assets: The Case of Spain

Sergio Mayordomo
University of Navarra

María Rodríguez-Moreno
European Central Bank

Juan Ignacio Peña
Universidad Carlos III de Madrid

Portfolio Choice with Indivisible and Illiquid Housing Assets: The Case of Spain

Sergio Mayordomo, María Rodríguez-Moreno, Juan Ignacio Peña

Working Paper No.24/12
December 2012

ABSTRACT

This paper presents a procedure for computing the theoretically optimal portfolio under the assumption that housing is an indivisible, illiquid asset that restricts the portfolio choice decision. The analysis also includes the financial constraints households may face when they apply for external funding. The set of financial assets that constitute the household's portfolios are bank time deposits, stocks, mortgage, and housing. We compare the theoretically optimal portfolio against Spanish households' actual choices using a unique data set, the Spanish Survey of Household Finance. In comparison with the optimal portfolio, households significantly underinvest in stocks and deposits. In the case of mortgages, the optimal and actual portfolios weights are not unequal. At a more disaggregated level, some additional differences emerge that are explained by demographic, educational, and income characteristics.

Sergio Mayordomo
School of Economics and Business Administration
University of Navarra
smayordomo@unav.es

María Rodríguez-Moreno
European Central Bank
maria.rodriguez_moreno@ecb.int

Juan Ignacio Peña
Department of Business Administration
Universidad Carlos III de Madrid
ypenya@eco.uc3m.es

Portfolio Choice with Indivisible and Illiquid Housing Assets: The Case of Spain

Sergio Mayordomo*, María Rodríguez-Moreno and Juan Ignacio Peña

Abstract

This paper presents a procedure for computing the theoretically optimal portfolio under the assumption that housing is an indivisible, illiquid asset that restricts the portfolio choice decision. The analysis also includes the financial constraints households may face when they apply for external funding. The set of financial assets that constitute the household's portfolios are bank time deposits, stocks, mortgage, and housing. We compare the theoretically optimal portfolio against Spanish households' actual choices using a unique data set, the Spanish Survey of Household Finance. In comparison with the optimal portfolio, households significantly underinvest in stocks and deposits. In the case of mortgages, the optimal and actual portfolios weights are not unequal. At a more disaggregated level, some additional differences emerge that are explained by demographic, educational, and income characteristics.

JEL classification: C61, D14, G11

Keywords: Portfolio choice, Households, Indivisible illiquid assets, Financial constraints, Under-investment, Over-investment.

*Sergio Mayordomo is at the School of Economics and Business Administration, University of Navarra, Edificio Amigos, 31009 Pamplona (Spain), smayordomo@unav.es. María Rodríguez-Moreno is at the European Central Bank, Neue Mainzer Strasse 66, 60311 Frankfurt am Main (Germany), maria.rodriguez_moreno@ecb.int. Juan Ignacio Peña is at the Department of Business Administration, Universidad Carlos III de Madrid, C/ Madrid 126, 28903 Getafe (Madrid, Spain), ypenya@eco.uc3m.es. We thank Anatoli Segura, Costanza Torricelli, and participants in the IX INFINITI Conference, the 2011 Conference of the International Finance and Banking Society, and the XIX Meeting of the Spanish Finance Association for insightful comments. Peña acknowledges financial support from MCI grant ECO2009-12551.

Corresponding author: Sergio Mayordomo, School of Economics and Business Administration, University of Navarra, Edificio Amigos, 31009 Pamplona (Spain), E-mail: smayordomo@unav.es. Phone: 0034 948 425600 Ext. 802435. Fax: + 34 948 425626

1. Introduction

Investing in housing represents the main asset for households in many countries, particularly in Spain, where housing represented an average of 66.5 % of the total assets in household portfolios in 2002 and 66.1 % in 2005. According to the Spanish Household Budget Continuous Survey (ECPF) carried out by the Spanish National Statistics Institute (INE), the percentage of homeowners increased from 84 % in 2002 to 86 % in 2005. These percentages suggest the importance of considering housing in analyses of households' optimal portfolio decisions. The vast literature on portfolio choice, starting with Markowitz (1952), Samuelson (1969), and Merton (1971) does not include housing explicitly. For example, recent articles by Ameriks and Zeldes (2000) or Cocco, Gomes, and Maenhout (2005) focus solely on the impact of the life cycle on household portfolios. By excluding housing, these studies also fail to include housing-related financial liabilities (i.e., mortgages) in their models of households' portfolio decisions. One way to take housing investments into account is differentiating liquid from illiquid assets, as do Koren and Szeidl (2002), Schwartz and Tebaldi (2006) and Anglin and Gao (2011). This differentiation implicitly considers investments in housing and mortgages, though the high heterogeneity among illiquid assets likely makes it necessary to deal separately with housing and mortgage investments.

Even recent research that includes housing and mortgage as additional financial assets or liabilities into household portfolio choice decisions tends to consider housing as a standard financial asset, in the sense that investors can decide what amount to invest in housing every year. Cocco (2005) employs a model in which in every period, the investor chooses the size of housing's share in an optimal portfolio. However, housing is not a standard financial asset whose size in the portfolio can be chosen freely in every period by selling or buying a certain portion of it. Of course, housing yields a return derived from its appreciation or depreciation (capital gains/losses) and has an opportunity cost of actually using the house as a place to live, which also require consideration. In our view, housing is an indivisible, illiquid asset; that is, it can be thought of as a durable consumption good.[1] This view is in line with Flavin and Yamashita (2002) who focus on the impact of the portfolio constraint imposed by the consumption demand for housing on the household's optimal holdings of financial assets. For this reason, we consider that housing constitutes a "restriction"on portfolio choice, as an investment already undertaken, that determines the investment in the other financial assets. Kallberg, Liu, and Greig (1996) address the separation among different types of assets in

[1] Grossman and Laroque (1990) employ a similar perspective, though they restrict the portfolio composition to stocks. Kallberg, Liu, and Greig (1996) also incorporate the real estate imperfections of indivisible assets and no short sales in their analysis of the role of direct real estate investment by real estate funds in a portfolio context.

the portfolio optimization context of real estate funds. These authors optimize first over all properties and then use the resulting real estate portfolio to subsequently optimize over the remaining financial assets. They conclude that the separation to selecting real estate represents a good approximation.

Finally, household portfolio choice literature suffers from a pervasive shortage of data on real-world households' portfolio choices. Such data might allow a more realistic assessment of the divergences between theory and practice though. Campbell (2006) suggests it is hard to obtain these necessary data, because households tend to guard their financial privacy jealously. The lack of data thus has forced some analysts, including Longstaff (2001) and Haliassos and Michaelides (2003), to perform simulations instead of testing their models with actual data.

To overcome this limitation, we employ the Spanish survey of household finance (EFF), a unique data set that gives us data (missing in other studies) to combine a theoretical model with actual data of Spanish families' financial decisions. Other studies employing a similar approach refer to U.S. and U.K. micro data , such as Campbell and Cocco (2007), Cocco (2005), and Flavin and Yamashita (2002). With micro data from the United Kingdom, Campbell and Cocco analyze how fluctuations in housing prices affect households' consumption decisions. Cocco determines how the investment in housing affects the portfolio composition of U.S. households and finds that the average portfolio shares of stocks, bills, and real estate are 4.9 %, 2.9 %, and 92.2 %, respectively, for households with a financial net worth less than $100,000, but they shift to 46 %, 1.3 %, and 52.7 % for households with a financial net worth of at least $100,000. Finally, Flavin and Yamashita employ a mean-variance framework to study the impact of the portfolio constraints derived from the consumption of housing in the United States. For all housing-to-net wealth ratios (i.e., the ratio of house value to wealth), and assuming a coefficient of relative risk aversion equal to 2, which is the same that we use in our analysis, households should maintain a portfolio in which the amount of their mortgage is equal to the value of their house.[2] The rest of the portfolio should be invested, on average, 0 % in treasury bills, 27 % in treasury bonds, and 73 % in stocks.

This article analyzes the optimization problem faced by homeowners. The household must determine the amount of the investment in housing to be funded by a mortgage, which in turn conditions the demand for other financial assets. We frame this optimization problem as a reallocation problem, in which the household's wealth is assigned across different assets (stocks, bank time deposits, and mortgage), conditioned to the housing value. When a household purchases a house, it does so because the house is consistent with either its true preferences or preferences restricted to its financial situation. Thus actual housing could dif-

[2] They assume that the maximum portion of mortgage relative to housing value is 100 %.

fer from the desired state. To solve this problem, we investigate households living in their desired housing to reduce the risk that they would move in the short-run. In addition, we focus on households who bought housing recently to reduce uncertainty.[3] We estimate the desired house value using Mayordomo's (2008) method and consider housing as the desired one whenever its desired value is below the housing's market price. With this assumption, we posit that the desired housing represents an illiquid financial asset, from the household's perspective, that will not be traded in the near future. Moreover, this premise enables us to assume that households solve a problem with infinite time horizons in which housing appears as a permanent financial restriction.

In the empirical section, we first study the actual composition of the households' portfolios, noting different demographic and financial characteristics. Then, we estimate an optimal investment portfolio for individual households and for different categories. Finally, by combining the two previous analyses, we can detect the demographic and financial characteristics that cause deviations from a household's optimal portfolio, that is, deviations between actual and optimal investments.

Our study adds to the existing literature in several ways. Our contributions to the methodology are: first, we use four financial assets in the optimization problem (stocks, bank time deposits, mortgage, and housing) instead of two assets (e.g., one liquid and one illiquid), as is commonly employed in prior literature. Second, we extend Koren and Szeidl's (2002) optimization methodology by including stock risk. And third, we consider the restrictions derived from the housing purchase that affect the mortgage decision. Our empirical contributions are: we use the Bank of Spain's EFF, a unique data set of Spanish households micro data, to compute actual portfolios and estimate the optimal portfolios for different individual households, as well as for different groups of households attending to several demographic characteristics. Finally, once the optimal portfolio has been estimated, we compare actual and optimal portfolios and study the factors affecting the actual portfolio's deviations from the optimal one.

Our model's baseline results show that the average actual proportion invested by Spanish households in housing is 128.2 % of their total net wealth, and in turn, the optimal (actual) proportion invested in stocks is 1.6 % (0.6 %), the optimal (actual) proportion invested in bank time deposits is 4.9 % (3.1 %), and the optimal (actual) average investment in mortgage is -34.7 % (-31.9 %) of total net wealth. Statistical significance tests indicate that Spanish households tend to invest significantly less in stocks and deposits than theory indicate they should. However their optimal and actual investment in mortage is not dissimilar. We also

[3] The more years in a given housing situation, the higher is the uncertainty about the preferences of the household and the greater the probability of moving.

find a significant relationship between the optimal proportion invested in stocks and deposits on the one hand and the age, education level, degree of financial sophistication, household income, and net wealth of members of the household on the other. Significant differences between the optimal and the actual investment in mortgages are only found in the case of highly financially sophisticated households and the individuals more than 55 years old or retired. The actual proportion of housing decreases with the age, education level, and household net wealth.

In Section 2, we describe the theoretical optimization model and the semi-analytical technique that we employ to solve it. Section 3 deals with the calibration procedure. In Section 4, we describe the data. Section 5 presents the empirical results. In Section 6, we present a comparative statics analysis and in Section 7, we analyze the household characteristics that determine the deviation of the actual portfolios from the optimal ones. Section 8 concludes.

2. Model

We present the portfolio decision problem for a household subject to financial or borrowing restrictions due to its housing investment and exposure to liquidity shocks. As in Koren and Szeidl (2002), we use a relatively simple functional form that enables us to find a semi-analytic solution for the value function and for the optimal consumption and portfolio policy. We analyze a time-discrete portfolio choice decision model for infinitely persisting households with exogenous initial wealth and labor income, such that the utility function has a constant relative risk aversion coefficient.

We assume that the household can invest in three types of assets: liquid, semi-liquid, and illiquid. The liquid assets are stocks available to the household that can be employed in the very short run for consumption.[4] The set of illiquid assets comprises the house and the mortgage used to buy that housing. We assume that among the illiquid assets, the only tradable asset is the mortgage, whereas the investment in housing is given and remains constant over time. Therefore we restrict our analysis to households living in their desired house, to reduce the risk that they would move in the short-run. Choosing households that dwell in their desired home is crucial; otherwise, there is uncertainty about the time period the household will remain in the less desired home, such that the house provides "transitory"

[4] Mutual funds might be additional instrument to consider in this optimization problem. However, most mutual funds investments involve equity or fixed-income, so we consider this financial instrument partly represented by deposits and equity instruments. The same argument holds for the absence of pension funds among the set of assets we consider. Thus, we avoid using redundant assets but still select the most representative assets of Spanish households' portfolios. Finally, we also ignore contractual savings for housing, because the decision about the amount to allocate to this asset occurs before the housing purchase, which we consider a given, so this asset should not affect the portfolio choice or reallocation problem.

housing to be sold before buying the desired one. The way housing affects allocation choices is different if the level of consumption of housing services is optimally set or it is considered as an exogenous constraint affecting the investment decision. Focusing in the households living in the desired housing guarantees the role of housing not just as an investment but also a durable consumption good. Thus, independently on whether the housing investment is the optimal or not, the households who live in their desired home should not be planning to optimize the investment in housing because they are not interested in moving. For this reason, we can consider this investment as an investment already undertaken and otherwise the inclusion of housing in the portfolio optimization of these households could bias the results.

Apart from liquid and illiquid assets, we include a semi-liquid asset, namely, bank time deposits, that yield a riskless return.[5] This class of assets commonly imposes restrictions on the investment horizon or the availability of funds to make payments. Moreover, this class encompasses a wide variety of investment products with varying characteristics. To be consistent with the information provided by the EFF, we employ a standard bank time deposit. Such deposits are not available to households in the very short run, unless they pay a cancellation fee. Therefore, the household employs these deposits in the very short run, subject to a penalty payment, or waits until maturity. The latter decision implies that these deposits may be employed to make payments or consumed in the future. In this case, the household receives the interest payment and does not pay any cancellation fee.[6]

Contrary to previous literature, we do not restrict our model to just liquid or illiquid assets, because in each of the three subgroups we consider, the assets present different characteristics, returns, and volatilities. We thus assume that the market for mortgages and deposits, assuming the household does not pay the deposit cancellation fee, operates with a lag with respect to the liquid assets. The household is free to place any order to buy and sell at the prevailing price at any point in time. However, an order placed at the beginning of period t will only be executed at the end of that period, after consumption has taken place. Although the availability of liquid assets for consumption is immediate, illiquid assets are not available for immediate consumption. This formulation captures the time needed to sell a given asset, which mainly reflects liquidity. The household therefore solves the following optimization problem:

[5] Other studies employ fixed-income instruments such as short- and long-run government bonds. We employ deposits instead of other fixed-income instruments because of the low presence of such assets in Spanish households' portfolios. Less than 2 % of households invest in either sovereign or corporate fixed-income instruments; more than 15 % of households invest in bank time deposits.

