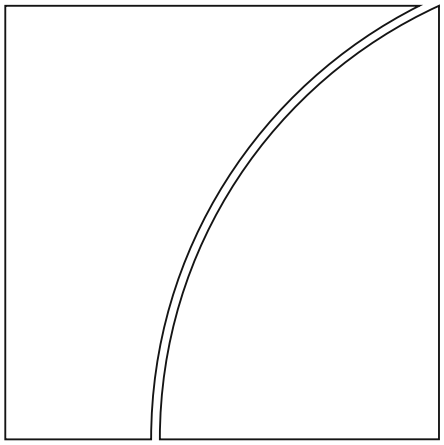

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MPC Heterogeneity and the Dynamic Response of Consumption to Monetary Policy*

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

May 30, 2023

Abstract

This paper studies how household financial choices affect the impact of monetary policy on consumption. Based on micro data from four major euro area countries, we estimate structural parameters to match moments related to asset market participation rates, portfolio shares and wealth-to-income ratios by education and country. The country specific distributions of the marginal propensity to consume out of income and financial wealth are not degenerate, reflecting, among other factors, costs to both asset market participation and portfolio adjustment. Due to the 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. Monetary policy has a larger impact on consumption in Italy and Spain compared to France and Germany. An extension of the model linking mortgage payments to monetary policy strengthens these findings.

Keywords: heterogeneity, marginal propensity to consume, monetary policy

1 Motivation

This paper studies a central question in monetary economics: how does monetary policy influence consumption? Over recent years, the literature has evolved in favour of models in which monetary policy effects on consumption

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†Bank for International Settlements, Miguel.ampudia@bis.org

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

§Joint Research Centre, European Commission, Julia.Le-Blanc@ec.europa.eu

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

are amplified by heterogeneity in the marginal propensity to consume (MPC).

Existing studies have taken two main avenues in terms of methodology to analyze the effects of household heterogeneity in the transmission of monetary policy. The first, exemplified by Kaplan, Moll, and Violante (2018), model the effects of monetary policy shocks on consumption through the endogenous heterogeneity in portfolio holdings and MPCs. The analysis is theory based, combining a rich model of household choices into a more standard New Keynesian framework. One of their main findings is that the indirect effects of monetary policy, modelled as income responses through the New Keynesian structure, are more powerful than the standard intertemporal substitution mechanism.

The second approach, exemplified by Auclert (2019), is more empirical and takes households' portfolio compositions and the distribution of MPCs from micro data and the reactions of real rates and income to monetary policy shocks from time-series data. Then it derives the impact on consumption using minimal theory. Cloyne, Ferreira, and Surico (2020) go directly to the data and estimate consumption responses to monetary innovations, conditioning on homeowner status.

Our methodology combines the strengths of these approaches. It starts with the construction and estimation of a rich structural model of household consumption and portfolio choice to derive endogenously the distribution of MPCs. We take the income and return responses to monetary policy directly from the data using VAR models with properly identified shocks as external instruments. To study the impact of monetary policy on consumption, our approach embeds this data consistent stochastic structure linking monetary innovations with income and return variations into the household optimization problem. With these inputs, we quantify the effects of monetary policy on household consumption, based upon income and return responses that are data consistent.

The reasoning supporting this approach is that we know well how to model consumption, savings, and portfolio choice with heterogeneity, participation costs and incomplete markets. But the production side of the economy (the New Keynesian Phillips curve) and the policy rule (the Taylor rule) are the weaker components of general equilibrium models. In fact, as in Kaplan, Moll, and Violante (2018), the analysis is often not based upon the equilibrium of an economy with monetary shocks but rather studies the effects of a surprise policy change.

There are three steps in our analysis. The initial step is the estimation of structural parameters and the characterization of the household's optimal behavior. Our estimation takes the income and stock return processes as given, and employs the life-cycle patterns of the household financial choices as the moments. The exogenous processes and moments are all country specific, leading to country specific parameter estimates that are informative about why consumption responses to monetary innovations differ across countries.

The second step is the characterization of the distributions of MPCs across heterogeneous households.[1] These distributions are obtained by simulating the response to income and return shocks using the estimated household-level policy functions, rather than estimated directly from the data. This approach enables us to trace the cross-country difference in MPC distributions back to the differences in the income processes, stock return processes,

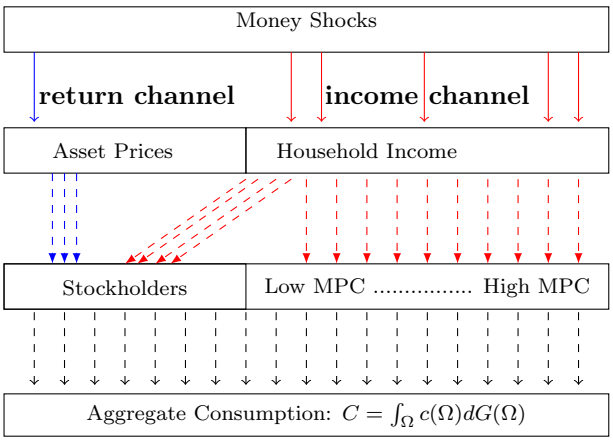
[1] Carroll, Slacalek, and Tokuoka (2014) look across EU countries and generate an MPC distribution in an alternative setting which does not emphasize participation and adjustment frictions. Their focus is on the relationship between the wealth distribution and the aggregate MPC.

and structural parameters. The resulting country-specific MPC distributions are used as inputs in the monetary policy analysis.

Finally, the estimated model is used to study the impact of monetary policy on consumption. The distribution of households across income and asset holdings creates a distribution of MPCs out of income and return shocks. This generates a non-degenerate distribution of consumption responses to monetary policy innovations. The aggregate response will depend on both the impact of the monetary shock and the distribution of consumption responses, driven by the distribution of household across income and wealth states. Monetary policy will consequently have distributional effects.[2]

Figure 1 illustrates the effects of a monetary policy shock on aggregate consumption through the logic of our model. An innovation influences both asset returns and household labor income. These effects are taken as given by the household but may themselves be driven by intertemporal substitution, say through firm investment, that lie outside of the model. The variations in income are heterogeneous, reflecting both endogenous asset market decisions as well as the differences in the sensitivity across households of labor income to monetary shocks. Due to household heterogeneity, these income and asset return shocks induce different consumption responses. In our analysis, this is captured by the estimated MPC distribution across households by country. In the figure, households are distinguished by both asset market participation and their state dependent MPCs out of income. Aggregating across households within a country then generates the aggregate consumption response.

Figure 1: Impact of Monetary Policy



This figure indicates the flow of our analysis of a monetary shock, emphasizing the heterogenous response across households. Here Ω indicates the household state and $G(\cdot)$ is the cdf across states.

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 MPCs. But this response of

[2]These effects are highlighted in Ampudia, Georgarakos, Slacalek, Tristani, Vermeulen, and Violante (2018), Casiraghi, Gaiotti, Rodano, and Secchi (2018) and Coibion, Gorodnichenko, Kueng, and Silvia (2017) as well.

consumption induced by income variations is very much country-specific, in part because of the large cross-country differences in the estimated parameters.[3] Additionally, the income response to monetary shocks, which we estimate directly from the data, is not uniform across countries.

Regarding the stock return channel, the effects of monetary innovations on stock prices only influence the consumption of stock market participants. We find that participants with higher income have MPCs (in response to a stock return shock) that are mildly smaller than low income participants, but consumption of these high income participants responds significantly more to monetary shocks through the stock return channel because they have more wealth in the stock market relative to lower income participants.

Put together, these channels induce consumption responses to monetary shocks that depend on income. This is a novel feature of our analysis, created by the presence of the two channels that arise from different sections of the income distribution.[4] The lowest income households have the highest MPCs out of income and respond to monetary shocks through the income channel. The highest income group is more likely to participate in stock markets and responds more to monetary shocks through the stock return channel. As a result, the middle income group responds to monetary shocks mildly relative to the other two groups. The overall effect of monetary policy on consumption is U-shaped in income in Germany and France and declining in income in Italy and Spain.

Our paper differs from the literature in several ways. First, the dynamic discrete choice problems of heterogenous households provide the framework for parameter estimation. Crucially, this includes the estimation of asset market participation costs, portfolio adjustment costs and consumption floors, representing income dependent government transfers to households, in our four countries: France, Germany, Italy and Spain.

Second, from the estimated parameters, we compute distributions of MPCs. To be clear, the computation of these MPC distributions rests on the estimated parameters and is not taken from an auxiliary regression. These MPC distributions are a fundamental element in the analysis of consumption responses to monetary innovations.

Third, we use the responses of labor income and stock returns to monetary innovations estimated from the data as inputs into the determination of the consumption response. This allows us to use a rich household optimization model to study the effects of monetary innovations on aggregate consumption without explicitly modelling how monetary innovations lead to changes in income and stock returns. The advantage of this approach is that it brings to life these two important channels through which monetary innovations impact aggregate consumption, while keeping the focus on how the consumption of heterogenous households responds differently to income shocks and stock return shocks induced by monetary innovations.

Overall, our approach generates a number of insights. First, it uncovers a U-shaped response through the interaction of the income and return channels. Second, we find differences in household behavior across countries that eventually translate into differences in the impact of monetary policy. The parameter estimates and resulting MPC distributions vary across countries. This leads to country specific responses to monetary innovations. Third, we find differences across households in a given country generated by underlying heterogeneous shocks coupled with non-convex adjustment costs and participation decisions. This heterogeneity persists into the empirically based

[3] A number of counterfactuals serve to study the contribution of different parameters.

[4] For example, the return channel is not present in Kaplan, Moll, and Violante (2018).

analysis of monetary policy. For example, the return channel of monetary policy specifically impacts households with large stock holdings.

Although our life-cycle model of household financial choices includes rich dynamics arising from stock market participation and portfolio adjustment decisions in the presence of the participation cost, the adjustment cost and the consumption floor, the baseline model does not include an explicit housing channel which is emphasized by Cloyne, Ferreira, and Surico (2020) and Hintermaier and Koeniger (2018) among others. Our quantitative approach takes housing out of the model by conditioning the data moments on homeownership status. In other words, the effects of home ownership are controlled in the regression that generates the moments we match.

An extension supplements the analysis of monetary policy with a housing channel.[5] The goal is to introduce the effects of changes in the policy rate on the mortgage payments of homeowners. Doing so requires key inputs of the distribution of homeownership and the sensitivity of mortgage payments to the policy rate. From this exercise, we see first that this channel is country specific as well, being largest in countries, such as Spain, where the homeownership rate is high and the response of mortgage rates to monetary shocks is large as well. Further, there is a dynamic response of consumption through this channel due to the lagged relationship between mortgage rates and monetary policy shocks.

The paper is organized as follows. Section 2 presents basic data facts. Section 3 introduces the life-cycle optimization problem of households and the estimation of structural parameters. Section 4 studies MPC distributions of the four countries, and section 5 quantitatively evaluates the effects of monetary policy on consumption. Section 6 adds housing to the model. Section 7 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, providing motivation for our analysis and the model of dynamic household choices. The data come from the Household Finance and Consumption Survey (HFCS) 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 by the non-zero holding of stocks, either directly or indirectly through mutual funds and pension plans. The table also displays the median financial wealth-to-income ratio. The moments are presented by education group: college or no college attainment. As discussed in Cooper and Zhu (2015), education potentially matters both in terms of differences in income processes, patience, asset market participation and adjustment costs through financial literacy.

Participation rates in stocks are well below 100% in all countries. These rates are somewhat higher for college graduates. 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. As established

[5]We appreciate the guidance of the editor and referees in undertaking this extension.

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

Table 1: Household Finance Facts by Education by Country

	Germany		**Spain**		**France**		**Italy**	
edu	low	high	low	high	low	high	low	high
participation	45.4	66.7	23.2	47.0	39.2	56.0	19.5	36.0
stock share	50.0	44.7	50.8	45.1	50.0	44.5	47.3	37.6
W/I	0.350	0.749	0.180	0.399	0.303	0.552	0.287	0.519
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 asset market participation rate (in percent), the average share of stocks over total liquid assets (for participants, in percent), the median financial wealth-to-income ratio (W/I) for households in each country by educational attainment, low (no college) and high (college). Standard errors for these moments are shown in Online Appendix Table 2. Data source: HFCS first wave.

later, these differences in participation rates translate into differences in response to monetary policy, particularly through asset prices.

For those who participate in the stock market, the share of stocks in their portfolio 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. The median financial wealth-to-income ratio is less than 1 for all countries and is higher for the higher education groups.

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. The differences in portfolios across countries are studied in Christelis, Georgarakos, and Haliassos (2013), as well as in Guiso, Haliassos, and Jappelli (2003).

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 and Parameter Estimation

This section covers the first phase of the analysis: the estimation of the dynamic household choice problem. The household optimization contains both an asset market participation and a portfolio adjustment choice. The parameters are estimated by country. These parameter estimates and associated policy functions are used in the construction of the MPC distributions which, in turn, are the key inputs into the analysis of monetary policy.

