NBER WORKING PAPER SERIES

MPC HETEROGENEITY IN EUROPE: SOURCES AND POLICY IMPLICATIONS

Miguel Ampudia
Russell Cooper
Julia Le Blanc
Guozhong Zhu

Working Paper 25082
http://www.nber.org/papers/w25082

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2018, Revised June 2019

Russell Cooper thanks the European Central Bank for supporting this research. Thanks to David Lander for research assistance on this project. Comments from Jirka Slacalek, Joao Cocco, Chris Carroll, Ernesto Pasten and participants at the HFCN meeting in Bratislava, the HFCN research workshop, the HEC meeting in Moscow, the Joint European Central Bank/Centre for Economic Policy Research Workshop on Household Heterogeneity in Macroeconomics, CREST, the Central Bank of Chile research seminar and the International Conference on Macroeconomic Analysis and International Finance are greatly appreciated. The views expressed in this paper are those of the authors and do not necessarily reflect the position of the European Central Bank, the Deutsche Bundesbank, or the National Bureau of Economic Research.

MPC Heterogeneity in Europe: Sources and Policy Implications
Miguel Ampudia, Russell Cooper, Julia Le Blanc, and Guozhong Zhu
NBER Working Paper No. 25082
September 2018, Revised June 2019
JEL No. E21,E52

ABSTRACT

This paper studies household financial choices in four euro area countries. The goal of the analysis is to understand the sources of the differences in these choices and their implications for the impact of monetary policy on consumption. The estimation of key parameters uses a simulated method of moments approach to match moments related to asset market participation rates, portfolio shares and wealth to income ratios by education and country. The policy functions based upon the estimation are used to characterize the distributions of the marginal propensity to consume across households for each of the four countries. Due to this heterogeneity in consumption responses, monetary policy, operating through its effects on household income and asset market returns, has a differential impact on individuals within and across countries. Generally, poor households respond more to the income variations produced by monetary policy innovations while rich households respond more to policy-induced variations in stock returns. Finally, monetary contractions have a larger impact on consumption in Germany and France while expansions have a larger impact in Italy and Spain.

Miguel Ampudia
Sonnemannstr. 20
60314 Frankfurt am Main
Germany
Miguel.Ampudia@ecb.int

Julia Le Blanc
Deutsche Bundesbank
Wilhelm Epstein Strasse 14
60431 Frankfurt am Main
Germany
julia.le.blanc@bundesbank.de

Russell Cooper
Department of Economics
European University Institute
Villa La Fonte
Via delle Fontanelle 18
I-50014 San Domenico di Fiesole (FI)
ITALY
and NBER
russellcoop@gmail.com

Guozhong Zhu
University of Alberta
Edmonton , Alberta
CANADA
guozhong@ualberta.ca

MPC Heterogeneity in Europe: Sources and Policy Implications *

Miguel Ampudia†, Russell Cooper‡, Julia Le Blanc§, and Guozhong Zhu¶

June 18, 2019

Abstract

This paper studies household financial choices in four euro area countries. The goal of the analysis is to understand the sources of the differences in these choices and their implications for the impact of monetary policy on consumption. The estimation of key parameters uses a simulated method of moments approach to match moments related to asset market participation rates, portfolio shares and wealth to income ratios by education and country. The policy functions based upon the estimation are used to characterize the distributions of the marginal propensity to consume across households for each of the four countries. Due to this heterogeneity in consumption responses, monetary policy, operating through its effects on household income and asset market returns, has a differential impact on individuals within and across countries. Generally, poor households respond more to the income variations produced by monetary policy innovations while rich households respond more to policy-induced variations in stock returns. Finally, monetary contractions have a larger impact on consumption in Germany and France while expansions have a larger impact in Italy and Spain.

1 Motivation

Heterogeneity matters for the analysis of monetary policy. Focusing on four euro area countries, Germany, Spain, France and Italy, this paper studies how *ex ante* heterogeneity in income and education of households leads to *ex post* heterogeneity in financial choices, which in turn generates differential responses to income shocks and asset return shocks induced by monetary policy. Low income, low education households have the largest consumption response to income changes induced by monetary interventions. High income, high education households also respond to monetary policy through induced changes in asset returns. This pattern of responses is common across countries.

*Russell Cooper thanks the European Central Bank for supporting this research. Thanks to David Lander for research assistance on this project. Comments from Jirka Slacalek, Joao Cocco, Chris Carroll, Ernesto Pasten and participants at the HFCN meeting in Bratislava, the HFCN research workshop, the HEC meeting in Moscow, the Joint European Central Bank/Centre for Economic Policy Research Workshop on Household Heterogeneity in Macroeconomics, CREST, the Central Bank of Chile research seminar and the International Conference on Macroeconomic Analysis and International Finance are greatly appreciated.

†European Central Bank, Miguel.Ampudia@ecb.int

‡Department of Economics, the Pennsylvania State University, the European University Institute and the NBER, russellcoop@gmail.com

§Deutsche Bundesbank, Julia.Le.Blanc@bundesbank.de

¶School of Business, University of Alberta, guozhong@ualberta.ca

There are three steps in the analysis. First is the estimation of household preferences, stock market participation costs and portfolio adjustment costs by education and country. The estimation uses a simulated method of moments approach based on on a life-cycle model of household financial choice. The model includes both stock market participation and portfolio adjustment decisions. Both of these discrete choices are relevant for understanding household financial decisions.[1]

The second step is the characterization of the distributions of the marginal propensity to consume (MPC) across heterogeneous households by country.[2] This distribution is obtained by simulating the response to income and return shocks using the estimated household-level policy functions. The resulting country-specific MPC distributions are used as inputs in the monetary policy analysis with heterogeneous households facing stock market participation and adjustment frictions.[3]

Finally, the estimated model is used to study the impact of monetary policy on consumption. Similar to Kaplan, Moll, and Violante (2018) and Auclert (2017), a monetary policy innovation influences consumption through (non-asset) income and stock market returns.[4] Given the heterogeneity across households within a country, there is a non-degenerate distribution of consumption response. Joint with the distribution of heterogeneous households, this differential response generates a country specific MPC distribution. The distribution itself will depend on both the nature of monetary shock and its magnitude. The latter point arises from the nonlinear response of households to income and return shocks. Monetary policy will consequently have distributional effects in terms of households' income and wealth as in Ampudia, Georgarakos, Slacalek, Tristani, Vermeulen, and Violante (2018), Casiraghi, Gaiotti, Rodano, and Secchi (2018) and Coibion, Gorodnichenko, Kueng, and Silvia (2017).

We find that the main effects of monetary policy on consumption are largely channeled through relatively poor (low income) households. This reflects two factors: (i) the income of poor households reacts more intensively to monetary shocks and (ii) it is precisely these households who have the largest marginal propensity to consume (MPC). But this response of consumption induced by income variations is very much country specific, in part because the income response to monetary shocks is not uniform across countries.

There is an additional stock return channel, operating through the effects of monetary innovations on stock prices. This channel clearly only influences the consumption of asset market participants. This is where the differences in asset market participation rate across countries is relevant. Although these households have more modest MPCs out of financial income, there is nonetheless a consumption response through this channel.

Put together, these channels induce a U-shaped consumption response to monetary shocks relative to the income distribution. Both the lowest and highest income level households respond to monetary policy more than the middle income households. This is seen most clearly in Germany and France as shown in Table 16.

Finally, we present evidence of non-linearity in terms of consumption response to monetary shocks. In particular,

[1] A discussion of our results relative to the literature is postponed until the presentation of our estimates.

[2] Carroll, Slacalek, and Tokuoka (2014) look across EU countries and generate an MPC distribution in an alternative setting which does not emphasize participation and adjustment frictions. Their focus is on the relationship between the wealth distribution and the aggregate MPC.

[3] A leading example in the European context would be Kaplan, Violante, and Weidner (2014). Guerrieri and Mendicino (2018) estimate the MPC across euro area countries from quarterly Household Sector Report data and conclude that the cross-country averages of MPC out of financial wealth are between 0.7 and 4.5 cents per euro.

[4] Another important element, emphasized in Hintermaier and Koeniger (2018) is homeownership status.

monetary contractions have a larger impact in Germany and France while monetary expansions have a larger impact in Italy and Spain.

Relative to existing studies, our paper makes several advances. First, household preference parameters, asset market participation costs and adjustment costs are estimated by country. Second, the distribution of MPCs is generated by the estimated model, not from auxiliary regressions. Third, the effects of monetary innovations on income and returns that are inputs into the estimated household model are themselves estimated from the data. In this sense, our analysis is data consistent. This approach allows us, among other things, to display the full dynamic response of consumption across heterogeneous households to monetary innovations, although we do not present a dynamic equilibrium model that generates endogenous responses of household income and asset return to monetary shocks.

The rest of the paper is organized as follows. Section 2 presents basic data facts. Section 3 introduces the life-cycle optimization problem of households. Section 4 shows the exogenous processes that are used as input in the model, as well as the moments used to identify key model parameters. Section 5 discusses the results of structural estimation. Section 6 studies MPC distributions of the four countries, and section 7 quantitatively evaluates the effects of monetary policy on consumption. Section 8 concludes and provides a discussion of potential future studies.

2 Data Facts

This section presents facts about household financial decisions in Germany, Spain, France and Italy. The data come from the Household Finance and Consumption Survey for the 2008-2010 period.[5] As shown in Table 1, we focus on the financial portfolio of the household and its relation to income defined as the labor income of a household plus transfers from the government (e.g. unemployment benefits). Participation is defined as the holding of stocks, either directly or indirectly. There are three alternative measures of participation: (i) direct holdings of stocks, (ii) direct holdings plus mutual funds invested mainly in stocks and (iii) adding pension plans to (ii). So (ii) and (iii) are lower and upper bounds for indirect stock market participation, respectively. For each of these measures, a stock share is reported, which is computed conditional on participation in asset markets. The table also displays two definitions of the wealth to income ratio, one in which wealth includes housing and another in which it does not. For most of the subsequent analysis, wealth is defined as financial assets, excluding housing. The moments are presented by education group: college or no college attainment.

This section presents facts about household financial decisions in Germany, Spain, France and Italy. The data come from the Household Finance and Consumption Survey for the 2008-2010 period.[6] As shown in Table 1, we focus on the financial portfolio of the household and its relation to income defined as the labor income of a household plus transfers from the government (e.g. unemployment benefits). Participation is defined as the holding of stocks, either directly or indirectly. There are three alternative measures of participation: (i) direct holdings of stocks,

[5] See `https://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_hfcn.en.html`.
[6] See `https://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_hfcn.en.html`.

(ii) direct holdings plus mutual funds invested mainly in stocks and (iii) adding private pension plans invested in stocks to (ii). So (ii) and (iii) are lower and upper bounds for indirect stock market participation, respectively. For each of these measures, a stock share is reported, which is computed conditional on participation in asset markets. The table also displays two definitions of the wealth to income ratio, one in which wealth includes housing and another in which it does not. For most of the subsequent analysis, wealth is defined as financial assets, excluding housing. The moments are presented by education group: college or no college attainment.

Table 1: Household Finance Facts by Education across Countries

	Germany		**Spain**		**France**		**Italy**	
edu	low	high	low	high	low	high	low	high
part. direct	6.4	19.9	6.5	21.3	11.6	24.7	3.8	10.5
share	18.9	19.2	26.8	26.9	22.7	23.1	28.0	20.5
part. indirect	9.5	31.5	7.0	22.5	13.0	28.2	4.7	12.8
share	12.8	12.1	28.2	28.4	23.2	23.6	30.5	24.0
part. indirect max	45.4	66.7	23.2	47.0	39.2	56.0	19.5	36.0
share	50.0	44.7	50.8	45.1	50.0	44.5	47.3	37.6
WI	0.350	0.749	0.180	0.399	0.303	0.552	0.287	0.519
WI(h)	1.038	3.133	8.039	7.650	4.113	4.794	5.563	6.064
avg. age	52.5	53.0	54.4	47.0	54.8	43.7	56.7	51.0
sample size	2085	1480	3988	2209	10833	4173	7013	938

This table displays the participation rate in stocks (defined in three different ways, row 1: direct, row 3: stocks plus mutual funds invested mainly in stocks and row 5: stocks, mutual funds invested mainly in stocks plus private pension plans), the share of stocks over total liquid assets (for participants), the median wealth income ratio, with and without housing (h) for households in each country by educational attainment, low (no college) and high (college). Standard errors for these moments are shown in Table 17. Data source: the HFCS.

Participation rates in stocks are well below 100% in all countries. Direct participation is very low, particularly for the low education groups. These rates are somewhat higher for college graduates, but still range between 11%-25%. Indirect participating rates are higher, in particular when we include pensions. Still, there is wide dispersion across country/education level groups: participation is less than 20% in Italy for the low education group and reaches almost 67% in Germany for college graduates.

For the broadest measure of participation, the stock share averages between 40% and 50%. There are not large differences across countries. Further, differences between the two education groups are small, with households without a college degree holding larger shares than college educated ones. Note that this share is much larger than that computed using either the direct or direct plus mutual fund holdings of households.

The median financial wealth to income ratio is less than 1 for all countries and is higher for the higher education groups. The increase in the wealth to income ratio when (gross) home equity is included is much larger in Italy and Spain, countries with higher homeownership rates. Within countries, the difference across education groups in the wealth to income ratio including housing is small except for Germany, and in Spain this ratio is higher for the low education group.

These are important features that a model of household finance must take into account. The model does so by

introducing two frictions into the standard life-cycle model: a cost of asset market participation and a portfolio adjustment cost.

The literature on stock market participation has concluded that some level of fixed costs are necessary to improve the empirical fit of life-cycle models. For example, Vissing-Jorgensen (2002), Gomes and Michaelides (2005), Alan (2006) and Cooper and Zhu (2015) study life-cycle models with portfolio choice and fixed stock market entry cost to explain the low stock market participation rates and/or moderate equity holdings of stock market participants. Christelis, Georgarakos, and Haliassos (2013) study the differences in portfolios across countries. The articles in Guiso, Haliassos, and Jappelli (2003) provide a first look into differences in portfolios across countries.

Our analysis is motivated by these same dimensions of household financial decisions. But our approach and hence insights differ both due to the emphasis on estimation of key parameters and the consequent use of these estimates for policy evaluation.

3 Household Dynamic Optimization

The dynamic optimization model for the households is a modified version of that presented in Cooper and Zhu (2015). A key element is the presence of non-convexities due to both participation and adjustment costs.[7] A household works for T^r periods and survives up to $T > T^r$ periods. The two phases of life are distinguished by income risk. Income is stochastic during working life. Once the households retires, income is deterministic and country-specific.

The household optimization problem entails a number of decisions. First, there is the choice of asset market participation.[8] Second, conditional on participating the agent can choose whether or not to adjust the portfolio, i.e. to change the amount of investment in the stock market. In the case of non-adjustment, we assume the return on stocks is automatically reinvested. Finally, there is a continuous choice over consumption and saving.

It is important to note that the model excludes durable goods, particularly housing.[9] The effects of home ownership are controlled in the regression that generates the moments we match. Adding housing separately as another state variable is computationally very burdensome. There are alternatives. Kaplan, Moll, and Violante (2018) include housing in illiquid assets, assuming households hold a fixed fraction of total illiquid assets as housing. This approach makes asset market participation and home ownership, as well as trading frictions, difficult to separate. Cooper and Zhu (2015) treat housing as bond holdings (their section 5.2.1) which does separate home and stock ownership but ignores costs of trading houses.