[6] The standard bank time deposit is similar to a fixed-term deposit.

$$\max_{\{C_t,\alpha_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \chi_t^\theta \frac{C_t^{1-\theta}}{1-\theta} \tag{1}$$

$$\begin{aligned}
s.t. \quad : \quad & W_t = \alpha_t' W_t && \text{(i)}\\
\alpha_t' 1 \quad = \quad & 1 && \text{(ii)}\\
\alpha_{t,M} \quad \leqslant \quad & 0 && \text{(iii)}\\
\alpha_{t,i} \quad \geqslant \quad & 0 \quad for\ i = 1, ..., 3 && \text{(iv)}\\
C_t \quad \leqslant \quad & (\alpha_{t,1} + \alpha_{t,2}(1 - fee) + r_{t,p} - \alpha_2 r_2) W_t + L_t && \text{(v)}\\
R_{t,p} \quad = \quad & 1 + r_{t,p} && \text{(vi)}\\
\alpha_t' r_t \quad = \quad & r_{t,p} && \text{(vii)}\\
W_{t+1} \quad = \quad & R_{t,p} W_t - C_t + L_t && \text{(viii)}\\
-0.8 H_t \quad \leqslant \quad & \alpha_{t,M} W_t \leqslant 0 && \text{(ix)}\\
R_{t,M} \alpha_{t,M} W_t \quad \leqslant \quad & 0.33 Y_t, && \text{(x)}
\end{aligned}$$

where C_t represents consumption at time t, θ is the relative risk aversion coefficient, β is the subjective discount factor that measures the preference for future consumption, and χ_t is the taste (liquidity) shock at a given time, independent and identically distributed over time. We assume that when a household suffers a liquidity shock in a given period, the marginal utility of consumption increases with respect to that observed in normal times, which causes households to consume more during a liquidity shock. Furthermore, W_t represents the total financial net wealth obtained as the sum of liquid, illiquid, and semi-liquid assets (restriction i). The vector α_t' features the share of wealth held in each financial asset at the beginning of t, so the sum of the components of the vector is equal to 1 (restriction ii). This vector also consists of liquid (stocks, $\alpha_{t,1}$) semi-liquid (bank time deposits, $\alpha_{t,2}$), and illiquid (housing, $\alpha_{t,3}$, and mortgage, $\alpha_{t,M}$) assets, respectively. The vector α_{t+1}' includes the share of wealth invested in each financial asset, once the order placed at time t has been settled, which means the portfolio recomputation, started at time t has been completed. Among these αs, we include the proportion of wealth invested in the mortgage, $\alpha_{t,M}$, and because it is equivalent to a short position in a bond, we set its value to be negative (restriction iii).[7] The other portfolio weights are restricted to be positive (restriction iv), because we assume no

[7]Another illiquid financial assets, such as bonds or long-run deposits, that cannot be used in the short run after the payment of a cancellation fee would be a perfect substitute for an opposite position in the mortgage. In that case, if the illiquid asset's returns are higher than the mortgage, the investor would demand the maximum amount of mortgage to invest in that asset. If the returns are lower than the mortgage rate, investors will not invest in it. Therefore, the share invested in the illiquid asset and the mortgage cancel each other.

short sales are allowed. Because household needs to borrow to fund the housing purchase, consumption cannot be higher than total holdings in stocks and deposits, plus the return earned on asset holdings and the labor income at year t, which we denote as L_t.[8] Moreover, when the household withdraws the bank time deposit before maturity, it pays a cancellation fee, denoted fee, and does not receive the returns derived from such investment ($\alpha_2 r_2$).[9] Restriction v illustrates this scenario. The R_t and r_t vectors contain the gross and net real return of all financial assets (deflated by the appropriate price index), respectively, from period t to period $t+1$ (restriction vi), so for example, $R_{t,M}$ is the gross return of the mortgage. In contrast, $r_{t,p}$ refers to the net portfolio return, composed of the weighted average of r_t, where the weights depend on the portion of wealth invested in the corresponding asset (restriction vii). Total net wealth one step ahead (W_{t+1}) is the updated portfolio value plus labor income minus consumption in period t (restriction $viii$).

The model also imposes two constraints related to mortgage policy recommendations. H_t is the housing's value at time t, and Y_t is the households' income at time t. First, the mortgage must be lower than 80 % of the value of the housing. The value 0.8 is common for all the households and compatible with a bank's standard provisions. If this proportion is higher than 0.8, the provisions offered by the lender must increase (see de Lis, Martinez Pagés and Saurina (2001) for further details). Thus, this constraint aligns with good banking practices in banks, which generally do not lend the whole value of the house, to avoid moral hazard problems and ensure the compatibility of incentives (restriction ix). During the period of the surveys (2002 and 2005), the ratio of mortgage to housing value was 80 % and in more recent years (2006, 2007), this ratio increased towards (and even surpassed) 100 %.

Second, the mortgage payments must be lower than 33 % of household income. This financial constraint, set by financial institutions, helps ensure that the household will be able to pay the mortgage and avoids potential high delinquency ratios. The value 0.33 represents an approximation in relation to the income requirements that a given household must fulfill to obtain the loan (restriction x).[10]

The taste (liquidity) shock at time t is independently and identically distributed over

[8] We consider labor income an implicit holding of safe assets, such that the household receives a fixed amount of money every month for the rest of its life.

[9] This fee is equal to 5 %, the average bank time deposits' return during the study period, as we explain in the calibration section. We use a fee equal to the previous percentage because if the bank time deposit is cancelled, the investor does not receive the whole notional but rather the notional minus a given amount, which cannot exceed the received interest. Because we work in annual terms, we use this 5 % to control for the received interest without imposing any concrete investment horizon.

[10] In their study of how credit quality affects homeownership in the United States, Barakova et al. (2003) use a ratio of mortgage to housing value of 90 %, and a limit for the mortgage payments relative to household income of 33 %. For more robust results, we develop a sensitivity analysis in Section 6 in which we modify the percentages employed in the financial restrictions (80 % for wealth and 33 % for income).

time, and can take two only values:

$$\chi_t = \begin{cases} \gamma > 1 \text{ with probability } \mu \\ 1 \text{ with probability } 1-\mu. \end{cases} \tag{2}$$

When $\chi_t = \gamma$, the investor suffers a liquidity shock in period t. If $\gamma > 1$, the marginal utility of consumption is higher during a liquidity shock than at normal times, which leads households to consume more during a liquidity shock.

The taste shock is independently distributed over time, so there are only two state variables, total net wealth (W_t) and the share of financial assets (α_t). With these two states in terms of the shock realization, we consider two different types of consumption for each household. When there is a liquidity shock, the household consumes $C_{1,t}$, otherwise, it consumes $C_{2,t}$. In addition to the liquidity state and a wide number of available financial assets, we assume there are three states of nature that are closely related to the state of the economy. Ideally, we would consider three different states of nature for each asset (i.e., 64 states), but for the sake of tractability, we concentrate on the three states of nature defined by the stock indexes. This decision reflects the close relation between the economy and the stock indexes. Moreover, stocks are the riskiest assets among the set of financial assets employed in this analysis. We therefore assume a favorable state when the return of the stock index, or in Spain the IBEX35, exceeds the third quartile of its distribution; an intermediate state when the return is between the first and the third quartiles and an unfavorable state when the return is below the first quartile of its distribution. The stock returns also include dividends. We include six control variables for consumption, depending on the states of nature associated with both the liquidity regime and the economic regime. Moreover, we have an extra control variable, that is, the next period's portfolio share for every financial asset.[11]

The timing for asset trade, consumption, and interest earned in our model is as follows: at the beginning of period t, the interest earned on the portfolio between period t and $t+1$, determined at $t-1$, is paid in advance. Then, the taste shock is realized. Given the taste shock, the household chooses consumption subject to its current liquidity constraints, as well as the portfolio composition for the next period. Then, the state of nature is realized. At the end of period t, the buy or sell order is executed on the market, and thus the portfolio composition at $t+1$ is determined. We illustrate this timing in Figure 1.

<Insert Figure 1 here>

[11] Koren and Szeidl (2002) only consider two assets, liquid and illiquid, without taking into account any division in each category. Moreover, they limit the investor's uncertainty to the existence of a liquidity shock that exists in two potential consumption regimes. However, they ignore the states of nature defined by the asset returns.

The value function and household's optimal program can be characterized by the following Bellman equation:

$$V(W,\alpha') = \max_{\alpha'} \left\{ \mu \left[\begin{array}{c} \lambda_1 \left(\max\limits_{C_1^H \leqslant Liq.Wealth^H} \left[\gamma^{\theta} \frac{C_1^{H,1-\theta}}{1-\theta} + \beta V(R_p^H W - C_1^H + L, \alpha') \right] \right) + \\ +\lambda_2 \left(\max\limits_{C_1^M \leqslant Liq.Wealth^M} \left[\gamma^{\theta} \frac{C_1^{M,1-\theta}}{1-\theta} + \beta V(R_p^M W - C_1^M + L, \alpha') \right] \right) + \\ +(1-\lambda_1-\lambda_2) \left(\max\limits_{C_1^L \leqslant Liq.Wealth^L} \left[\gamma^{\theta} \frac{C_1^{L,1-\theta}}{1-\theta} + \beta V(R_p^L W - C_1^L + L, \alpha') \right] \right) \end{array} \right] + \right.$$

$$\left. +(1-\mu) \left[\begin{array}{c} \lambda_1 \left(\max\limits_{C_2^H \leqslant Liq.Wealth^H} \left[\frac{C_2^{H,1-\theta}}{1-\theta} + \beta V(R_p^H W - C_2^H + L, \alpha') \right] \right) + \\ +\lambda_2 \left(\max\limits_{C_2^M \leqslant Liq.Wealth^M} \left[\frac{C_2^{M,1-\theta}}{1-\theta} + \beta V(R_p^M W - C_2^M + L, \alpha') \right] \right) + \\ +(1-\lambda_1-\lambda_2) \left(\max\limits_{C_2^L \leqslant Liq.Wealth^L} \left[\frac{C_2^{L,1-\theta}}{1-\theta} + \beta V(R_p^L W - C_2^L + L, \alpha') \right] \right) \end{array} \right] \right\} \quad (3)$$

where $Liq.\,Wealth^i = (\alpha_1+\alpha_2(1-fee)+r_p^i-\alpha_2 r_2)W+L$ $(for\ i = H, M, L)$ refers to the liquid wealth in each state of nature, as summarized in restriction v in the optimization problem Equation (1). In turn, C_1^H, C_1^M, and C_1^L represent the consumption profile in a favorable (H), an intermediate (M), and a unfavorable (L) state if a liquidity shock occurs. The consumption profile in a normal regime with no liquidity shock is defined by C_2^H, C_2^M, and C_2^L for the same three states: favorable, intermediate, and unfavorable, respectively. Parameter μ represents the probability of the occurrence of a taste (liquidity) shock. Parameters λ_1 and λ_2 represent the probabilities of the occurrences of a favorable and an intermediate state, respectively. The returns r_p^H, r_p^M, and r_p^L (R_p^H, R_p^M, and R_p^L) refer to the net (gross) portfolio returns, obtained in the three possible states, H, M, and L, respectively. Finally, the vector α' denotes the fraction of wealth in each of the financial assets after this period's order is executed.

The intuition behind the Bellman equation is as follows: there are three different states of nature, favorable (H), intermediate (M), and unfavorable (L). Because the riskiest asset is the stock, we consider the three states of nature (scenarios) determined by the stock return's behavior. Thus, using historical stock returns, we define a favorable scenario as one in which the average real annual returns exceed 37.77 %. In 2002, this return corresponds to the 75th percentile in the stock returns distribution of the IBEX35 index, so the probability of this scenario is 25 %, represented by the parameter λ_1. The intermediate scenario occurs when the average return falls between the 25th and 75th percentiles, such that the average annual stock return is between 37.77 % and -13.87 % in 2002, observed with a probability of 50 % (i.e., $\lambda_2 = 0.5$). In an intermediate scenario, the investors receive the average of the stock's returns distribution, equal to 16.86 %. Finally, the unfavorable scenario corresponds to average annual stock returns below -13.87 % in 2002, which represents the 25th percentiles occurs with a probability of 25 % (i.e., $1 - \lambda_1 - \lambda_2$).[12] The state of nature conditions the stock' returns. It is important to note that these returns also include dividends. Before the state of nature is known, a liquidity shock may happen with probability μ. When a liquidity shock occurs, current consumption delivers higher marginal utility, so the marginal utility increases by γ^{θ}. However, consumption cannot be more than current liquid wealth, and the constraint is binding in the maximization problem (Equation (3)). The next-period net wealth equals the net wealth plus the interest earned in this period and the labor income minus the consumption. The second part of the maximization problem (Equation (3)) describes the case in which there is no liquidity shock, but we still must consider the effect of the state of the economy. This maximization can be interpreted similarly to that which corresponds to the part of the liquidity shock. We assume that both the liquidity shock and the state of nature are independent over time, in any of the six possible regime/state combinations, and the household chooses the same optimal portfolio share for the next period, α', before the state of nature is known.

Because all the constraints are linear in consumption and wealth, and the utility function is a power utility, the value function is homogeneous to degree $1 - \theta$ in wealth. In turn we can show that there exist a function $\phi(\alpha)$ such that[13]

$$V(W, \alpha') = \phi(\alpha)^{-\theta} \frac{W^{1-\theta}}{1-\theta}. \tag{4}$$

The existence of homogeneity in wealth means that the investor's portfolio share choice for next period is independent of wealth. The implication is that there is an optimal portfolio share to be invested in the assets, $\alpha_i^{*\prime}$ for i in $1, 2, 3$, and M. Thus, according to the previous expression, the value function is maximal for any wealth level when $\phi(\alpha)^{-\theta} \frac{1}{1-\theta}$ is maximal. For $\theta > 1$, it can be formally expressed as

$$\alpha^* = \arg \max_{\alpha} \phi(\alpha). \tag{5}$$

[12] The stock return distribution shows that these annual returns are lower (higher) than -13.87 % (37.77 %) with a probability of 25 %. We use the more conservative scenario in which the returns in the unfavorable (favorable) scenario are -13.87 (37.77 %), but not the average of the returns below (over) this threshold.

[13] Koren and Szeidl (2002) offer a proof for this statement; they consider a given positive constant k, such that $k > 0$. Because all constraints are linear, the optimal contingent plan for initial wealth kW and portfolio α will be just k times the optimal contingent plan for initial wealth W and porfolio share α. Then, the per period utility is homogeneous to the degree $1 - \theta$, so it follows that the total value of initial wealth kW will be equal to $k^{1-\theta}$ times the total value of initial wealth W. Therefore the value function of the problem will also be homogeneous to the degree $1 - \theta$, and it is also a smooth function of W. For this reason, it must assume the functional form in Equation (4).

To solve this optimization problem, we adopt Koren and Szeidl's (2002) methodology. We already know that the optimal policy involves a constant share of liquid wealth and that the value function is separable in W. Thus, we begin by defining the subset of all feasible policies from all restrictions that involve portfolio shares α. The optimal policy falls within this subset and corresponds to the one that offers higher utility for the consumer (i.e., first best policy). Liquidity shocks could appear during households' lives, causing the consumer to spend all the liquid wealth on consumption, because before the next period, they have a new opportunity to rebalance their portfolios. These possible rebalances make holding more liquidity than needed during a liquidity shock unnecessary. However, consumption during a liquidity shock is limited by the amount of liquid assets and the total portfolio's returns, such that the consumption in this regime is less than the consumption in the unconstrained first best policy. In an unfavorable state, the household may be unwilling to hold stocks, because they give negative returns, but we assume that the preference for consumption in the case of a liquidity shock is so high that the household sells its stocks in spite of any potential losses. Similarly. a preference for consumption leads the household to withdraw its bank time deposits, despite any cancellation fees.

For an optimal policy of this form, we focus on a set of policies consistent with the optimal policy. That is, during a liquidity shock, all the liquid and semi-liquid wealth is consumed; otherwise, the household chooses consumption optimally. We solve the problem for fixed values of α, denoted $\widetilde{\alpha}$, which include the optimal policy, and impose the extra restrictions we detailed previously. This approach is equivalent to solving the optimal problem with one extra restriction, which eliminate some of the control variables such as consumption given a liquidity shock. This simplification leads to a modified problem that is much easier to solve.