3.1 The model

This section presents the household dynamic optimization problem, drawing on Cooper and Zhu (2015). The purpose of this section is two-fold. First, the estimation of dynamic financial choices at the household level is of interest in its own right: we want to know what the key country-specific features are that explain the different patterns shown in Table 1. Second, we want to shed light on how the differences in financial decisions, captured through the estimated parameters, influence the effects of monetary policy.

A key element is the presence of non-convexities due to both participation and adjustment costs.[7] As we shall see, these elements of the model are important not only for matching the moments of household financial choices but also influence the household response to monetary policy. In particular, the impact of monetary policy is through a distribution of MPCs that itself rests upon the individual choice problem.

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 its 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.

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 the working life. Once the households retires, income is deterministic and country-specific.

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.

3.1.1 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 participant 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.

[7] Kaplan, Moll, and Violante (2018) includes a version of these frictions while Auclert (2019) 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.

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

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

s.t.

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

$$A' = R^b A^{b'} + R^{s'} A^{s'} \quad (4)$$

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

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. Following Epstein and Zin (1989) and Weil (1990) we assume a recursive utility representation.[9] Here γ captures the attitude of the agent towards risk and θ is the elasticity of intertemporal substitution. With this specification, the two key aspects of household choices are estimated independently.

There is a consumption floor of $\underline{c}$ representing a transfer from the government to the household. 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 captures transfers beyond those included in the income measure. Importantly, the floor operates in a very non-linear way, compared to the log-linear representation of disposable income used in our quantitative analysis. Based upon the results reported in Cooper and Zhu (2015), the consumption floor is important for matching the wealth-to-income ratios of low education households.

$B(A')$ in equation (2) is the value of leaving a bequest of size A', 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:

$$B(A') = L(\phi + A'). \quad (6)$$

The curvature over the bequests, parameterized by γ, appears through equation (2). Here $\phi > 0$ measures to what extent the bequest is luxurious. It also allows for $A' = 0$ while keeping $B'(0)^{1-\gamma}$ a finite number.

In this problem, there is a lower bound to bond holdings, $\underline{A}^b$, which can be negative to allow borrowing. When this lower bound is binding, households are liquidity constrained. 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 exist on adjustment rates for the asset market participants in our sample countries. This parameter is identified through portfolio composition: a high value of F

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

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 income 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.

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

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

3.1.2 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:

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

for all Ω. The budget constraints are:

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

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:

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

subject to the following constraints:

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

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'.

3.2 Estimation

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, $\Theta \equiv (\beta_i, \gamma, \Gamma, F, L, \phi, \underline{c}, \theta, \underline{A}^b)$ which characterize households in a country are estimated via simulated method of moments. The discount factor, β_i, is indexed by education attainment, $i = 0, 1$, for no college and college respectively.[10] The vector Θ is chosen to solve:

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

Here W is a diagonal weighting matrix calculated as the inverse of the variances of the moments taken from Online

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

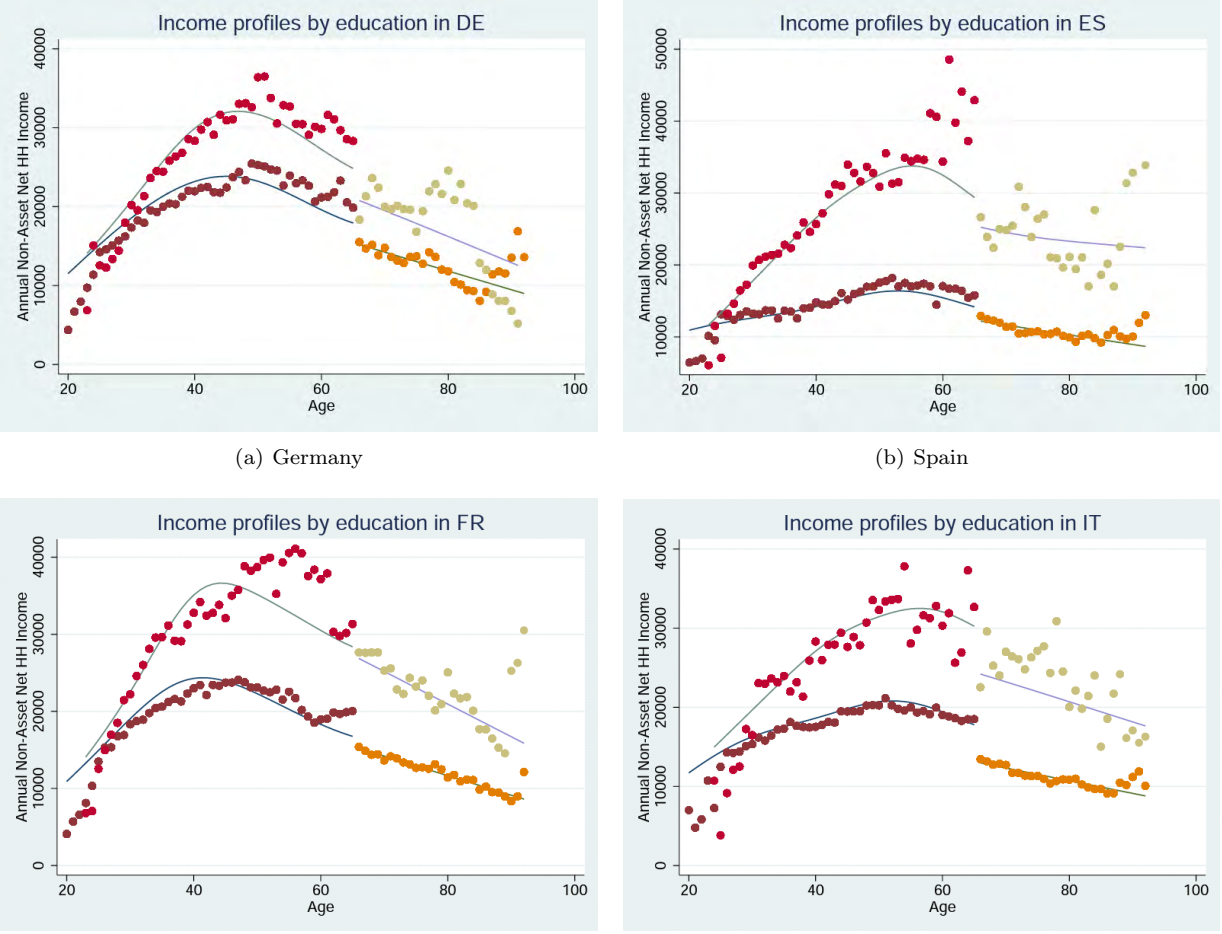
Appendix Table 2. The simulated moments, $M^s(\Theta)$, are calculated from a simulated data set created by solving the household optimization problem. For each country, the initial distribution of asset holdings, needed as an input into the computation of moments, is taken from the data.

3.2.1 Income and Return Processes

The individual optimization problems require income and return processes as inputs. These are taken as given by the household.

3.2.1.1 Income

Figure 2: 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.

Income is measured as labor earning after taxes and inclusive of social transfers.[11] We use the European Community Household Panel (ECHP) to estimate an income process for each country and education group (college vs no college household heads). For a detailed explanation of the estimation see sub-section 1.1.1 in the Online Appendix, we provide a summary of the results here.

Income processes have both a deterministic and a stochastic component. Figure 2 shows the estimated 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 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.

The stochastic component contains both persistent and transitory shocks. Over the whole sample, households in Germany face the lowest persistence of income shocks while Italian and French households have highly persistent shocks. 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 in Germany display low permanent and transitory shocks. In Italy and Spain, less educated households face large and very persistent permanent shocks.[12] Over time the large and persistent shocks are translated into more income dispersion, which in turn generates more dispersion in MPCs in our simulated data. As we will show, Spain and Italy exhibit much larger consumption responses to monetary innovations because of the large MPCs of low income households in these countries.

3.2.1.2 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 the 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.

[11] Importantly, the inclusion of transfers in the income measure might seem in conflict with the consumption floor included in the theory and estimated models. Many of these transfers are income dependent and thus are not neatly captured by a log linear process. Our estimated consumption floor may be picking up this nonlinearity of the income process. See Lander (2019) for further discussion and evidence of this point. Online Appendix sub-section 1.7 reports estimates of the income process that excludes many of these transfers. From Online Appendix Table 8, the parameters of the stochastic process, particularly for the low income households, are very similar regardless of the income measure.

[12] One 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: Stock Return Processes

	mean	standard deviation
DE	0.102	0.262
ES	0.077	0.251
FR	0.091	0.246
IT	0.065	0.276

This table reports the mean and standard deviation of real stock return by country between 1951-2012.

The annual mean return ranges from a low of 6.4% in Italy to 10.2% 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.[13]

It is noteworthy that, among the four countries, Italy has the lowest stock return but the highest standard deviation of stock return. This partly explains the low stock market participation rate of Italy.

3.2.2 Moments

The moments for the structural estimation are shown in the left panel of Table 3.[14] 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 home ownership 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, controlling for home ownership.

A couple of points stand out. Education has an impact on 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-to-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-to-income ratio in all countries except Italy. For Italy, the wealth-to-income ratio falls with education up to age 55.

To illustrate the life-cycle aspects of these moments, Figure 3 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 both are well below 100%. The wealth-to-income ratio is increasing in age for both education groups.

The regressions control for home ownership status and home equity. Table 4 summarizes the findings on the effects of home ownership on household financial moments: these are the regression coefficients for the home ownership dummy. For all countries, home ownership is complementary to asset market participation, particularly in Italy and France. Though not reported in the table, this is true for home equity as well. The correlation of

[13] 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.

[14] The standard errors are reported in Online Appendix Table 2.

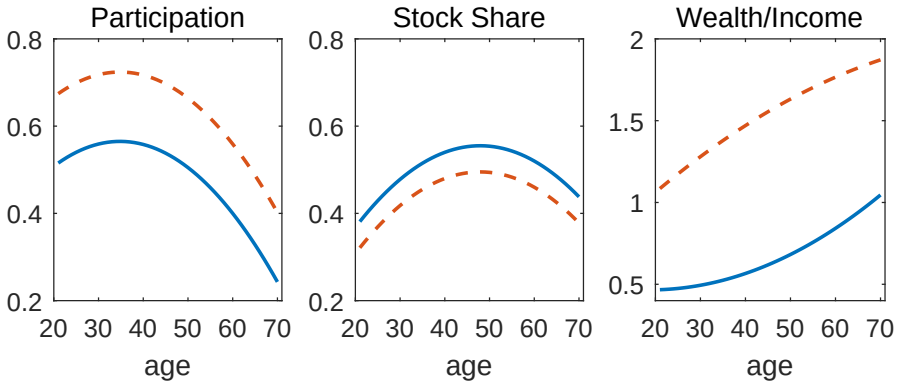
Table 3: Data and Model Moments

	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		-0.314	0.033	-0.00023	0.105	
Share	0.004	0.023	-0.00024	-0.060		0.020	0.024	-0.00023	-0.060	
W/I	0.542	-0.008	0.00022	0.037	-0.00036	1.082	-0.030	0.00036	-0.028	0.00061
			Spain: Data					Spain: Model		
Part.	-0.716	0.035	-0.00034	0.161		-0.489	0.039	-0.00032	0.251	
Share	-0.116	0.027	-0.00025	-0.049		-0.094	0.027	-0.00024	-0.044	
W/I	-1.675	0.065	-0.00036	0.013	0.00012	0.824	-0.007	0.00003	-0.059	0.00131
			France: Data					France: Model		
Part.	-0.090	0.015	-0.00013	0.148		-0.173	0.030	-0.00025	0.222	
Share	0.056	0.013	-0.00007	-0.017		0.048	0.010	-0.00008	-0.019	
W/I	1.344	-0.050	0.00070	-0.004	0.00030	0.805	-0.018	0.00031	-0.074	0.00234
			Italy: Data					Italy: Model		
Part.	-0.117	0.014	-0.00017	0.089		-0.188	0.027	-0.00019	0.171	
Share	0.225	0.015	-0.00016	-0.082		0.284	0.015	-0.00017	-0.078	
W/I	-0.062	0.023	-0.00018	-0.023	0.00042	0.268	0.010	-0.00005	-0.050	0.00125

This table reports data and model moments. For the wealth-to-income ratio regression, the regressors include a constant, age, age-squared, college*age, college*age-squared. For all regressions, controls included home equity and home ownership status.

home ownership and the shock share is negative for Germany and France, but positive for Spain and Italy. The correlation with the financial wealth-to-income ratio is negative, except for Germany.

Figure 3: 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.

These results make clear the importance of conditioning on home ownership and housing wealth in the calculation of the moments we match. To be clear, our approach uses these regressions with home ownership and housing wealth to generate moments we match in a model without housing. By conditioning on these housing moments, we are controlling for their effects on financial choices. In section 6 we provide additional evidence on the robustness of

Table 4: Housing Impact on Household Financial Choices

Country	participation	share	wealth-to-income ratio
DE	0.071	-0.043	0.425
ES	0.051	0.033	-0.259
FR	0.103	-0.043	-0.269
IT	0.081	0.033	-0.218

This table summarizes the effects of the home ownership on financial choices (i.e. the coefficient of the home ownership dummy) by country. These estimates are all significantly different from zero at the 5% significance level.

this approach.

The moments in the left panel of Table 3 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.