The optimization problem discussed below is generic. The indices indicating country and education level are dropped. It is understood that the exogenous income process is both country and education specific. Further, the parameters to be estimated are country specific as well.

[7] Kaplan, Moll, and Violante (2018) includes a version of these frictions while Auclert (2017) does not.

[8] The model abstracts from the distinction between direct and indirect holdings of stocks, and thus participation can be understood in its broadest sense, i.e., including both direct and indirect participation.

[9] In contrast, Hintermaier and Koeniger (2018) emphasizes homeownership differences across countries and links these with monetary policy effects. The model includes adjustment costs for housing. The model does not focus on asset market participation and portfolio adjustment as in our model.

3.1 Participants

$\Omega = (y, A)$ represents the current state of the household where y is current labor income and $A = (A^b, A^s)$ is the current value of the holdings of bonds and stocks respectively. A household that is currently holding stocks, i.e. $A^s > 0$, is a participant and chooses between (i) portfolio adjustment, (ii) no portfolio adjustment and (iii) exiting the asset markets by selling all stocks. The discrete choice of an age t household is given by:

$$v_t(\Omega) = \max\{v_t^a(\Omega), v_t^n(\Omega), v_t^x(\Omega)\} \tag{1}$$

for all states Ω.

A household choosing to adjust the portfolio selects the amount of stocks and bonds to solve:

$$v_t^a(\Omega) = \max_{A^{b'} \geq \underline{A}^b, A^{s'} \geq 0} \left\{ (1-\beta)c^{1-1/\theta} + \beta \left[(1-\nu_{t+1}) \left(E_t v_{t+1}(\Omega')^{1-\gamma} \right)^{\frac{1}{1-\gamma}} + \nu_{t+1} \left(E_t B(A')^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \right]^{1-1/\theta} \right\}^{\frac{1}{1-1/\theta}} \tag{2}$$

s.t.

$$c = y + TR + \textstyle\sum_{i=b,s} R^i A^i - \sum_{i=b,s} A^{i'} - F \tag{3}$$

$$A' = R^b A^{b'} + R^{s'} A^{s'} \tag{4}$$

$$TR = \max\{0, \underline{c} - (y + \textstyle\sum_{i=b,s} R^i A^i)\}. \tag{5}$$

where the expectation is taken with respect to future income and asset returns. The probability of surviving to the next period is ν_{t+1} which depends on both age and, implicitly, the education of the agent. There is a consumption floor of $\underline{c}$ representing a transfer from the government to the household.[10] Following Epstein and Zin (1989) and Weil (1990) we assume a recursive utility representation.[11] Here γ captures the attitude of the agent towards risk and θ parameterizes the substitution effects of a change in the real interest rate. With this specification, the two key aspects of household choice are estimated independently.

$B(A')$ in (2) is the value of leaving a bequest of size w', including the liquidated value of stocks as shown in equation (4). The household chooses a bequest portfolio without knowing the stock return that will determine the full value of the inheritance. The bequest function is given by:

$$B(A') = L(\phi + w'). \tag{6}$$

The curvature over the bequests, parameterized by γ, appears through (2). Here $\phi > 0$ allows for $w' = 0$ while keeping $B'(0)^{1-\gamma}$ a finite number.

In this problem, there is a lower bound to bond holdings, $\underline{A}^b$, which is estimated along with other parameter values via simulated method of moments. When this lower bound is binding, households are liquidity constrained.

[10] This feature of the model is taken from Hubbard, Skinner, and Zeldes (1995) and DeNardi, French, and Jones (2010). In the empirical implementation, this floor includes transfers beyond UI and those transfers included in the income measure. Based upon the results reported in Cooper and Zhu (2015) the consumption floor is important for matching the wealth income ratios of low education households.

[11] As reported in Cooper and Zhu (2015), a recursive utility formulation fits the moments for the US best.

Note that this constraint can bind for participants who have illiquid stock holdings so that these (rich) agents too are liquidity constrained. Short sales of stocks are not allowed.

The F in equation (3), the budget equation, represents the cost of portfolio adjustment which includes fees paid as well as time costs incurred. In Bonaparte, Cooper, and Zhu (2012) and Cooper and Zhu (2015), this cost is used, in part, to match portfolio adjustment rates. But no data exists on adjustment rates for the asset market participants in our sample countries. This parameter is identified through portfolio composition: a high value of F discourages households to participate in asset markets or lower the share of stocks in total wealth for participants, thus helping to match these aspects of the data for each country. As discussed further below, this illiquidity of stock investment can create a high MPC even for wealthy households.

If the household chooses not to adjust its portfolio, then the cost F is avoided and there is re-optimization over consumption and bond holdings. The household chooses bonds to maximize:

$$v_t^n(\Omega) = \max_{A^{b\prime} \geq \underline{A}^b} \left\{ (1-\beta)c^{1-1/\theta} + \beta \left[(1-\nu_{t+1}) \left(E_t v_{t+1}(\Omega')^{1-\gamma} \right)^{\frac{1}{1-\gamma}} + \nu_{t+1} \left(E_t B(A')^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \right]^{1-1/\theta} \right\}^{\frac{1}{1-1/\theta}}$$

s.t.

$$c = y + TR + R^b A^b - A^{b\prime}$$
$$A^{s\prime} = R^s A^s$$
$$A' = R^b A^{b'} + R^{s'} A^{s'}$$
$$TR = \max\{0, \underline{c} - (y + \textstyle\sum_{i=b,s} R^i A^i)\}.$$

Here we assume that if there is no portfolio rebalancing, any return on stocks is automatically put into the stock account, i.e. $A^{s\prime} = R^s A^s$.

A household currently participating may choose to end its stock holdings. Though there is no flow cost of participating, a household will exit asset markets when a large shock leads to the liquidation of stock holdings. The value from exiting the asset markets is given by:

$$v_t^x(\Omega) = \max_{A^{b\prime} \geq \underline{A}^b} \left\{ (1-\beta)c^{1-1/\theta} + \beta \left[(1-\nu_{t+1}) \left(E_t w_{t+1}(\Omega')^{1-\gamma} \right)^{\frac{1}{1-\gamma}} + \nu_{t+1} \left(E_t B(A')^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \right]^{1-1/\theta} \right\}^{\frac{1}{1-1/\theta}}$$

s.t.

$$c = y + TR + \textstyle\sum_{i=b,s} R^i A^i - A^{b\prime}$$
$$A' = R^b A^{b'} + R^{s'} A^{s'}$$
$$TR = \max\{0, \underline{c} - (y + \textstyle\sum_{i=b,s} R^i A^i)\}.$$

where $w_{t+1}(\Omega')$ denotes the value function of stock market non-participants given the future state Ω'.

3.2 Non-Participants

A household currently not holding stocks can, at a cost, enter into asset markets. Or the household can remain a non-participant. The values for this decision are given by:

$$w_t(\Omega) = \max\{w_t^n(\Omega), w_t^p(\Omega)\} \tag{7}$$

for all Ω.

Even if the household remains a non-participant, it can adjust its bond account in response to income shocks. The optimization problem of a non-participant choosing not to enter the asset markets is:

$$w_t^n(\Omega) = \max_{A^{b\prime} \geq \underline{A}^b} \left\{ (1-\beta)c^{1-1/\theta} + \beta \left[(1-\nu_{t+1}) \left(E_t w_{t+1}(\Omega')^{1-\gamma} \right)^{\frac{1}{1-\gamma}} + \nu_{t+1} \left(E_t B(A')^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \right]^{1-1/\theta} \right\}^{\frac{1}{1-1/\theta}} \tag{8}$$

for all Ω. The budget constraints are:

$$\begin{aligned} c &= y + TR + R^b A^b - A^{b\prime} \\ A' &= R^b A^{b'} \\ TR &= \max\{0, \underline{c} - (y + R^b A^b)\} \end{aligned}$$

If a household switches its status and decides to purchase stocks, it must pay an entry cost of Γ. There is no lag so that the household can instantaneously trade in the stock market. The value from participating is given by:

$$w_t^p(\Omega) = \max_{A^{b\prime} \geq \underline{A}^b, A^{s\prime} \geq 0} \left\{ (1-\beta)c^{1-1/\theta} + \beta \left[(1-\nu_{t+1}) \left(E_t v_{t+1}(\Omega')^{1-\gamma} \right)^{\frac{1}{1-\gamma}} + \nu_{t+1} \left(E_t B(A')^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \right]^{1-1/\theta} \right\}^{\frac{1}{1-1/\theta}} \tag{9}$$

subject to the following constraints:

$$\begin{aligned} c &= y + TR + R^b A^b - A^{b\prime} - A^{s\prime} - \Gamma \\ A' &= R^b A^{b'} + R^{s'} A^{s'} \\ TR &= \max\{0, \underline{c} - (y + R^b A^b)\}. \end{aligned}$$

It is noteworthy that the future value in equation (9) is denoted by $v_{t+1}(\Omega')$ which is the value function of stock market participants given the future state Ω'.

4 Quantitative Approach

There are two stages in the estimation. First, income and return processes, by country, are estimated directly from micro data. These processes are used as inputs to solve the household optimization problem so that conditional

expectations of exogenous variables are consistent with the data.

Second, the parameters, $\Theta \equiv (\beta_i, \gamma, \Gamma, F, L, \phi, \underline{c}, \theta, \underline{\underline{A}}^b)$ which characterize households in a country are estimated via the simulated method of moments. The discount factor, β_i, is indexed by education attainment, $i = 0, 1$, for no college and college respectively.[12] The vector Θ is chosen to solve:

$$\pounds = min_{\Theta}(M^s(\Theta) - M^d)W(M^s(\Theta) - M^d)'. \tag{10}$$

Here W is a weighting matrix calculated as the inverse of the variance-covariance of the moments taken from Table 17. The simulated moments, $M^s(\Theta)$, are calculated from a simulated data set created by solving the household optimization problem. For each country, the initial distribution of asset holdings, needed as an input into the computation of moments, is taken from the data.

4.1 Income Process

We estimate household income processes using the European Community Household Panel (ECHP) during the period of 1994-2001 (8 waves). The ECHP is a panel survey collecting internationally comparable data on income and demographics of a representative sample of households year after year in several euro area countries.[13] Our income measure is defined as total reported after-tax, non-asset household income. This definition includes labor income received by the household head and all other members of the household, such as income from work (wages, salaries and self-employment earnings) and social cash transfers (government transfers, workers compensation, unemployment insurance and old-age pensions), net of any taxes and social contributions paid. We use a broad definition of labor income to allow for insurance mechanisms other than asset accumulation within each country, such as unemployment benefits and other welfare programs present in the European countries we consider. Including only labor income would overstate the variability in income that households face while including also financial asset and capital income would understate the risk coming from earnings.[14] Income from the ECHP relates to the year immediately preceding the survey (e.g. 2000 for wave 8 conducted in 2001), whereas the household composition and the sociodemographic characteristics of household members are those registered at the moment of the interview. To ensure international comparability, income data are PPP-adjusted.[15]

[12] From Cooper and Zhu (2015) differences in discounting across education groups was important in explaining financial choices.

[13] In 2001, the ECHP was discontinued, and since 2004, replaced by the EU Statistics on Income and Living Conditions (EU-SILC), a survey which covers similar topics but is not suitable for our analysis due to its different design. Note that the exposition of the estimation of labour income processes follows closely Le Blanc and Georgarakos (2013).

[14] There are other important insurance mechanisms that our definition does not capture, namely: receipts in kind, transfers paid to and received from other households, negative capital income and imputed rents (i.e. the money value by not having to pay full market rent by living in one's own accommodation) The latter could be meaningful in particular in the Southern European countries where home ownership rates are high.

[15] We exclude all households whose heads are younger than 20 years of age, that report annual income smaller than zero euro, that have any crucial variable missing or who have not participated for at least two years in the survey.

4.1.1 Profiles

As the slope of the deterministic income profiles and the risk properties of labor income differ by education, we split households in each country into a subsample of households whose head has a college degree and a subsample of households with a head without college degree.[16] For each education group and country, data from various years are pooled together. We then regress log income on household characteristics, an age polynomial of order three and either cohort or time effects. As age, time and birth year are perfectly correlated, we estimate age-income profiles controlling for time effects and assume that cohort effects are fixed:[17]

$$log(Y_{it}) = const. + polynomial(age_{it}) + HHComp_{it} + Time_t. \tag{11}$$

Household composition, $HHComp_{it}$, includes the number of children in the household, the number of dependent adults, the number of heads in the household and time dummies. The ECHP population weights are used in the regression equation (11).[18]

For each country and education group, we estimate this equation twice, once for households in the labor force and once for households above age 65. We assume for now that retirement takes place exogenously at age 65, the statutory retirement age in all countries, which makes the profiles comparable over all ages. To obtain smoothed age-income profiles suitable as ingredients into the model, we fit a cubic age polynomial for our pre-retirement regression and assume that income is linear in age for the post-retirement period.[19]

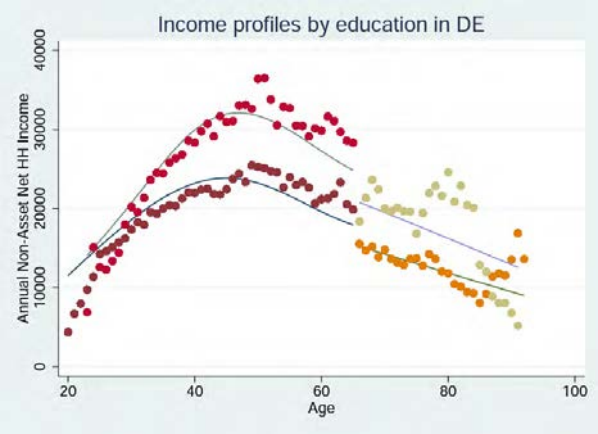
[16] Ideally, one would define smaller education groups depending on number of years in schooling (see e.g. Cooper and Zhu (2015), Laibson, Repetto, and Tobacman (2001)) or differentiate by highest degree obtained (no high school, high school, college), see e.g. Cocco, Gomes, and Maenhout (2005), Hubbard, Skinner, and Zeldes (1994). Unfortunately, this would make the number of observations in some cells too small.

[17] We also estimated a version of the same equation including cohort instead of time effects. The shapes, levels and growth rates of these estimations are very similar to our profiles. We therefore conclude that our specification is robust to using cohort or time effects.

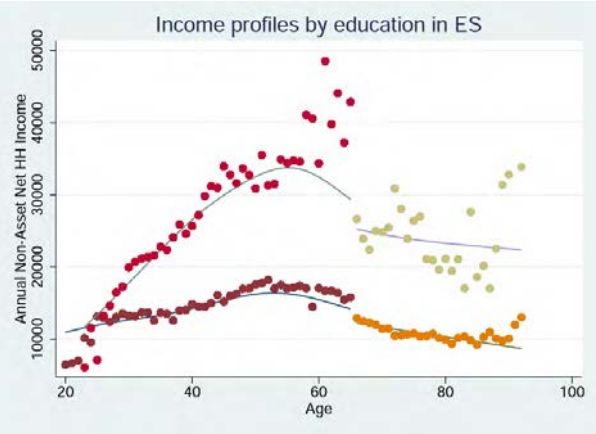
[18] Unweighted results are essentially the same.

[19] Note that the retirement period is left out by most papers and many authors assume a flat income scheme after retirement, e.g. Cocco, Gomes, and Maenhout (2005). We find the resulting age-decreasing pattern more plausible.