Accordingly, we set the grid of $\widetilde{\alpha}$ that satisfies all restrictions and employ them to obtain the optimal value given by the portfolio shares $\widetilde{\alpha}^*$. Thus, we first must characterize the value function of the modified problem for any $\widetilde{\alpha}$, then maximize by substituting over the grid of $\widetilde{\alpha}$ to obtain $\widetilde{\alpha}^*$. This value function is denoted $\widetilde{V}(W, \widetilde{\alpha}')$, and we can show that the value of the modified problem is less than or equal to the value of the original problem, with equality, if and only if $\widetilde{\alpha}^* = \alpha^*$:

$$\widetilde{V}(W, \widetilde{\alpha}') \leqslant V(W, \widetilde{\alpha}'). \tag{6}$$

The homogeneity property of the utility function means the value function of the modified problem also will be homogeneous to the degree $1-\theta$ in wealth. As in Equation (3), we have:

$$\widetilde{V}(W, \widetilde{\alpha}') = f(\widetilde{\alpha})^{-\theta} \frac{W^{1-\theta}}{1-\theta}. \tag{7}$$

In summary, we recast the initial optimization problem into a simpler modified problem, and to solve it, we set a grid of $\widetilde{\alpha}$ that represents different portfolios that hold all required restrictions. Once the grid of portfolios is set, we replace each portfolio in the value function $\widetilde{V}(W,\widetilde{\alpha}')$ to find the portfolio that gives the maximum $\widetilde{V}(W,\widetilde{\alpha}')$. From Equation (7), to find the optimal value function, we must define the function $f(.)$ first. Once we define $f(.)$, the problem is reduced to maximizing $f(\widetilde{\alpha})$ in $\widetilde{\alpha}$ to find $\widetilde{\alpha}^*$ and to finding the optimal consumption when there is no liquidity shock, that is, the first best rule consumption.

The value function under the modified problem is given by the following Bellman equation:

$$\widetilde{V}(W,\widetilde{\alpha}') = \left\{ \mu \left[\begin{array}{c} \lambda_1 \left[\gamma^{\theta}\frac{C_1^{H,1-\theta}}{1-\theta}+\beta\widetilde{V}(R_p^H W - C_1^H+L,\widetilde{\alpha}')\right] + \\ +\lambda_2 \left[\gamma^{\theta}\frac{C_1^{M,1-\theta}}{1-\theta}+\beta\widetilde{V}(R_p^M W - C_1^M+L,\widetilde{\alpha}')\right] + \\ +(1-\lambda_1-\lambda_2)\left[\gamma^{\theta}\frac{C_1^{L,1-\theta}}{1-\theta}+\beta\widetilde{V}(R_p^L W - C_1^L+L,\widetilde{\alpha}')\right] \end{array} \right] + \right.$$

$$\left. +(1-\mu)\underset{\widetilde{\alpha}'}{\text{máx}} \left[\begin{array}{c} \lambda_1 \left(\underset{C_2^H \leqslant Liq.Wealth^H}{\text{máx}} \left[\frac{C_2^{H,1-\theta}}{1-\theta}+\beta\widetilde{V}(R_p^H W - C_2^H+L,\widetilde{\alpha}')\right]\right) + \\ +\lambda_2 \left(\underset{C_2^M \leqslant Liq.Wealth^M}{\text{máx}} \left[\frac{C_2^{M,1-\theta}}{1-\theta}+\beta\widetilde{V}(R_p^M W - C_2^M+L,\widetilde{\alpha}')\right]\right) + \\ +(1-\lambda_1-\lambda_2)\left(\underset{C_2^L \leqslant Liq.Wealth^L}{\text{máx}} \left[\frac{C_2^{L,1-\theta}}{1-\theta}+\beta\widetilde{V}(R_p^L W - C_2^L+L,\widetilde{\alpha}')\right]\right) \end{array} \right] \right\} \quad (8)$$

where by assumption, $C_1^H = (\alpha_1+\alpha_2(1-fee)+r_p^H-\alpha_2 r_2)W+L = Liq.Wealth^H$, $C_1^M{=}(\alpha_1+\alpha_2(1-fee)+r_p^M-\alpha_2 r_2)W+L = Liq.Wealth^M$, and $C_1^L{=}(\alpha_1+\alpha_2(1-fee)+r_p^L-\alpha_2 r_2)W+L = Liq.Wealth^L$. This expression is obtained by rewriting the original Bellman equation, imposing the restrictions that the portfolio share must be equal to $\widetilde{\alpha}$, and assuming that the household consumes all liquid wealth (stocks, deposits, assets' returns, and labor income) during a shock. The last restriction implies that in the modified problem, only consumption in the normal state (C_2^H, C_2^M, and C_2^L) remains as a choice variable. This consumption level is determined as follows: if the household's liquidity constraint is not binding in the normal state (because it has enough cash), then C_2^i (for $i = H, M, L$) can be chosen according to the first-order condition of the problem.

From the Bellman Equation (8), and using the functional form of Equation (7), we derive the first-order condition of C_2^i:

$$C^i_{foc,2} = \frac{f(\widetilde{\alpha})\beta^{-1/\theta}\left(R_p^i W + L\right)}{1-\beta^{-1/\theta}f(\widetilde{\alpha})} \; for \; i = H, M, L. \quad (9)$$

If the liquidity constraint binds and the household consumes all its liquid wealth, then:

$$C^i_{const,2} = (\alpha_1+\alpha_2(1-fee)+r_p^i-\alpha_2 r_2)W+L \; for \; i = H, M, L. \quad (10)$$

Note that $C^i_{foc,2}$ is only feasible if $C^i_{foc,2} \leq C^i_{const,2}$. For this reason, the household chooses C^i_2 as the minimum of these two consumption levels:

$$C^i_2 = \text{mín}\left\{(\alpha_1 + \alpha_2(1-fee) + r^i_p - \alpha_2 r_2)W + L, \frac{f(\widetilde{\alpha})\beta^{-1/\theta}\left(R^i_p W + L\right)}{1-\beta^{-1/\theta}f(\widetilde{\alpha})}\right\} \; for\; i = H, M, L. \tag{11}$$

According to these expressions, there should be a level of the portfolio weights at which the liquidity constraint becomes binding in the normal state, and hence, $C^i_{foc,2}$ and $C^i_{const,2}$ coincide. For such a level of portfolio weights in which the consumption obtained from the first-order condition is higher than the constraint consumption in all states of nature, the corresponding value function, $f_1(\widetilde{\alpha})$, is given by

$$\begin{aligned} f_1(\widetilde{\alpha}) &= \left[\frac{1-\beta\left(1-\widetilde{\alpha}_1-\widetilde{\alpha}_2(1-fee)\right)^{1-\theta}}{\mu\gamma^\theta+(1-\mu)}\right]^{\frac{1}{\theta}}\left[\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^H_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+\right. \\ &+\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^M_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+ \\ &\left.+(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^L_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}\right]^{\frac{-1}{\theta}}. \end{aligned} \tag{12}$$

The value function's implicit expression for the level of portfolio weights in which the consumption obtained from the first-order condition is lower than or equal to the constraint consumption in all states of nature, $f_2(\widetilde{\alpha})$, is obtained as the root of the following equation:

$$\begin{aligned} 1 &= \left[(1-\widetilde{\alpha}_1-\widetilde{\alpha}_2(1-fee))^{1-\theta}\beta\mu\right]+ \\ &+f_2(\widetilde{\alpha})^\theta\gamma^\theta\mu\left[\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^H_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+\right. \\ &+\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^M_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+ \\ &\left.+(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^L_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}\right] \\ &+(1-\mu)\beta\left[\lambda_1 R_p^{H1-\theta}+\lambda_2 R_p^{M1-\theta}+(1-\lambda_1-\lambda_2)R_p^{L1-\theta}\right]\left(1+\beta^{\frac{-1}{\theta}}f_2(\widetilde{\alpha})\right)^\theta. \end{aligned} \tag{13}$$

Appendix A.1 contains the implicit expressions for the remaining value functions, which depend on the scenario in which the liquidity constraint is binding. We obtain the corresponding $f_j(\widetilde{\alpha})$ for each value of $\widetilde{\alpha}$, then find the optimal portfolio weights that lead to the maximum $f_j(\widetilde{\alpha})$. The numerical strategy that we use to solve the optimization problem is similar to that employed by Koren and Szeidl (2002). The grid of vectors αs represent different portfolio weights, so for each candidate portfolio weight $\widetilde{\alpha}$, we solve $f_2(\widetilde{\alpha})$, which implies that the liquidity constraint is not binding in any of the three scenarios (i.e., $i = H, M, L$). With the value of $f_2(\widetilde{\alpha})$, we can verify whether the assumption that the liquidity constraint is not binding in any of the three scenarios holds. We thus test if the corresponding consumption levels obtained under $f_2(\widetilde{\alpha})$ in the three states of nature verify that $C^H_{foc,2} \leq C^H_{const,2} \cap C^M_{foc,2} \leq C^M_{const,2} \cap C^L_{foc,2} \leq C^L_{const,2}$. If so, we can conclude that the true value of $f(\widetilde{\alpha})$ is given by Equation (13), which implicitly determines $f_2(\widetilde{\alpha})$. If the condition does not hold though, the true value of $f(\widetilde{\alpha})$ is given by any other functions $f(\widetilde{\alpha})$, as defined by Equation (12) or the expressions in Equations (A1.1)-(A1.6) in Appendix A.1. We repeat the analysis for a value of $f(\widetilde{\alpha})$ obtained with Equation (12), $f_1(\widetilde{\alpha})$, and test if the condition $C^H_{foc,2} > C^H_{const,2} \cap C^M_{foc,2} > C^M_{const,2} \cap C^L_{foc,2} > C^L_{const,2}$ holds. If the previous condition is not satisfied, we repeat the experiment with Equation (A1.1), taking into account the implicit condition that the corresponding consumption paths must hold, and so on, successively up to the last value function. Thus, we obtain different portfolios weights and determine the corresponding function $f_*(\widetilde{\alpha})$ for each portfolio weight.[14] We find that for 99.90 % of the portfolio weights, the functions to be employed are either $f_1(\widetilde{\alpha})$ or $f_2(\widetilde{\alpha})$. Therefore, in most of the cases, $C^H_{foc,2} > C^H_{constr,2} \cap C^M_{foc,2} > C^M_{constr,2} \cap C^L_{foc,2} > C^L_{constr,2}$ or $C^H_{foc,2} \leq C^H_{const,2} \cap C^M_{foc,2} \leq C^M_{const,2} \cap C^L_{foc,2} \leq C^L_{const,2}$. The difference among the different scenarios reflects the stock returns (H, M, L); in a state of nature, when consumption (as obtained under the first-order condition or constraint) is higher than another form of consumption, this inequality persists for the remaining states of nature.

The next step is to find the portfolio weights among the set of portfolios defined by the grid of $\widetilde{\alpha}s$ that maximizes $f_*(\widetilde{\alpha})$. The optimal portfolio weight vector is denoted $\widetilde{\alpha}^*$, and it gives the value function of the modified problem. After obtaining $\widetilde{\alpha}^*$ and $f_*(\widetilde{\alpha})$, we can easily derive the optimal consumption path in the different liquidity regimes and scenarios. Thus, the main point of this optimization problem is to maximize the function $f(\widetilde{\alpha})$, which has been implicitly determined. The advantage of this methodology is the use of numerical methods to compute the corresponding $f(\widetilde{\alpha})$ for each value of $\widetilde{\alpha}$ and thus obtain the optimal portfolio $\widetilde{\alpha}^*$. This methodology implies a substantial simplification in comparison with other numerical methods that rely on iterative procedures to approximate the value function.

3. Calibration

In this section, we provide adequate ground for the values of the benchmark parameters we use in the portfolio problem optimization. The parameter β is set in agreement with the values employed in macroeconomic literature, including Jofre-Bonet and Pesendorfer (2000)

[14] A detailed review of the different possibilities appears in Appendix A.1.

and Asiedu and Villamil (2000), equal to 0.95.

Previous literature has employed a wide variety of values for the relative risk aversion coefficient. According to Gollier (2001), it seems reasonable to assume a relative risk aversion coefficient ranging between 1 and 4. We adopt a conservative approach and choose θ equal to 2 for all households in the sample to prevent the results being unduly influenced by high risk aversion.

The time interval is one month, which means that an order is executed one month after it is placed. Although this time interval may be too long, we note that other that for stocks, it is not particularly high if we consider to the behavior of the rest of the assets, households' efforts to rebalance portfolios, and the time spent to do so. According to the model, the time interval is also the length of the liquidity shock.[15] A shorter length may imply a very short time interval with regard to the illiquidity restrictions on selling the assets and a very short duration of the effective consumption period.

We assume that the liquidity shocks occur once every four years on average and so, in annualized terms $\mu = 0.25$. We also assume that the size of the shock is equal to 1.18 ($\gamma = 1.18$), so if liquidity shock exists then consumption during this shock gives the individual 1.4 times more utility than consuming during normal liquidity regimes (i.e., γ^{θ}). To confirm the suitability of these parameters, we employ implied moments for the growth of final consumption expenditures of Spanish households. The standard deviation of annual consumption growth equals 2.79 %, in line with the data reported by Campbell (2003) for France (2.9 %) and Germany (2.43 %). However, because we assume that portfolio rebalancing takes place monthly and our benchmark is the standard deviation of quarterly consumption growth equal to 3.2 %, we calibrate μ and γ to ensure that the standard deviation of the liquidity shock is compatible with our benchmark and the level of extra utility accords with common sense (i.e., a liquidity shock increases the utility of consumption, but an increment 100 or 1000 times higher than in periods without shock would conflict with common sense; the value proposed by Koren and Szeidl [2002], where $\gamma^{\theta} = 11^2 = 121$, thus seems too high). Setting $\mu = 0.25$ and $\gamma = 1.18$, the standard deviation of the liquidity shock is 3.25 %, which is very similar to our benchmark value. We use quarterly consumption to calibrate the parameter γ, because we lack of monthly consumption data. Moreover, the similar standard deviation observed in the annual and quarterly consumption growths indicates that the results will be independent to the use of annual or quarterly consumption, so we can capture patterns

[15] Koren and Szeidl (2002) recognize that this point seems to create a potential weakness, but if a liquidity shock has a longer length than the waiting time before the trade takes place, the household can optimally trade to counteract continuing liquidity shock after the trade is executed. Thus, a longer liquidity shock should not change the optimal portfolio substantially.

observed in quarterly consumption that likely would be cancelled out in annual data.[16] The annualized benchmark parameters employed in the analysis are as follows: $\beta = 0{,}95$, $\theta = 2$, $\Delta t = 1/12$, $\gamma = 1{,}18$, and $\mu = 0{,}25$.

We employ annual[17] historical real returns from 1991 (one year prior to the first year for which we have information on homeowners in the EFF) to the date of the survey, or the year we set as the initial date in the optimization problem (2002 or 2005). Because we consider three different scenarios, we must set different returns for the financial assets, depending on the realized scenario. However, the complexity of the model makes it infeasible to associate three different scenarios with each of the considered assets. The riskiest asset is stock, so we include stock returns depending on the state of nature. We further assume that bank time deposits,[18] mortgage, and housing returns are defined by the average of the historical returns with no volatility, so the stocks are the only assets that pose risk to the households portfolios.[19] Table 1 summarizes the descriptive statistics of the historical real returns. The standard deviation of the stocks is ten times larger than the standard deviation of the other assets, in support of our assertion that the main source of risk in the asset returns comes from stocks. Moreover, with the exception of housing,[20] these returns offer a low correlation with the stock returns.[21,22]

[16] According to the low variation in the standard deviation of the annual and quarterly consumption growth, we use slightly higher and lower values than 3.25 %, to acknowledge that the standard deviation of the monthly consumption may be slightly higher or lower than the previous value. For a standard deviation in the monthly consumption growth equal to 3 %, we find that the parameter γ should be equal to 1.16; for a standard deviation equal to 3.5 %, the same parameter should be equal to 1.20. We thus confirm the low variation in the parameter γ for such levels of volatility. We find very similar results using any of the three values for parameter γ.

[17] The available data for IBEX35 plus dividends, mortgage, and housing are in annual terms; information about deposits are monthly. As a robustness test, we estimate the same descriptive statistics in quarterly terms for housing (using data obtained from the Secretary of State for Housing), deposits, and mortgage, and we obtaine similar results.

[18] It is important to note that the deposit does not have any specific maturity.

[19] Appendix A.2 includes details about the estimation of the housing returns.

[20] Housing and stocks engage in a negative relationship, such that the bursting of the dot-com bubble in the early 2000s coincided with the starting point of the process of rapid revalorization in housing prices, which persisted up to 2008.

[21] Bank time deposits and mortgages are highly correlated, though that correlation does not generate any problem with regard to portfolio weights, because for these assets, we assume a constant return through the states of nature.