3.3 Results

The moments from the estimated model are reported in the right panel of Table 3 and the parameter estimates appear in Table 5. The latter table includes a goodness of fit measure, computed using (10).

There are a couple of key findings, both of direct interest and used later in the analysis of monetary policy. First and foremost, the estimation uncovers statistically and economically significant costs of asset market participation and portfolio adjustment. Second, we find some support for borrowing constraints, as we are unable to reject $\underline{A}^b = 0$. The economic significance is seen by the contribution of the financial frictions and the borrowing constraints to the distribution of MPCs. As we shall see, this distribution is key to understanding the channels of monetary policy.

3.3.1 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 0.79 for the low education group, and it increases with educational attainment. The estimates range from 0.848 in Germany to 0.895 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-to-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

Table 5: Parameter Estimates

	β_0	β_1	γ	Γ	F	L	ϕ	$\underline{c}$	θ	$\underline{A}^b$	Fit
DE	0.822	0.848	17.638	0.014	0.011	0.030	0.103	0.290	0.509	-0.072	1343
	(0.009)	(0.004)	(2.358)	(0.001)	(0.009)	(0.012)	(0.312)	(0.301)	(0.018)	(0.249)	
ES	0.779	0.860	10.275	0.010	0.011	0.054	0.425	0.299	0.357	-0.062	687
	(0.009)	(0.005)	1.196)	(0.002)	(0.006)	(0.014)	(1.273)	(0.035)	(0.046)	(1.174)	
FR	0.752	0.867	21.309	0.008	0.017	0.060	0.589	0.134	0.373	-0.088	7175
	(0.008)	(0.002)	(0.056)	(0.001)	(0.002)	(0.001)	(0.139)	(0.825)	(0.008)	(0.971)	
IT	0.823	0.895	8.255	0.011	0.006	0.100	0.823	0.329	0.436	-0.085	717
	(0.01)	(0.002)	(0.455)	(0.003)	(0.002)	(0.026)	(0.859)	(0.063)	(0.126)	(0.123)	

This table reports parameter estimates and the corresponding standard errors. The last column is model fit calculated using equation (10).

participation costs needed to match the life-cycle savings and portfolio choices.

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. In their paper, the estimates are obtained by matching moments of the liquid asset holdings distribution of households.

The estimated risk aversion, ranging from 8.255 in Italy to 21.308 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 low 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) abstracts 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.

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.

As emphasized later, the distinction between risk aversion and intertemporal substitution through the EZW preference specification is quite important for understanding the response of households to variations in income and stock returns induced by monetary policy. The identification of these parameters is discussed in Online Appendix sub-section 1.2.1.

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.

From the perspective of the channels of monetary policy, the financial frictions are important. 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 1.4% of permanent income in Germany is the highest among the four countries, and the cost is relatively low in France. The adjustment costs are relatively high in France and Spain, while for Italy the adjustment cost is relatively small, though 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 France and Italy. Further, there is a positive point estimate of ϕ, the luxuriousness of bequest, in all four countries but these are only significantly different from zero in France.

The consumption floor, $\underline{c}$, is reported as the fraction of a country's average income. For Spain and Italy $\underline{c}$ is around 0.3, i.e., 30% of the respective average income, larger than in France and Germany, and is precisely estimated.[15] Given the large consumption floor in these two countries, low income households who are more likely to hit the floor tend to have very high MPCs, leading to the larger consumption response to monetary innovation in Spain and Italy, as we will report later in this paper.

The model estimates a borrowing constraint. The point estimates are negative for each country, indicating that some borrowing is feasible. But these estimates are not precise, and not statistically different from zero.[16]

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.[17] Of course, this does not mean that the borrowing constraint does not influence behavior. As indicated in Online Appendix Table 3, 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.

Other implications from these estimates are shown in Table 6. The table reports the average participation rates, the adjustment rates conditional on participation and the fraction of households hitting the consumption floor, by country and by permanent income realization.[18] 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.

[15] Re-estimating the model with an income measure that excludes many means-tested transfers increased the point estimate of $\underline{c}$ by between 0.03 to 0.05.

[16] At the suggestion of a referee, we estimated the model for France and Germany allowing the discount factor and the borrowing constraint to be dependent on education. In both cases the borrowing capacity is estimated to be slightly larger, i.e. $\underline{A}^b$ is larger in absolute value, for educated households, with the remaining parameters close to their baseline values. The consumption response to monetary policy in this case is consequently close to the baseline.

[17] 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.

[18] These three states correspond to the three permanent income states in the discrete representation of the income process. Online Appendix Table 4 summarizes the distribution across these states.

Table 6: Participation and Adjustment Rates

Country	Ed \ Inc	Participation Rate			Adjustment Rate			Fraction of HHs
		low	middle	high	low	middle	high	hitting $\underline{c}$
Germany	low	0.161	0.853	0.984	0.302	0.193	0.219	0.057
	high	0.542	0.913	0.995	0.279	0.244	0.309	0.000
Spain	low	0.143	0.668	0.912	0.171	0.134	0.219	0.106
	high	0.646	0.899	0.998	0.178	0.295	0.440	0.001
France	low	0.101	0.741	0.913	0.002	0.008	0.072	0.000
	high	0.645	0.981	1.000	0.132	0.324	0.579	0.000
Italy	low	0.142	0.776	0.988	0.229	0.195	0.317	0.092
	high	0.618	0.913	0.994	0.394	0.409	0.553	0.002

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

4 MPC Distributions

Using the estimated model, this section studies the distribution of the MPCs across households by country in response to shocks to income and stock returns. The MPC is the natural summary statistic for a household response to a shock, thus the distribution of MPCs matters in determining the impact of monetary policy on aggregate consumption through the income and return channels.

4.1 An Overview of MPC Heterogeneity

Heterogeneity in the consumption response of households to variations in income and stock returns is a natural consequence of our model. 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 MPCs. 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 wealthy 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 MPCs include Cocco, Gomes, and Maenhout (2005) and Gomes and Michaelides (2005) where older unconstrained households have higher MPCs 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 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 MPCs 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.

There is also a large literature that focuses on the household response to fiscal policy. A notable contribution related to our findings is Misra and Surico (2014), who study the response to US tax rebates, stressing the role of heterogeneous households. They find a sizeable dispersion of responses, with almost 50% of the households saving the entire rebate. They include durable spending in their empirical analysis and find an interesting interaction between the durability of goods and the responsiveness of spending to the tax rebate. Finally, they too talk of a U-shaped response to the tax rebate. That seems to arise for different reasons than in our model where there are both income and return channels that jointly produce this pattern of consumption responses.

Here we focus on the MPC distribution from (positive) transitory income and return shocks. Our methodology is quite different from existing studies. We do not rely on auxiliary regressions. Instead, we simulate income and return variations and determine the response using the country-specific estimated decision rules.

4.2 Income Shock

This sub-section studies the consumption response to 1% and 10% increases in transitory income. The increase in income is given as a lump sum to all households. Thus differences in consumption responses among households are not driven by differences in the amount of the transfer. For this exercise, we simulate the consumption of each household in the baseline economy, then we impose an exogenous increase in transitory income to all households

Table 7: MPC Distribution: Income Shock

Country	Ed \ Inc	1% All Households low	1% All Households middle	1% All Households high	1% Participants low	1% Participants middle	1% Participants high	10% All Households low	10% All Households middle	10% All Households high	10% Participants low	10% Participants middle	10% Participants high
DE	low	0.603	0.255	0.204	0.267	0.241	0.203	0.599	0.249	0.204	0.251	0.237	0.202
	high	0.405	0.205	0.147	0.246	0.203	0.150	0.408	0.204	0.147	0.240	0.202	0.149
ES	low	0.684	0.338	0.222	0.327	0.250	0.211	0.677	0.320	0.217	0.323	0.242	0.206
	high	0.306	0.191	0.150	0.226	0.178	0.150	0.304	0.188	0.150	0.221	0.177	0.150
FR	low	0.441	0.242	0.189	0.301	0.233	0.188	0.429	0.239	0.188	0.288	0.231	0.188
	high	0.242	0.114	0.122	0.159	0.111	0.144	0.238	0.114	0.124	0.158	0.112	0.146
IT	low	0.778	0.260	0.164	0.411	0.221	0.167	0.790	0.255	0.164	0.405	0.217	0.167
	high	0.330	0.163	0.125	0.189	0.147	0.124	0.323	0.162	0.125	0.185	0.147	0.124

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 attainment for all households as well as those participating in asset markets. The left block is for a 1% transitory shock and the right is for a 10% transitory income shock.

and re-simulate their consumption. For each household, the MPC is calculated as the contemporaneous change in consumption divided by the change in income.[19]

4.2.1 MPC Distributions by Country

Table 7 presents MPCs by country for each of the three levels of permanent income by education group. Within each experiment, we report MPCs for all households and for stock market participants only. The numbers reported are the mean value of the MPCs for each cell.

A couple of features are apparent. First, for all countries and education groups, the MPC falls with the level of permanent income and education. The low education, low permanent income group has the highest MPC in each country.

Second, the low income and low education group has a much higher MPC in Italy and Spain relative to France and Germany. For this cell, the MPC is over two-thirds in the former two countries. This is partly due to their larger and more persistent income shocks as reported in Online Appendix Table 1. The estimated consumption floors are also larger for these two countries, further increasing the MPC of the low income and low education group. In addition, as shown in Online Appendix Table 4, Spain and Italy have the largest fractions of low income and low education households among the four countries. Thus the highest MPC group gets more weight, which further strengthens the consumption responses to monetary innovations in these two countries.

Third, in almost all cells, the MPC is lower for stock market participants. This is particularly clear for the low income group where participation rates are lowest. In France and Germany stock market participants have a slightly higher MPC than non-participants for the high education and high income cell. 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 face more liquidity constraints. Thus for them a positive income shock leads to a rapid

[19] To be clear, this is the change in consumption in period t in response to an income change in period t.

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 are identified by their behavior in the absence of the income shock.

Table 8: Income MPC of Consumption Floor Hitters and Stock Market Participants

	1%			10%		
	Hitter	Adjustors	Non-adustors	Hitter	Adjustors	Non-adustors
DE	1.000	0.180	0.204	1.000	0.179	0.201
ES	1.000	0.150	0.202	1.000	0.149	0.199
FR	n.a	0.114	0.176	n.a.	0.116	0.175
IT	1.000	0.152	0.176	1.000	0.150	0.175

This table reports the mean MPC of consumption floor hitters and stock market participants. Adjustors are the participants who engaged in portfolio re-balancing.

As shown in Table 8, non-adjustors have a higher mean level of MPC in each country, which is consistent with our conjecture. In particular, the MPC of non-adjustors in France is almost 55% larger than that of adjustors. This is then consistent with the finding in Table 7 of higher MPCs for stock market participants with high education and high permanent income.

Table 8 also reports the income MPCs of consumption floor hitters, households who receive transfers to attain the consumption level of $\underline{c}$. Not surprisingly these hitters have an MPC of 100%. Recall that the estimated consumption floors are larger in Spain and Italy, implying that low income households in these two countries should have larger consumption responses to monetary shocks because they are more likely to hit the consumption floor.

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).

The MPC distribution generated by our model can be compared with that 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%.

4.2.2 Wealth and MPCs

Table 9 presents regression results that explain the variations in MPC across households within each country. The dependent variable is the household level 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

Table 9: MPC Regressions: Income Shock

						wealth percentile				
	const.	*age*	age^2	*income*	*edu*	10-50%	50-70%	70-90%	90-95%	95-100%
1% increase in transitory income										
DE	0.378	0.018	-0.0002	-0.064	0.022	-0.0000	-0.130	-0.156	-0.201	-0.218
ES	0.490	0.008	-0.0001	-0.013	-0.001	-0.0000	0.090	0.060	0.008	0.003
FR	0.295	0.014	-0.0002	-0.040	-0.012	0.0000	-0.192	-0.245	-0.258	-0.262
IT	0.332	0.019	-0.0002	-0.068	-0.022	-0.0000	-0.212	-0.236	-0.274	-0.281
10% increase in transitory income										
DE	0.363	0.018	-0.0002	-0.059	0.021	-0.0000	-0.154	-0.179	-0.224	-0.242
ES	0.483	0.008	-0.0001	-0.012	-0.001	-0.0000	0.089	0.061	0.009	0.004
FR	0.277	0.014	-0.0002	-0.037	-0.016	0.0000	-0.187	-0.241	-0.253	-0.257
IT	0.344	0.018	-0.0002	-0.064	-0.027	-0.0000	-0.203	-0.227	-0.265	-0.272

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 (dummy) and wealth percentiles.

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 7 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.

4.2.3 The Nonlinearity of MPCs

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, Table 10 studies the factors that contribute to the nonlinearity of the MPC for Germany. The top row reports the MPCs from the baseline, indicating the disparity in the responses of consumption to transitory income shocks by education and permanent income realization. The other rows set factors potentially contributing to the nonlinearity of the MPCS, starting with the borrowing constraint. From this table, there is no single change that eliminates the disparity in MPC.