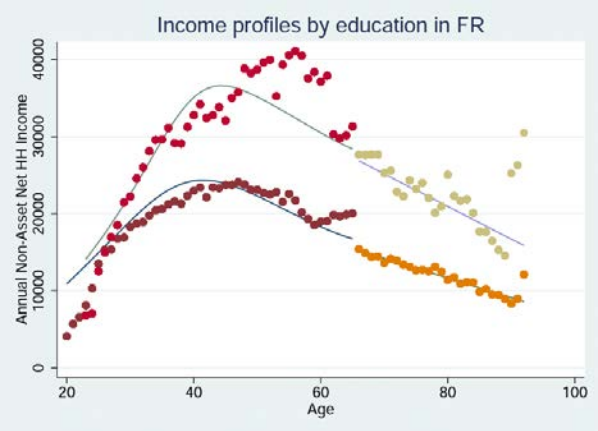
Figure 1: Age-Income Profiles



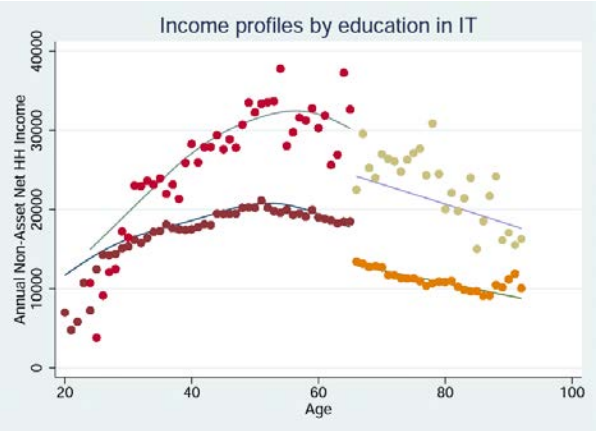
(a) Germany



(b) Spain



(c) France



(d) Italy

The figures display fitted household income over the life-cycle for those headed by college graduates and those whose heads do not have a college degree. We fit a cubic age polynomial for our pre-retirement regression and assume a linear relation between income and age for the post-retirement period. The higher curve represents higher education households in all countries.

The resulting profiles illustrate age and education-specific variations in expected income over the life-cycle for a household that has a typical life-cycle evolution in household size and has a typical time effect.[20]

Figure 1 displays the fitted (exponentiated) values of the income predictions for each education group and each country. The dots around the lines in Figure 1 represent the means of observed household income by age, suggesting that we fit the data reasonably well.

The resulting age-income profiles display heterogeneity with respect to both the steepness and peaks of the income profiles. After a sharp increase in the beginning of working life, income for college graduates peaks in mid-working life in Germany and France. Households whose heads are without a college degree present relatively

[20]For details on the exact regressions and robustness checks of the income profiles see Le Blanc and Georgarakos (2013) and the literature therein.

flat profiles at a lower level than college graduates, reflecting the college premium. In the two Southern countries income of college graduates grows slowly until it reaches a peak late in working life, around age 55 to 60 when the income of households within the same education group already decreases in Germany and France. Households without a college degree in Italy and Spain have on average an even flatter income profile that hardly grows over the life-cycle. The gap between employment income and retirement income varies across countries, reflecting the different generosity of the pension systems and other transfers after retirement. In particular, in Italy and Spain, reaching retirement age is connected to a large loss in income.

4.1.2 Stochastic Components

We use the variation in log income residuals from our estimation of the country- and education-specific income profiles from equation (11) to characterize the uncertainty of earnings over the life-cycle. Following Carroll (1992), Guvenen (2009), Laibson, Repetto, and Tobacman (2001), among others, assume that the log income residuals, $\tilde{y}_{i,t}$, reflect income shocks and follow the stochastic process given by:

$$\begin{aligned} \tilde{y}_{i,t} &= z_{i,t} + \epsilon_{i,t} \\ z_{i,t} &= \rho z_{i,t-1} + \eta_{i,t} \end{aligned} \tag{12}$$

where $\epsilon_{i,t}$ and $\eta_{i,t}$ are independent zero-mean random shocks, with variance σ_ϵ^2 and σ_η^2 respectively. The shock $\eta_{i,t}$ is persistent, with a persistence parameter of ρ.

The identification of the structural parameters in equation (12), i.e. $(\sigma_\epsilon^2, \sigma_\eta^2, \rho)$, is achieved by minimizing the distance between the theoretical and the empirical autocovariances of the process using an iterative process that employs an optimal weighting matrix, as proposed by Hansen (1982) and Chamberlain (1984).[21]

Table 2 displays the estimates of the variances of the persistent and transitory shocks and the persistence parameter by education level for each country. Over the whole sample, households in Germany face the lowest persistence of income shocks ($\rho = 0.91$) while Italian and French households have highly persistent shocks (ρ =0.98 and 0.96 respectively). Permanent shocks to income are lower for college graduates than for non-college educated households. This is consistent with the notion that shocks to more educated households are small but they could be very persistent as their human capital is more specific. Also, the transitory component of income is usually lower for households with a college degree (with the exception of France). College graduates Germany display low permanent and transitory shocks. In Italy and Spain, lower educated households face large and very persistent permanent shocks.[22]

[21] In particular, we use a Generalized Method of Moments (GMM) estimator to minimize the distance between the theoretical and empirical autocovariances which has the advantage of requiring strong distributional assumptions while still achieving asymptotic efficiency. For details about moments construction and the estimation method, see Le Blanc and Georgarakos (2013) and Guvenen (2009).

[22] On interpretation of this result is that the economic expansion that started roughly 10 years before the first wave of our data set (in particular in Spain but also in Italy) mostly benefited the more educated while permanent income uncertainty increased for the less educated.

Table 2: Stochastic Processes by education and country

	Germany			Spain		
	ρ	σ^2_η	σ^2_ϵ	ρ	σ^2_η	σ^2_ϵ
No college	0.895***	0.022***	0.016***	0.951***	0.092***	0.016***
	(0.005)	(0.001)	(0.001)	(0.007)	(0.004)	(0.002)
College	0.937***	0.020***	0.011***	0.986***	0.058***	0.004**
	(0.008)	(0.001)	(0.001)	(0.007)	(0.004)	(0.002)
	France			Italy		
	ρ	σ^2_η	σ^2_ϵ	ρ	σ^2_η	σ^2_ϵ
No college	0.971***	0.031***	0.006*	0.944***	0.072***	0.020***
	(0.014)	(0.006)	(0.003)	(0.005)	(0.003)	(0.002)
College	0.941***	0.023***	0.018***	0.921***	0.029***	0.022***
	(0.007)	(0.003)	(0.002)	(0.016)	(0.01)	(0.006)

Robust standard errors in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$
The model is $\tilde{y}_{i,t} = z_{i,t} + \epsilon_{i,t}$; $z_{i,t} = \rho z_{i,t-1} + \eta_{i,t}$ where $\tilde{y}_{i,t}$ is the logarithm of after-tax, after unemployment benefits, non-capital income of the household head and spouse (if present), net of the predictable part of income. The regression includes year dummies. The error structure is estimated by optimally weighted GMM, minimizing the distance between the theoretical and the empirical first six autocovariances (including the autocovariance of lag 0, i.e. the cross-sectional variance). The reported variances are pooled over the sample period and over cohorts.

4.2 Asset Returns

The real return on bonds is non-stochastic and is set at 2% for all countries. The real return on stock investment, including both dividends and capital gains, is assumed to be i.i.d. at annual frequency, with the return shocks normally distributed. The mean and standard deviation of stock return shocks for each country are given by the following table.

Table 3: Stock Return Processes

	mean	standard deviation
Germany	0.085	0.310
Spain	0.078	0.245
France	0.092	0.291
Italy	0.046	0.290

This table reports the mean and standard deviations of real stock return by country between 1930-2012.

The annual mean return ranges from a low of 4.6% in Italy to twice that in France. The standard deviation is about the same across countries. To be clear, these are returns by country not by household residing in a country. Given the amount of home bias existing in these households' portfolios, this distinction is not very important.[23]

[23]That said, an extension of the model that distinguishes between participation in home vs foreign markets could be of interest in smaller very open economies. Unfortunately, the participation measure in the HFCS data does not distinguish between home and foreign markets.

4.3 Moments

The moments for the structural estimation are shown in the left panel of Table 4.[24] The moments come from country specific regressions of a particular household financial variable on a constant, age, age-squared, a dummy for better education that is set to one for college graduates, and home equity and homeownership status to control for housing which is outside the structural model. Thus the moments used for the estimation go beyond the summary moments presented in Table 1 by allowing the dependence of financial decisions on age and educational attainment.

As the model lacks a distinction between direct and indirect holdings, the participation is taken as the broadest measure and thus includes all types of indirect holdings, as discussed in section 2. As noted earlier, throughout, wealth refers to financial wealth.

A couple of points stand out. Education matters for households' financial decisions. It has a significant positive association with participation and a negative association with stock share in all countries. Further, both participation and the stock share exhibit a significant hump-shape in all countries. Finally, the wealth-income ratio is increasing with age in all four countries. The shape is convex in Germany and France and concave in Spain and Italy. An increase in education increases the wealth income ratio in all countries except Italy. For Italy, the wealth income ratio falls with education up to age 55.

Table 4: Data and Model Moments

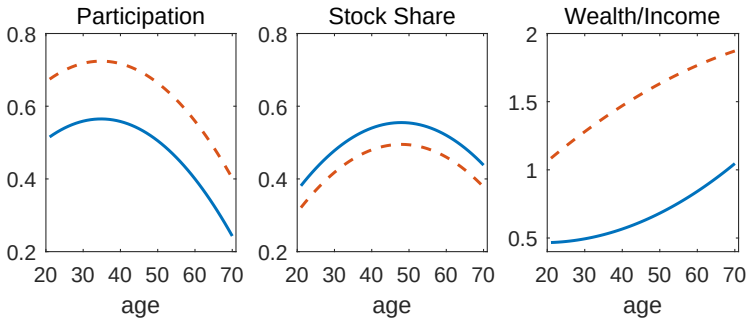
	con.	age	age^2	$college$ $(*age)$	$college$ $*age^2$	con.	age	age^2	$college$ $(*age)$	$college$ $*age^2$
			Germany: Data					Germany: Model		
Part.	0.250	0.018	-0.00026	0.159		0.276	0.0157	-0.00014	0.164	
Share	0.004	0.023	-0.00024	-0.060		0.025	0.0235	-0.00023	-0.062	
W/I	0.542	-0.008	0.00022	0.037	-0.00036	1.143	-0.0326	0.00031	-0.041	0.000929
			Spain: Data					Spain: Model		
Part.	-0.716	0.035	-0.00034	0.161		-0.475	0.0376	-0.00029	0.210	
Share	-0.116	0.026	-0.00025	-0.049		-0.076	0.0273	-0.00025	-0.042	
W/I	-1.675	0.065	-0.00036	0.013	0.00012	1.227	-0.0246	0.00024	-0.071	0.00158
			France: Data					France: Model		
Part.	-0.090	0.015	-0.00013	0.148		-0.020	0.0235	-0.00016	0.161	
Share	0.056	0.013	-0.00007	-0.017		0.052	0.0102	-0.00009	-0.017	
W/I	1.344	-0.050	0.0007	-0.004	0.0003	2.753	-0.1060	0.00124	-0.092	0.002534
			Italy: Data					Italy: Model		
Part.	-0.117	0.014	-0.00017	0.089		-0.694	0.0413	-0.00032	0.234	
Share	0.225	0.015	-0.00016	-0.082		0.201	0.0137	-0.00014	-0.079	
W/I	-0.062	0.023	-0.00018	-0.023	0.00042	-0.635	0.0416	-0.00039	-0.016	0.00035

This table reports data and model moments from regressing financial choices on household characteristics by country. Each regression controls for home equity and homeownership status.

To illustrate the life-cycle aspects of these moments, Figure 2 shows the age-profile of these moments for Germany for the two education groups. There are slight hump-shapes in participation and the stock share. And

[24] The standard errors are reported in Table 17.

Figure 2: Graphical Presentation for Household Finance Moments in the Data (Germany)



This figure shows the average profiles of stock market participation, stock share in wealth and the wealth to income ratio by education for Germany. The high education group is indicated by the broken curves and the low education group by the solid curves.

both are well below 100%. The wealth income ratio is increasing for the high education group and has a slight dip for the low education group

To be clear, these moments summarize patterns in the data. Understanding the features of preferences and the shocks that drive these patterns will come through the estimation of the household dynamic optimization model.

5 Results

The moments from the estimated model are reported in the right panel of Table 4 and the parameter estimates appear in Table 5. The latter table includes a goodness of fit measure, computed using (10).

5.1 Preference Parameters

As Cooper and Zhu (2015) found for the US, the discount factor is considerably lower than the conventional value of 0.95 but in line with models of buffer stock saving like Deaton (1991). It averages about 0.80 for the low education group, and it increases with educational attainment. The estimates range from 0.857 in Germany to 0.873 in Italy for the high education group. An important role for the discount factor is to limit the accumulation of savings to match the wealth income ratio that differs by educational attainment, given the high mean returns on stocks relative to bonds. Our estimates are in line with those of Fagereng, Gottlieb, and Guiso (2017), who use Norwegian tax data to estimate a discount factor in the range from 0.77 to 0.82. The authors argue that impatience is necessary to limit liquid asset accumulation and discourage stock market participation in the presence of participation and adjustment costs. Calvet, Campbell, Gomes, and Sodini (2016) use household-level administrative data from Sweden in a life-cycle model with Epstein-Zin-Weil preferences. They estimate the discount factor to be 0.993 when they include real estate as risky investment which makes the risky share of households considerably higher, and drops to 0.923 when they exclude it. Their model, unlike ours, abstracts from a bequest motive and fixed participation costs needed to match the life-cycle savings and portfolio choices.

Table 5: Parameter Estimates

	β_0	β_1	γ	Γ	F	L	ϕ	$\underline{c}$	θ	$\underline{A}^b$	Fit
DE	0.800	0.857	14.920	0.002	0.011	0.032	0.680	0.219	0.445	-0.123	1111
	(0.009)	(0.008)	(0.245)	(0.001)	(0.014)	(0.010)	(0.522)	(0.052)	(0.029)	(0.045)	
ES	0.770	0.859	9.802	0.012	0.013	0.055	0.751	0.305	0.303	-0.050	773
	(0.019)	(0.022)	(0.336)	(0.001)	(0.007)	(0.014)	(0.963)	(0.035)	(0.067)	(1.349)	
FR	0.792	0.864	18.522	0.008	0.016	0.027	1.55	0.150	0.401	-0.130	7617
	(0.006)	(0.005)	(0.023)	(0.003)	(0.004)	(0.004)	(0.155)	(0.020)	(0.009)	(0.040)	
IT	0.841	0.873	7.346	0.006	0.002	0.241	1.255	0.357	0.545	-0.077	2637
	(0.018)	(0.018)	(1.142)	(0.002)	(0.002)	(0.155)	(0.515)	(0.025)	(0.158)	(0.008)	

This table reports the estimates of structural parameters and the corresponding standard errors. The last column reports the model fit as defined in equation (10).

These findings also contrast with the estimates reported in Carroll, Slacalek, and Tokuoka (2014) who allow heterogeneity in discount factors across households and estimate the distribution of discount factors around 0.97 with a relatively small variation across households. There the estimates are obtained by matching moments of the liquid asset holdings distribution of households.