[22] We do not take into account the correlation between housing and stock returns for several reasons. First, the investment share in housing is not used in the optimization problem, so using three states of nature for the housing returns would not have any effect on the optimal investment in housing. Second, the optimization methodology we implement does not include a mean-variance framework in which the covariances or correlations among assets are crucial for determining the optimal shares, because of the potential diversification or redundancies among the different assets. Third, the volatility of housing returns is almost seven times lower than the volatility of stock returns, so the housing returns in the different scenarios should not change materially from the average return value. Thus, the results should be similar to those obtained under the current model specification. Fourth, using the three states of nature in the housing returns determined by

<Insert Table 1 here>

Finally, we analyze the effects of changing each of the previously calibrated parameters, ceteris paribus, on the optimal portfolio shares, and we test the effects of a different banking policy in terms of the households' portfolio composition.

4. Data

The data employed for this study come from the Spanish Survey of Household Finance (EFF), managed by the Bank of Spain (Spain's central bank). This survey gathers data about the financial and economic situation of Spanish households in the years 2002 and 2005. The survey also includes detailed information on their assets, liabilities, incomes, use of financial services, demographic characteristics, and housing. The EFF also offers certain retrospective information about housing, such as the year and price of acquisition, and the amount and conditions related to the mortgage at both the origination and the survey date, if the mortgage is still in existence. Detailed information about the financial assets of a given household also appear in the EFF.

The housing price index came from the Secretary of State for Housing. The variables related to the interest rates of bank time deposits and EURIBOR were obtained from the Statistical Bulletin of the Bank of Spain. To generalize as much as possible and avoid using maturities or the particularities of the different deposits, the bank time deposit interest rate we use corresponds to the Spanish Federation of Savings Banks (CECA) passive reference rate. This conservative methodology implies a widely accepted interest rate. The property tax values were obtained from different city council web-pages. Appendix A.2 includes a definition of the variables we constructed, such as housing returns, mortgage payments, the value of the desired housing, household financial constraints (wealth and income), the degree of the household's financial constraints (degree of wealth and degree of income), the degree of financial sophistication, and consumption.

We filter the data to detect inappropriate, anomalous, or outlying observations. Because the analysis is based on portfolio choice restricted to the decision made about housing ownership, we discard data from households that rent their house and those that did not pay market prices but obtained their housing by means of a bequest or legacy. A key variable for defining borrowing constraints and the portion of wealth invested in housing is the housing

the three states of nature in the stock returns could demand three states of nature in the mortgage returns, given that the correlation between mortgage and housing returns is close to 0.7. At the end, the states of nature in the stock returns can determine the remaining returns, so we just pretend to reflect the much higher volatility in the stock returns and consider it the only risky asset, once an investment in housing is made.

value at the survey moment, as reported by the household. Thus, we eliminate data from households that bought their housing before 1992. The further from the survey date, the more subjective is the value that the household reveals. This step also guarantees that any retrospective imputation used to calculate, for example, the mortgage payment will offer at least minimum reliability. Our model also assumes individuals with infinite life spans. For this reason and to reduce the heterogeneity that could influence portfolio choices, we discard data from households in which the head is older than 60 years of age. The households in our sample dwell in their desired housing, as we noted previously, because we consider housing a long-run asset whose purchase determines others investments. If we include households in a house whose value is conspicuously below that of their desired housing, their investments plans could be influenced by the desire to change houses, which would shift the main asset in Spanish households' portfolios. We estimate the desired house value using Mayordomo's (2008) method and consider housing as the desired one whenever its desired value is below the housing's market price**.** We also exclude data from households that have undertaken repairs to their housing that were valued at more than 50,000 Euros, to avoid deviations between the real housing market value and the subjectively considered value claimed by the households after the renovations. Moreover, if such a significant renovation were to take place, then it would be difficult to assume that the house was the one desired at the moment of the purchase. Finally, we discard data households that reveal anomalous information.[23]

To impute any missing data in the survey, we use a multiple imputation procedure. The EFF user guide indicates that imputations already are provided for any 'No Answer' or 'Don't Know' replies for the variables in the survey, with a few specific exceptions. The use of imputed values enables an analysis of the data with complete data methods. Multiple imputations also help mitigate the uncertainty associated with process (Rubin (1987)) and are relevant for estimating the regression's parameters and calculating descriptive statistics, especially those related to income and wealth dispersion.[24] The households in the EFF have different probabilities of entering the sample, so we associate each household with its corresponding selection weight, to ensure we obtain representative statistics of the population. We use the weights to calculate the descriptive statistics as well, such that the mean and median are averages across the corresponding values of the statistics in the five imputations, and the variances are obtained according to the user guide indications.[25]

The final sample consists of 427 households for the 2002 survey. The EFF reports the

[23]For example, some households report that the housing value at the survey date, without any renovation, is more than 50 times the value of the house when they bought it.

[24]For an introduction to the reasons for the imputation and the choice of the imputation method used, see Bover (2004); for a detailed description of imputation in the EFF, see Barceló (2005).

[25]See the Spanish Survey of Household Finances (EFF) 2005 User Guide: http://www.bde.es/webbde/es/estadis/eff/userguide_2005.pdf.

representativeness (weights) of the households in the Spanish population, so we can translate this number of households into a value that indicates their representativeness in the total population. These weights also enable us to construct different estimates and their variances. The 427 households thus are representative of 1,249,355 Spanish households. We provide the main descriptive statistics in Table 2 and define the variables in Appendix A.2. Housing accounts for the main portion of households' wealth, and we note the significant difference between the purchase value and the value in 2002, which indicates the high appreciation of the asset and emphasizes the importance of including it as a determinant restriction when analyzing Spanish households' portfolios. Regarding contributions to the total net wealth of different assets, the data shows the importance of housing; on average, it is 1.282 times net wealth. Households usually resort to external funding to buy housing, so the rate of the mortgage over the wealth is 31.9 %. The proportion of net wealth invested in deposits is 3.1 %, whereas stocks represent 0.6 % of total net wealth. We find that annual income, annual labour income, annual consumption, the amount invested in the different financial assets, and the housing purchase price achieve asymmetry.

We also employ the EFF 2005 survey to investigate portfolio rebalancing for a total of 130 households (representative of 390,300 households), for which we have information from both the 2002 and the 2005 waves. Moreover, we employ 230 households (representative of 714,902 households) from 2002 survey who bought housing between 1997 and 2001, as well as 323 households (representative of 1,169,080 households) from the 2005 survey who bought housing between 2000 and 2004. With these samples, we can investigate differences in the portfolio choice decision that might result from less restrictive banking practices.[26]

<Insert Table 2 here>

5. Empirical Results

In Table 3, we report the optimal portfolio composition in our baseline situation: $(\beta, \theta, \Delta t, \gamma, \mu) = (0.95,\ 2,\ 1/12,\ 1.18,\ 0.25)$. We estimate the optimal portfolio composition, household by household, for each imputation, then, aggregate the individual portfolios for nine categories into which a given household may be classified and that are available in the EFF: age, education, degree of financial sophistication, economic sector, labor situation,

[26] We only present the descriptive statistics for the EFF 2002 survey because these data constitute the core of this investigation; the EFF 2005 data merely extend our main results of the paper. However, the descriptive statistics for households in the EFF 2005 survey are available on request.

sex, household income, net wealth, and type of financial restrictions.[27] Stocks and bank time deposits offer responses to a liquidity shock, which makes them substitutes in terms of their utility for increasing consumption when a liquidity shock occurs. However, bank time deposits also might be considered illiquid assets which may be converted into liquid assets in exchange for a cancellation fee. The baseline model assigns optimal weights of 1.6 %, 4.9 %, and -34.7 % to stocks, bank time deposits, and mortgage, respectively; the actual weights are 0.6 %, 3.1 %, and -31.9 %. The optimal and actual weights are close in absolute terms but not in relative terms. In relative terms, the optimal investments in stocks, deposits, and mortgage are 166 %, 58 %, and 9 % higher than the actual investments. Statistical significance tests indicate that the optimal investment in stocks and deposits are significantly higher than the actual ones Therefore, Spanish households tend to invest less in stocks and deposits than theory indicate they should.

Next, we analyze the effect of several groups of variables referred to different household's characteristics on the allocation behavior of the households. Although these variables are unrelated to the portfolio choice decision model, its use enables us to understand the sources of heterogeneity in the allocation choices. The investment in stocks also varies considerably among different subgroups, such that the optimal proportion varies from 0.2 % (households constrained in wealth or in both wealth and income) to 7.4 % (financially sophisticated households). In almost all cases the optimal investment is significantly higher than the actual one. There are two exceptions: first, the case of highly financially sophisticated households whose optimal investment in stocks is significantly lower than the actual one. Second, the households that are constrained in wealth or in both wealth and income whose optimal and actual investments in stocks are very similar. The model posits a positive and linear relation between the optimal investment in stocks and particular categories, such as the education level and household net wealth. This linear relationship also emerges in the actual portfolios. The higher the education level, the higher the level of stock ownership should be, whereas lower education levels imply, lower investments in stocks (0.7 %); households headed by a person with a university education should invest the highest proportion (2.3 %). This pattern is consistent with the actual investments, though the proportions of 0.1 % and 1.2 % are well below the optimal levels, consistent with Haliassos and Bertaut's (1995) finding that education is important for overcoming barriers to stockholding erected by ignorance. Regarding the economic sector, the optimal stock proportion for households headed by a person who works in the primary sector is 0.7 %, but it is equals 1.6 % and 1.7 % for households headed by someone in the secondary and tertiary sectors, respectively. In the actual weights, we observe

[27] Appendix A.2 contains definitions of the degree of financial sophistication and the type of financial restriction.

differences between the primary (0.1 %) and secondary and tertiary (0.6 %) sectors that are broadly consistent with the optimal pattern. The net wealth variable has an increasing effect, from an optimal investment of 0.5 % for the households with the lowest net wealth to 4.2 % for the households with the highest net wealth. Again the same pattern, though with lower proportions, appears in the EFF data (actual proportions range from 0.2 % to 2.3 %). As documented by Campbell (2006), Carroll (2002), and King and Leape (1998), wealthy households are willing to take greater risk in their portfolios. We similarly find greater participation in risky asset classes by wealthy households.

For groups defined by age, degree of financial sophistication, or household income, the model instead predict a non-linear relationship with stock investment. In the case of age, the optimal maximum investment in stocks should be by households headed by a person between the ages of 45 and 55 years (3.2 %), and decreasing in the following age group. This results is not consistent with the actual data, which shows a linear relationship between stock ownership and age, such that the highest investment in stocks is by the group older than 55 years (1.9 %). For the degree of financial sophistication, the model posits maximum investments by highly sophisticated households (7.4 %) and minimum investments by investors with an average level of sophistication (1.4 %). Again the actual data disagrees with the optimal choice; we find a linear, positive relationship between stock ownership and degree of financial sophistication, such that higher sophistication means, higher investments in stocks. With regards to household income, the model posits a non-linear relationship, starting with an investment of 1.5 % by the group of households that earn less than 20,000€, then a decrease for groups earning 20,000€ - 40,000€ or 40,000€ - 60,000€ (minimum investment, 1.1 %). Finally, the model predicts an increase for the group that earns more than 60,000€ (3.4 %). In the actual data though, there is a linear and positive relationship between stock ownership and household income. The remarkable non-linear patterns observed for different groups and assets mainly reflect the non-linear pattern of housing shares across these groups (e.g., degree of financial sophistication category). Moreover, for the cases that reveal a linear pattern in housing shares and a non-linear pattern for a given asset for a given group or category, the differences within each group and asset are low, considering the levels of the investment shares in absolute terms.

The gender of the head of the household has no significant effect, in either the model or the actual data. However, the theoretical investment weights (1.5 - 1.6 %) again are significantly higher than the observed (0.5 - 0.6 %). For the labor situation, the theoretical pattern and the actual one are broadly consistent. The highest investment comes from the retired group, and the lowest is associated with the self-employed group. Bertaut and Starr-McCluer (2001) obtain similar results for U.S. data. This result likely reflects the idea that investing in one's own business makes a household reluctant its risk exposure any further.

The investment in bank time deposits does not exhibit a clear pattern across different categories and also reveals much lower variation than stocks. However, in almost all cases the optimal investment in deposits is significantly higher than the actual one. There are two exceptions: first, the case of highly financially sophisticated households whose optimal investment in deposits is significantly lower than the actual one. Second, the cases of households with income higher than 60000€; or net wealth higher than 300000€; or without financial constraints, whose optimal and actual investments in deposits are very similar. The proportion invested in bank time deposits varies from 2.4 % (head of household is retired) to 5.7 % (head of household employed in the primary sector). In some cases, there is a negative relation between the optimal investment in bank time deposits and some demographic categories, such as age and economic sector. That is, the optimal proportion in bank time deposits for the youngest households and households headed by a person who works in the primary sector are 5.2 % and 5.7 %, respectively, but these values equal to 4.5 % and 4.7 % for the oldest households and households that belong to the tertiary sector.

The actual proportions are almost constant with age (with a decrease in the 35 - 55 years age group) and non-linear with the sector. Household income and net wealth indicate a non-linear z-shape in their optimal weights, in contrast with the v-shaped pattern observed in actual data. According to the labor situation, households headed by a retired person should invest the lowest proportion in bank time deposits (2.4 %), and the highest proportion of investment should align with self-employed households (5.5 %). This behavior is mirrored in the actual weights: 1.9 % and 4.6 %, respectively. The optimal amount to be invested depending on gender is similar between men and women (5 % and 4.6 %, respectively) and comparable to the actual weights (3.2 % and 3 %). Households unconstrained by either income or wealth should invest less than households with any type of constraint. On the contrary, the actual proportions show that unconstrained households invest the highest proportion (4.4 %) in this category.

Mortgage and housing are closely interconnected, such that the lower the proportion of housing, the lower the proportion of mortgage. Recall that we consider the investment in housing an already committed investment; we optimize the weight of the mortgage in the household portfolio, conditional on the investment in housing. The overall pattern of the theoretical portfolio weights and the actual weights are pretty similar across groups, with the exception of the net wealth variable. The proportion (optimal and actual) of housing and mortgage decreases with the age and education. We also may observe a v-shaped pattern in both optimal and actual weights relative to the degree of sophistication, economic sector, and household income categories. The optimal mortgage proportions decrease with net wealth, whereas in the actual proportions, we find an initial decrease, followed by an increase among the wealthiest group, which is somewhat surprising. However , in almost all cases, the optimal and actual proportions invested in mortgages are statistically indistinguishable.

Regarding employment, the model predicts that retired households should have the lowest levels of mortgage (-7.3 %) and housing (100.8 %), because older households should have paid for most of their housing, as is consistent with the actual weights (-4.1 % and 100.8 %, respectively). Men should have higher mortgage levels than women (-35.5 % and -32.7 %, respectively), partially because housing represents a higher proportion of their net wealth (129 % and 126.5 %, respectively). We observe the same behavior in the actual weights with proportions of -32.6 % and -30.2 % for men and women, respectively. The constraint in wealth is the dominant constraint in this setting. Thus, we find similar proportions in housing and mortgage for households constrained in their wealth (-74.6 %) and also for those constrained in both their wealth and income (-75.3 %). These proportions are much higher than the optimal weight for households constrained in income (-35.2 %). The proportions of housing and mortgage relative to net wealth for unconstrained households show the lowest values (-21.5 %). In the actual proportions, we observe very close values to the optimal ones. Significant differences between the optimal and the actual investment in mortgages are only found in the case of highly financially sophisticated households (the observed mortgage is significantly higher than the optimal one) and the individuals more than 55 years old or retired (the observed mortgage is significantly lower than the optimal one).