It is instructive to see how the MPC of the low education, low income group responds to these changes. The elimination of each source of the nonlinearity reduces the MPC for this group. Eliminating the opportunity to borrow, relative to the estimated of $\underline{A}^b = -0.072$, reduces the MPC by 4 percentage points. Eliminating the consumption floor reduces this MPC further and hence reduces the difference in MPC across groups. In the bottom row, all types of nonlinearities are removed with the discount factors of the low education group set equal

Table 10: The Nonlinearity of MPCs (Germany)

		All Households			Participants		
	Ed \ Inc	low	middle	high	low	middle	high
baseline	low	0.603	0.255	0.204	0.267	0.241	0.203
	high	0.405	0.205	0.147	0.246	0.203	0.150
$\underline{A}^b = 0$	low	0.558	0.260	0.205	0.297	0.256	0.204
	high	0.407	0.205	0.151	0.251	0.199	0.150
$\underline{A}^b = \underline{c} = 0$	low	0.443	0.258	0.204	0.296	0.254	0.203
	high	0.407	0.205	0.151	0.251	0.199	0.150
$\underline{A}^b = \underline{c} = \Gamma = F = \phi = 0$	low	0.346	0.236	0.168	0.360	0.236	0.181
	high	0.337	0.181	0.146	0.337	0.197	0.149
$\underline{A}^b = \underline{c} = \Gamma = F = \phi = 0$, $\beta_0 = \beta_1$	low	0.287	0.194	0.143	0.287	0.194	0.143
	high	0.337	0.181	0.146	0.337	0.197	0.149

This table shows the MPCs for Germany under different parameter setting. For the last row, the discount factor of the low education group is set to the same level as the high education group.

to that of the high education group, and increase of 0.026. This reduces the MPC of the low education, low income close to 0.29, compared to its baseline value of 0.603,

Interestingly, these experiments reduce but do not eliminate the MPC disparities. What remains, in part, is the standard concave relationship between consumption and income. So given education, and thus an income process, the MPC falls with income.[20] Further, if there is more riskiness in the income for low education compared to high education households, this would lead to differences in the MPCs.

These findings are important as they provide the crucial link between the household choice problem and the impact of monetary policy. The monetary policy exercises will rest upon the MPC distributions without direct reference to the underlying frictions and other elements of the household choice problem. But clearly those frictions matter for monetary policy insofar as they generate the MPC distributions.

4.3 Return Shocks

Here we study the contemporaneous MPCs of households in response to a 1% and a 10% shock in the return to stocks.[21] Note that this shock only affects the choices of households who participate in asset markets, with the impact dependent on financial wealth. For these agents, a higher return impacts consumption through an increase in financial income which, through a portfolio adjustment decision, leads to a change in current consumption. As the returns are iid, conditional expectations of future returns are independent of current returns implying there are no direct intertemporal substitution effects. Further, the asset market participation decision can be impacted by stock returns: e.g., the reduction in wealth from an adverse shock might reduce participation.

[20] For example, as presented in Carroll (1992).

[21] We assume the variation in stock return is purely transitory, thus it does not change the household's expectations on the mean stock return in the future. As the return on bonds is deterministic, it makes no sense to explore the response to a zero probability event.

The MPC distribution with respect to these return shocks is reported in Table 11.[22] Higher permanent income or higher education households have lower MPCs on average. The MPCs are essentially independent of the size of the return shock. Importantly, the MPC in the low income and low education cells in Table 11 is not strikingly higher than in the other cells, while the same comparison leads to much larger difference in the case of income shocks in Table 7. This is because the asset market participation rate is very low among households with low income and low education as shown in Table 6, and the small fraction of participants from this group is relatively rich, thus they have relatively low MPCs.

Comparing the MPCs across countries, we find that the low income and low education groups exhibit significantly larger MPCs in Italy and Spain relative to Germany and France, a pattern similar to the findings in income MPC. This pattern explains the larger consumption response to monetary innovations in Italy and Spain studied in Section 5.

Table 11: MPC Distribution: Return Shocks for Participants

Country	Ed \ Inc	1%			10%		
		low	middle	high	low	middle	high
DE	low	0.248	0.192	0.162	0.248	0.192	0.162
	high	0.207	0.169	0.137	0.207	0.169	0.137
ES	low	0.328	0.177	0.160	0.328	0.177	0.160
	high	0.181	0.161	0.140	0.181	0.161	0.140
FR	low	0.235	0.202	0.161	0.235	0.202	0.161
	high	0.165	0.131	0.131	0.165	0.129	0.131
IT	low	0.367	0.170	0.160	0.367	0.170	0.160
	high	0.168	0.134	0.123	0.168	0.134	0.123

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

As noted earlier, there are many factors that contribute to create a non-degenerate MPC distribution, including the financial frictions. Those influences are present here for asset market participants. In addition, there is the extensive margin of asset market participation so that only a fraction of households, country specific, are impacted through the return channel.

5 Monetary Policy Implications

From the analysis of the MPC distribution, it is clear that the consumption response to income and return shocks is heterogenous across households both within and between countries.[23] This section turns to the main focus of our study: the dynamic consumption response to monetary innovations. Insofar as the MPC distributions themselves

[22] Online Appendix sub-section 1.4 provides a further analysis of this distribution of MPC out of stock returns by age and wealth.

[23] This is emphasized in 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).

come from the estimated model, the effects of monetary policy on consumption uncovered here are linked to parameter estimates.

To be clear, the effects of monetary policy come from a single experiment of a reduction in the target rate. From our experiments, the aggregate consumption response is independent of the direction and magnitude of the intervention. From that perspective, the non-linearities at the individual level disappear through aggregation **but** there are economically significant differences in the effects of monetary policy across households.

5.1 Our Approach

There are a couple of key elements to our approach. First, as in Kaplan, Moll, and Violante (2018), the focus is on the response of aggregate consumption to a monetary innovation. Second, we highlight two channels, one operating through income and the other through returns. Third, the analysis does not characterize the entire monetary transmission process. There are no firms, no durables (until we extend the discussion to housing in section 6) and, perhaps most importantly, the way in which the monetary innovation sets in motion the variations in income and returns is absent. With our methodology, we take those responses as given, taken from the data, and use them as inputs into the household dynamic choice problem.

Let $\tau \geq 0$ be the time since the monetary policy innovation. The effect of a period t monetary policy innovation on aggregate consumption in period $t+\tau$ can be written as:

$$\frac{dC_{t+\tau}}{dMP_t} = \overbrace{\int_\Omega \frac{dc(\Omega_{t+\tau})}{dY_{t+\tau}} \frac{dY_{t+\tau}}{dMP_t} dG_{t+\tau}(\Omega)}^{Income\ Channel} + \underbrace{\int_\Omega \frac{dc(\Omega_{t+\tau})}{dR^s_{t+\tau}} \frac{dR^s_{t+\tau}}{dMP_t} dG_{t+\tau}(\Omega)}_{Return\ Channel} \tag{11}$$

where $\Omega_{t+\tau}$ is an index of the individual's state in period $t+\tau$. Recall that both income and the return on stocks are in this state vector. Here $G_{t+\tau}(\Omega)$ is the cross sectional distribution of households over the state space in period $t+\tau$.

Equation (11) summarizes two channels through which a monetary policy innovation impacts aggregate consumption.[24] 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.[25] In the following discussion, these are referred to as the "income" and "return" channels. We have studied the MPC distribution in response to a change in income or return independently. But it is important to keep in mind that consumption response through these two channels interact: the decision about portfolio adjustment depends on the total utility gain in response to income and return changes which will generally not be the same as the sum of the utility gain from either of the change independently.

Equation (11) delineates three important dimensions to the policy response. First, 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

[24] A channel through mortgage payments is studied in section 6.

[25] 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 a constant in our model. Further, the impact of interest rate changes on fiscal policy, emphasized in Kaplan, Moll, and Violante (2018), do not appear in our model.

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) portfolio composition as well as the magnitude of financial wealth. Second, the response depends on the cross sectional distribution in period $t+\tau$, $G_{t+\tau}(\Omega)$, for each country.[26] To the extent that the intervention itself changes the cross sectional distribution, there will be an additional dynamic to the policy response. Put differently, the MPCs are state dependent and will evolve with the state of a household. So the distribution of MPC will evolve with the distribution of households over the state space, Ω. Third, the response is persistent and dynamic, reflecting both the lasting effects of the monetary innovation on income and returns and the evolution of the cross sectional distribution.

Building on the estimated model, we take an empirical approach to study how monetary policy innovations impact the two key channels: income and stock returns. In contrast to other studies, such as Kaplan, Moll, and Violante (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 effects of monetary policy.

To be clear, this approach is consistent with a quantitative exercise built upon a stochastic general equilibrium model.[27] In such a model, households would be responding to monetary shocks through a variety of channels, particularly income, returns and taxes. Our approach guarantees that the impulses into the household decision rules are data consistent. The analysis is partial only insofar that other effects of the innovation, say on debt obligations and thus on the tax burden that is reduced by a monetary innovation, are ignored.

Throughout, we emphasize differences in households within a country as well as differences across countries 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.

There are a few important details underlying the calculation of these responses. First, as described in more detail below, the income and return responses that are inputs into equation (11) are assumed to last for only three periods. But the consumption responses persist for about 15 years in simulation, which comes from the endogenous response of consumption induced by the times series variation in the household's state and its distribution. Second, the 15 year responses come from households that survive the full 15 years of the simulation, and this selection puts more weight on younger households.

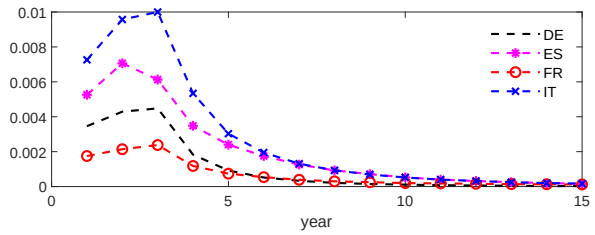
5.2 Income Channel

We begin by looking at the first term on the right side of equation (11). Evaluating the effects on consumption of monetary policy through the income channel requires two steps. Both of these components are country-specific so

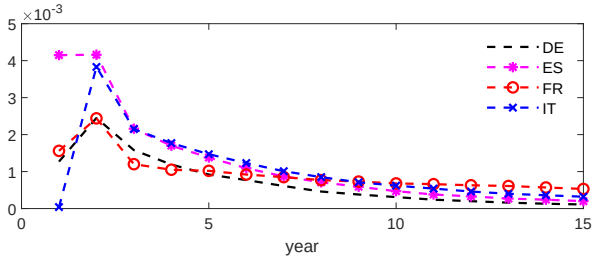
[26] This exercise requires an initial distribution. The distribution of income and wealth for those aged 21 was taken directly from the data. The distributions of income and wealth for other ages was taken from model simulation, along with the monetary shock. The results reported in these figures and tables are an average of those responses to monetary policy shocks relative to the outcome without monetary shocks.

[27] Online Appendix sub-section 1.6 illustrates the logic of this approach through the familiar RBC model. The point is to show that the approach captures the general equilibrium response of consumption to monetary innovations through the general equilibrium response of income and stock market returns through the estimated impulse response functions.

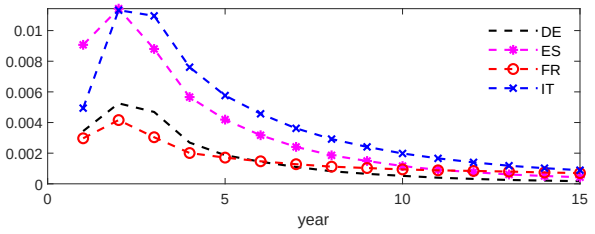
Figure 4: Consumption Response to Monetary Policy



(a) Income Channel



(b) Return Channel



(c) Both Channels

These figures show the channels and the total 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. The vertical axis measures the percent change in consumption relative to the case of no intervention.

that the consumption responses to monetary policy through the income channel vary by country.

The first step is to determine the responses of income to the monetary innovations.[28] We take the responses from Lenza and Slacalek (2018) summarized in Table 12. These responses combine the effects of monetary innovations on wages and on the probability of employment.[29] Note that the responses are heterogenous in that the income effects differ based upon the household's income quintile. The income response to monetary innovations is much larger in Spain, particularly for the lowest income quintile. Table 12 also indicates that the response of income

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

[29]Specifically, 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. Thanks to Michele Lenza and Jiri Slacalek for sharing with us these effects on wages not contained in their paper.

to monetary innovations are persistent. Since the largest responses come in the first two to three years, we feed into the simulation only three years of income changes shown in the table. In the simulation we have three income groups, with the low and the high income groups corresponding to the lowest and highest income quintiles in the table, and the middle income group corresponding to quintiles 2 to 4.[30]

Table 12: 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 Lenza and Slacalek (2018), combining the effect on wages and employment.

The second step is to determine the response of consumption to the change in income. This is also state dependent since, as illustrated above, there are ample MPC heterogeneities. For this response, we take the income changes given by Table 12 as exogenous changes to the transitory income in the model, and re-compute the policy functions, then we use the new policy functions to simulate consumption responses at the household level and the aggregate level.[31]

The results are summarized by the top panel of Figure 4. Clearly, the consumption response is the largest in Italy, more than twice that of Germany and almost three times that of France. Consumption responses through the income channel are all hump-shaped.