The estimated risk aversion, from 7.35 in Italy to 18.52 in France, is considerably higher than the estimated value of around 4 for the US reported in Cooper and Zhu (2015). This is not surprising given the small participation rates in the stock market in our sample countries compared with the US. Increases in risk aversion reduce both participation and stock share in the portfolio. In addition, Cooper and Zhu (2015) abstract from borrowing, which reduces risky investment without imposing higher risk aversion of households. Our estimates are consistent with other estimates for Europe. Fagereng, Gottlieb, and Guiso (2017) estimate a risk aversion parameter of 11 to 14 depending on whether they allow for a small disaster probability and a bequest motive. Calvet, Campbell, Gomes, and Sodini (2016) estimate the average relative risk aversion parameter to be 4.15 when they include real estate as a risky investment and 10.9 when they do not.

Other studies have used information from direct or indirect questions on risk and time preferences from surveys to infer risk aversion parameters (see, for example, Guiso and Paiella (2006), Guiso and Paiella (2008), Bonin, Dohmen, Falk, Huffman, and Sunde (2007)). Making use of a question on households' willingness to pay for a hypothetical risky security in the 1995 Bank of Italy Survey of Household Income and Wealth (SHIW), Guiso and Paiella (2006) and Guiso and Paiella (2008) infer a relative risk aversion measure of 6 which ranges from 1.9 to 13.3 in the data.

The stock market participation cost, Γ, and portfolio adjustment cost, F, are given as fractions of average income in a country. The participation cost of 1.2% in Spain is the highest among the four countries, and the cost is relatively low in Germany. The adjustment costs are relatively high in France and Spain, while for Italy the adjustment cost is not statistically significant. These variations in participation and adjustment costs influence the life-cycle patterns of participation. The adjustment costs also directly impact the stock share since they generate a demand for liquidity through bond holdings.

The point estimates of L indicate a bequest motive and are statistically significant in all countries except Italy.

Table 6: Participation, Adjustment Rate and Consumption Floor From the Model

Country	Ed \ Inc	Participation Rate			Adjustment Rate			Fraction of HH
		low	middle	high	low	middle	high	hitting $\underline{c}$
DE	low	0.358	0.754	0.863	0.004	0.011	0.065	0.028
	high	0.587	0.899	0.964	0.036	0.110	0.255	0.000
ES	low	0.216	0.705	0.966	0.172	0.132	0.209	0.105
	high	0.638	0.887	0.997	0.186	0.302	0.456	0.001
FR	low	0.259	0.806	0.942	0.007	0.027	0.113	0.000
	high	0.637	0.983	0.999	0.152	0.325	0.536	0.000
IT	low	0.083	0.407	0.979	0.222	0.223	0.330	0.132
	high	0.507	0.806	0.984	0.288	0.323	0.476	0.003

This table summarizes stock market participation rate, stock adjustment rate and the fraction of household hitting the consumption floor by education and permanent income for each country. All the numbers are calculated from simulated data.

Further, there is a positive point estimate of ϕ, the luxuriousness of bequest, in all four countries but these are not significantly different from zero in Germany and Spain.

The elasticity of intertemporal substitution, θ, is also statistically significant in all countries. It is far from the inverse of the risk aversion estimate, thus inconsistent with the CRRA model.

Other implications from these estimates are shown in Table 6. In this table, by country and by permanent income realization are indicated the average participation rates, the adjustment rates conditional on participation and the fraction of households hitting the consumption floor. The participation rates are increasing in income and education, and are nearly 100% for the richest, highly educated households. The adjustment rates, obtained by simulation, are much lower than those found in US data. In comparison to these findings, Cooper and Zhu (2015) report an average adjustment rate of about 60% for US households.

5.2 Consumption Floor

The consumption floor, $\underline{c}$, is estimated relative to a country's average income. For each country $\underline{c}$ is precisely estimated. The estimate is the highest for Italy and lowest for France.

Table 6 provides additional information on the incidence of households hitting the consumption floor by country and education attainment. The consumption floor plays an important role in determining the magnitude of precautionary saving.[25] As seen from this table, the consumption floor affects only low education households and essentially only in two countries, Spain and Italy. Perhaps not surprisingly, the estimated consumption floor is larger for these two countries. From Table 1, this is consistent with the lower wealth to income ratio in Italy and Spain relative to Germany and France.

[25]This is made precise in the elasticities of moments with respect to parameters presented in Table 18 and discussed below.

5.3 Borrowing Constraints

As detailed in the optimization model, households are allowed limited borrowing in the unsecured debt market. The borrowing limits are estimated as relative to the average income in a country. As shown in Table 5, the estimates are statistically significant for Germany and France, amounting to 12.3 to 13.0 percent of average income respectively. The estimates for Spain and Italy are lower and in Spain it is insignificant.

However, as will become clear in the remainder of the text the frequency of households actually being bound by the borrowing constraint is essentially zero.[26] Of course, this does not mean that the borrowing constraint does not influence behavior. As indicated in Table 18, variations in the borrowing limit influence moments. In particular, an increase in $\underline{A}^b$ increases the share of risky assets in the portfolio and increases the wealth to income ratio, while reducing the participation rate. Intuitively, if households are less able to borrow, then they will save more as a buffer. To the extent they do so by holding bonds, this will reduce the participation rate.

5.4 Local Identification

Another perspective on the link between parameters and moments is given in Table 18 in the appendix. The table shows the elasticity of the model moments, i.e., coefficients in the participation, share, and wealth to income ratio regressions, with respect to a small variation in the structural parameters, one at a time. A large elasticity indicates that a moment is important in identifying a particular parameter. These elasticities are informative about local identification as the variations in parameters are in the neighborhood of the estimated values. This table provides information about local identification for a single country, Spain.

For example, an increase in the coefficient of relative risk aversion, γ, increases the constant term in the wealth to income ratio regression, but it decreases stock market participation and stock share in wealth. The signs are exactly what is expected and it is clear that this response is key to the identification of γ.

The participation cost has a large negative effect on the constant terms for participation and stock share regressions. These parameters also interact with age and educational attainment, particularly in the participation regression. As mentioned earlier, although we do not observe the frequency of portfolio adjustment in the data, the portfolio adjustment cost, F, is identified through its effects on stock market participation and stock share in wealth. As shown in the table, the negative effects on F on stock share moments are quite significant. F also has a negative effect on the wealth to income ratio, as it lowers the overall effective return on the household's financial investment and hence lowers the savings motives.

The local changes in discount factors exhibit large effects on simulated moments, leading to the precise estimates for both parameters. An increase in β_0 leads to more savings and hence higher wealth to income ratios for the less educated group. This is reflected in the negative elasticities on the coefficients of $age * college$ and $age^2 * college$ in the wealth to income ratio regression, resulting from a small education gap in terms of the wealth to income ratio. As shown in the first row of the table, the elasticities are both negative for the coefficients on education dummies

[26] This is reminiscent of Krusell and Smith (1998) where the presence of a borrowing constraint does not create a nonlinearity as relatively few households are bound by the constraint.

in the participation and stock share regression. The two negative coefficients also indicate a reduced education gap in terms of stock market participation and stock share in wealth. The negative elasticity for the constant term in the participation regression reflects earlier participation of the less educated group.[27] Similarly, an increase in β_1 widens the education gap in terms of stock market participation rates and wealth income ratios, which is evident in the last row of the table.

6 MPC Distribution

This section of the paper studies the distribution of the marginal propensity to consume (MPC) across households by country. Heterogeneity in the consumption response of households to variations in income and stock returns is a natural consequence of our model. These differences matter in determining the impact of policies that influence income and returns. The responses to shocks tend to be nonlinear, due to the discrete choices by households and the non-homothetic feature of household preferences introduced through the consumption floor and luxuriousness of bequest. Further, the evolution of the cross sectional distribution across households can generate endogenous persistence. Of course, all of these features may themselves differ across countries.

In particular, the frictions in asset market participation and adjustment matter for the response of households to shocks. As emphasized in Bonaparte, Cooper, and Zhu (2012), the non-convex portfolio adjustment cost implies a non-linear response to income and interest rate variations. Further, borrowing constraints can bind, even for apparently wealthy households due to liquidity shortages, as suggested by Kaplan and Violante (2014). This has policy implications as shown by the recent work of Kaplan, Violante, and Weidner (2014), Kaplan and Violante (2014) and Kaplan, Moll, and Violante (2018).

Beside the discrete choices and the binding borrowing constraint, it is important to note that the consumption floor $\underline{c}$ is much more relevant for low income households than high income households, which also leads to heterogeneity in MPCs. This is related to the discussion in Kaplan and Violante (2014) since households relying on the consumption floor are more likely to be hand-to-mouth households and thus have high marginal propensities to consume. We will characterize these households both in actual and simulated data.

In addition, the parameter ϕ in our model captures the degree of luxuriousness of bequest. For households with low income, it is optimal to run down their wealth as their death probability rises with age. But for high income or high wealth level households, the optimal decision rule is to keep the high level of wealth as bequests. This non-homotheticity in preferences further leads to heterogeneity in MPCs.

Other studies on life-cycle portfolio choice and MPC include Cocco, Gomes, and Maenhout (2005) and Gomes and Michaelides (2005) where older unconstrained households have higher MPC to transitory income (or wealth) shocks, since they consume those gains over a shorter period of time and they face significantly less uncertainty about their lifetime income and wealth. We also fit a realistically calibrated income process to our model and

[27] This is confirmed when we compare the participation profiles before and after the local changes in β_0. The comparison also shows that the the less educated group to leave the stock market earlier given the higher β_0. This is because the higher β_0 causes some low income households to enter the stock market when they are young, and they exit early after retirement as they rely on the consumption floor toward the later stage of life.

calculate MPCs out of transitory income shocks.

Jappelli and Pistaferri (2014) study MPC heterogeneity of Italian households. They find that households with low cash-on-hand exhibit a much higher MPC than affluent households, which is in agreement with models with precautionary savings where income risk plays an important role. They find that a debt-financed increase in transfers of 1 percent of national disposable income targeted to the bottom decile of the cash-on-hand distribution would increase aggregate consumption by 0.82 percent.

Christelis, Georgarakos, Jappelli, Pistaferri, and van Rooij (2018) use a representative survey of the Dutch population to characterize empirically the distribution of the MPC in response to small and large as well as positive and negative unexpected transitory income changes and compare the findings with several predictions of intertemporal consumption models. They find that the average MPC is in the 15-25% range. Also, the consumption response to income shocks declines with economic resources, it is larger for negative income shocks and smaller if consumers have relatively long horizons.

Here we focus on the MPC distribution from (positive) transitory income and return shocks. We do so by using the baseline estimates by country. In contrast to numerous other studies, the MPC distribution is computed from the simulated data rather than from a reduced form regression.

Table 7: Household Distribution in the Model

Country	Ed \ Inc	low	middle	high
DE	low	0.146	0.292	0.146
	high	0.104	0.208	0.104
ES	low	0.180	0.361	0.180
	high	0.070	0.139	0.070
FR	low	0.161	0.322	0.161
	high	0.089	0.178	0.089
IT	low	0.221	0.441	0.221
	high	0.029	0.059	0.029

This table summarizes the fractions of households in cells defined by education and permanent income for each country in the simulated data.

Table 7 summarizes the distribution by education and permanent income within each country for all households.[28] As we proceed through the various experiments this distribution will remain fixed. For all of the countries, the largest cell is the low education middle income group.

6.1 Income Shock

In this sub-section, the experiments come from a 1% and a 10% increase in transitory income. The increase in income is given as a lump sum to all households. Thus differences in consumption responses do not reflect differences in the amount of the transfer. For this exercise, we simulate the consumption of each household in the

[28]These were calculated based upon a simulation using the initial distribution of asset holdings from the data and then averaging over aggregate return shocks to obtain a cross sectional distribution, conditional on age.

Table 8: MPC Distribution (Income Shock)

		1%						10%					
		All Households			Participants			All Households			Participants		
	Inc / Ed	low	middle	high	low	middle	high	low	middle	high	low	middle	high
DE	low	0.438	0.263	0.233	0.336	0.289	0.232	0.399	0.251	0.201	0.273	0.245	0.200
	high	0.311	0.191	0.142	0.262	0.187	0.142	0.295	0.186	0.139	0.240	0.182	0.139
ES	low	0.686	0.303	0.191	0.328	0.223	0.177	0.663	0.232	0.172	0.197	0.197	0.167
	high	0.286	0.180	0.145	0.199	0.167	0.144	0.255	0.178	0.142	0.186	0.164	0.141
FR	low	0.382	0.198	0.149	0.304	0.199	0.155	0.306	0.192	0.147	0.241	0.192	0.153
	high	0.235	0.132	0.086	0.152	0.130	0.145	0.206	0.128	0.100	0.140	0.126	0.164
IT	low	0.834	0.539	0.198	0.460	0.306	0.196	0.803	0.488	0.192	0.405	0.271	0.190
	high	0.446	0.234	0.161	0.282	0.206	0.161	0.387	0.218	0.157	0.251	0.199	0.156

This table summarizes the distribution of MPC from transitory income shocks. The three columns (low, middle and high) represent three levels of permanent income. The rows, by country, are for low and high educational attainments. The left block is for a 1% shock and the right is for a 10% shock.

baseline economy, then we impose an exogenous increase in transitory income to all households and re-simulate their consumption. For each household, the MPC is calculated as the change in consumption divided by the change in income.

Table 8 presents the MPC by country for each of the three levels of permanent income by education group. Within each experiment, we report the MPC for all households and for stock market participants only. The numbers reported are the mean value of the MPC for each cell.

A couple of features are apparent. First, for all countries and education groups, the MPC is highest for the low permanent income group and then falls with the level of permanent income. Second, while the low education, low permanent income group has the highest MPC in each country, the MPC of this group is much higher in Italy and Spain relative to France and Germany. For this cell, the MPC is about two-thirds in the latter two countries. Interestingly, the lowest MPC is associated with the high education, high permanent income group and there are relatively small differences in this cell across countries. From Table 7, Spain and Italy have the largest fractions of low education, low permanent income and low education middle income households among the four countries. Thus the highest MPC group gets more weight in these two countries.

Second, in almost all cells, the MPC is lower for stock market participants. It is noteworthy that in each country, stock market participants have a higher MPC than non-participants for the high education and high income cell. This is particularly apparent in France. In the data as well as in the model, these high education and high income participants have a larger stock share on average. It is likely that they have a high MPC relative to non-participants because in the presence of portfolio adjustment costs, some of these participants may be relatively illiquid. Thus for them a positive income shock leads to a rapid increase in consumption.

To explore this conjecture, we calculate the mean MPCs for both adjustors and non-adjustors in the stock market. In each period, a household is defined as an adjustor if she re-balances her portfolio. To be clear, adjustors and non-adjustors were identified by their behavior in the **absence** of the income shock.

As shown in Table 9, non-adjustors have a higher mean level of MPC in each country, which is consistent with

Table 9: Income MPC of Consumption Floor Hitters and Stock Market Participants

	1%			10%		
	Floor Hitter	Adjustor	Non-adjustor	Floor Hitter	Adjustor	Non-adjustor
DE	0.550	0.125	0.211	0.458	0.125	0.212
ES	1.000	0.139	0.188	0.999	0.134	0.170
FR	n.a.	0.102	0.156	n.a.	0.112	0.146
IT	1.000	0.212	0.203	1.000	0.200	0.192

This table reports the mean MPC of consumption floor hitters, stock adjustors and non-adjustors in response to a transitory income shock. Adjustors (non-adjustors) are stock market participants who do (do not) engaged in portfolio re-balancing.

our conjecture. In particular, the MPCs of non-adjustors in Germany and Spain are almost twice as large as those of adjustors. This is then consistent with the finding in Table 8 of higher MPCs for stock market participants with high education and high permanent income.