<Insert Table 3 here>

From these optimal and actual portfolios in 2002, we extend the analysis using the EFF 2005 survey. We study the portfolio rebalancing, from 2002 to 2005, for a total of 130 households for which we have information from both surveys. Table 4 reports the difference between the optimal portfolio for the baseline optimization problem and the actual portfolio, according to the EFF information for the 2002 and 2005 surveys for seven subgroups.[28] Because we still assume that housing value is given by households decision, there is no difference between the optimal and the observed housing value relative to wealth. On average, households underinvest in stocks and bank time deposits. The under-investment is similar in both surveys (1.3 %) for stocks, but decreases for deposits from 1.7 % to 1.2 %.

We find significant under-investment in stocks in 2002 and 2005 in almost all the categories across the different groups with few exceptions. Regarding bank time deposits, we again

[28] Note that we are considering 130 households instead of the 427 households that composed the 2002 wave so Tables 3 and 4 results' for the year 2002 are not strictly comparable.

observe that most categories of households, across subgroups and surveys, tend to significantly underinvest. Finally, there is scarce difference between observed and optimal investment in mortgages for almost all categories and all the different groups.[29]

<Insert Table 4 here>

Then, we employ 230 households that bought the housing between 1997 and 2001 and 323 households that bought the housing between 2000 and 2004 to investigate the differences in the portfolio choices derived from supposedly less restrictive banking practices. According to the optimal portfolios for these households, as we report in Table 5 the average optimal investment in mortgages is slightly higher in 2005 than in 2002 (-54.1 % and -49.3 %, respectively), perhaps due to the increase in housing prices and somewhat less restrictive banking practices. The optimal investment in bank deposits is similar in 2002 (5 %) and 2005 (5.2 %), but the optimal investment in stocks in 2005 (1.6 %) is more than 70 % higher than in 2002 (0.9 %).

For all the categories in each subgroup, we observe that the optimal investment in mortgages is higher in 2005 than in 2002, again due to the increase in housing prices and the higher loan-to-value ratio. There are some exceptions though, such as categories in which the optimal investment in mortgages is higher than it was in 2002, including the households headed by someone who works in the primary sector, the self-employed, less sophisticated households, and those with net wealth higher than 300,000€. These exceptions are mainly due to the higher weight devoted to housing investments in 2002 than in 2005.

The optimal investment in stocks increases in 2005 relative to 2002 in some categories: the oldest households, with the highest income and net wealth, and unconstrained households. However, we observe the opposite pattern among highly sophisticated households.

Finally, the optimal investment in bank time deposits presents a lower variation from 2002 and 2005 relative to other financial assets. The most significant difference appears for households with higher net wealth, whose optimal level of investment in 2002 is 1.9 % higher than in 2005. For this reason, the optimal investment level in stocks is 1.8 % higher in 2005 than in 2002. In the remaining categories, the level of the difference between shares in 2002 and 2005 is rarely higher than 1 % in absolute terms. The overall impression is that the portfolio's structure has barely changed from 2002 to 2005.

<Insert Table 5 here>

[29] Because the mortgage shares are negative, the signs should be interpreted in the opposite way: when the difference between the optimal and the observed portfolio is negative, it implies an underinvestment.

6. Comparative statics analysis

This section presents a comparative statics analysis based on alternative values for the main calibrated parameters $(\beta, \gamma, \mu, \Delta t)$ and for our assumptions about banking practices, in terms of the amount of wealth and income required for households to receive a mortgage. We report the results in Table 6. Regarding the parameter β, we explained in Section 2 the calibration procedure and why 0.95 provides a benchmark value; here we employ two discount factors, 0.975 and 0.99. By increasing the discount factor, we decrease the penalty for delaying consumption. The proportion invested in stocks slightly decreases with the discount factor, and with a higher discount factor, the proportion invested in deposits declines. Because larger βs imply more concern about the future, households should be willing to decrease their investments in stocks and deposits, as well as their leverage, when β varies from the baseline.

In Table 6, we also report the comparative statics related to the size of the/liquidity shock (γ). The baseline is 1.18, and the alternatives for the parameter γ are 1.1 and 1.5. The higher the taste shock, the higher is the proportion of investments in deposits, likely because a larger taste shock increases the deposit's utility, so households prefer to maintain larger proportions of "risk-free" assets to avoid the possible losses to stock investments, were the scenario to turn unfavorable. The investment in stocks does not change across the different sizes of the taste/liquidity shock. As the size of the shock increases, the mortgage share also increases. The mortgage could even be used as an additional source of liquidity to obtain cash that could be invested in deposits.

In the baseline scenario, we calibrate the parameter μ such that it is equal to 0.25, which means that there is a liquidity shock every four years. We set other values for this parameter (0.15, 0.35) and find that, similarly to the outcomes for the parameter γ, the higher the probability of a liquidity shock, the higher is the proportion invested in deposits. The intuition also remains the same: both parameters are related to the liquidity shock, so the more probable the taste shock, the larger the proportions of "risk-free" assets households maintain to avoid possible losses due to an unfavorable stock scenario. The optimal share to be invested in stocks thus slightly decreases as the parameter μ increases. As occurs with the optimal investment in the mortgage when we analyze variations in parameter γ, the higher the probability of a shock, the higher is the optimal investment. This result stresses the role of the mortgage as a source of liquidity that gets invested in deposits whenever the loan-to-value ratio is below 0.8.

The length of the liquidity shock (Δt) is one month in the baseline case, but for longer periods, the proportion invested in stocks increases, and the proportion invested in deposits decreases. As the shock duration increases, households prefer to invest in assets with more risk but also higher expected returns. The mortgage share also decreases as the shock duration increases.

Finally, we evaluate the effect of bank practices (restrictions *ix* and *x* in Equation (1)) on the portfolio composition and mortgage demand in Spain. Mayordomo (2008) analyzes changes in banking sector practices related to the mortgage-granting process and finds that if mortgages increased to constitute more than the 80 % of housing value, housing demand would increase considerably. However, other changes in these practices, such as income requirements or variations in the mortgage interest rate, have a lower impact. Therefore, we estimate how households' would change if the financial institutions obey the mortgage policy recommended by the regulator.

That is, we restrict the maximum loan-to-value ratio to 70 %, and we thus find that optimization is not possible for some households, namely those whose mortgage loan value exceeds that figure. If the loan-to-value ratio decreases to 70 %, some households thus could not have become homeowners. When these households disappear from the optimization problem, the share of housing decreases. In contrast, when the maximum loan-to-value ratio increases to 90 %, some households for which the optimization problem could not be solved because their mortgage loan value exceeded 80 % enter the analysis, which increases the overall housing share. Moreover, this less restrictive banking policy increases the weight of the mortgage in the households' portfolios. However, the optimal share of stocks and deposits does not change materially for the different loan-to-value ratios.

Change in the income requirements for mortgage payments thus does not cause material variations in the optimal portfolio composition, in line with Mayordomo's (2008) finding that income requirements have a negligible impact on a household's housing purchase decision. We extend this result to other financial assets in the household portfolio.

<Insert Table 6 here>

7. Household characteristics and deviations from the optimal portfolio

In this section we analyze the factors that determine the under- or over-investments relative to the optimal benchmark. We are conscious that the effects of these factors depend on the optimization methodology and the assumptions employed to obtain the optimal benchmark. Nevertheless, these results complement the ones reported in Table 4 and could contribute to a better design and implementation of financial education programs that may help households with certain characteristics to achieve effectively more optimal investments. To analyze the effect of households' demographic characteristics on their deviation from the optimal investment, we need individual optimal portfolios for the different households in the sample. We calculate the difference between the observed investment and the optimal portfolio for each household in the five imputations of the EFF. This deviation defined in percentages, then serves as the dependent variable in a regression in which the explanatory variables reflect different households' characteristics. To distinguish between over- and under-investments in each asset, we redefine the dependent variable. The over-investment in a given asset is defined as the maximum of zero or the difference between the observed and optimal investment in a given asset: *max (0, observed – optimal investment in asset X)*. We define the under-investment as -1 times the minimum of zero or the difference between the observed and the optimal investment in a given asset: - *min (0, observed – optimal investment in asset X)*.[30] We employ the same explanatory variables we used to classify households in Table 3: logarithm of net wealth, logarithm of household income, age, sex, education, labor situation of the head of household, economic sector of employment, degree of financial sophistication, degree of wealth financial constraints, degree of income financial constraints, and year of housing purchase. Moreover, we add two variables: the difference between the logarithm of the desired housing value and the logarithm of the actual housing value, and the year of housing purchase, employed in this case to control for the effect of current banking practices on the portfolio choice decision.

To analyze the determinants of the deviations from the optimal investment, we employ a cross-section of households (EFF 2002 survey) and estimate the effect of these determinants using a bootstrapped truncated ordinary least squares regression with standard errors that is robust to heteroskedasticity.[31] We repeat the same regression for the five imputations of the EFF, such that the coefficient for a given variable is the average of the five coefficients gathered from the different imputations. To compute the standard errors, we use the instructions described in the user guide of the EFF.[32] The regression is truncated such that the upper (lower) limit for the over- and under-deviations from the optimal investment in stocks and

[30] Note that mortgage share has a negative sign. Therefore, when we study the over-/under-investment in this asset, we change the sign of the observed and optimal investment shares and proceed, as with the other assets, to define the over-/under-investment value.

[31] We employ the bootstrap method to avoid any bias in the standard errors due to generated regressors.

[32] To make inferences from the five multiple imputed data sets, we first must analyze each set using complete data methods, then combine the results. To obtain a point estimate of some parameter (e.g., mean, median, regression parameter), we can use the average of the five estimates obtained in each of the five imputations that form the survey. The variance associated with this estimate has two components: the within-imputation sampling variance, which is the average of the five variance estimates, and the between-imputations variance, which reflects variability due to imputation uncertainty and is the variance of the complete data point estimates. The total variance for the estimate is the sum of the within-imputation sampling variance and 6/5 times the between-imputations variance.

deposits is 100 % (0 %). The upper (lower) limit for the over- and under-deviations from the optimal investment in a mortgage is 80 % (0 %), which is consistent with banking practices (i.e., maximum loan-to-value ratio is 80 % of housing value).

We report the estimated effects for the different financial instruments from the previous sections in Table 7. In Panel A, we provide the determinants of the deviations from the optimal investment in stocks. The first column contains the determinants of the over-investment in stocks; the second one reports the determinants of the under-investment. The only significant deviations from the optimal portfolio are due to under-investments, which are significant in rich and old households, households whose desired housing value is high relative to their current housing value, financially less sophisticated households, and households that suffer high financial constraints in their wealth. As Calvet, Campbell, and Sodini (2006) suggests, this result may imply that less sophisticated households fail to invest in stocks or invest cautiously because they are aware that they lack the skills to invest efficiently. Rich and old households should invest more in stocks but are very conservative. Finally, households whose ideal housing is more expensive than that which they own and those that are financially constrained in their wealth are more willing to save than invest in risky assets. In general, all these households can be considered conservative, because stocks are the only risky asset included in the optimization problem.

In Panel B of Table 7, we provide the results for the analysis of deviations from the optimal investment in deposits. Unlike our findings for stocks, we observe that financial and demographic characteristics affect not only under-investments but also over-investments significantly. Nearly all the characteristics that caused significant under-investments on stocks also cause over-investments in deposits. The richer and older households, those for which the value of the desired housing is high relative to their current housing value, and households that are financially less sophisticated tend to be very conservative. They under-invest in stocks and over-invest in deposits. Unemployed households also tend to over-invest in deposits, likely because their labor situation and potential need for cash in the short run, in case of a liquidity shock, leaves them unable to rely on labor income to face such shocks. Households that bought their housing in years close to the survey date also tend to over-invest in deposits. The housing purchase implies a significant investment, so these households prefer to invest in liquid assets. However, our finding that highly financially sophisticated households deviate from the optimum, by over-investing in deposits, seems more surprising. Although they invest the right proportion in the risky asset, they tend to over-invest in the non-risky asset. Some other financial and demographic variables also affect the existence of under-investments. Specifically, households with a high income, those in which the head of household is a man, and households that are financially constrained in income tend to under-invest in deposits with respect to the optimum.

For completeness, although there is no significant difference in the aggregate optimal and actual investments in mortgage, in Panel C of Table 7, we show the determinants of the deviations from the optimal investment in the mortgage. Some households' characteristics lead to a significant over-investment in their mortgage, such as a high difference between the desired and the real housing value, a high degree of financial sophistication, and a recent purchase of housing. Similar to the results in Panel B of Table 7, some of these characteristics have positive effects on a potential over-investment in deposits. If households desire a house much more expensive than their current one, they likely over-invest in their mortgage while also saving money in deposits, which they can later use to buy their preferred house. Surprisingly, the highly sophisticated households over-invest in their mortgage, perhaps simply because these households tend to live in expensive houses (the correlation between the high sophistication dummy and the housing price is close to 0.3) and prefer a mortgage with an excessive loan-to-value ratio, such that they have some extra liquidity to face potential liquidity shocks. This extra liquidity could be reflected in an over-investment in deposits. The over-investment observed among the households that have bought their house recently could reflect banking practices in Spain. Around 2002, the year of the survey, the portion of the housing value able to be financed by a mortgage increased to more than 80 % and grew significantly higher than in preceding years. The result therefore implicitly reflects the increase in the mortgage loan-to-value ratio over time. Households with a high income have a smaller mortgage than its optimal value; this income effect also emerges for households with financial constraints, which tend to under-invest in their mortgage. Also, households headed by men tend to under-invest in mortgages. Most households that under-invest in their mortgage also under invest in deposits, which is consistent with households employing their savings in deposits to pay for their mortgage.

< Insert Table 7 here>

8. Conclusions

Housing represents almost 70 % of households' portfolio value in most countries. To model optimal portfolio choices, two approaches can be followed. On the one hand one may include housing as an additional asset in the standard portfolio choice problem. On the other, one may consider housing as the primary asset that determines the composition of the rest of the portfolio. In the latter case, the housing investment represents a decision already made by households, so estimates of the optimal portfolio must be conditional on the housing value. We adopt the latter approach in this paper.

In the theoretical part of the paper, we present an optimization problem with four different financial assets: stocks, deposits, mortgage, and housing. We apply this model in the empirical section to micro data from the Bank of Spain's EFF. We present estimates of optimal portfolios for different individual households and for different groups of households, defined according to their demographic characteristics. Finally, after having estimated the optimal portfolio, we compare it with the actual portfolio and study the factors affecting the deviations between both portfolios.

Our baseline results show that, given the actual proportion invested on average by Spanish households in housing, they invest significantly less in stocks and deposits than theory indicate they should**.** The optimal investment in mortgage is higher than the observed one but the difference between them is not statistically significant. We also find a positive relationship between the optimal proportion invested in stocks and the households' age, education level, degree of financial sophistication, income, and net wealth. The proportion of housing decreases with age, education level, and household net wealth. The optimal mortgage also depends on the housing investment. Finally, the optimal amount to be invested in bank time deposits is around 4-5 % and nearly constant across demographics groups

From our study of portfolio rebalancing from 2002 to 2005, we find that on average, households under-invest in stocks in similar proportions in 2002 and 2005 and slightly less so in deposits. Actual investment in mortgage is similar in both periods and very close to the optimal one.

Finally, the deviation of households' investment in stocks from the optimal value depends significantly on their net wealth, the difference between the desired housing value and the actual housing value, the age of the reference person, the degree of financial sophistication, and the degree of wealth financial constraints. These factors all lead to significant under-investments. The deviation in the case of deposits is mainly due to net wealth, differences between the desired housing value and the actual housing value, age, unemployment, degree of financial sophistication, and year of housing purchase, which prompt over-investments. The household's income, the sex of the head of household, and the degree of income financial constraints are the main determinants of under-investments in deposits.

This study also leaves several interesting directions for further extensions. On the theoretical side, it would be interesting to include more assets in the optimization procedure, as well as specific tax effects. From a substantive, empirical perspective, it would be interesting to analyze portfolio rebalancing in the context of the current global financial crisis.