One might conjecture that the hump-shape is driven by the assumed three-year responses of income to monetary

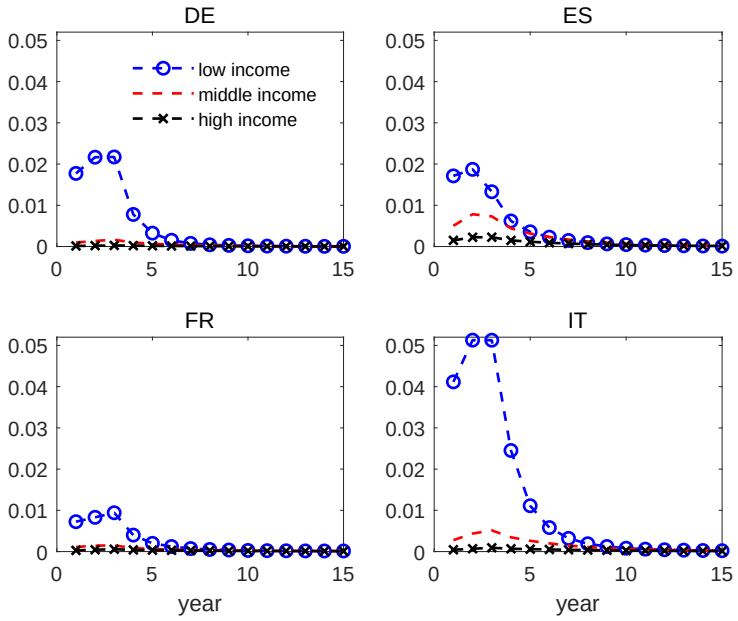
[30] As a robustness check, we map the income quintile to the six cells of different income and education groups. Based on the average incomes of the six education/income cells, we assign the first income quintile (Q_1) to the low-income and low-education cell, and the fifth quintile to the high-income and high-education cell. Q_2 is assigned to the middle-income and low-education cell and Q_3 to the low-income and high-education cell. The fourth quintile, i.e. Q_4, is assigned to two cells: the high-income and low-education cell, and the middle-income high-education cell, which is consistent with the data fact that income in these two cells for similar for each of the four European countries that we study. It is also noteworthy that the two cells have similar income MPCs as shown in Table 7. Given this mapping, we re-compute the dynamic consumption response to a monetary policy channelled through income changes, and find that the responses are almost identical to those shown in top panel of Figure 4.

[31] In this formulation, households do not distinguish an income variation due to a monetary innovation from a standard transitory shock. Thus the MPC used is from a transitory shock applied to the income change in each period. The consumption response will be larger if we have treated the income changes as persistent income shocks.

innovations. To study this, we conduct the experiments where the income response lasts for only one year. Results (not shown) indicate that the hump-shaped responses remain. Thus the humps and persistence of the consumption responses are partly driven by the endogenous evolution of the asset holdings by the heterogenous households.

Figure 5 reports consumption responses of different permanent income groups. For each country, clearly the low income group has the largest consumption response, and the response is significantly larger in Italy. This is consistent with the observation in Table 12 that the lowest income quintile has the largest income effect of monetary innovations, particularly for Italy and Spain.

Figure 5: Distribution of 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.

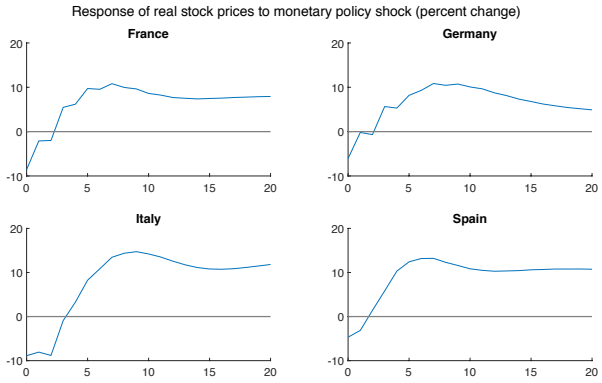
5.3 Return Channel

We next turn to the second component in equation (11), the return channel of consumption response to a monetary innovation. In general, these responses reflect both the participation rates in the stock market and the consumption response to variations in returns, governed in part by the elasticity of substitution parameter, θ.

We study this channel also in two steps. First, there is a country-specific VAR which determines the impact of monetary policy innovations on stock returns.[32] The details of the procedure to uncover these responses are provided in Online Appendix sub-section 1.5.[33] The second step evaluates how the return shocks leads to consumption responses over time.

[32]Here we broadly follow the analysis in Lettau, Ludvigson, and Steindel (2002).
[33]We are grateful to Sebastian Rast for his preparation of these impulse responses.

Figure 6: Stock Price 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.

The impulse response functions showing how stock returns react to monetary policy innovations are shown in Figure 6. 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 to decrease. This is often interpreted as a reaction to the informational content of the intervention.[34] By the end of the first year there is a sizable, positive response of real stock prices in all four countries.

In addition to the heterogenous response of returns 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 are present in the earlier calculations of the MPC after a return shock as shown in Table 11.

The overall consumption responses by country are shown in middle panel of Figure 4. The aggregate consumption response is hump-shaped and largest in Italy and Spain.

These responses of consumption to monetary innovations are strikingly different from the model created responses reported in Kaplan, Moll, and Violante (2018).[35] In particular, as seen in Figure 4 of Kaplan, Moll, and Violante (2018), the response to asset returns in their model is negligible. This reflects two offsetting influences. The lower rates increase asset 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.[36]

5.4 Aggregate Impact

The bottom panel of Figure 4 combines income and asset return channels to assess the total effect on consumption of a monetary innovation that reduces the target interest rate by 100 basis points. The responses are largest in

[34] Relatedly, output actually contracts in the impact period as well.
[35] Conversations with Gianluca Violante have been very helpful to our understanding these differences.
[36] From Christiano, Eichenbaum, and Evans (2005), real profits increase in response to a monetary innovation.

Italy and Spain and there is a pronounced hump-shape.

5.4.1 Consumption Response

For each country, the response is hump-shaped with a peak response in the second year (with the exception of Italy). Regarding the magnitude, at the peak after the monetary shock the consumption levels in Italy and Spain are about 1.25% higher than the baseline consumption without monetary innovations, nearly three times those in France and Germany. This reflects the significantly larger MPCs of the low income and low education group in Spain and Italy, a point that will be clearer as we decompose the consumption responses.

Our results are in line with the few studies that have quantified the response of consumption to monetary policy at the country level for specific euro area countries. Corsetti, Duarte, and Mann (2022) and Slacalek, Tristani, and Violante (2020) also find effects of monetary policy on consumption that are larger in Spain and Italy than in Germany and France. Quantitatively, we report very similar results to those studies for Germany, France and Italy: around 0.5% peak decrease in consumption after a 100 bps tightening for the first 2 countries and around 1.25% for Italy. Their estimates for Spain are somewhat higher than ours, around 2% vs 1.25% in our case (see Figure 6 of Corsetti, Duarte, and Mann (2022) and Figure 7 of Slacalek, Tristani, and Violante (2020)).

The hump-shaped consumption response is consistent with numerous earlier studies that document a similar pattern for euro-area countries. Smets and Wouters (2005) study an interest rate shock and find a hump-shaped response of consumption in both the US and Europe. The results are also consistent with those for the US reported in Christiano, Eichenbaum, and Evans (2005). For additional evidence on euro area countries, see Figure 3 in Slacalek, Tristani, and Violante (2020).

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.[37] 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 monetary innovations, which is 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.

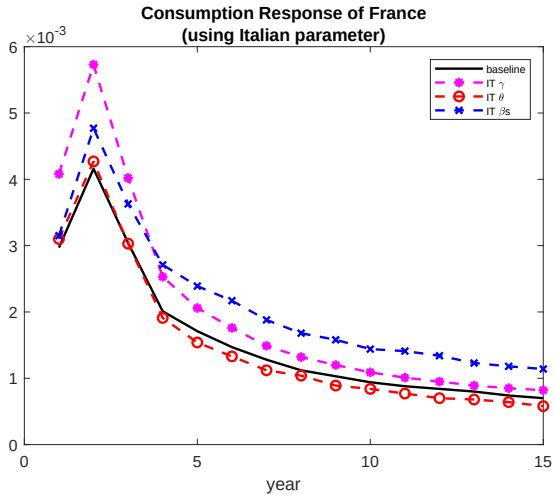
5.4.2 Country Comparisons

One way to understand how these simulated responses depend on the parameter estimates is to look at differences across countries. For this, we take the baseline response of France to a monetary shock and compare it against the response created by imposing the estimated parameters for Italy on their French counterparts. So, for example, the

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

estimated γ of 21.308 for France is substituted by the estimate of 8.255 for Italy. Then the household optimization problem is re-solved using the new parameter, and the effects of a monetary shock are re-simulated.

Figure 7: Consumption Response to a Monetary Shock in France using Italian Parameters

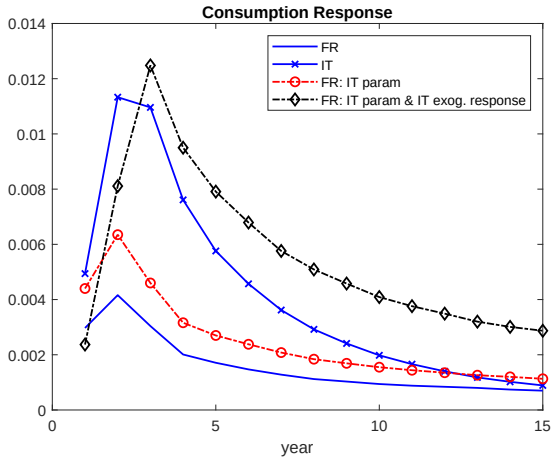


This figure shows the aggregate consumption response in France over time to a 100 basis point decrease using the the estimated values of γ, θ and βs for Italy, along with the baseline results that use France's own parameter values The vertical axis measures the percent change in consumption relative to the case of no intervention.

For this exercise, we identify three parameters that have a large impact on the consumption response of France: (γ, θ, β). Figure 7 illustrates the results of these counterfactual exercises. Reducing the risk aversion from the French to the Italian estimates has a large impact on the consumption response. The period 1 consumption response increases from 0.3% to 0.41%. As indicated in the figure, consumption remains higher throughout the simulation. Likewise, imposing the larger estimate of θ, the EIS, on France also leads to a larger consumption response, but not of the magnitude of the reduction in the risk aversion. Finally, using the Italian estimates of the discount factors, which are larger than those estimated for France, also has a large impact. As indicated in the figure, the increase in patience led to a more persistent consumption response to monetary innovations relative to the baseline response.

Figure 8 goes further and addresses the question of whether differences between France and Italy come from parameters or other between-country differences. Here we impose all the estimated Italian parameters on France. Furthermore, we experiment with a case where both the Italian parameters and the Italian income and stock return changes in response to a monetary shock, which we have taken exogenously from the data, on the French households. The figure shows that while the Italian parameters raise the consumption response of France, the response of France is still significantly less than the response of Italy. However, when we impose the Italian income and return changes on France, the response of France becomes larger than Italy. Presumably this "over-prediction" is caused by the between-country difference in the income processes and stock return processes.

Figure 8: Consumption Response: Parameters and Exogenous Processes



This figure shows the aggregate consumption response in France and Italy over time to a 100 basis point decrease. It also shows the response of France using the the estimated parameters of Italy, and also using the exogenous income and stock return changes of Italy in response to the monetary shock.

5.4.3 Dependence on Parameters

Table 10 highlighted the effects of various sources of non-linearity on the MPC distributions. Here we study how those parameters that cause the non-linearities affect the dynamic consumption responses. To do so, we study how the elimination of these nonlinearities affects the consumption by contrasting the responses in Germany and Spain.

This is shown in Figure 9. It is clear that setting the borrowing constraint, $\underline{A}^b$, to zero make little difference in Germany, but it makes a difference in Spain, which is consistent with the fact that $\underline{A}^b$ is not statistically different from zero for Germany. It is also noteworthy that removing the entry and adjustment costs in the stock market leads to larger consumption responses in both countries.

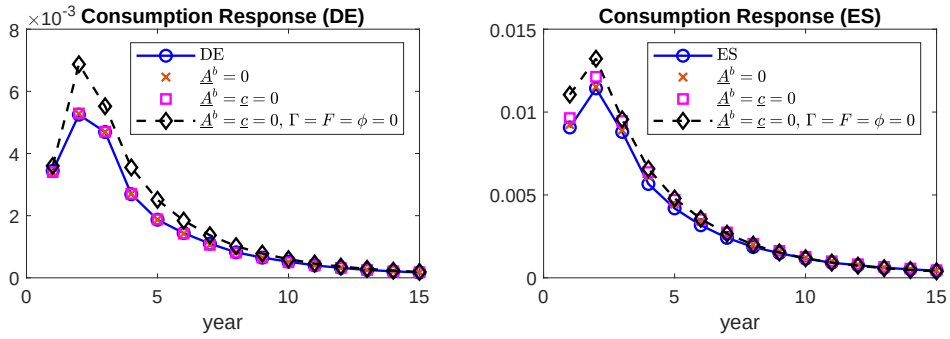
5.5 Distributional Effects

A novelty of our approach 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 households through the return channel. The implication is that the overall consumption response is larger for the two extremes of the income distribution.[38]

It is natural to partition households into groups based upon education and permanent income, along the lines of Table 7. The top panel of Table 13 summarizes the effects of monetary policy on these households. The bottom panel aggregates over education in order to highlight the difference across income groups. These numbers are the averages of the consumption response in the first three years after a monetary innovation.