Finally, while the aforementioned patterns are also seen in the 10% shock scenario, the numbers are somewhat overall smaller. This reflects the existence of non-linearities with respect to the shock size and is also consistent with the findings of Christelis, Georgarakos, Jappelli, Pistaferri, and van Rooij (2018) who argue that in the presence of liquidity constraints the size of the shock also matters, especially at low levels of economic resources. For large increases in income, consumers are more likely to overcome the constraint (and therefore, the MPC is lower than for small increases).

Table 10: MPC Regression (Income Shock)

						wealth percentile				
	const.	age	age2	income	edu	10-50%	50-70%	70-90%	90-95%	95-100%
1% increase in transitory income										
DE	0.253	0.028	0.000	-0.081	0.004	-0.047	-0.184	-0.302	-0.370	-0.382
ES	0.245	0.018	0.000	-0.042	-0.025	0.099	-0.150	-0.175	-0.224	-0.226
FR	0.324	0.016	0.000	-0.044	0.008	-0.066	-0.232	-0.260	-0.268	-0.272
IT	0.270	0.016	0.000	-0.050	0.003	0.000	-0.018	-0.111	-0.210	-0.231
10% increase in transitory income										
DE	0.241	0.028	0.000	-0.078	-0.003	-0.044	-0.179	-0.296	-0.363	-0.374
ES	0.269	0.015	0.000	-0.033	-0.011	0.050	-0.166	-0.192	-0.239	-0.240
FR	0.255	0.014	0.000	-0.033	0.008	0.000	-0.181	-0.206	-0.208	-0.218
IT	0.355	0.015	0.000	-0.030	-0.003	0.000	0.105	0.050	0.027	0.007

This table presents regression results of MPCs in response to positive transitory income shocks of 1% and 10%, respectively. The dependent variable is the MPC. The explanatory variables are a constant, age, age-squared, income, education and wealth percentiles.

Table 10 presents regression results that explain the variations in MPC across households within each country. The dependent variable is the household specific MPC as computed above. The explanatory variables are those in the state vector of the dynamic optimization problem. Included are dummies for the household's position in the wealth distribution of that country. The regression has the interpretation of an approximation to (a derivative of) one of the consumption rules.

From these results, there is a slight hump-shape in the MPC, though the variation over the life-cycle is small

relative to other household moments. The MPC is falling in income while the effect of education is ambiguous. Note that the big differences across education groups reported in Table 8 are now subsumed by the income and wealth variables.

Most interesting is the nonlinear relationship between the MPC and relative wealth of the household. Here we see that the MPC falls non-linearly with the wealth percentile. This is true for both a 1% and a 10% increase in transitory income.

The MPC distribution generated by our model can be compared with those reported in Carroll, Slacalek, and Tokuoka (2014). They report estimates of average MPC values of between 20% and 40%, when matching the liquid wealth distribution. Of our four countries, their estimate of the aggregate MPC for Germany is lowest at 26% and Spain is the largest at 38%.

The large heterogeneity in MPCs across income and education groups is driven by the non-homotheticity in preferences and the discrete choices of households, as discussed earlier. To quantitatively examine this point, we conducted two experiments. The first experiment sets the consumption floor, the luxuriousness of bequest and the portfolio adjustment costs to zero, thus turning off the potential sources of heterogeneity in MPCs with respect to income. The second experiment further sets the discount factor of the less educated group to be the same as the more educated group, thus making the two groups of households equally patient. The results are reported in Table 19 in the Appendix. The first experiment brings the MPCs of the three permanent income groups within each education group close to each other. Within the elements of the first experiment, each contributed to the non-linearity. The second experiment essentially equalizes the MPCs of the two education groups.

6.2 Return Shocks

Here we study the response of households to a 1% and a 10% shock in the return to stocks.[29] Note that this shock only affects the choices of households who participate in asset markets and are adjusting their portfolio. The point of studying both small and large shocks is to understand the non-linearity in response due to the non-convex adjustment costs.

The MPC distribution with respect to these return shocks is reported in Table 11. It is comparable to the response to income shocks reported in Table 8. Higher permanent income households have lower MPCs, across countries and education groups. Further, the MPC is lower for higher education households. The MPCs are generally slightly higher for the larger return shock. As in the estimates of θ reported in Table 5, German households have a larger response to return shocks than households in Spain and Italy.

Finally, Table 12 presents regression results to summarize how the households' state variables impact the MPC from a stock market return shock. There is no strong dependence of the MPC on age. The MPC falls with both income and with the wealth to income ratio, and in general with education.

Our findings are also related to evidence in a recent paper by Di Maggio, Kermani, and Majlesi (2018) that studies the MPC out of stock market returns for Swedish households participating in stock markets. They regress

[29] As the return on bonds is deterministic, it makes no sense to explore the response to a zero probability event.

Table 11: MPC Distribution (Return Shock)

Country	Inc / Ed	1%			10%		
		low	middle	high	low	middle	high
DE	low	0.311	0.246	0.202	0.311	0.250	0.202
	high	0.278	0.175	0.137	0.278	0.175	0.139
ES	low	0.258	0.163	0.149	0.258	0.163	0.149
	high	0.164	0.149	0.152	0.164	0.149	0.153
FR	low	0.202	0.185	0.162	0.202	0.185	0.162
	high	0.140	0.116	0.159	0.140	0.118	0.161
IT	low	0.472	0.274	0.176	0.472	0.274	0.178
	high	0.249	0.193	0.153	0.249	0.193	0.155

This table summarizes the distribution of MPC from a 1% shock and a 10% shock to the stock return. The three columns represent three levels of permanent income. The rows, by country, are for low and high educational attainments for households participating in asset markets.

Table 12: MPC Regression (Return Shock)

						wealth percentile				
	const.	age	age2	income	edu	10-50%	50-70%	70-90%	90-95%	95-100%
1% increase in stock value										
DE	0.398	0.015	-0.00022	-0.052	-0.0345	0.000	-0.182	-0.196	-0.208	-0.164
ES	0.275	0.011	-0.00015	-0.014	-0.0111	0.000	-0.131	-0.144	-0.144	-0.098
FR	0.615	-0.007	0.00003	-0.008	-0.0798	0.000	-0.106	-0.085	-0.050	0.031
IT	0.340	0.011	-0.00014	-0.047	0.0064	0.000	-0.193	-0.213	-0.242	-0.229
10% increase in stock value										
DE	0.476	0.013	-0.00020	-0.053	-0.0349	0.000	-0.148	-0.152	-0.171	-0.139
ES	0.279	0.010	-0.00015	-0.013	-0.0116	0.000	-0.132	-0.142	-0.141	-0.114
FR	0.647	-0.008	0.00005	-0.008	-0.0766	0.000	-0.108	-0.087	-0.055	0.049
IT	0.347	0.012	-0.00015	-0.045	-0.0001	0.000	-0.155	-0.156	-0.205	-0.200

This table presents regression results. The dependent variable is the MPC from a stock return shock. The explanatory variables are a constant, age, age-squared, income, education and wealth percentiles.

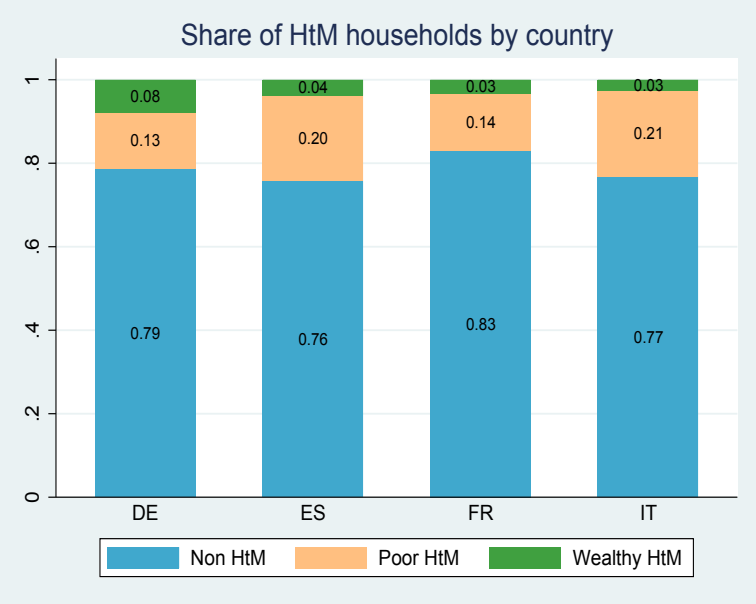
consumption growth on changes in dividends and capital gains. They find that the MPC out of capital gains for households in the top 50% of the financial wealth distribution is around 5%. On the other hand, it is significantly higher and more than 10% for the bottom 50% of the distribution. Note that over 93% of the stock ownership is by the top 50%.

6.3 Hand-to-Mouth Households

As suggested in Kaplan and Violante (2014), there may be households with relatively high MPC due to binding liquidity constraints. While this may arise due to illiquid housing, portfolio adjustment costs, as in our model, can also generate this result.

Following Kaplan, Violante, and Weidner (2014), Hand-to-Mouth (HtM) households are those whose liquid assets are less than half of their income over a pay period. Some of these households have negative illiquid assets

Figure 3: HtM Households



This figure shows the fraction of HtM households in our sample by country. The vertical axis measures the average years of schooling within each of the groups.

and are termed poor HtM households. Others with positive levels of illiquid wealth, such as a house or illiquid holdings of stocks as in this model, are termed rich HtM households. These latter households are the focus of our analysis since the borrowing constraints, though negative, do not lead to large accumulations of debt and relatively few households are bound by these constraints.

The literature has used different characterizations of liquid and illiquid assets. Kaplan, Moll, and Violante (2018) also treats equity as illiquid and includes housing there as well, though there is no distinct state variable for houses. In contrast, for their study of European households, Kaplan, Violante, and Weidner (2014) treat stocks as liquid assets. To be clear, for our analysis, bond are the only liquid asset, while stocks are viewed as illiquid.

Figure 3 shows the fraction of HtM households in our sample. For each country, the fraction of rich, poor and non-HtM households are indicated. To be clear, for this figure housing is excluded and stocks are viewed as illiquid assets, as in the model. [30] About 20% of households in the euro area are classified as HtM. The fraction of HtM households is highest in Germany (DE) and lowest in Italy. In all countries except Spain (ES), there are more wealthy than poor HtM households. The average amount of education is lowest for the poor HtM households and highest for those who are not in the HtM classification.

Using simulated data from the estimated model, Table 13 reports the fraction of HtM consumers in each education-income cell and the corresponding average MPC from a 1% transitory income shock. Clearly, the less educated and/or low income household groups have a higher fraction of HtM consumers. As before, these low income HtM consumers generally have higher MPCs. It is interesting to see positive fractions of HtM consumers

[30] Kaplan, Violante, and Weidner (2014) restrict the sample to households aged 22-79 while we present numbers for the whole sample in Figure 3, hence the small differences.

even among the high education households, though most are in the low income group.

Table 13: Hand-to-Mouth Consumers (1% Income Shock)

Country	Inc / Ed	Fraction of HtM'ers				Mean MPC of HtM'ers		
		low	middle	high	total	low	middle	high
DE	low	0.082	0.065	0.013	0.249	0.564	0.357	0.485
	high	0.060	0.027	0.001		0.512	0.323	0.281
ES	low	0.097	0.062	0.010	0.233	0.814	0.465	0.414
	high	0.033	0.026	0.004		0.503	0.287	0.212
FR	low	0.055	0.007	0.000	0.098	0.588	0.328	0.361
	high	0.033	0.003	0.000		0.544	0.321	0.140
IT	low	0.118	0.145	0.008	0.370	0.863	0.733	0.359
	high	0.054	0.042	0.003		0.680	0.431	0.228

This table reports the fraction of HtM households and their mean MPCs by permanent income and educational attainment.

Table 14 reports on how hand to mouth households, who are stock market participants, respond to return shocks. As in the case of income shocks, the mean MPC for each group is very large, though there are relatively few hand to mouth households.

7 Monetary Policy Implications

The differences in response to shocks both across countries and states are certainly relevant for policy analysis. This is the point behind the analysis of fiscal interventions on European countries in Kaplan, Violante, and Weidner (2014). An analysis of monetary interventions for the US is contained in Kaplan, Moll, and Violante (2018).

Here we take an empirical approach to study how monetary policy innovations impact consumption through two channels: income and stock returns. In contrast to these other studies, such as Kaplan, Moll, and Violante

Table 14: Hand-to-Mouth Consumers (1% Return Shock)

Country	Inc / Ed	Fraction of HtM'ers				Mean MPC of HtM'ers		
		low	middle	high	total	low	middle	high
DE	low	0.022	0.049	0.010	0.140	0.449	0.308	0.175
	high	0.028	0.030	0.001		0.349	0.334	0.259
ES	low	0.014	0.036	0.010	0.110	0.508	0.203	0.136
	high	0.015	0.029	0.006		0.207	0.227	0.213
FR	low	0.007	0.006	0.000	0.022	0.225	0.132	0.120
	high	0.007	0.001	0.000		0.185	0.156	0.148
IT	low	0.009	0.035	0.009	0.098	0.704	0.347	0.195
	high	0.019	0.024	0.003		0.176	0.302	0.207

This table reports the mean MPCs of stock market participants who are hand-to-mouth consumers in response to a return shock that is 1% of the stock value.

(2018), the policy effects on income and interest rates will not be generated by a model. Instead, we take them from empirical analyses of the channels of monetary policy. The analysis is partial in that other effects of the innovation, say on debt obligations and thus on the tax burden that is reduced by a monetary expansion, are ignored.

Throughout, we emphasize differences in households within a country as well as country differences in the response to policy innovations. In general, the different responses across countries come from the different behavior of households, as seen through the different parameter estimates that lead to the state-contingent MPCs. Further, countries differ in the distributions of households over these states. Finally, there are country specific elements of the effects of monetary innovations on income and stock returns.

The effect of a period t monetary policy innovation on aggregate consumption in period $t+\tau$ can be written as:

$$\begin{aligned}\frac{dC_{t+\tau}}{dMP_t} = \quad & \int_s \frac{dc(Y, R^s, R^b, \Omega)}{dY_{t+\tau}(\Omega)} \frac{dY_{t+\tau}(\Omega)}{dMP_t} dG_{t+\tau}(\Omega) + \\ & \int_s \frac{dc(Y, R^s, R^b, \Omega)}{dR^s_{t+\tau}(\Omega)} \frac{dR^s_{t+\tau}(\Omega)}{dMP_t} dG_{t+\tau}(\Omega) \end{aligned} \tag{13}$$

where Ω is an index of the individual's state, $Y_{t+\tau}$ is the common component of income in period $t+\tau$, $R^s_{t+\tau}$ is the period $t+\tau$ return on stocks and dMP_t denotes a period t monetary innovation. Here $G_{t+\tau}(\Omega)$ is the cross sectional distribution over the individual states in period $t+\tau$.

There are two components to equation (13). The first is the response in income created by the monetary innovation. The second is the effect of the monetary innovation on the return to risky assets.[31] In the following discussion, these are referred to as the "income" and "return" channels. But it is important to keep in mind that these channels interact: the decision about portfolio adjustment depends on the total utility gain in response to income and return shocks which will generally not be the same as the sum of the utility gain from each of the shocks independently.