Appendix A.1. Consumption Schedules and Implicit Expression of Value Functions

In this appendix, we define the different consumption schedules and the corresponding implicit expression of the value functions, $f_i(\widetilde{\alpha})$ for $i = 3, ..., 8$, depending on the liquidity shock realization and the state of nature:[33]

- If $((C^H_{foc,2} > C^H_{constr,2})$ *and* $(C^M_{foc,2} > C^M_{constr,2})$ *and* $(C^L_{foc,2} > C^L_{constr,2}))$, then $f(\widetilde{\alpha}) = f_1(\widetilde{\alpha})$.

$$C^i_{constr,2} = (\alpha_1 + \alpha_2(1 - fee) + r^i_p)W + L \quad for\ i = H, M, L. \tag{A1.a}$$

- If $((C^H_{foc,2} \leqslant C^H_{constr,2})$ *and* $(C^M_{foc,2} \leqslant C^M_{constr,2})$ *and* $(C^L_{foc,2} \leqslant C^L_{constr,2}))$, then $f(\widetilde{\alpha}) = f_2(\widetilde{\alpha})$.

$$C^i_{foc,2} = \left[f_2(\widetilde{\alpha})\beta^{\left(\frac{-1}{\theta}\right)}(R^i_pW + L)\right]/(1 + \beta^{\frac{-1}{\theta}} f_2(\widetilde{\alpha})) \quad for\ i = H, M, L. \tag{A1.b}$$

- If $((C^H_{foc,2} > C^H_{constr,2})$ *and* $(C^M_{foc,2} > C^M_{constr,2})$ *and* $(C^{L,3}_{foc,2} \leqslant C^L_{constr,2}))$, then $f(\widetilde{\alpha}) = f_3(\widetilde{\alpha})$.

$$\begin{aligned}1 \;=\; & \left[(1-\widetilde{\alpha}_1-\widetilde{\alpha}_2(1-fee))^{1-\theta}\beta(\mu+(1-\mu)(\lambda_1+\lambda_2))\right]+ \\ & +f_3(\widetilde{\alpha})^{\theta}\gamma^{\theta}\mu\left[\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^H_p-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}+\right. \\ & +\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^M_p-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}+ \\ & \left.(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^L_p-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}\right]+ \\ & +f_3(\widetilde{\alpha})^{\theta}(1-\mu)\left[\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^H_p-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}+\right. \\ & \left.+\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^M_p-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}\right] \\ & +(1-\mu)\beta(1-\lambda_1-\lambda_2)R^{L1-\theta}_p\left(1+\beta^{\frac{-1}{\theta}}f_3(\widetilde{\alpha})\right)^{\theta}.\end{aligned} \tag{A1.1}$$

$$\begin{aligned}C^{L,3}_{foc,2} &= \left[f_3(\widetilde{\alpha})\beta^{\left(\frac{-1}{\theta}\right)}(R^L_pW+L)\right]/(1+\beta^{\frac{-1}{\theta}}f_3(\widetilde{\alpha})), \\ C^i_{constr,2} &= (\alpha_1+\alpha_2(1-fee)+r^i_p)W+L \quad for\ i=H,M.\end{aligned} \tag{A1.c}$$

[33] The value function $f(\widetilde{\alpha})$ should be obtained as the root of the corresponding equations.

- If $((C^H_{foc,2} > C^H_{constr,2})$ *and* $(C^{M,4}_{foc,2} \leqslant C^M_{constr,2})$ *and* $(C^L_{foc,2} > C^L_{constr,2}))$, then $f(\widetilde{\alpha}) = f_4(\widetilde{\alpha})$.

$$\begin{aligned}
1 &= \left[(1-\widetilde{\alpha}_1-\widetilde{\alpha}_2(1-fee))^{1-\theta}\,\beta(\mu+(1-\mu)(\lambda_1+(1-\lambda_1-\lambda_2)))\right]+ \\
&+f_4(\widetilde{\alpha})^\theta\gamma^\theta\mu\left[\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^H_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+\right. \qquad \text{(A1.2)}\\
&+\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^M_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+ \\
&\left.+(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^L_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}\right]+ \\
&+f_4(\widetilde{\alpha})^\theta(1-\mu)\left[\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^H_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+\right. \\
&\left.+(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^L_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}\right] \\
&+(1-\mu)\beta\lambda_2 R^{M\,1-\theta}_p\left(1+\beta^{\frac{-1}{\theta}}f_4(\widetilde{\alpha})\right)^\theta.
\end{aligned}$$

$$\begin{aligned}
C^{M,4}_{foc,2} &= \left[f_4(\widetilde{\alpha})\beta^{\left(\frac{-1}{\theta}\right)}(R^M_p W+L)\right]/(1+\beta^{\frac{-1}{\theta}}f_4(\widetilde{\alpha})), \qquad \text{(A1.d)}\\
C^i_{constr,2} &= (\alpha_1+\alpha_2(1-fee)+r^i_p)W+L \quad for\ i=H,L.
\end{aligned}$$

- If $((C^{H,5}_{foc,2} \leqslant C^H_{constr,2})$ *and* $(C^M_{foc,2} > C^M_{constr,2})$ *and* $(C^L_{foc,2} > C^L_{constr,2}))$, then $f(\widetilde{\alpha}) = f_5(\widetilde{\alpha})$.

$$\begin{aligned}
1 &= \left[(1-\widetilde{\alpha}_1-\widetilde{\alpha}_2(1-fee))^{1-\theta}\,\beta(\mu+(1-\mu)(\lambda_2+(1-\lambda_1-\lambda_2)))\right]+ \\
&+f_5(\widetilde{\alpha})^\theta\gamma^\theta\mu\left[\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^H_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+\right. \qquad \text{(A1.3)}\\
&+\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^M_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+ \\
&\left.+(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^L_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}\right]+ \\
&+f_5(\widetilde{\alpha})^\theta(1-\mu)\left[\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^M_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+\right. \\
&\left.+(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r^L_p-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}\right] \\
&+(1-\mu)\beta\lambda_1 R^{M\,1-\theta}_p\left(1+\beta^{\frac{-1}{\theta}}f_5(\widetilde{\alpha})\right)^\theta.
\end{aligned}$$

$$\begin{aligned}
C^{H,5}_{foc,2} &= \left[f_5(\widetilde{\alpha})\beta^{\left(\frac{-1}{\theta}\right)}(R^H_p W+L)\right]/(1+\beta^{\frac{-1}{\theta}}f_5(\widetilde{\alpha})), \qquad \text{(A1.e)}\\
C^i_{constr,2} &= (\alpha_1+\alpha_2(1-fee)+r^i_p)W+L \quad for\ i=M,L.
\end{aligned}$$

- If $((C^{H}_{foc,2} > C^{H}_{constr,2})$ *and* $(C^{M,6}_{foc,2} \leqslant C^{M}_{constr,2})$ *and* $(C^{L,6}_{foc,2} \leqslant C^{L}_{constr,2}))$, then $f(\widetilde{\alpha}) = f_6(\widetilde{\alpha})$.

$$\begin{aligned}1 &= \left[(1-\widetilde{\alpha}_1-\widetilde{\alpha}_2(1-fee))^{1-\theta}\beta(\mu+(1-\mu)\lambda_1)\right]+ \\ &+f_6(\widetilde{\alpha})^{\theta}\left\{\gamma^{\theta}\mu\left[\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^H-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}+\right.\right. \\ &+\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^M-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}+ \\ &\left.+(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^L-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}\right] \\ &\left.+(1-\mu)\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^H-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}\right\} \\ &+(1-\mu)\beta\left[\lambda_2R_p^{M\,1-\theta}+(1-\lambda_1-\lambda_2)R_p^{L\,1-\theta}\right]\left(1+\beta^{\frac{-1}{\theta}}f_6(\widetilde{\alpha})\right)^{\theta}.\end{aligned} \tag{A1.4}$$

$$\begin{aligned}C^{i,6}_{foc,2} &= \left[f_6(\widetilde{\alpha})\beta^{\left(\frac{-1}{\theta}\right)}(R_p^iW+L)\right]/(1+\beta^{\frac{-1}{\theta}}f_6(\widetilde{\alpha})) \quad for\ i=M,L, \\ C^{H}_{constr,2} &= (\alpha_1+\alpha_2(1-fee)+r_p^H)W+L.\end{aligned} \tag{A1.f}$$

- If $((C^{H,7}_{foc,2} \leqslant C^{H}_{constr,2})$ *and* $(C^{M}_{foc,2} > C^{M}_{constr,2})$ *and* $(C^{L,7}_{foc,2} \leqslant C^{L}_{constr,2}))$, then $f(\widetilde{\alpha}) = f_7(\widetilde{\alpha})$.

$$\begin{aligned}1 &= \left[(1-\widetilde{\alpha}_1-\widetilde{\alpha}_2(1-fee))^{1-\theta}\beta(\mu+(1-\mu)\lambda_2)\right]+ \\ &+f_7(\widetilde{\alpha})^{\theta}\left\{\gamma^{\theta}\mu\left[\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^H-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}+\right.\right. \\ &+\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^M-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}+ \\ &\left.+(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^L-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}\right]+ \\ &\left.+(1-\mu)\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^M-\widetilde{\alpha}_2r_2+\frac{L}{W})^{1-\theta}\right\} \\ &+(1-\mu)\beta\left[\lambda_1R_p^{H\,1-\theta}+(1-\lambda_1-\lambda_2)R_p^{L\,1-\theta}\right]\left(1+\beta^{\frac{-1}{\theta}}f_7(\widetilde{\alpha})\right)^{\theta}.\end{aligned} \tag{A1.5}$$

$$\begin{aligned}C^{i,7}_{foc,2} &= \left[f_7(\widetilde{\alpha})\beta^{\left(\frac{-1}{\theta}\right)}(R_p^iW+L)\right]/(1+\beta^{\frac{-1}{\theta}}f_7(\widetilde{\alpha})) \quad for\ i=H,L, \\ C^{M}_{constr,2} &= (\alpha_1+\alpha_2(1-fee)+r_p^M)W+L.\end{aligned} \tag{A1.g}$$

- If $((C^{H,8}_{foc,2} \leqslant C^{H}_{constr,2})$ *and* $(C^{M,8}_{foc,2} \leqslant C^{M}_{constr,2})$ *and* $(C^{L}_{foc,2} > C^{L}_{constr,2}))$, then $f(\widetilde{\alpha}) =$

$f_8(\widetilde{\alpha})$.

$$
\begin{aligned}
1 \;=\; & \left[(1-\widetilde{\alpha}_1-\widetilde{\alpha}_2(1-fee))^{1-\theta}\beta(\mu+(1-\mu)(1-\lambda_1-\lambda_2))\right]+ \\
& +f_8(\widetilde{\alpha})^{\theta}\left\{\gamma^{\theta}\mu\left[\lambda_1(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^H-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+\right.\right. \\
& +\lambda_2(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^M-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}+ \\
& \left.+(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^L-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}\right]+ \\
& \left.+(1-\mu)(1-\lambda_1-\lambda_2)(\widetilde{\alpha}_1+\widetilde{\alpha}_2(1-fee)+r_p^L-\widetilde{\alpha}_2 r_2+\frac{L}{W})^{1-\theta}\right\} \\
& +(1-\mu)\beta\left[\lambda_1 R_p^{H1-\theta}+\lambda_2 R_p^{M1-\theta}\right]\left(1+\beta^{\frac{-1}{\theta}}f_8(\widetilde{\alpha})\right)^{\theta}.
\end{aligned} \tag{A1.6}
$$

$$
\begin{aligned}
C^{i,8}_{foc,2} &= \left[f_8(\widetilde{\alpha})\beta^{\left(\frac{-1}{\theta}\right)}(R_p^i W+L)\right]/(1+\beta^{\frac{-1}{\theta}}f_8(\widetilde{\alpha})) \quad for\ i=H,M, \\
C^{L}_{constr,2} &= (\alpha_1+\alpha_2(1-fee)+r_p^L)W+L.
\end{aligned} \tag{A1.h}
$$

Ultimate consumption is determined by the grid of $\widetilde{\alpha}s$ that maximizes $f_*(\widetilde{\alpha})$. When we have maximized $f(\widetilde{\alpha})$, we can easily derive the optimal consumption path in the different liquidity regimes and scenarios.

Appendix A.2. Definition of Variables

A.2.1. Housing returns

The estimation of the housing returns is based on the estimation of the user cost of homeowners provided by Diaz and Luengo-Prado (2008). The housing returns can be defined as:

$$hr_{it}=\frac{q_{it}(1-\delta+\tau)-q_{it-1}+rent_{it}}{q_{it-1}}, \tag{A2.1}$$

where $hr_{i,t}$ represents the housing returns per square meter for a given household i at period t, and $q_{i,t}$ and $q_{i,t-1}$ are the housing prices per square meter at periods t and $t-1$, respectively. The parameter δ represents housing's rate of depreciation, which is set to 0.043.[34] The parameters τ is the property tax, equal to 0.0068.[35] Finally, $rent_{it}$ reflects the income that the household would have received if it had rented the housing, estimated as:

[34] Díaz and Luengo-Prado (2008) base their rate estimates on information from the Bureau of Economic Analysis.

[35] The property tax is called "Impuesto sobre Bienes Inmuebles (IBI)", and in Spain, it comes into effect at a local jurisdiction level, such that it varies across localities. We employ an average value that reflects the IBI for Madrid and Barcelona.

$$rentr_{it} = (r_t^d + \delta)q_{it-1} + \tau q_{it}, \tag{A2.2}$$

where r_t^d is the EURIBOR rate after taxes in year t.[36]

Flavin and Yamashita (2002) also obtain average annual housing returns as average returns across all homeowners' returns. To estimate returns on housing, they use data from the 1968–1992 waves of the PSID, using the return on owner-occupied housing at the household level.[37]

A.2.2. Mortgage Payments

The annual payments were obtained from the remaining amount of the loan principal at the survey year (2002), according to a French amortization system and using either fixed or variable interest rates, depending on the loan's characteristics.

A.2.3. Value of the desired housing

The estimation of the value of the desired housing follows Linneman and Wachter (1989) and Zorn (1989). To estimate the desired value, we employ a subsample formed by (i) financially unconstrained households, (ii) households in which the head of household is between 25 and 60 years old, and (iii) households that bought their housing within the previous five years; thus, we avoid subjective revelations about the housing price that might deviate from the real value. The equation estimated with this sample allows us to infer or predict the desired value for a wider sample of households that includes constrained members. Thus, it is equivalent to estimating the housing demand in the absence of financial constraints.

The final sample comprises 399 households. We employ a generalized Tobit model to estimate the desired value. The censure is set according to the following expression:

$$V_i \geq Z_i, \tag{A2.3}$$

where V_i is the housing purchase price, and $Z_i \equiv \text{mín}(\frac{NW_i}{1-0.8}, \frac{0.33Y_i}{r0.8})$ is the minimum of the limit values set when a household is constrained in wealth or rent, equivalent to constraints (ix) and (x) in Equation (1).

Thus, under the Tobit specification, we regress the housing purchase price on a group of variables whose values correspond with the year the housing was bought: permanent income, net wealth, the user cost of the housing, age, and different demographic characteristics of the

[36]The use of the EURIBOR rate in this expression reflects the assumption that this rate coincides with the average market return.

[37]The construction of housing returns from micro data based on households' subjective housing value measures may not be addeaquate. However, Skinner (1994) compares the annual rate of self-reported price changes with objective Commerce Department measures and finds that the house price changes over the 1970 and 1980 observed in the two series are very close.

head of the household. The estimated coefficients enable us to predict the desired value by a wider sample of households.

A.2.4. Household financial constraints

A.2.4.1. Wealth

We define a limit value (V_i^W) that indicates if a given household i is constrained or unconstrained in wealth as:

$$V_i^W = \frac{NW_i}{1 - 0.8}, \tag{A2.4}$$

where NW_i is household $i's$ net wealth the year the housing was bought. The limit value V_i^W is related to the restriction (ix) in Section 2, which reflects good banking practices and implies that the initial payment for the housing purchase must be at least 20 % of the housing price. For this reason, the value 0.8 is the maximum portion of the mortgage with respect to the housing purchase price that banks offer borrowers.

We consider a given household i constrained in wealth whenever the desired housing value is higher than the value limit V_i^W.