[38] As emphasized in Auclert (2019), these distributional aspects, particularly the income effects operating through high MPC households, serve to amplify the affects of monetary policy interventions.

Figure 9: Non-linearities and the Consumption Response to a Monetary Shock in Germany and Spain



This figure shows how the parameters related to nonlinearities in the household problem affect the aggregate consumption response in Germany and Spain over time to a 100 basis point decrease in the target rate. As indicated, the decomposition eliminates the sources of nonlinearities sequentially.

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. This is seen in the "Return Channel" panel of the table which reports consumption responses of asset market participants. Here households with low income and low education have negligible consumption responses, a pattern that is most visible in Germany and France. This is because only a small fraction of the low income and low education group participates in asset markets and the participants are selected to be relatively wealthy, thus their consumption is less responsive to return shocks. The high income and high education group participates more in asset markets, and the participants are more responsive to return shocks.

The income channel and return channel decomposition explains a U-shaped consumption response to monetary innovations, which is shown in the right panel of the table that shows the overall consumption response. An innovation largely affects low and high income households, but in very different ways. The low income households are sensitive to the monetary innovation through the income channel, thus the consumption response is large. The high income households participate more in asset markets and thus have financial income that is sensitive to monetary innovations through the return channel, so is their consumption.

Importantly, the total effect is not simply the sum of effects from the two channels. This reflects the inherent non-linearities in the problem. For example, the two channels together might induce portfolio adjustment though no such adjustment arises in response to one independent channel. Further, some wealthy households save more when their higher income is accompanied by a high stock return, thus their aggregate consumption response is smaller relative to the response when they receive only income shocks.

Table 13: 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	1.203	0.067	0.009	0.030	0.137	0.248	0.411	0.271	0.320
	high	1.124	0.045	0.006	0.052	0.229	0.402	0.432	0.321	0.447
ES	low	1.685	0.493	0.138	0.282	0.344	0.477	1.478	0.839	0.673
	high	0.854	0.243	0.066	0.353	0.479	0.560	1.002	0.729	0.648
FR	low	0.645	0.100	0.031	0.012	0.111	0.236	0.375	0.224	0.285
	high	0.223	0.027	0.011	0.115	0.295	0.426	0.232	0.329	0.440
IT	low	3.698	0.234	0.040	0.150	0.139	0.201	1.158	0.375	0.165
	high	2.044	0.115	0.016	0.103	0.212	0.216	0.714	0.209	0.123
DE	all	1.170	0.058	0.008	0.039	0.175	0.312	0.420	0.292	0.373
ES	all	1.454	0.424	0.118	0.302	0.382	0.500	1.345	0.808	0.667
FR	all	0.495	0.074	0.024	0.049	0.177	0.303	0.324	0.262	0.340
IT	all	3.503	0.220	0.037	0.145	0.148	0.202	1.106	0.355	0.160

This table summarizes the consumption response in percentage from a monetary shock (100 basis points decrease in interest rate). The bottom panel aggregates over education groups.

6 A Housing Channel

The baseline model focuses on asset market participation, portfolio adjustment and the impact of monetary policy through income and return channels. It ignores the effects of monetary policy through housing. While we have argued that our moments and thus estimates are purged of the influence of homeownership, that does not negate the effects of monetary policy through housing. Moreover, the effects may interact with the income and return channels given the nonlinearity of the underlying model.

This section studies two issues. First, it looks at the interaction of the MPC out of income and homeownership status. This is relevant for assessing the validity the model generated MPCs used in evaluating (11). Here we report MPC estimates from data allowing the interaction with homeownership status.

The second issue is the introduction of a housing channel for monetary policy, emphasizing its interaction with the elements influencing household financial choice. In the model developed below, we focus on the sensitivity of mortgage payments in response to monetary policy shocks.[39] In the end, this reduces to another source of variation in income less housing payments for the set of households with mortgages. In effect, this channel leaves intact the MPC distribution with the income flows supplemented by mortgage payments.

6.1 MPCs Revisited

One concern is that by taking housing out of the moments and the model, our MPC estimates are biased. The literature does not fully inform us on this issue. Garbinti, Lamarche, Lecanu, and Savignac (2020) estimate the MPC out of financial and housing wealth. For two countries, Spain and Italy, they find that the MPC out of financial wealth is much larger than it is from variations in housing wealth. The opposite is true for Germany, where they

[39]This focus follows, with gratitude, the suggestion of a referee and is in keeping with Di Maggio, Kermani, Keys, Piskorski, Ramcharan, Seru, and Yao (2017) and Flodén, Kilström, Sigurdsson, and Vestman (2021) who also find support for this channel.

see a small response of consumption to financial wealth. Cloyne, Ferreira, and Surico (2020) identify a housing-specific channel of monetary policy as those with housing debt (mortgagors) respond more to monetary policy than outright homeowners, but the income effects of monetary policy are about the same regardless of indebtedness and homeowner status, implying higher MPCs of mortgagors. Hintermaier and Koeniger (2018) conduct an interest rate experiment in a calibrated model and find a large response through refinancing. It is important to note that none of the above papers provides direct evidence on the effects of home ownership on the estimated MPC in response to monetary shocks.

But there is no evidence in the literature on the interaction between home ownership status (or housing wealth) and the effects of income on consumption that are a key to our analysis. In this section we report some results specifically on estimation of the interaction between homeownership status and MPC out of income. The analysis uses the 1981-2016 waves of the Italian Survey of Household Income and Wealth (SHIW).[40]

We follow the estimation procedure of Kaplan, Violante, and Weidner (2014) and Blundell, Pistaferri, and Preston (2008) to look at the relationship between consumption growth and income growth. In a first step, we regress log income and log consumption on demographics (year and cohort dummies, education, employment, family size and geographical information and interaction of year dummies with education, employment and region dummies). In a second step, we construct first-differenced residuals of log consumption and income and then use an IV regression of Δc_{it} on Δy_{it}, instrumented by Δy_{it+1}.[41]

Table 14 shows the estimated MPCs by homeownership status. Mortgaged owners have the highest MPC of around 26%, followed by outright owners (23%) and renters (20%). Given the biannual nature of the data set, households would spend 20-26% of an unexpected transitory income shock over a two-year period. The owners and renters, who are at the extremes of this interval, make up about 40% of the observations. We conclude from this exercise that while homeownership and housing decisions are important over the life cycle, the differences in MPCs across homeownership status are economically small and statistically insignificant.[42]

Table 14: MPC Estimates by Home Ownership Status

	Owner: Mortgage	Owner: No Mortgage	Renter
MPC	0.262	0.232	0.202
	(0.063)	(0.031)	(0.044)
proportion	0.14	0.63	0.27

This table summarizes the estimated MPC out of income by homeownership from the SHIW data. Standard errors are shown below the point estimates.

[40] Thanks to Chloe Larkou and Adam Monninger who were research assistants for this part of the analysis. The data is organized by Banca d'Italia. Since 2010, a large part of the SHIW is the Italian contribution to the HFCS. However, the SHIW has been running as a representative sample of the Italian resident population since the late 1960's, and the necessary information on household income, homeownership status and main consumption items (food at home, food away, dwelling utilities, holiday, rent, imputed rent, fringe benefits) is available since 1981. The survey was annual until 1986 and became biennial starting in 1987.

[41] See Blundell, Pistaferri, and Preston (2008) and Kaplan, Violante, and Weidner (2014) for further details.

[42] Additional findings along the same line for the US are reported in Cooper and Larkou (2022).

6.2 Housing Channel of Monetary Policy

The effects of monetary policy on consumption in (11) are augmented through the mortgage payment channel given by:

$$\int_{\Omega} \pi(\Omega) \frac{dc(\Omega_{t+\tau})}{dMortPay_{t+\tau}} \frac{dMortPay_{t+\tau}}{dR^m_{t+\tau}} \frac{dR^m_{t+\tau}}{dMP_t} dG_{t+\tau}(\Omega) \tag{12}$$

Here $\pi(\Omega)$ is the type contingent homeownership rate, $\frac{dc(\Omega_{t+\tau})}{dMortPay_{t+\tau}}$ captures the response of consumption to variations in the mortgage payment and $\frac{dMortPay_{t+\tau}}{dR^m_{t+\tau}}$ summarizes how the mortgage payment changes in responses to changes in the mortgage rate and $\frac{dR^m_{t+\tau}}{dMP_t}$ is the period $t+\tau$ response of mortgage rates to a period t monetary policy innovation.[43]

To study the channels in (12), the extended model with housing adds three features to the baseline. First, there is an additional term in the budget constraint that captures the cash flow aspect of an outstanding mortgage. Second, there is the homeownership rate by education and permanent income level, by country. From Table 15, in Spain about 80% of households own their residence while in Germany most are renters. Within the countries, homeownership depends on education and income. Third, there is country specific response of mortgage rates to monetary policy. Specifically, this is measured as the response of the average rate of outstanding mortgages to a monetary innovation. In this way, any refinancing of existing mortgages as a consequence of the monetary shock will be captured. As we shall see this generates an interesting dynamic in the response of consumption to monetary policy.[44]

To be clear, this exploration of housing builds on the structure of the baseline model, with minimal but economically significant modifications. Adding housing separately as another state variable is computationally very burdensome.[45] The current approach stops short of a complete model of housing and mortgage financing choices along with the financial decisions captured in the baseline.

6.2.1 Data Inputs

There are three data inputs needed for the evaluation of (12). The first is the homeownership rates by type for each country. The second is a measure of the responsiveness of mortgage rates to monetary policy. The final input captures the response of mortgage payments to the mortgate rate.

Table 15 shows the homeownership rates by household type for each country. These rates are used as $\pi(\Omega)$ in (12). The rates generally increase with income and education. The homeownership rates are higher in Italy and Spain so that, all else the same, the mortgage payment channel will be larger in these countries. Since the MPCs

[43] Capital gains are not included in this channel.

[44] The focus on this channel follows the spirit of Eichenbaum, Rebelo, and Wong (2022). Our model does not have the richness explored there through the evolution of the mortgage distribution. But, that model does not have the portfolio choice of households that is integral to our paper.

[45] 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 (in section 5.2.1), which does separate home and stock ownership but ignores costs of trading houses.

differ by household type, larger effects will occur if the high ownership rates are in the groups, such as those with both low education and low income, with the higher MPCs.

Table 15: Homeownership Rates and Consumption Responses

Country	Ed \ Inc	Homeownership Rates			Consumption Response		
		low	middle	high	low	middle	high
DE	low	0.18	0.37	0.61	0.379	0.365	0.261
	high	0.22	0.44	0.63	0.325	0.235	0.202
ES	low	0.67	0.84	0.89	1.573	0.795	0.526
	high	0.63	0.80	0.87	0.911	0.375	0.520
FR	low	0.32	0.59	0.82	0.433	0.150	0.316
	high	0.25	0.53	0.82	0.249	0.351	0.386
IT	low	0.57	0.75	0.84	1.308	0.536	0.319
	high	0.49	0.67	0.91	0.608	0.338	0.241

This table summarizes home ownership rates from the data and the consumption response to monetary policy by education and income from simulated data.

The response to mortgage rates was obtained from the following regression:

$$R^m(t+h) = \alpha_0^h + \alpha_1^h * MP(t) + \varepsilon(t) \tag{13}$$

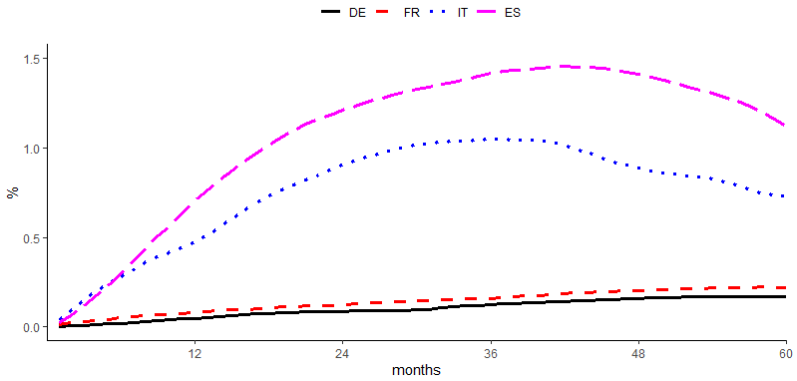
where $R^m(t+h)$ is the mortgage rate in time $t+h$ and $MP(t)$ is the period t policy rate (we use the EONIA rate). The equation was estimated for $h = 0, 1, 2, ...$ to uncover dynamic responses which are then fed into (12). Country-level mortgage rates are obtained from the ECB's Monetary Financial Institutions Interest Rate Statistics. They are the average lending rates on all outstanding home mortgages. These rates capture the changing composition of mortgages as these are generated and terminated, as well as the refinancing of mortgages that takes place over time.