There are three important dimensions to the policy response that this equation makes clear. First, the response is state dependent at the individual level and thus dependent on the cross sectional distribution in period $t+\tau$, $G_{t+\tau}(\Omega)$, for each country. To the extent that the intervention itself changes the cross sectional distribution, there will be an additional dynamic to the policy response. Second, the response is individual state dependent. This is made explicit in the income response: $\frac{dY_{t+\tau}(\Omega)}{dMP_t}$ allows the income effect of monetary policy to depend on the individual's state. The effect of the change in the stock returns induced by the innovation will also be individual specific, reflecting both the (endogenous) participation decision as well as the magnitude of financial wealth. Third, the response is dynamic both reflecting the lasting effects of the monetary intervention on income and returns and the evolution of the cross sectional distribution.

The impact of a monetary shock is most easily summarized as a U-shaped function of income. The consumption responses are largest for poor households, with a positive but smaller impact for high income households and with

[31] Another channel that accounts for the effect of the policy innovation on the return of the risk free asset is outside of the model since the risk free return is constant. Further, the impact of interest rate changes on fiscal policy, emphasized in Kaplan, Moll, and Violante (2018), do not appear.

a negligible effect on the consumption of the middle income group. The response of the low income households is through an income channel: the income of these households is very sensitive to monetary shocks **and** these households have relatively large MPCs. The richer households are the ones with the highest asset market participation rates and largest financial wealth so that the stock price channel of monetary policy operates mainly through them.

Of course, the relative magnitudes of these effects differ by country, in part because of differences in asset participation rates. Further the impact of monetary policy on income differs considerably across countries. Details on these differences are provided below.

7.1 Aggregate Impact

Here we focus on the aggregate impact. The distributional considerations as well as decompositions by the two channels are described in detail below.

There are a few important details underlying the calculation of these responses. First, as described in more detail below, the income response that is an input into equation (13) is assumed to last for only three periods. The remaining periods of the 15 year simulation come from the return channel as well as the endogenous response to consumption induced by the times series variation in the household's state. Second, the 15 year responses come from households that survive the full 15 years of the simulation. This selection puts more weight on younger households.

7.1.1 Response to Monetary Easing

The top panel of Figure 4 shows the overall response by country to a monetary innovation of a 100 basis point cut in the target rate over 15 years.[32] Along the vertical axis is the change in consumption relative to the case without any monetary shocks.

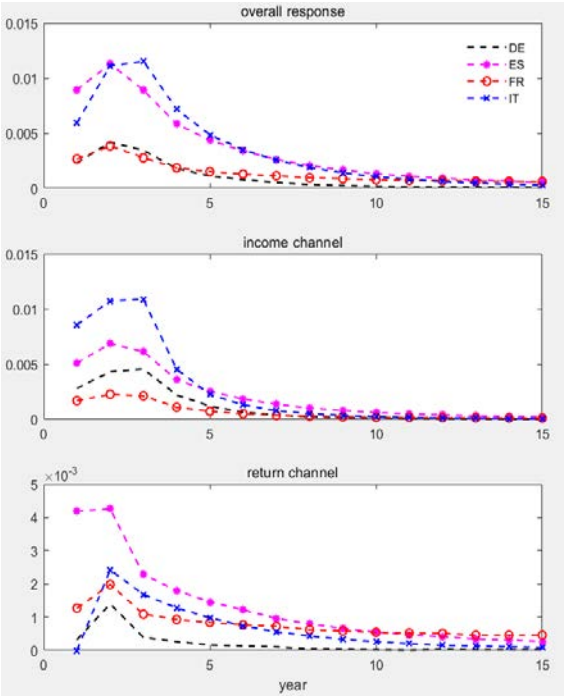
To be clear about the units, at the peak the consumption levels in Italy and Spain are about 1.25% higher than the baseline. At the peak, these responses are nearly three times those in France and Germany. For all countries, the response is hump-shaped with a peak response in the second year (with the exception of Italy).

Relative to the results reported in Kaplan, Moll, and Violante (2018), the magnitude of the responses in Italy and Spain are slightly larger than their findings for the US, though the experiments are different. From their Figure 4, a 0.5 annual percentage point increase in consumption following a 0.25% negative innovation in the quarterly Taylor rule, which mean reverts at a constant rate of 0.5.[33] That said, there are interesting differences underlying the total response. As in our results, the main channel of response is through labor income. But, in our setting a second major channel is through the effect of monetary policy on stock returns. This channel is negligible in their model. For some countries, such as Spain, we find that the component due to changes in returns is more than a third of the entire consumption response. As noted earlier, our analysis omits the response of fiscal transfers to

[32] As before, these were calculated based upon a simulation using the initial distribution of asset holdings from the data and then averaging over aggregate return shocks to obtain a cross sectional distribution, conditional on age.

[33] Roughly speaking, over a year, their shock is half of ours and the response is also nearly half of ours.

Figure 4: Dynamic Consumption Response to a Monetary Shock



This figure shows the aggregate consumption response over time to a 100 basis point decrease in the target rate based on the estimated model for each of the four European countries.

monetary innovations, which was a large part of the response in the Kaplan, Moll, and Violante (2018) analysis. In this way, the relative importance of the channels differs across the studies.

From Christiano, Eichenbaum, and Evans (2005), the peak response to a one standard deviation shock to the federal funds rate is an increase in consumption of about 0.2% relative to the baseline. As in their analysis, the consumption response is hump-shaped in our model, though we do not have any habit formation. Instead our dynamics are induced by the dynamic response of income and stock returns to the monetary innovations and the evolution in the underlying distribution across heterogeneous households.

The next sub-sections decompose these aggregate responses in terms of the income and return channels. For each, we look at types of households within each country.

7.1.2 Income Channel

Evaluating the effects on consumption of monetary policy through the income channel requires two steps. Both of these channels are country specific so that the consumption responses to monetary policy through this channel vary by country.

First is the response of income to the monetary innovation.[34] These responses are taken from Lenza and Slacalek (2018), displayed in their Figure 4, and are summarized in Table 15. These responses combine the effects of the intervention on wages and the probability of employment. In particular, it is assumed that households who move from unemployment to employment increase their income by a percentage determined by the inverse of the prevailing net replacement rate in their country. Then these responses are combined with the responses of wages according to the proportion in the population of households moving from unemployment to employment and those already employed and just increasing their wage. Note that these are individual specific responses in that the income effects differ based upon the household's income quintile. As is quite clear, most of the income effect is operating through the lowest quintile of the income distribution, particularly for Germany and Spain. The income effect is much larger in Spain, particularly for the lowest income group. These responses are persistent.

Table 15: Monetary Policy Effect on Income in the Data

Income Quintile	Year	DE	FR	ES	IT
1	1	3.39	1.49	8.21	3.57
	2	3.25	1.55	7.87	2.62
	3	3.17	1.25	6.70	1.26
2	1	0.87	0.94	2.35	3.15
	2	0.87	0.94	2.34	2.51
	3	0.87	0.70	1.85	1.05
3	1	0.34	0.88	1.68	2.51
	2	0.34	0.88	1.68	2.30
	3	0.34	0.64	1.52	1.05
4	1	0.29	0.45	1.01	2.09
	2	0.30	0.45	1.01	2.09
	3	0.30	0.45	1.01	1.48
5	1	0.15	0.45	0.68	1.87
	2	0.15	0.45	0.67	1.88
	3	0.15	0.45	0.68	1.05

This table reports the response of household income to a 100 basis point monetary policy rate reduction by income quintile in year 1, year 2 and year 3, respectively. Numbers are taken from Ampudia, Georgarakos, Slacalek, Tristani, Vermeulen, and Violante (2018), combining the effect on wages and employment.

The second part of the income channel is the response of consumption to this change in income. This is also state dependent since, as illustrated above, there is ample MPC heterogeneity. For this response, we use the estimated MPCs from a transitory income change given by Table 15.[35]

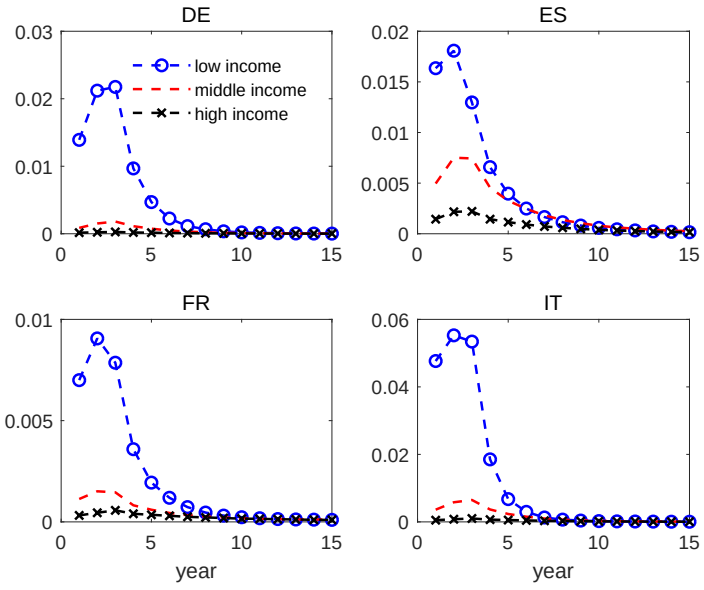
The results are summarized by the middle panel of Figure 4. Clearly, there is a large and persistent income response in Italy, more than twice that of Germany and almost three times that of France. The responses are persistent.

Looking at Figure 5, there is clearly only a single low income group within each country that creates the income

[34]This builds upon the study of Italian households in Casiraghi, Gaiotti, Rodano, and Secchi (2018). Discussions on this with Marco Casiraghi were much appreciated.

[35]In this formulation, households do not distinguish an income variation due to a monetary innovation from a standard transitory shock. The fact that they treat this as a transitory income variation serves to reduce the consumption response.

Figure 5: Consumption Response to a Monetary Shock (Income Channel)



This figure shows the consumption response of different income groups to a 100 basis point decrease in the target rate through the income channel based on the estimated model for each country.

response.[36] This is significantly larger in Italy than the other countries. Interestingly the response of this group in Germany is about the same as in Spain. The aggregate response is larger though because the MPC of this group is itself larger in Spain, as indicated in Table 8.

There are distributional consequences of the income response by education as well. That is, even though the income response to the monetary innovation is not estimated to depend on education, the responses are different by education group. These are shown by education and permanent income group in Table 8 for the two income innovations. Here we see that the consumption response is largest for low education, low income households, particularly in Italy and Spain.

7.1.3 Return Channel

This section studies return shocks induced by monetary policy. We study this through a country specific VAR which allows us to determine the impact of monetary policy innovations on stock returns.[37] The details of this procedure to uncover these responses are provided in Appendix 9.2.[38]

The impulse response functions showing how stock returns react to monetary policy innovations are shown in Figure 6 and discussed in more detail in the Appendix. The underlying estimation is based upon quarterly data. It is interesting to note that the immediate response of the stock market to expansionary policy is for the returns

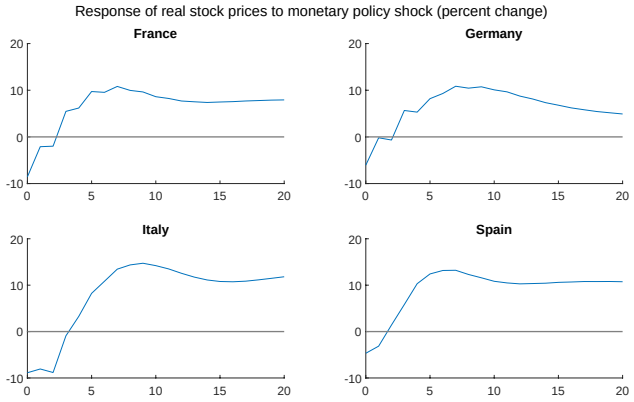
[36] For this figure and associated discussion, the low and the high groups are the lowest and highest income quintiles. The middle group combines quintiles 2 to 4.

[37] Here we broadly follow the analysis in Lettau, Ludvigson, and Steindel (2002).

[38] We are grateful to Sebastian Rast for his preparation of these impulse responses.

to decrease. This is often interpreted as a reaction to the informational content of the intervention.[39] By the end of the first year there is a sizable, positive response of real stock prices in all four countries.

Figure 6: Stock Return Response to a Monetary Shock in the Data



This figure shows the quarterly response of real stock price in terms of percentage changes to a monetary policy shock based on data over the period 1999 Q1-2018 Q4.

In addition to the differential response by country, households within each country are influenced differently as well based upon their asset market participation status and the size of their financial holdings. These differences were present in the earlier calculations of the MPC after a return shock in Table 11. They reappear in the overall consumption response by country shown in the bottom panel of Figure 4.

This response of stock returns to monetary policy is strikingly different from the model created responses reported in Kaplan, Moll, and Violante (2018).[40] In particular, as seen in Figure 4 of Kaplan, Moll, and Violante (2018), the response to asset returns is negligible. This reflects two offsetting influences. The lower rates increase assets values through standard discounted present value calculations. But, at the same time, profits are countercyclical in the model and thus asset values fall. Evidently these effects essentially cancel and thus asset returns respond very little in the Kaplan, Moll, and Violante (2018) model to monetary innovations.[41]

[39] Relatedly, output actually contracts in the impact period as well.
[40] Conversations with Gianluca Violante were very helpful to understand these differences.
[41] From Christiano, Eichenbaum, and Evans (2005), real profits increase in response to a monetary innovation.

7.2 Non-Linearities

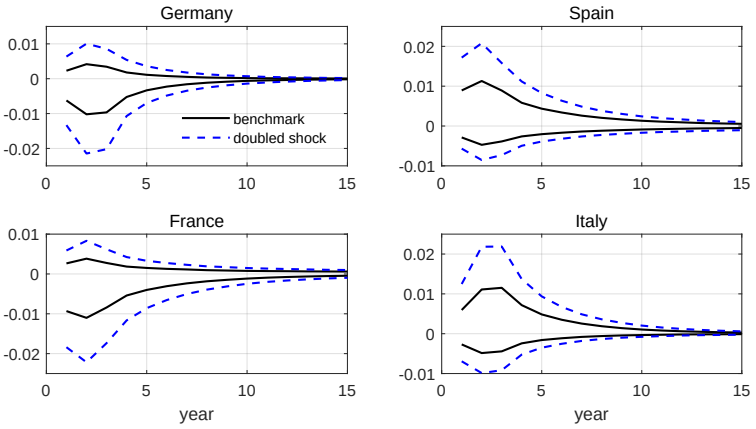
Given the non-linearity of decision rules at the household level, it is interesting to study whether the aggregate consumption response is non-linear as well.

The non-linearity could take two forms. First, the response to a large shock might differ from that to a small shock. Second, monetary tightening might impact consumption differently than the monetary expansion shown in Figure 4.

Further, a non-linearity could come from the response of income and returns to the monetary policy innovation or could reflect household choices. We focus here on the latter channel and so, in reference to equation (13) the (type specific) income and return responses to monetary policy are simply doubled and the resulting aggregate consumption response is determined.

Figure 7 shows the response by country to the four innovations distinguished by their size (100 or 200 basis points) and sign (positive or negative). Along the size dimension, the results seem nearly linear: the impulse response from doubling the monetary shock is about twice that of the baseline, regardless of the sign. There are some small variations, such as the slightly larger response in Germany and the slightly small response in Italy to an expansionary shock.

Figure 7: Nonlinear Aggregate Consumption Response to Monetary Shock



This figure shows the consumption response, by country, to positive and negative innovations in the target rate based on the simulated data. Consumption always increases (decreases) in response to a negative (positive) innovation to the target rate. The responses in black are for 100 basis point innovations and those in blue are for 200 basis point innovations.