A.2.4.2. Income

We define a limit value (V_i^Y) that indicates if a given household i is constrained or unconstrained in income as:

$$V_i^Y = \frac{0.33Y_i}{r0.8}, \tag{A2.5}$$

where Y_i is household i's total annual income the year it bought housing, and r is the mortgage rate. The limit value V_i^Y relates to restriction (x) in Section 2, which implies that mortgage payments must be lower than 33 % of household income. For this reason, the value 0.33 reflects the maximum portion of the mortgage payment with respect to household income.

We consider a given household i constrained in income whenever the desired housing value is higher than the value limit V_i^Y.

A.2.5. Grade of household financial constraints

Alternatively, we can employ the ratio between the desired housing value and the value limits as a continuous indicator of these restrictions. This indicator reveals the importance of the desired value with respect to each of the two value limits. Thus, if the ratio is higher than 1 for a given household, that household is financially constrained. The higher the ratio, the higher is the grade of the restriction.

A.2.5.1. Grade of wealth financial constraints

This value is the ratio between the desired housing value and the wealth value limit V_i^W.

A.2.5.2. Grade of income financial constraints

This value is the ratio between the desired housing value and the income value limit V_i^Y.

A.2.6. Grade of financial sophistication

To construct a proxy of the financial knowledge of a given household, we employ information that appears in the EFF. Specifically, we consider seven different groups of financial instruments or actions that may indicate strong financial knowledge: realization of electronic payments; investment in options, futures, swaps or other derivatives; use of credit cards; use of checks; use of direct billing or direct deposit; use of telephone banking; and use of Internet banking. For a given household, each action equals 1 if the household uses it and 0 otherwise. We consider a household *less sophisticated* when the sum of these values is less than 3. A household is a *midly sophisticated investor* if the sum of these values is between 4 and 5, inclusive. Finally, a given household is *highly sophisticated* if the sum is 6 or 7.

A.2.7. Consumption

The consumption variable represents households' expenditures, including food, but excluding durable goods (e.g., cars, electrical appliance, ...), housing rentals or other property costs, mortgage payments, insurance, housing alterations, and housing maintenance costs.

Referencias

[1] Ameriks, J., and Zeldes, S. (2000),"How Do Household Portfolio Shares Vary with Age?", Working Paper, Columbia University.

[2] Anglin, P., and Gao, Y. (2011), "Integrating Illiquid Assets into the Portfolio Decision Process", Real Estate Economics, 39, 277-311.

[3] Asiedu, E., and Villamil, A.P. (2000), "Discount Factors and Thresholds: Foreign Investment When Enforcement Is Imperfect", Macroeconomic Dynamics, 4, 1-21.

[4] Barakova, I., Bostic, R., Calem, P., and Wachter, S. (2003), "Does Credit Quality Matter for Homeownership?", Journal of Housing Economics, 12, 318-336.

[5] Barceló, C. (2005), "Imputation of the 2002 Wave of the Spanish Survey of Household Finances (EFF)", mimeo.

[6] Bertaut, C. and Starr-McCluer, M. (2001), "Household Portfolios in the United States" in Luigi Guiso, Michael Haliassos, and Tullio Jappelli, eds., Household Portfolios. Cambridge, MA: MIT Press.

[7] Bover, O. (2004), "The Spanish Survey of Household Finances (EFF): Description and Methods of the 2002 Wave", Occasional Paper N^o 0409, Banco de España.

[8] Calvet, L. E., Campbell, J. Y., and Sodini, P. (2007), "Down or Out: Assessing the Welfare Costs of Household Investment Mistakes", Journal of Political Economy, 115, 707-747.

[9] Campbell, J. Y. (2003), "Consumption-Based Asset Pricing", in G. Constantinides, M. Harris, and R. Stulz(eds.), Handbook of the Economics of Finance, North-Holland, Amsterdam.

[10] Campbell, J. Y. (2006), "Household Finance", Journal of Finance, 61, 1553-1604.

[11] Campbell, J. Y., and Cocco, J. F. (2007), "How Do House Prices Affect Consumption? Evidence from Micro Data", Journal of Monetary Economics, 54, 591-621.

[12] Carroll, C. D. (2002), "Portfolios of the Rich", in Luigi Guiso, Michael Haliassos, and Tullio Jappelli, eds. Household Portfolios. Cambridge, MA: MIT Press.

[13] Cocco, J. F. (2005), "Portfolio Choice in Presence of Housing", Review of Financial Studies, 18, 535-567.

[14] Cocco, J. F., Gomes, F. J., and Maenhout, P. J. (2005), "Consumption and Portfolio Choice over the Life Cycle", Review of Financial Studies, 18, 491-533.

[15] De Lis, F. S., Martinez Pagés, J., and Saurina, J. (2001), "Credit Growth, Problem Loans and Credit Risk Provisioning in Spain", BIS Papers, 1, 331-353.

[16] Díaz, A. and Luengo-Prado, M.J. (2008), "On the User Cost and Home Ownership", Review of Economic Dynamics, 11, 584-613.

[17] Flavin, M. and Yamashita, T. (2002), "Owner-Occupied Housing and the Composition of the Household Portfolio Over the Life Cycle", American Economic Review, 92, 345-362.

[18] Gollier, C. (2001), The Economics of Risk and Time, Hong Kong: MIT Press

[19] Grossman, S., and Laroque, G. (1990), "Asset Pricing and Optimal Portfolio Choice in the Presence of Illiquid Durable Consumption Goods", Econometrica, 58, 25-52.

[20] Haliassos, M., and Bertaut, C. (1995), "Why Do So Few Hold Stocks?", Economic Journal, 105, 1110-1129.

[21] Haliassos, M., and Michaelides, A. (2003), "Portfolio Choice and Liquidity Constraints", International Economic Review, 44, 143-177.

[22] Jofre-Bonet, M. and Pesendorfe, M. (2000), "Bidding Behavior in a Repeated Procurement Auction: A Summary", European Economic Review, 44, 1006-1020.

[23] Kallberg, J. G., Liu, C. H., and Greig, D. W. (1996), "The Role of Real Estate in the Portfolio Allocation Process". Real Estate Economics, 34, 359-377.

[24] King, M. A., and Leape, J. I. (1998), "Wealth and Portfolio Composition: Theory and Evidence", Journal of Public Economics, 69, 155-193.

[25] Koren, M., and Szeidl, A. (2002), "Portfolio Choice with Illiquid Assets", Working Paper, Harvard University.

[26] Linneman, P. and Wachter, S. (1989), "The Impacts of Borrowing Constraints on Homeownership", Journal of the American Real State and Urban Economics Association, 17, 389-402.

[27] Longstaff, F. A. (2001), "Optimal Portfolio Choice and the Valuation of Illiquid Securities", Review of Financial Studies, 14, 407-431

[28] Markowitz, H. (1952), "Portfolio Selection", Journal of Finance, 7, 77-92.

[29] Mayordomo, S. (2008), “Do Financial Constraints Have an Effect on Housing Tenure Choices?”, Investigaciones Económicas, 32, 289-324.

[30] Schwartz, E. S., and Tebaldi, C. (2006) “Illiquid Assets and Optimal Portfolio Choice”, NBER Working Paper No. 12633.

Table 1: Asset Returns. Descriptive Statistics (%)

This table reports the descriptive statistics of the historical real asset returns. The statistics are calculated using data from 1991 to 2002. Panel A reports the expectation ($E(r_i)$) and the standard deviation (SD(r_i)) of the annual asset's returns which are deflated by the appropriate price index. For the stocks, we present the average returns under a favorable (r_H); an intermediate (r_M), and an unfavorable scenario (r_L). Panel B reports the correlations for the different pairs of asset's returns.

	Stocks			Bank Time Deposits	Housing	Mortgage
	L	M	H			
E[R]	-13.87	16.86	37.77	1.15	3.66	4.53
SD[R]		28.96		1.11	4.32	2.18

Correlation Matrix

	Stocks	Bank Time Deposits	Housing	Mortgage
Stocks	1			
Bank Time Deposits	0.217	1		
Housing	-0.715	-0.631	1	
Mortgage	0.204	0.971	-0.673	1

Table 2: Households Descriptive Statistics

This table reports the some descriptive statistics (mean, median and standard deviation) referred to the households' demographic characteristics, financial assets and housing. The statistics refer to the EFF 2002 survey wave.

	Mean	Median	Std. Dev.
Age of the head of household	39.979	38.000	8.897
Head of household has primary education (1 if yes, 0 otherwise)	0.374	0.000	0.484
Head of household has secondary education (1 if yes, 0 otherwise)	0.378	0.000	0.485
Head of household has university education (1 if yes, 0 otherwise)	0.248	0.000	0.432
Less sophisticated investor (1 if yes, 0 otherwise)	0.166	0.000	0.372
Midly sophisticated investor (1 if yes, 0 otherwise)	0.832	1.000	0.374
Highly sophisticated investors (1 if yes, 0 otherwise)	0.002	0.000	0.039
Head of household works in the primary sector (1 if yes, 0 otherwise)	0.058	0.000	0.234
Head of household works in the secondary sector (1 if yes, 0 otherwise)	0.292	0.000	0.455
Head of household works in the tertiary sector (1 if yes, 0 otherwise)	0.606	1.000	0.489
Head of household is employed (1 if yes, 0 otherwise)	0.687	1.000	0.464
Head of household is self-employed (1 if yes, 0 otherwise)	0.124	0.000	0.329
Head of household is retired (1 if yes, 0 otherwise)	0.013	0.000	0.115
Head of household is unemployed or non-active (1 if yes, 0 otherwise)	0.186	0.000	0.389
Sex of the head of household (1 if men, 0 women)	0.702	1.000	0.457
Annual Income (€)	38,693	29,916	33,509
Annual Labor Income (€)	32,208	26,728	25,230
Annual Consumption (€)	12,302	10,800	7,813
Net Wealth (€)	159,542	131,460	108,845
Stocks (€)	902	0	16,073
Deposits (€)	5,035	2,151	11,254
Mortgage (€)	-50,948	-25,139	33,702
Housing (€)	204,552	153,193	100,586
Portion of net wealth invested in stocks (%)	0.006	0.000	0.026
Portion of net wealth invested in deposits (%)	0.031	0.016	0.048
Portion of net wealth invested in mortgage (%)	-0.319	-0.191	0.381
Portion of net wealth invested in housing (%)	1.282	1.165	0.386
Housing purchase price (€)	90,741	83,440	60,755
Year of housing purchase	1,997	1,997	2.497
Household constrained in wealth (1 if yes, 0 otherwise)	0.281	0.000	0.449
Household constrained in income (1 if yes, 0 otherwise)	0.901	1.000	0.297
Household constrained in wealth and income (1 if yes, 0 otherwise)	0.263	0.000	0.440
Household unconstrained (1 if yes, 0 otherwise)	0.080	0.000	0.271
Number of observations	1,249,355		

Table 3: Optimal Portfolio Choice Baseline Results

This table reports the optimal portfolio (i.e., optimal proportion of stocks, deposits, mortgage and housing) of the baseline optimization problem ($\beta = 0.95$, $\gamma = 1.18$, $\theta = 2$, $\Delta t = 1/12$, and $\mu = 0.25$), and the actual portfolio attending to the EFF information for seven subgroups referred to the head of household: age, education, degree of financial sophistication, economic sector of employment, labor situation, sex, income, net wealth, and type of financial constraints that household faces. The first group of columns reports the estimation of the optimal portfolio while the second group of columns reports the actual portfolio. The symbols ** and * (^^ and ^) indicate whether the optimal shares are significantly higher (lower) than the observed shares at 1 and 5% significance levels, respectively.

Subgroup	Optimal Portfolio				Observed Portfolio			
	Stocks	Bank Time Deposits	Mortgage	Housing	Stocks	Bank Time Deposits	Mortgage	Housing
All Individuals								
All Individuals	0.016**	0.049**	-0.347	1.282	0.006	0.031	-0.319	1.282
Age								
Less than 35	0.006**	0.052**	-0.452	1.394	0.002	0.035	-0.430	1.394
Between 35 and 45	0.012**	0.048**	-0.384	1.323	0.004	0.025	-0.353	1.323
Between 45 and 55	0.032**	0.046**	-0.181	1.103	0.010	0.035	-0.147	1.103
More than 55	0.029**	0.045**	-0.125*	1.051	0.019	0.035	-0.104	1.051
Education								
Primary Education	0.007**	0.051**	-0.387	1.329	0.001	0.025	-0.356	1.329
Secondary Education	0.019**	0.045**	-0.329	1.265	0.006	0.035	-0.305	1.265
University Education	0.023**	0.051**	-0.312	1.238	0.012	0.035	-0.285	1.238
Degree of Financial Sophistication								
Less Sophisticated	0.022**	0.044**	-0.248	1.182	0.003	0.030	-0.213	1.182
Midly Sophisticated	0.014**	0.050**	-0.367	1.303	0.006	0.031	-0.341	1.303
Highly Sophisticated	0.074^	0.047^^	-0.052^^	0.931	0.090	0.063	-0.086	0.931
Economic Sector								
Primary Sector	0.007**	0.057**	-0.390	1.327	0.001	0.027	-0.353	1.327
Secondary Sector	0.016**	0.050**	-0.408	1.342	0.006	0.033	-0.380	1.342
Tertiary Sector	0.017**	0.047**	-0.323	1.259	0.006	0.032	-0.297	1.259
Labor Situation								
Employed	0.016**	0.047**	-0.355	1.291	0.006	0.029	-0.327	1.291
Self-Employed	0.012**	0.055**	-0.320	1.252	0.003	0.046	-0.301	1.252
Retired	0.041**	0.024**	-0.073**	1.008	0.014	0.019	-0.041	1.008
Unemployed/Non-Active	0.015**	0.052**	-0.344	1.277	0.005	0.031	-0.313	1.277
Sex								
Men	0.015**	0.050**	-0.355	1.290	0.005	0.032	-0.326	1.290
Women	0.016**	0.046**	-0.327	1.265	0.006	0.030	-0.302	1.265
Income								
Less than 20,000€	0.015**	0.049**	-0.328	1.264	0.002	0.031	-0.297	1.264
Between 20,000 and 40,000€	0.012**	0.048**	-0.387	1.327	0.002	0.027	-0.355	1.327
Between 40,000 and 60,000€	0.011*	0.050**	-0.358	1.297	0.008	0.034	-0.339	1.297
More than 60,000€	0.034**	0.047	-0.261	1.180	0.020	0.040	-0.241	1.180
Net Wealth								
Less than 100,000€	0.005**	0.053**	-0.664	1.606	0.002	0.027	-0.635	1.606
Between 100,000 and 200,000€	0.015**	0.046**	-0.249	1.187	0.003	0.031	-0.222	1.187
Between 200,000 and 300,000€	0.023**	0.049**	-0.119	1.047	0.010	0.030	-0.087	1.047
More than 300,000€	0.042**	0.048	-0.114	1.024	0.023	0.047	-0.093	1.024
Type of Financial Restrictions								
Constrained in Wealth	0.002	0.054**	-0.746	1.690	0.003	0.038	-0.731	1.690
Constrained in Income	0.014**	0.049**	-0.352	1.289	0.005	0.030	-0.324	1.289
Constrained in Wealth and Income	0.002	0.056**	-0.753	1.697	0.003	0.038	-0.737	1.697
Unconstrained	0.036**	0.048	-0.215	1.131	0.020	0.044	-0.194	1.131

Table 4: Optimal Portfolio Choice Baseline Results

This table reports the deviation between the optimal portfolio (i.e., optimal proportion of stocks, deposits, mortgage and housing) for the baseline optimization problem ($\beta = 0.95$, $\gamma = 1.18$, $\theta = 2$, $\Delta t = 1/12$, and $\mu = 0.25$), and the actual portfolio attending to the EFF information for the 2002 and 2005 surveys for seven subgroups which are referred to the head of household: age, education, degree of financial sophistication, economic sector of employment, labor situation, sex, income, net wealth, and type of financial constraints that household faces. The households employed in this analysis are the ones for which we have information from both surveys (we end with 130 households instead of 427 as in Table 3). The first group of columns reports the deviation between the optimal and the actual portfolios in 2002 while the second group of columns reports the equivalent result in 2005. The symbols ** and * (^^ and ^) indicate whether the deviation between the optimal and observed shares is significantly higher (lower) than zero at 1 and 5% significance levels, respectively.