The results are shown in the Figure 10. The vertical axis represents the response coefficient from the regression. The horizontal axis is in terms of months. Looking, for example, at Germany after 24 months, the 100 basis point increase in the target rate raises the mortgage rate in Germany by about 10 basis points. In contrast, for Spain after 2 years the increase in the mortgage rate is over 100 basis points. These differences in responses will be key to understanding the magnitude of this channel across our four countries.

There is a interesting contrast with the income response. As shown in Table 12, the effect of monetary policy on income is largest in the first year and falls over time, though more slowly in Germany compared to Italy. In contrast, the effects of changes in the policy rate on the mortgage rate grows over time. This in part due to the refinancing of mortgages and the fraction of outstanding mortgages that are newly issues.

The final piece of the logic relates the change in mortgage payments to the changes in these rates. This is obtained from the average mortgage to income ratio for each household education level, by country. These rates are needed to calculate the magnitude of changes in mortgage payments in response to the mortgage rate.

Figure 10: Dependence of Mortgage Rates on Monetary Policy



This figure shows the response over time by country in mortgage rates to a 100 basis point increase in the monetary target rate.

6.2.2 Housing in the Household Choice Problem

Focusing on the effects of monetary policy through mortgage payments, the budget constraint for a household that is both a homeowner as well as a stockholder adjusting their portfolio becomes

$$c = y + TR + \sum_{i=b,s} R^i A^i - \sum_{i=b,s} A^{i'} - F - M(\Omega, R^m) \tag{14}$$

where $M(\Omega, R^m)$ is the mortgage payment of a household in state Ω when the mortgage rate is given by R^m. Similar adjustments are made to the other budget constraints, including non-adjusters and non-participants. In effect, the mortgage payment is simply a recalculation of income.

For homeowners, the dynamic optimization problem, including the choices of asset market participation is resolved given the addition of the mortgage payment to the budget constraint.[46] Further, we assume renters receive housing shocks each period. Upon receiving the shock, the household enters a 30-year mortgage contract and makes a 20% downpayment of the house value, where the mortgage is proportional to deterministic income. In the case the household is not able to afford the down payment, she remains a renter. Then at the end of the year the household pays the mortgage, as in (14). With a given probability, the homeowner exits the housing market by selling the house and paying off the mortgage outstanding. To avoid keeping track of the mortgage outstanding, we assume homeowners refinance the mortgage each year by paying off the old mortgage and enter a new 30-year mortgage contract. The arrival rates are set to match the homeownership rates in Table 15.

We solve the extended model to obtain the new policy functions. These policy functions are used to determine the impact of the variation in the mortgage payment induced by the monetary policy shock. This is the $\frac{dc(\Omega_{t+\tau})}{dMortPay_{t+\tau}}$ term in (12). Note that here the variation in the mortgage payment is indexed by $t+\tau$, allowing the dynamics of

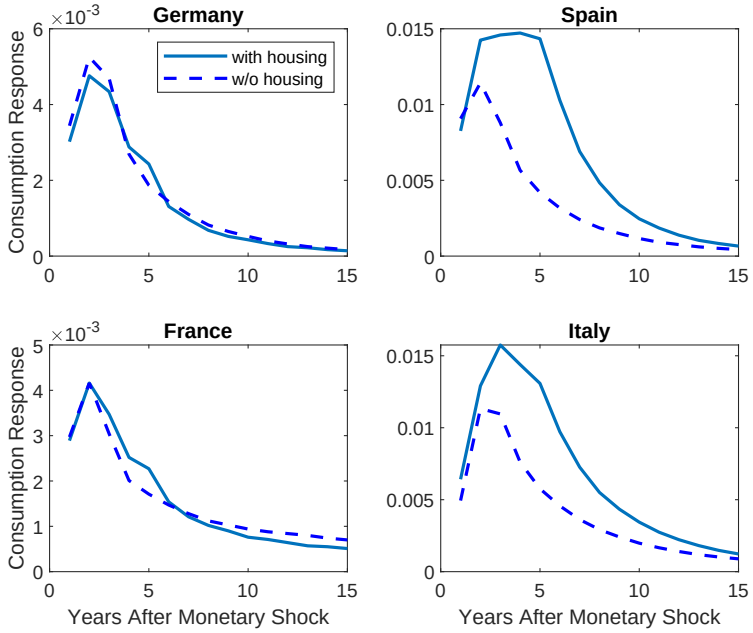
[46] The choice of homeownership is not part of the model. Nor are any financial choices regarding the size of the downpayment or the financing package.

that rate illustrated in Figure 10 to have a dynamic influence on consumption.

6.3 Results

Our findings are summarized in Figure 11 which illustrates the effects of a 100 basis point reduction in the policy rate on aggregate consumption by country. The first response, "without housing", shown as a solid line, reproduces the baseline. The second, "with housing", shown as a dashed line, includes the supplemental effects on mortgage payments by country, given both the homeownership rates and also the response of mortgage rates to monetary policy innovations.

Figure 11: Consumption Response to a Monetary Shock with and without housing



This figure shows the consumption response by country to a 100 basis point decrease in the target rate with housing as well as the baseline.

The figure shows that consumption responses are much larger in the extended model than in the benchmark model for Italy and Spain, the two countries where: (i) the elasticities of mortgage rate with respect to the benchmark rate are large and (ii) homeownership rates are larger.[47] In contrast, the responses are not statistically significantly different from those in the baseline model in Germany and France.

The larger responses of consumption in the extended model compared with the baseline model are from two potential sources. First, there is a cash flow effect of the interest cut operating through the reduced mortgage payment. Secondly, policy functions from the dynamic model are altered by the newly introduced housing and mortgage in the extended model.

[47] From the results in Table 14, the response in Italy is not due to differences in MPCs. Rather, along the lines of Cloyne, Ferreira, and Surico (2020), there are other factors that associate the consumption response to homeownership status.

The right panel of Table 15 provides the distribution of the consumption responses, including housing. It is comparable to the right most panel of Table 13. The differences in the consumption response indicate the contribution of housing. As noted, the big differences in consumption responses arise in Italy and Spain. It is noteworthy that for these two countries, the homeownership rates are relatively high for low income, low education groups. And, returning to Table 7, it is precisely in these cells that the MPC from income variations is high.

7 Conclusion

This paper uses a life-cycle framework to study how households' financial choices affect the impact of monetary policy innovations on aggregate consumption. The analysis emphasizes the importance of participation in stock markets and portfolio adjustment choices. The country-specific model parameters are estimated via the simulated method of moments, using moments that highlight the life-cycle patterns in household financial choices.

The estimation uncovers the presence of asset market participation cost as well as portfolio adjustment cost. These costs and consumption floors all differ significantly across countries, reflecting the large cross country differences in stock market participation rates and income risks facing households. The estimated discount factors lie between 0.75 and 0.80 for low education households to between 0.85 and 0.90 for high education households. These estimates are well below traditional calibrations, but they lead to wealth-to-income ratios from the model that are consistent with the data.

From the estimated model we obtain the distributions of MPCs in response to transitory income shocks and stock return shocks. Within a country these distributions are not degenerate due to household heterogeneity. Generally, the MPC is higher for low income, low education households. The relatively small fraction of liquidity-constrained asset market participants (non-adjustors) also have large MPCs. Households that hit the consumption floor have an MPC that is 100%.

After analyzing the distribution of MPCs in response to income shocks and return shocks, we characterize both the average and distributional effects of monetary innovations on consumption through two channels: (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, Spain has the largest response to monetary innovations through the return channel while Italy has the largest response through the income channel. When the two channels are combined, the aggregate response of consumption to a monetary innovation is the largest in Italy and smallest in France.

When housing is included, the effects of monetary policy on aggregate consumption do not change much in France and Germany but in Italy and Spain the consumption response is much larger. The latter two countries feature both higher homeownership rates and also a bigger response of mortgage rates to monetary policy.

Our analysis identifies a number of factors that are relevant for the transmission of monetary policy. For example, the large consumption response in Italy and Spain are largely driven by their large and persistent income shocks and high levels of consumption floors relative to their income. Also, counterfactual experiments show that the small consumption response to monetary innovations in France is partly driven by the estimated large coefficient

of risk aversion and low elasticity of intertemporal substitution.

More generally, the different parameters, along with heterogeneity in the exogenous processes, lead to the cross country difference in the aggregate consumption response to monetary innovations. The combined effects of these differences lead to drastically different consumption responses to monetary innovations. This discussion should help policy makers evaluate ex-ante the potential effects of monetary policy decisions.

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8 Online Appendix

8.1 Income processes

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.[48] 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.[49] 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.[50]

8.1.1 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.[51] 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:[52]

$$log(Y_{it}) = const. + polynomial(age_{it}) + HHComp_{it} + Time_t. \tag{15}$$

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 (15).[53]

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

[48] In 2001, the ECHP was discontinued, and since 2004, replaced by the EU Statistics on Income and Living Conditions (EU-SILC), an income survey. But it is not suitable for our analysis due to its limited panel dimension. Note that the exposition of the estimation of labour income processes follows closely Le Blanc and Georgarakos (2013).

[49] 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.

[50] 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.

[51] 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.

[52] 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.

[53] Unweighted results are essentially the same.

regression and assume that income is linear in age for the post-retirement period.[54]

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.[55]

Figure 2 displays the fitted (exponentiated) values of the income predictions for each education group and each country. The dots around the lines in Figure 2 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 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.

8.1.2 Stochastic Components

We use the variation in log income residuals from our estimation of the country- and education-specific income profiles from equation (15) to characterize the uncertainty of earnings over the life-cycle. Following Carroll (1992), Guvenen (2009), Laibson, Repetto, and Tobacman (2001), among others, we assume that the log income residuals, $\tilde{y}_{i,t}$, reflect income shocks and follow the stochastic process given by:

$$\begin{aligned} \tilde{y}_{i,t} &= z_{i,t} + \epsilon_{i,t} \\ z_{i,t} &= \rho z_{i,t-1} + \eta_{i,t} \end{aligned} \tag{16}$$

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 (16), 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).[56]

Table 16 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 in Germany display low permanent and transitory shocks. In Italy and Spain, lower educated households face large and very persistent permanent shocks.[57] Over time the large and persistent shocks are translated into more income dispersion, which in turn generates more dispersion in MPCs in our simulated data. As we will show, Spain and Italy exhibit much

[54] 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.

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

[56] In particular, we use a Generalized Method of Moments (GMM) estimator to minimize the distance between the theoretical and empirical autocovariance. For details about moments construction and the estimation method, see Le Blanc and Georgarakos (2013) and Guvenen (2009).

[57] 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 16: Stochastic Processes by education and country

	Germany			Spain		
	ρ	σ^2_ϵ	σ^2_η	ρ	σ^2_ϵ	σ^2_η
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_ϵ	σ^2_η	ρ	σ^2_ϵ	σ^2_η
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)

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.

larger consumption responses to monetary innovation because of the large MPCs of low income households in these countries.

8.2 Standard Errors of Data Moments

Table 17 provides the standard errors for the data moments used in the estimation.

Table 17: Standard Errors of Data Moments

		con.	age	age^2	$college$ $(*age)$	$college$ $*age^2$
DE	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
ES	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
FR	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
IT	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

8.2.1 Local Identification

Another perspective on the link between parameters and moments is given in Table 18. 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.

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. As reflected in the negative elasticities on the coefficients of $age * edu$ and $age^2 * edu$ in the wealth-to-income ratio regression, an increase in β_0 also leads to a smaller education gap in terms of the wealth-to-income ratio. Also for β_0, the elasticity is negative for the coefficients on the education dummy in the participation regression, which indicates a reduced education gap in terms of stock market participation. The negative elasticity for the constant term in the participation regression reflects earlier participation of the less educated group.[58] Similarly, an increase in β_1 widens the education gap in terms of stock market participation rates and wealth-to-income ratios, which is evident in the second row of the table.

An increase in the coefficient of relative risk aversion, γ, decreases stock market participation and the stock share in wealth, conditional on participation. The signs are exactly what is expected and it is clear that this response is key to the identification of γ. The effect of γ on wealth accumulation is less straightforward. On the one hand, a higher γ leads to a safer portfolio that generates lower return and hence less wealth accumulation. On the other hand, a higher γ implies the lower certainty equivalent future value due to Jensen's inequality, which leads to more wealth accumulation. Table 18 indicates that the first effect is more important around the point estimate of γ, especially for the less educated households.

Variations in the inter-temporal elasticity of substitution, θ, also have substantial effects on the wealth-to-income ratio. A higher θ implies a higher degree of inter-temporal substitution and the lower preference for consumption smoothing over time, which leads to less wealth accumulation.

The participation cost, Γ, has a negative effect on stock market participation. Consequently, the participants are wealthier due to the selection effect, thus they have a higher stock share in total wealth on average. The

[58] This is confirmed when we compare the participation profiles before and after the local changes in β_0. The comparison shows that the the less educated group 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.