In contrast, there are nonlinearities that appear in comparing monetary easing and tightening. In Germany and France, the (negative) consumption response to an increase in the target rate is much larger than is the (positive) consumption response to easing. The opposite is true for Spain and Italy.

These differences can be understood as coming from differences in the consumption response to return shocks. Figure 10 indicates the decomposition of the response to these shocks into the income and return channels. Note that, by construction, the response of stock returns to the monetary shock is symmetric. Thus the asymmetries

come from the response of households. For Germany, for example, the consumption decline from a fall in stock returns triggered by a negative innovation is larger than the response to a positive innovation. The opposite is the case, for example, in Italy.

7.3 Distributional Effects

An additional perspective on the effects of monetary policy is to look at the total effect through both channels on particular groups in the population. The analysis further establishes an important theme: monetary policy impacts the relatively poor households through the income channel and the relatively rich through the return channel. The implication is of consumption growth for the two extremes of the income distribution, but much less for the middle.[42]

A natural starting point is to partition households into groups based upon education and permanent income, along the lines of Tables 7 and 8. Table 16 summarizes the effects of monetary policy on these households.

Looking at the income channel alone, the impact of monetary policy on consumption is decreasing in income, for both education groups. This again reflects the effects of the policy on income by quintile and the relatively high MPC of low income groups. This is seen in the "Income Channel" panel of the table.

For the return channel, the picture is just the opposite. The low education, low income households have relatively low participation rates and so their consumption response is negligible, with the exception of Spain. This is seen in the "Return Channel" panel of the table.

The income and return channel panels highlight the U-shaped response described earlier. Monetary policy largely affects low and high income households, but in very different ways. The income of poorer households is sensitive to monetary innovations and they have relatively large MPCs. The consumption response is large. The richer households participate in asset markets and thus have financial income that too is sensitive to monetary innovations. So is their consumption, though their MPCs are smaller.

The last panel puts these effects together. Importantly, the total effect is not simply the sum of the two channels. This reflects the inherent non-linearities in the problem. For example, the shocks together might induce portfolio adjustment though no such adjustment arose in response to the shocks independently. Further, it seems some high income households save more of the financial income from a high return, thus reducing their MPC.

As made clear in Tables 13 and 14, the HtM households have relatively high MPCs and thus respond more to these monetary policy innovations, particularly through the income channel. These are mainly low education and low and middle income types and thus captured by the appropriate blocks of Table 16. This concentration of HtM households is particularly apparent for Spain and Italy.

[42] As emphasized in Auclert (2017), these distributional aspects, particularly the income effects operating through high MPC households, serves to amplify the affects of monetary policy interventions.

Table 16: Heterogeneous Consumption Response to a Monetary Shock

Country	Ed \ Inc	Income Channel			Return Channel			Overall		
		low	middle	high	low	middle	high	low	middle	high
DE	low	1.724	0.133	0.019	0.004	0.025	0.093	0.516	0.288	0.234
	high	1.459	0.080	0.012	0.023	0.133	0.324	0.489	0.297	0.407
ES	low	2.904	0.738	0.219	0.246	0.611	0.809	2.499	1.369	1.121
	high	1.286	0.411	0.094	0.489	0.746	0.918	1.391	1.151	1.049
FR	low	0.923	0.163	0.044	0.017	0.149	0.296	0.543	0.329	0.382
	high	0.478	0.046	0.016	0.178	0.378	0.567	0.459	0.418	0.620
IT	low	6.439	0.573	0.078	0.086	0.155	0.237	1.996	0.908	0.313
	high	4.741	0.339	0.051	0.089	0.244	0.274	1.621	0.536	0.206

This table summarizes the consumption response in percentage to a negative monetary shock (100 basis points decrease in the target interest rate) for different income and education groups. The calculation is based on the estimated model for each country.

8 Conclusion

This paper uses a life-cycle framework to study household choices and their implications for the effects of monetary policy on household consumption, emphasizing the importance of participation in stock markets and stock adjustment choices. The country specific model parameters are estimated via a simulated method of moments approach, using moments that highlight the life-cycle patterns in financial choices.

The estimation uncovers the presence of asset market participation costs as well as portfolio adjustment costs. The estimated discount factors lie between an average of about 0.80 for low education households to between 0.855 and 0.875 for high education attainment households. These estimates are well below traditional calibrations.

The estimated model has implications for the distributions of marginal propensities to consume. Within a country these distributions are not degenerate due to household heterogeneity. Further, the MPC distribution is country specific, driven by differences in estimated parameters across countries.

The paper considers the distributions of MPC in response to both transitory income shocks and stock return shocks. Generally the MPC is higher for low income, low education households. The relatively small fraction of so-called hand-to-mouth households has particularly large MPCs.

Using the distributions of MPC as inputs for policy analysis, we characterize both the average and distributional implications of two channels of monetary policy effects on consumption: (i) the non-asset income channel and (ii) the stock return channel. Due to the distributional effects, differences in consumption responses across countries are obvious. Overall, Germany has the largest response to monetary innovations through the return channel while Spain has the largest response through the effects of monetary innovations on income. These responses are nonlinear: France and Germany respond more to monetary contractions while Italy and Spain respond more to expansions.

Our analysis identifies a number of factors that are relevant for the transmission of monetary policy. For example, countries differ in their preference parameters, stock market participation costs and adjustment costs, and response of income to monetary shocks. The combined effects of these differences lead to drastically different consumption response to monetary shocks. This should help policy makers evaluate ex-ante the potential effects

of monetary policy decisions.

To be clear, we focus on two monetary policy channels in our model, namely, the income channel and the stock return channel. Other influences of monetary innovation, for example, spending by households and firms on durables, are potentially important, and should be considered in the future extension.

References

Alan, S. (2006): "Entry Costs and Stock Market Participation over the life cycle," *Review of Economic Dynamics*, 9, 588–611.

Ampudia, M., D. Georgarakos, J. Slacalek, O. Tristani, P. Vermeulen, and G. Violante (2018): "Monetary policy and household inequality," *European Central Bank Working Paper #2170*.

Auclert, A. (2017): "Monetary policy and the redistribution channel," Discussion paper, National Bureau of Economic Research, forthcoming *American Economic Review*.

Bonaparte, Y., R. Cooper, and G. Zhu (2012): "Consumption Smoothing and Portfolio Rebalancing: The Effects of Adjustment Costs," *Journal of Monetary Economics*, 59, 751–68.

Bonin, H., T. Dohmen, A. Falk, D. Huffman, and U. Sunde (2007): "Cross-Sectional earnings risk and occupational sorting: The role of risk attitudes," *Labour Economics*, 14, 926–37.

Calvet, L., J. Campbell, F. Gomes, and P. Sodini (2016): "The Cross-Section of Household Preferences," mimeo.

Carroll, C. (1992): "The buffer-stock theory of saving: Some macroeconomic evidence," *Brookings papers on economic activity*, 1992(2), 61–156.

Carroll, C. D., J. Slacalek, and K. Tokuoka (2014): "The Distribution of wealth and the MPC: implications of new European data," *The American Economic Review*, 104(5), 107–111.

Casiraghi, M., E. Gaiotti, L. Rodano, and A. Secchi (2018): "A 'Reverse Robin Hood'? The distributional implications of non-standard monetary policy for Italian households," *Journal of International Money and Finance*, 85, 215–235.

Chamberlain, G. (1984): *Panel Data,*chap. 22, pp. 1274–1381. Amsterdam, North Holland.

Christelis, D., D. Georgarakos, and M. Haliassos (2013): "Differences in portfolios across countries: Economic environment versus household characteristics," *Review of Economics and Statistics*, 95(1), 220–236.

Christelis, D., D. Georgarakos, T. Jappelli, L. Pistaferri, and M. van Rooij (2018): "Asymmetric Consumption Effects of Transitory Income Shocks," *The Economic Journal, forthcoming*.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (2005): "Nominal rigidities and the dynamic effects of a shock to monetary policy," *Journal of political Economy*, 113(1), 1–45.

Cocco, J. F., F. J. Gomes, and P. J. Maenhout (2005): "Consumption and portfolio choice over the life cycle," *Review of Financial Studies*, 18(2), 491–533.

Coibion, O., Y. Gorodnichenko, L. Kueng, and J. Silvia (2017): "Innocent Bystanders? Monetary policy and inequality," *Journal of Monetary Economics*, 88(C), 70–89.

Cooper, R., and G. Zhu (2015): "Household Finance: Education, Permanent Income and Portfolio Choice," *Review of Economic Dynamics*, 20, 63–89.

Deaton, A. (1991): "Saving and Liquidity Constraints," *Econometrica*, 59(5), 1221–48.

DeNardi, M., E. French, and J. B. Jones (2010): "Why Do the Elderly Save? The Role of Medical Expenses," *Journal of Political Economy*, 118(1), 39–75.

Di Maggio, M., A. Kermani, and K. Majlesi (2018): "Stock Market Returns and Consumption," Discussion paper, Lund University.

Epstein, L., and S. Zin (1989): "Substitution, risk aversion, and the temporal behavior of consumption and asset returns: A theoretical framework," *Econometrica: Journal of the Econometric Society*, pp. 937–969.

Fagereng, A., C. Gottlieb, and L. Guiso (2017): "Asset market Participation and Portfolio Choice over the Life Cycle," *The Journal of Finance*, 72(2), 705–750.

Gomes, F., and A. Michaelides (2005): "Optimal life-cycle asset allocation: understanding the empirical evidence," *Journal of Finance*, 60(2), 869–904.

Guerrieri, C., and C. Mendicino (2018): "Wealth Effects in the Euro Area," mimeo.

Guiso, L., M. Haliassos, and T. Jappelli (2003): "Household stockholding in Europe: where do we stand and where do we go?," *Economic Policy*, 18(36), 123–170.

Guiso, L., and M. Paiella (2006): *Insurance: Theoretical Analysis and Policy,*chap. The role of risk aversion in predicting individual behavior. MIT Press.

——— (2008): "Risk Aversion, Wealth and Background Risk," *Journal of the European Economic Association*, 6, 1109–50.

Guvenen, F. (2009): "An Empirical Investigation of Labor Income Process," *Review of Economic Dynamics*, 12, 58–79.

Hansen, L. P. (1982): "Large Sample Properties of Generalized Methods of Moments Estimators," *Econometrica*, 50, 1029–1054.

Hintermaier, T., and W. Koeniger (2018): "Differences in euro-area household finances and their relevance for monetary-policy transmission," *CESifo Working Paper #7088*.

Hubbard, G., J. Skinner, and S. Zeldes (1994): "The Importance of Precautionary Saving in Explaining Individual and Aggregate Savings," in *Carnegie-Rochester Conference Series on Public Policy*, pp. 59–105.

Hubbard, R., J. Skinner, and S. Zeldes (1995): "Precautionary Saving and Social Insurance," *Journal of Political Economy*, 103(2), 360–399.

Jappelli, T., and L. Pistaferri (2014): "Fiscal policy and MPC heterogeneity," *American Economic Journal: Macroeconomics*, 6(4), 107–36.

Kaplan, G., B. Moll, and G. L. Violante (2018): "Monetary Policy According to HANK," *American Economic Review*, 108(3), 697–743.

Kaplan, G., G. Violante, and J. Weidner (2014): "The Wealth Hand-to-Mouth," *Brookings Papers on Economic Activity*, pp. 77–138.

Kaplan, G., and G. L. Violante (2014): "A model of the consumption response to fiscal stimulus payments," *Econometrica*, 82(4), 1199–1239.

Krusell, P., and A. A. Smith, Jr (1998): "Income and wealth heterogeneity in the macroeconomy," *Journal of political Economy*, 106(5), 867–896.

Laibson, D., A. Repetto, and J. Tobacman (2001): "A Debt Puzzle," Working Paper 7879, National Bureau of Economic Research.

Le Blanc, J., and D. Georgarakos (2013): "How Risky is Their Income? Labour Income Processes in Europe," Goethe University Frankfurt.

Lenza, M., and J. Slacalek (2018): "How does monetary policy affect income and wealth inequality? Evidence from the euro area," mimeo.

Lettau, M., S. Ludvigson, and C. Steindel (2002): "Monetary policy transmission through the consumption-wealth channel," *FRBNY Economic Policy Review*, 5, 117–133.

Vissing-Jorgensen, A. (2002): "Towards an explanation of household portfolio choice heterogeneity: Nonfinancial income and participation cost structures," NBER Working Paper #8884.

Weil, P. (1990): "Nonexpected utility in macroeconomics," *The Quarterly Journal of Economics*, 105(1), 29–42.

9 Appendix

9.1 Additional Findings

Additional finding are reported here. Table 17 provides the standard errors for the data moments used in the estimation.

Table 18 shows the elasticity of moments to parameters for Spain, at the baseline parameters. This table is useful for intuition about identification.

Table 19 studies the factors that contribute to the nonlinearity of the MPC. This is for Spain.

Table 17: Standard Errors of Data Moments

		con.	age	age^2	$college$ $(*age)$	$college$ $*age^2$
Germany	Part.	0.030	0.0012	0.00001	0.007	
	Share	0.003	0.0001	0.000001	0.001	
	W/I	0.211	0.0085	0.00008	0.004	0.00006
Spain	Part.	0.027	0.0011	0.00001	0.006	
	Share	0.004	0.0002	0.00000	0.001	
	W/I	0.459	0.0177	0.00016	0.007	0.00012
France	Part.	0.015	0.0006	0.00001	0.004	
	Share	0.001	0.0001	0.00000	0.000	
	W/I	0.124	0.0049	0.00004	0.003	0.00005
Italy	Part.	0.023	0.0008	0.00001	0.006	
	Share	0.005	0.0002	0.00000	0.001	
	W/I	0.336	0.0123	0.00010	0.007	0.00011

9.2 Monetary Innovations and Stock Returns

For each country a separate VAR is estimated over the period 1999 Q1 -2018 Q4 using data on the HICP index, GDP, stock price index and Eonia. The HICP index and GDP are used in log-levels and Eonia in levels. The stock price index is deflated by the HICP index and log-first differences are taken to obtain a measure of real stock returns.

The structural VAR can be written as

$$B_0 z_t = k + B_1 z_{t-1} + B_2 z_{t-2} + ... + B_p z_{t-p} + u_t$$

where $z_t = [\pi_t, y_t, R_t^S, \text{Eonia}_t]$ defined as described above and we set the number of lags p to 4. The monetary policy shock is identified by putting restrictions on the matrix B_0. We follow a similar approach as Ludvigson et

Table 18: Elasticity of Moments to Parameter Estimates (Spain)

	Participation				Share				Wealth-to-income Ratio				
	con	age	age^2	$edu_{(high)}$	con	age	age^2	$edu_{(high)}$	con	age	age^2	$age\times_{edu}$	$age^2\times_{edu}$
β_0	-5.180	-2.241	-5.343	-14.72	71.89	7.946	8.791	-16.50	5.502	18.31	33.27	-2.780	-3.583
β_1	0.685	0.421	0.520	0.547	-31.07	-3.774	-3.592	-2.253	-1.583	-4.141	-4.056	-0.004	0.085
γ	0.229	-0.093	-0.197	0.478	5.563	0.308	0.195	-2.529	-0.022	-0.057	-0.045	0.005	0.002
Γ	-0.217	-0.191	-0.248	-0.008	-2.171	-0.342	-0.369	-0.271	0.011	0.006	-0.010	0.003	0.000
F	-0.023	-0.013	0.020	0.144	-4.017	-0.501	-0.540	-0.150	-2.040	-4.330	-4.466	-0.491	-0.483
L	-0.012	-0.007	0.022	0.142	-2.768	-0.363	-0.406	-0.356	-0.381	-0.968	-1.169	0.004	-0.006
ϕ	0.017	-1.074	-1.495	3.593	0.113	-0.276	-0.371	-3.008	0.026	0.921	0.850	-0.181	-0.042
$\underline{c}$	0.657	-0.155	0.065	3.047	-10.85	-1.476	-1.853	-0.976	-3.221	-7.307	-9.443	-0.949	-0.971
θ	0.003	0.003	0.003	0.006	0.038	0.005	0.005	0.020	0.007	0.015	0.022	-0.002	-0.001
$\underline{A^b}$	2.391	1.467	1.939	3.102	-58.28	-4.514	-2.927	1.239	11.98	22.481	20.27	12.16	14.07

This table reports the elasticity of moments with respect to parameters at the baseline estimations for Spain.