Subgroup	Deviation from the optimal in 2002				Deviation from the optimal in 2005			
	Stocks	Bank Time Deposits	Mortgage	Housing	Stocks	Bank Time Deposits	Mortgage	Housing
All Individuals								
All Individuals	0.013**	0.017**	-0.030	0.000	0.013**	0.012**	-0.025	0.000
Age								
Less than 35	0.009**	0.023**	-0.033	0.000	0.037**	-0.007^	-0.029	0.000
Between 35 and 45	0.003*	0.024**	-0.026	0.000	0.007**	0.016**	-0.024	0.000
Between 45 and 55	0.042**	-0.008^^	-0.034	0.000	0.008*	0.014**	-0.022	0.000
More than 55	0.013**	0.015**	-0.028**	0.000	0.005	0.027**	-0.031	0.000
Education								
Primary Education	0.005**	0.032**	-0.037	0.000	0.013**	0.011**	-0.023	0.000
Secondary Education	0.019**	0.010	-0.028	0.000	0.010**	0.016**	-0.026	0.000
University Education	0.015**	0.010**	-0.026	0.000	0.018**	0.007**	-0.026	0.000
Degree of Financial Sophistication								
Less Sophisticated	0.062**	-0.033^^	-0.031	0.000	0.015**	0.011**	-0.027	0.000
Midly Sophisticated	0.008**	0.022**	-0.030	0.000	0.013**	0.012**	-0.025	0.000
Highly Sophisticated	-0.002	-0.056^^	0.059^^	0.000	0.029**	-0.009^^	-0.021	0.000
Economic Sector								
Primary Sector	0.010**	0.025**	-0.038	0.000	0.000	0.013**	-0.011	0.000
Secondary Sector	0.024**	0.011	-0.035	0.000	0.005**	0.029**	-0.035	0.000
Tertiary Sector	0.008**	0.018**	-0.026	0.000	0.018**	0.006**	-0.023	0.000
Labor Situation								
Employed	0.010**	0.023**	-0.032	0.000	0.014**	0.012**	-0.027	0.000
Self-Employed	0.015**	0.010*	-0.026	0.000	0.013**	0.007**	-0.020	0.000
Retired	0.045**	0.002**	-0.047**	0.000	0.004**	0.030**	-0.035	0.000
Unemployed/Non-Active	0.038**	-0.025^^	-0.014	0.000	0.011**	0.000	-0.011	0.000
Sex								
Men	0.015**	0.019**	-0.034	0.000	0.007**	0.018**	-0.026	0.000
Women	0.008**	0.010*	-0.018	0.000	0.023**	0.001	-0.024	0.000
Income								
Less than 20,000€	0.034**	0.004	-0.039	0.000	0.007**	0.027**	-0.035	0.000
Between 20,000 and 40,000€	0.010**	0.027**	-0.037	0.000	0.013**	0.012**	-0.024	0.000
Between 40,000 and 60,000€	-0.001	0.011**	-0.011	0.000	0.026**	0.001	-0.029*	0.000
More than 60,000€	0.006**	0.015**	-0.021	0.000	0.007**	0.007**	-0.013	0.000
Net Wealth								
Less than 100,000€	0.004**	0.034**	-0.039	0.000	-0.005^^	0.030**	-0.024	0.000
Between 100,000 and 200,000€	0.014**	0.006	-0.020	0.000	0.006**	0.025**	-0.032	0.000
Between 200,000 and 300,000€	0.036**	0.009	-0.045	0.000	0.021**	0.008**	-0.029**	0.000
More than 300,000€	0.008**	0.029**	-0.022	0.000	0.013**	0.000	-0.013**	0.000
Type of Financial Restrictions								
Constrained in Wealth	0.000	0.019**	-0.021	0.000	0.000	0.019**	-0.022	0.000
Constrained in Income	0.015**	0.017**	-0.031	0.000	0.014**	0.012**	-0.026	0.000
Constrained in Wealth and Income	0.000	0.020**	-0.021	0.000	0.000	0.009**	-0.010	0.000
Unconstrained	0.002	0.017**	-0.014	0.000	0.005	-0.015^^	0.010	0.000

Table 5: Optimal Portfolio Choice for the Recent Homeowners

This table reports the optimal portfolio (i.e. optimal proportion of stocks, deposits, mortgage and housing) of the baseline optimization problem ($\beta = 0.95$, $\gamma = 1.18$, $\theta = 2$, $\Delta t = 1/12$, and $\mu = 0.25$) for the recent homeowners. We distinguish the optimal portfolio for different subgroups referred to the head of household: age, education, degree of financial sophistication, economic sector of employment, labor situation, sex, income, net wealth, and type of financial constraints that household faces. The first group of columns reports the estimation of the optimal portfolio using the information of the housing buyers between 1997 and 2001 in the 2002 survey. The second group of columns reports the estimation of the optimal portfolio using the information of the housing buyers between 2000 and 2004 in the 2005 survey.

Subgroup	Optimal Portfolio for the Recent Homeowners in 2002				Optimal Portfolio for the Recent Homeowners in 2005			
	Stocks	Bank Time Deposits	Mortgage	Housing	Stocks	Bank Time Deposits	Mortgage	Housing
All Individuals								
All Individuals	0.009	0.050	-0.493	1.434	0.016	0.052	-0.541	1.473
Age								
Less than 35	0.006	0.051	-0.544	1.487	0.016	0.052	-0.665	1.597
Between 35 and 45	0.006	0.050	-0.577	1.521	0.012	0.053	-0.483	1.418
Between 45 and 55	0.030	0.047	-0.257	1.180	0.017	0.048	-0.378	1.313
More than 55	0.007	0.050	-0.147	1.090	0.035	0.058	-0.385	1.291
Education								
Primary Education	0.005	0.051	-0.553	1.496	0.010	0.054	-0.516	1.452
Secondary Education	0.011	0.049	-0.491	1.431	0.016	0.052	-0.626	1.558
University Education	0.014	0.050	-0.404	1.341	0.021	0.049	-0.452	1.382
Degree of Financial Sophistication								
Less Sophisticated	0.027	0.045	-0.426	1.354	0.018	0.048	-0.393	1.327
Midly Sophisticated	0.007	0.051	-0.504	1.446	0.016	0.052	-0.559	1.491
Highly Sophisticated	0.089	0.041	-0.078	0.948	0.010	0.052	-0.438	1.376
Economic Sector								
Primary Sector	0.009	0.054	-0.568	1.505	0.011	0.063	-0.199	1.125
Secondary Sector	0.011	0.050	-0.523	1.461	0.013	0.051	-0.625	1.560
Tertiary Sector	0.009	0.050	-0.478	1.419	0.017	0.052	-0.538	1.470
Labor Situation								
Employed	0.008	0.048	-0.473	1.417	0.013	0.052	-0.572	1.507
Self-Employed	0.012	0.059	-0.635	1.564	0.015	0.056	-0.380	1.309
Retired	0.009	0.061	-0.039	0.969	0.021	0.050	-0.275	1.203
Unemployed/Non-Active	0.016	0.053	-0.504	1.434	0.026	0.049	-0.518	1.443
Sex								
Men	0.009	0.051	-0.494	1.434	0.017	0.048	-0.560	1.495
Women	0.010	0.047	-0.490	1.433	0.014	0.057	-0.509	1.438
Income								
Less than 20,000€	0.018	0.049	-0.457	1.390	0.011	0.054	-0.489	1.425
Between 20,000 and 40,000€	0.007	0.050	-0.553	1.495	0.015	0.051	-0.691	1.625
Between 40,000 and 60,000€	0.005	0.051	-0.522	1.467	0.011	0.052	-0.497	1.433
More than 60,000€	0.005	0.051	-0.352	1.296	0.029	0.050	-0.358	1.280
Net Wealth								
Less than 100,000€	0.002	0.054	-0.764	1.707	0.015	0.059	-1.103	2.029
Between 100,000 and 200,000€	0.014	0.045	-0.335	1.276	0.006	0.051	-0.539	1.481
Between 200,000 and 300,000€	0.024	0.042	-0.175	1.109	0.016	0.049	-0.325	1.260
More than 300,000€	0.011	0.067	-0.180	1.102	0.039	0.048	-0.139	1.052
Type of Financial Restrictions								
Constrained in Wealth	0.001	0.056	-0.789	1.732	0.014	0.056	-0.992	1.922
Constrained in Income	0.010	0.050	-0.504	1.443	0.014	0.052	-0.540	1.474
Constrained in Wealth and Income	0.001	0.057	-0.797	1.740	0.015	0.056	-0.992	1.921
Unconstrained	0.004	0.051	-0.297	1.241	0.045	0.047	-0.388	1.296

Table 6: Optimal Portfolio Choice under Alternative Parameter's Values

This table reports the optimal portfolio choice under different parameter's values. The results presented in this table correspond to the average of all the individuals' portfolio choices using the subsample of 427 households (representative of 1,249,355 households) from the EFF 2002 data. In the first column we show the different values employed for each parameter (beta, gamma, mu, time, loan-to-value ratio, and income over mortgage payment) while in the second column we show the optimal investment in the corresponding financial asset (stocks, bank time deposits, mortgage, and housing).

Parameters Values	Stocks	Bank Time Deposits	Mortgage	Housing
		Beta		
Baseline (β=0.95)	0.016	0.049	-0.347	1.282
β=0.975	0.015	0.038	-0.335	1.282
β=0.99	0.015	0.030	-0.327	1.282
		Gamma		
γ = 1.1	0.015	0.048	-0.345	1.282
Baseline (γ = 1.22)	0.015	0.050	-0.347	1.282
γ = 1.5	0.015	0.062	-0.359	1.282
		Mu		
μ = 0.15	0.016	0.040	-0.338	1.282
Baseline (μ = 0.25)	0.016	0.049	-0.347	1.282
μ = 0.35	0.014	0.057	-0.354	1.282
		Time (Shock Duration in annual terms)		
Δt = 1/24	0.014	0.052	-0.348	1.282
Baseline (Δt = 1/12)	0.016	0.049	-0.347	1.282
Δt = 1/4	0.025	0.019	-0.326	1.282
		Loan-to-Value Ratio		
LTV = 70%	0.016	0.048	-0.333	1.270
Baseline (LTV = 80%)	0.016	0.049	-0.347	1.282
LTV = 90%	0.015	0.049	-0.352	1.287
		Income over Mortgage Payment		
IMP = 25%	0.016	0.049	-0.347	1.282
Baseline (IMP = 33%)	0.016	0.049	-0.347	1.282
IMP = 40%	0.016	0.049	-0.347	1.282

Table 7: Determinants of the Deviations from the Optimal Investment

This table reports the determinants of the deviations from the optimal investment in stocks, deposits, and mortgage. Panel A reports the determinants of the deviations from the optimal investment in stocks. Panel B shows the results for the analysis of the deviations from the optimal investment in deposits. Panel C and shows the determinants of the deviations from the optimal investment in mortgage. The first sub-column in each panel reports the estimated coefficients and the second one the corresponding *t-statistic*. The symbol:

*1 if men, 0 if women

**1 if yes, 0 otherwise

Panel A

	Over Investment		Under Investment	
	Coefficient	t-statistic	Coefficient	t-statistic
Logarithm of the net wealth	0.910	0.95	5.315	7.35
Logarithm of household income	0.424	1.78	-3.294	-7.65
Difference between the log of desired housing value and the log of real housing value	0.513	0.63	10.356	7.67
Age of the head of household	0.053	1.21	0.140	5.73
Sex of the head of household*	-0.500	-0.99	-0.991	-3.94
Head of household has primary education**	-0.467	-0.87	-1.929	-6.37
Head of household has university education**	0.005	0.02	-0.092	-0.39
Head of household is self-employed**	-0.113	-0.98	-0.768	-1.94
Head of household is retired**	-0.141	-0.89	0.768	1.75
Head of household is unemployed or non-active**	0.491	1.17	0.459	1.61
Head of household works in the primary sector**	-0.069	-0.73	0.169	0.38
Head of household works in the tertiary sector**	-0.189	-2.00	0.001	0.00
Less sophisticated investor**	0.297	1.09	2.382	7.49
Highly sophisticated investors**	-0.170	-0.04	-5.002	-3.87
Household constrained in wealth**	0.000	-0.59	0.000	2.02
Household constrained in income**	-0.208	-0.32	-4.512	-5.48
Year of housing purchase	0.254	1.17	0.039	0.34
Constant	-524.364	-1.17	-119.770	-0.51
Number of observations (using weights)	1,249,355		1,249,355	

Panel B

	Over Investment		Under Investment	
	Coefficient	t-statistic	Coefficient	t-statistic
Logarithm of the net wealth	3.374	7.48	-2.002	-8.97
Logarithm of household income	-1.103	-1.93	1.147	8.25
Difference between the log of desired housing value and the log of real housing value	11.299	8.12	-4.319	-23.78
Age of the head of household	0.102	3.84	0.005	0.70
Sex of the head of household*	-0.869	-3.38	1.056	7.56
Head of household has primary education**	-1.529	-12.75	0.087	0.36
Head of household has university education**	-1.907	-2.91	-0.101	-0.30
Head of household is self-employed**	0.231	0.40	-0.707	-3.88
Head of household is retired**	-0.151	-0.10	-1.807	-3.32
Head of household is unemployed or non-active**	1.021	4.75	0.629	1.80
Head of household works in the primary sector**	0.136	0.35	0.402	0.81
Head of household works in the tertiary sector**	-0.005	-0.04	0.057	1.00
Less sophisticated investor**	1.393	3.90	-0.470	-1.88
Highly sophisticated investors**	1.792	2.21	1.259	0.62
Household constrained in wealth**	0.000	0.95	0.000	-5.52
Household constrained in income**	-2.802	-2.96	1.472	5.20
Year of housing purchase	0.536	6.84	-0.135	-2.40
Constant	-1110.688	-6.88	286.829	2.53
Number of observations (using weights)	1,249,355		1,249,355	

Panel C				
	Over Investment		Under Investment	
	Coefficient	t-statistic	Coefficient	t-statistic
Logarithm of the net wealth	0.444	1.69	-2.272	-8.54
Logarithm of household income	0.063	0.30	0.752	4.75
Difference between the log of desired housing value and the log of real housing value	2.556	2.76	-5.239	-16.41
Age of the head of household	0.023	1.36	-0.005	-0.47
Sex of the head of household*	-0.708	-1.91	0.961	3.36
Head of household has primary education**	-0.244	-1.11	-0.244	-1.15
Head of household has university education**	-0.257	-1.96	0.471	1.43
Head of household is self-employed**	0.338	0.59	-1.167	-3.18
Head of household is retired**	0.232	0.25	-0.704	-0.79
Head of household is unemployed or non-active**	0.042	0.17	-0.076	-0.27
Head of household works in the primary sector**	-0.117	-0.56	0.182	0.40
Head of household works in the tertiary sector**	0.266	1.94	0.088	0.66
Less sophisticated investor**	0.121	0.53	-0.164	-0.57
Highly sophisticated investors**	2.523	7.08	-1.157	-2.42
Household constrained in wealth**	0.000	-0.27	0.000	-3.60
Household constrained in income**	-0.381	-0.98	1.570	4.60
Year of housing purchase	0.223	7.15	-0.370	-8.39
Constant	-454.164	-7.27	765.143	8.67
Number of observations (using weights)	1,249,355		1,249,355	

Figure 1: Timing for asset trade, consumption and interest earned

This figure illustrates the order of the different events. At the beginning of period t the interest earned from the portfolio between period t and t+1, which was determined on t-1, is paid out in advance. Then, the taste shock is realized. Given the taste shock, the household chooses consumption subject to its current liquidity constraint, and also the portfolio composition for next period. Then, the state of nature is realized. At the end of period t, the order is executed on the market, and thus, the portfolio composition on t+1 is determined.