Table 19: The Nonlinearity of MPCs (Spain)

		All Households			Participants		
	Inc / Ed	low	middle	high	low	middle	high
baseline	low	0.686	0.303	0.191	0.328	0.223	0.177
	high	0.286	0.180	0.145	0.199	0.167	0.144
$\underline{c} = \phi = F = 0$	low	0.675	0.697	0.701	0.145	0.167	0.176
	high	0.586	0.585	0.603	0.088	0.098	0.107
$\underline{c} = \phi = F = 0$, and $\beta_0 = \beta_1$	low	0.590	0.599	0.602	0.088	0.089	0.112
	high	0.586	0.585	0.603	0.088	0.098	0.107

This table shows the MPCs for Spain under different assumptions. When setting the parameters that cause non-linearity to zeros, households in different income groups have very similar MPCs. If in addition, the discount factor of the low education group is set to the same level as the high education group, then MPCs are similar across differnt education groups.

al. (2002) and apply the following nonrecursive identifying assumption on B_0

$$B_0 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ \beta_{21} & 1 & 0 & 0 \\ \beta_{31} & \beta_{32} & 1 & \beta_{34} \\ \beta_{41} & \beta_{42} & 0 & 1 \end{bmatrix}$$

The VAR is estimated using maximum likelihood estimation.

Summary Table The following table summarize the stock market response to monetary policy obtained from the 4 VARs estimated for France, Germany, Italy and Spain. The shock to the Eonia is normalized to a 1 percentage point increase on impact. The first row for every country corresponds to the estimates that come directly out of the VAR which includes deflated/real stock market **returns**. Overall the response of stock market returns is very volatile, maybe due to the relatively short sample period. Therefore, the second row for every country shows a centered three-quarter moving average of the response of stock market returns. The third row for every country contains the cumulative sum of the effect on returns, i.e. the change in the deflated stock price **index**.

Table 20: Real/Deflated Stock Market Response to 1 pp. Increase in Eonia

Quarter	0	1	2	3	4	5	6	7	8
France: Stock returns	0.086	-0.065	-0.001	-0.075	-0.007	-0.035	0.002	-0.013	0.008
France: 3 quarter MA	0.011	0.007	-0.047	-0.028	-0.039	-0.013	-0.015	-0.001	-0.001
France: Stock price	0.086	0.021	0.02	-0.055	-0.062	-0.097	-0.095	-0.108	-0.1
Germany: Stock returns	0.061	-0.059	0.005	-0.063	0.004	-0.029	-0.011	-0.016	0.004
Germany: 3 quarter MA	0.001	0.002	-0.039	-0.018	-0.029	-0.012	-0.019	-0.008	-0.005
Germany: Stock price	0.061	0.002	0.007	-0.056	-0.052	-0.081	-0.092	-0.108	-0.104
Italy: Stock returns	0.089	-0.008	0.008	-0.079	-0.042	-0.05	-0.026	-0.026	-0.009
Italy: 3 quarter MA	0.041	0.03	-0.026	-0.038	-0.057	-0.039	-0.034	-0.02	-0.013
Italy: Stock price	0.089	0.081	0.089	0.01	-0.032	-0.082	-0.108	-0.134	-0.143
Spain: Stock returns	0.047	-0.015	-0.046	-0.044	-0.045	-0.021	-0.007	0	0.009
Spain: 3 quarter MA	0.016	-0.005	-0.035	-0.045	-0.037	-0.024	-0.009	0.001	0.005
Spain: Stock price	0.047	0.032	-0.014	-0.058	-0.103	-0.124	-0.131	-0.131	-0.122

IRFs The detailed responses of all variables are shown in figures 8-9. The shock to the Eonia is normalized to a 1 percentage point increase on impact and the responses of the other variables are multiplied by 100 to be interpreted as percent change. Moreover, for illustrative reasons the bottom left chart shows the cumulative sum of real stock return response which can be interpreted as the percentage change in the deflated stock market index.

Figure 8: Response to a Monetary Shock

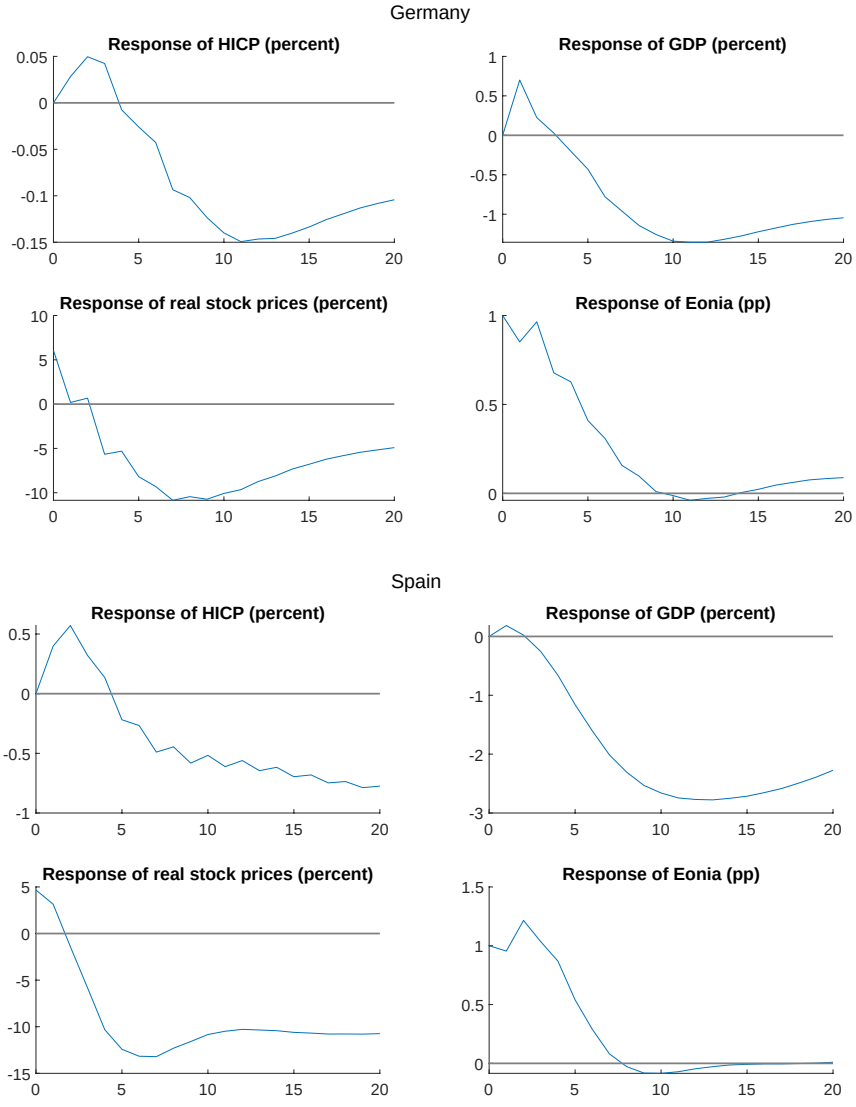


Figure 9: Response to a Monetary Shock

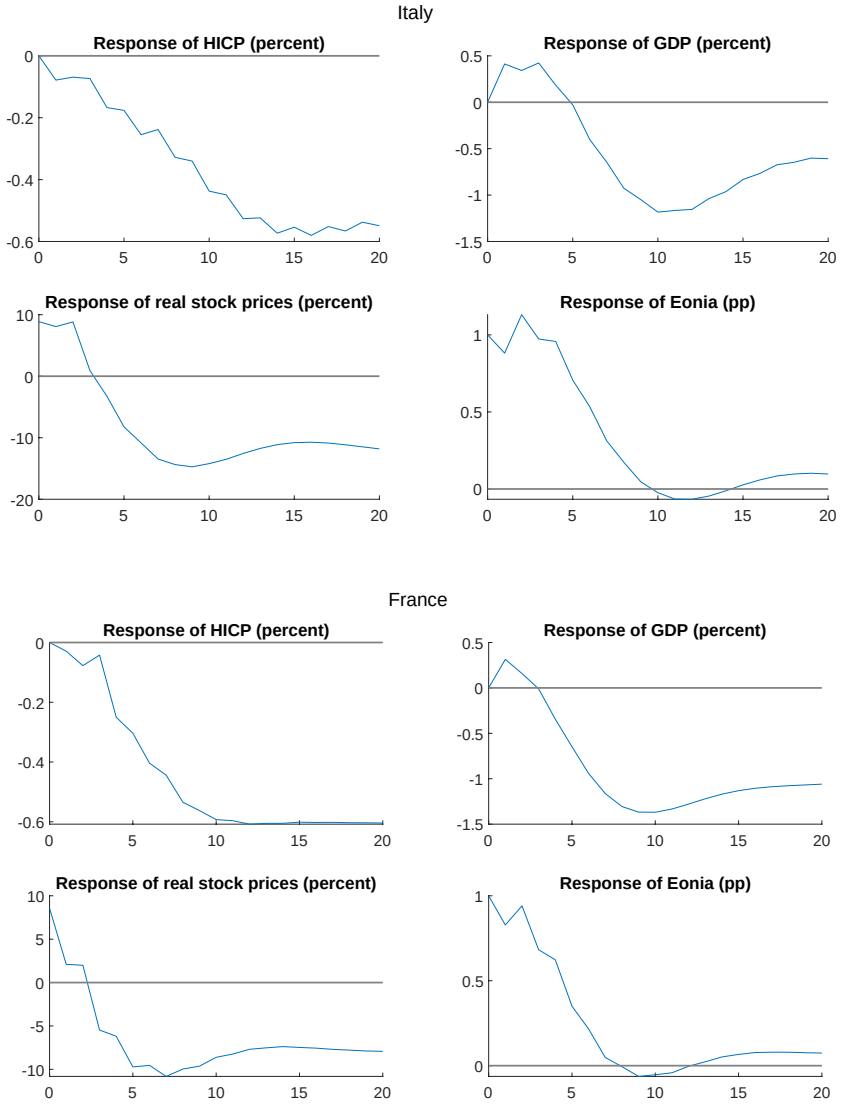
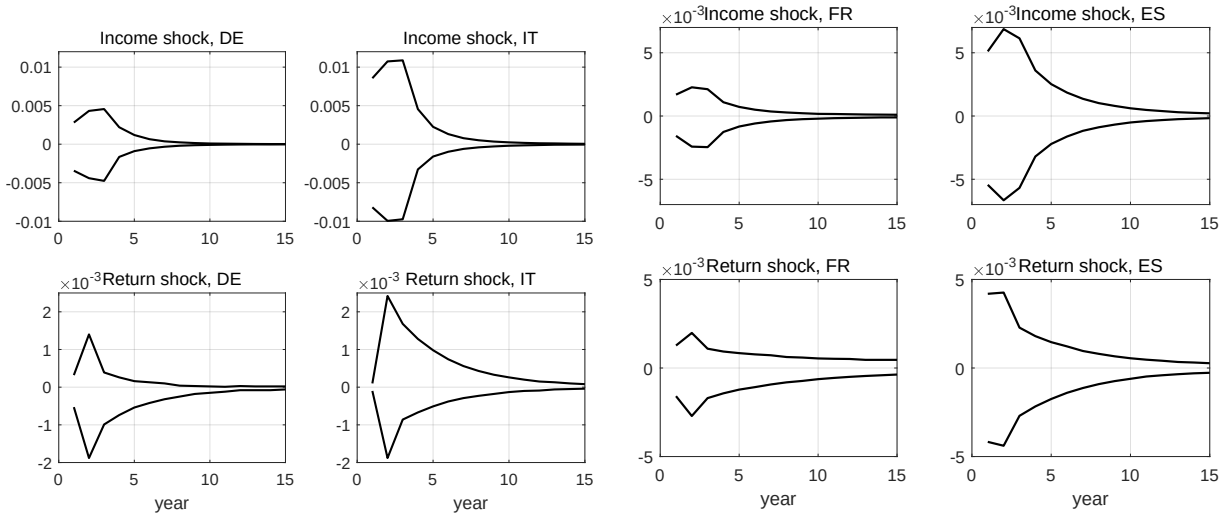


Table 21: Real/deflated stock market response to 1 pp. increase in Eonia

Quarter	0	1	2	3	4	5	6	7	8	9	10	11	12
France: Stock returns	0.086	-0.065	-0.001	-0.075	-0.007	-0.035	0.002	-0.013	0.008	0.003	0.01	0.004	0.005
France: 3 quarter MA	0.011	0.007	-0.047	-0.028	-0.039	-0.013	-0.015	-0.001	-0.001	0.007	0.006	0.006	0.004
France: Stock price	0.086	0.021	0.02	-0.055	-0.062	-0.097	-0.095	-0.108	-0.1	-0.097	-0.087	-0.083	-0.078
Germany: Stock returns	0.061	-0.059	0.005	-0.063	0.004	-0.029	-0.011	-0.016	0.004	-0.003	0.007	0.004	0.009
Germany: 3 quarter MA	0.001	0.002	-0.039	-0.018	-0.029	-0.012	-0.019	-0.008	-0.005	0.003	0.003	0.007	0.006
Germany: Stock price	0.061	0.002	0.007	-0.056	-0.052	-0.081	-0.092	-0.108	-0.104	-0.107	-0.1	-0.096	-0.087
Italy: Stock returns	0.089	-0.008	0.008	-0.079	-0.042	-0.05	-0.026	-0.026	-0.009	-0.004	0.005	0.007	0.009
Italy: 3 quarter MA	0.041	0.03	-0.026	-0.038	-0.057	-0.039	-0.034	-0.02	-0.013	-0.003	0.003	0.007	0.008
Italy: Stock price	0.089	0.081	0.089	0.01	-0.032	-0.082	-0.108	-0.134	-0.143	-0.147	-0.142	-0.135	-0.126
Spain: Stock returns	0.047	-0.015	-0.046	-0.044	-0.045	-0.021	-0.007	0	0.009	0.007	0.008	0.004	0.002
Spain: 3 quarter MA	0.016	-0.005	-0.035	-0.045	-0.037	-0.024	-0.009	0.001	0.005	0.008	0.006	0.005	0.002
Spain: Stock price	0.047	0.032	-0.014	-0.058	-0.103	-0.124	-0.131	-0.131	-0.122	-0.115	-0.107	-0.103	-0.101

9.3 Asymmetry

Figure 10: Asymmetry in Income and Return Shocks



(a) Germany and Italy (b) France and Spain

Notes: The figures display the nonlinear response to monetary policy, decomposed into income and return shocks, by country.