Table 18: Elasticity of Moments to Parameter Values (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	-3.765	-0.799	-2.396	-10.70	-37.47	-4.938	-5.383	10.40	10.84	68.17	217	-2.406	-3.313
β_1	2.135	1.371	1.771	2.723	-83.99	-8.185	-5.502	2.891	19.34	85.89	156	14.30	16.45
γ	-153	-67.5	-65.7	25.67	-79.76	-11.40	-11.46	6.599	-5.439	-27.83	-52.422	0.515	0.415
Γ	-0.272	-0.293	-0.377	0.159	3.042	0.157	0.053	-2.034	-0.015	-0.051	0.000	-0.005	-0.002
F	-0.253	-0.170	-0.190	0.043	0.075	-0.195	-0.314	1.513	0.156	0.850	1.816	-0.017	-0.017
L	0.016	0.006	0.002	-0.020	1.606	0.265	0.302	0.005	1.662	7.930	15.36	0.417	0.409
ϕ	-0.003	0.000	0.005	0.007	-0.286	-0.077	-0.108	-0.341	-0.230	-1.129	-2.336	-0.050	-0.051
$\underline{c}$	-154	-68.62	-67.02	27.77	-56.45	-7.619	-7.546	-0.939	-2.751	-8.416	-14.04	0.218	0.210
θ	-0.299	-0.514	-0.281	2.448	0.135	-0.291	-0.601	-5.144	-3.158	-16.03	-42.61	-1.494	-1.496
$\underline{A^b}$	-0.002	0.004	0.002	0.001	0.630	0.071	0.064	-0.127	0.037	0.192	0.419	-0.006	-0.003

This table reports the elasticity of moments with respect to parameter values, one at a time, at the baseline estimations for Spain.

participation cost also widens the gap in participation rates between the two education groups, as indicated by the positive coefficient on education dummy. This is because the more educated households care less about the participation cost which is small relative to their income and wealth.

The stock market adjustment cost, F, has a negative effect on both the stock market participation rate and stock share. It also widens the gap in stock shares between the two education groups.

A larger consumption floor lowers the precautionary saving motives, thus has a significantly negative effect on wealth accumulation, especially for the less educated households who rely more on the consumption floor. With the much reduced wealth, it is less attractive for less educated households to participate in the stock market or rebalance the portfolio, which lowers their stock market participation rate and stock share in wealth.

8.3 Simulated Distributions

Table 19 summarizes the distribution of households by education and permanent income within each country based upon a simulation using the initial distribution of households in the state space from the data and then averaging over aggregate return shocks to obtain a cross sectional distribution, conditional on age. This is used as a basis for construction of the MPC distributions.

Table 19: Household Distribution by Income and Education

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 distribution of households by education and permanent income for each country in the simulated data.

8.4 Decomposing the MPC out of Returns

Table 20 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.

Table 20: MPC Regressions: Return Shocks for Participants

						wealth percentile				
	const.	age	age2	income	edu	10-50%	50-70%	70-90%	90-95%	95-100%
1% increase in stock value										
DE	0.248	0.017	0.000	-0.041	-0.010	0.000	-0.088	-0.104	-0.115	-0.118
ES	0.158	0.018	0.000	-0.023	0.008	0.000	-0.144	-0.145	-0.175	-0.142
FR	0.594	-0.005	0.000	-0.012	-0.112	0.000	-0.101	-0.059	-0.046	0.003
IT	0.307	0.010	0.000	-0.025	-0.051	0.000	-0.114	-0.138	-0.141	-0.075
10% increase in stock value										
DE	0.230	0.018	0.000	-0.043	-0.004	0.000	-0.089	-0.107	-0.119	-0.125
ES	0.178	0.017	0.000	-0.022	0.007	0.000	-0.144	-0.147	-0.181	-0.148
FR	0.600	-0.006	0.000	-0.012	-0.110	0.000	-0.103	-0.064	-0.054	0.016
IT	0.322	0.009	0.000	-0.027	-0.050	0.000	-0.114	-0.139	-0.138	-0.080

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

8.5 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 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.

The following table summarizes 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**.

The detailed responses of all variables are shown in figures 12-13. 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

Table 21: Real/Deflated Stock Market Response to 1 pp. Increase in Eonia

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

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.

8.6 Analyzing the General Equilibrium Response to Shocks

The point of this section of the appendix is to make clear how we use the model of household choice to analyze the response of the household to monetary shocks in a general equilibrium. The neat feature of the analysis is that we are able to do so without embedding the household choice problem into an explicit general equilibrium model.

It is easier to illustrate our empirical approach through a transparent version of the now standard RBC model. We then return to the monetary economy below.

Consider a version of the RBC model in which there are:

- homogenous households who consume and supply labor inelastically;
- competitive firms who produce with a CRS technology
- technology (TRP, productivity) shocks
- no frictions

In this setting, the solution of the planner's problem generates a law of motion for the aggregate capital stock given by $k' = \phi_\Theta(A, k)$ where k is the per capita stock of capital and A is productivity. Here the policy function is indexed by Θ, a vector of parameters characterizing preferences, technology and the process of the technology shocks.

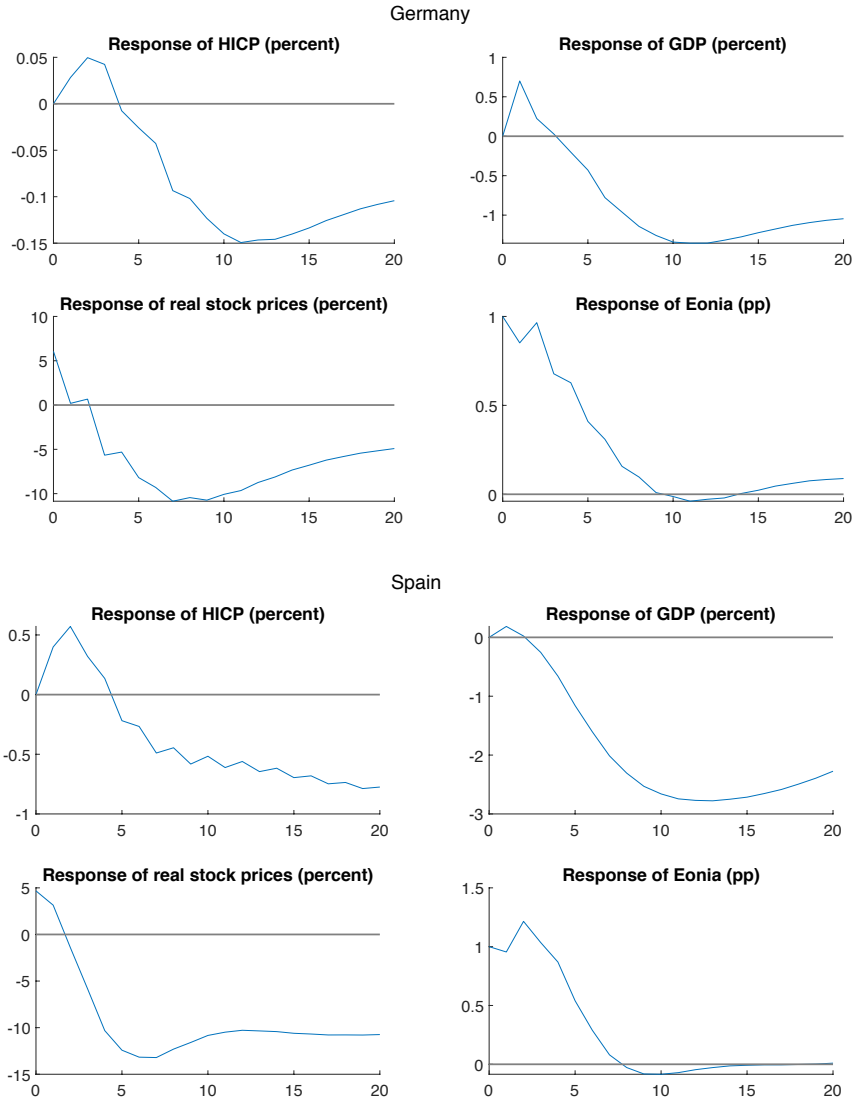
From the resource constraint, consumption is given by: $c_\theta(A, k) = Af(k) + (1 - \delta)k - \phi_\theta(A, k)$. Here $f(k)$ is the production function, $Af(k)$ is total output and $(1 - \delta)k$ is the undepreciated capital stock.

For a given Θ, the model can be solved to generate the policy function for capital dynamics. The model can be simulated using realizations of A to generate paths for the capital stock, output, consumption and investment.

Now, to generate an impulse response, one could simply design a shock to A and, given an initial capital stock, derive the paths for capital, consumption, output, etc. In the decentralized model, this would include the paths for wages and returns. This is the general equilibrium response to a technology shock.

Of course, from the fundamental welfare theorem, the planner's allocation can be decentralized as a recursive competitive equilibrium in which consumption depends on current wages and returns, $c(A, k, K) = \chi(\omega(A, k), R(A, k), K)$. In this decentralized setting, the household responds to the aggregate current state, (A, k) through wages and returns, having individual capital K. Using factor demand and factor market clearing, state contingent wages, $\omega(A, k)$ and capital returns, $R(A, k)$, are derived. This is a standard recursive equilibrium representation and it decentralizes the planner's solution.

Figure 12: Response to a Monetary Shock



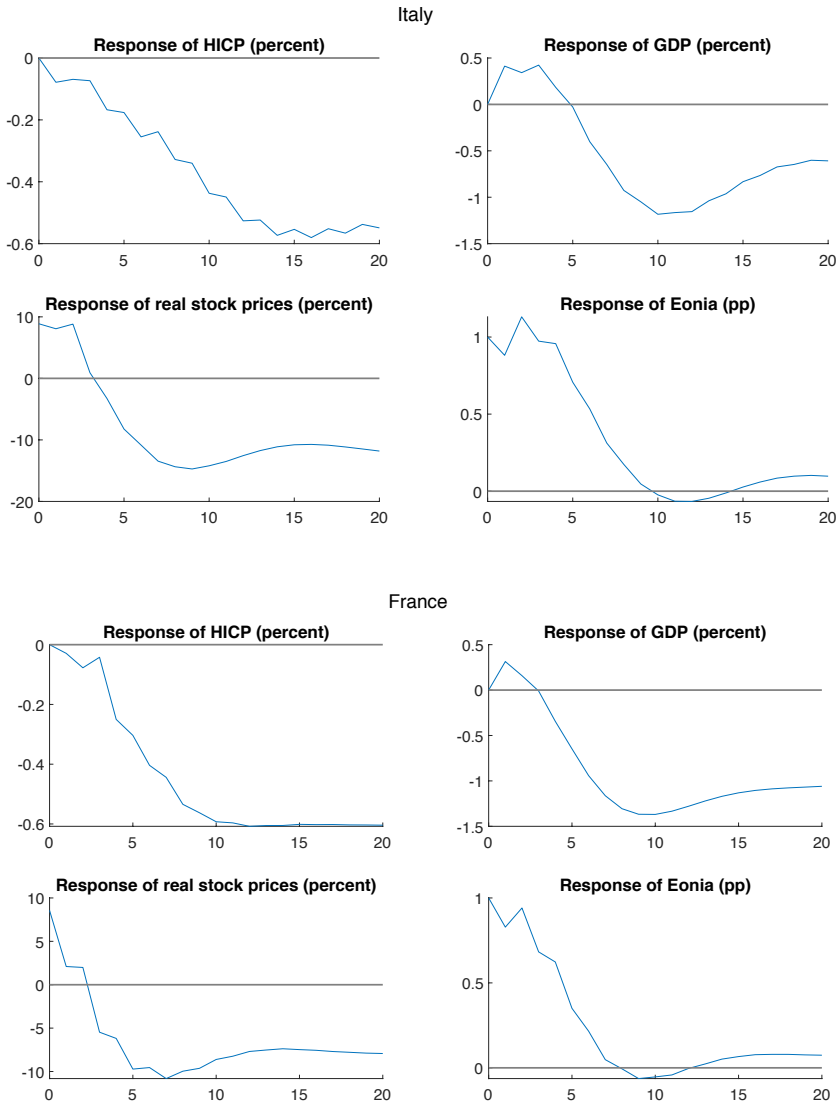
What about an impulse response? Again there is a shock to A and in the recursive competitive equilibrium we have the evolution of the aggregate capital stock as well as wages and interest rates. To determine consumption, we would just substitute the evolution and wages and capital returns into the $\chi(\omega(A,k),R(A,k),K)$, given initial capital holdings.

Focusing on the impulse response to consumption alone it would be equivalent to that from the planner's problem. The general equilibrium effects are all fully captured by the evolution of wages and capital returns created by the initial shock to A.

The approach taken in this paper is to essentially estimate the policy function $c(A,k,k) = \chi(\omega(A,k),R(A,k),k)$ from the data, with $k = K$ in equilibrium. The responses of wages and capital returns are estimated from the data and substituted into the household decision rule. As long as the data comes from an equilibrium model, we capture the response in equilibrium of the household.

Of course, the economy we study is richer than this standard RBC model. It includes heterogeneity as well

Figure 13: Response to a Monetary Shock



as non-convexities at the household level. But the logic of the argument still stands. The response to wages and capital returns to a monetary shock from the data capture the general equilibrium effects of the policy. We focus on the consumption response alone.

8.7 Robustness to Income Process

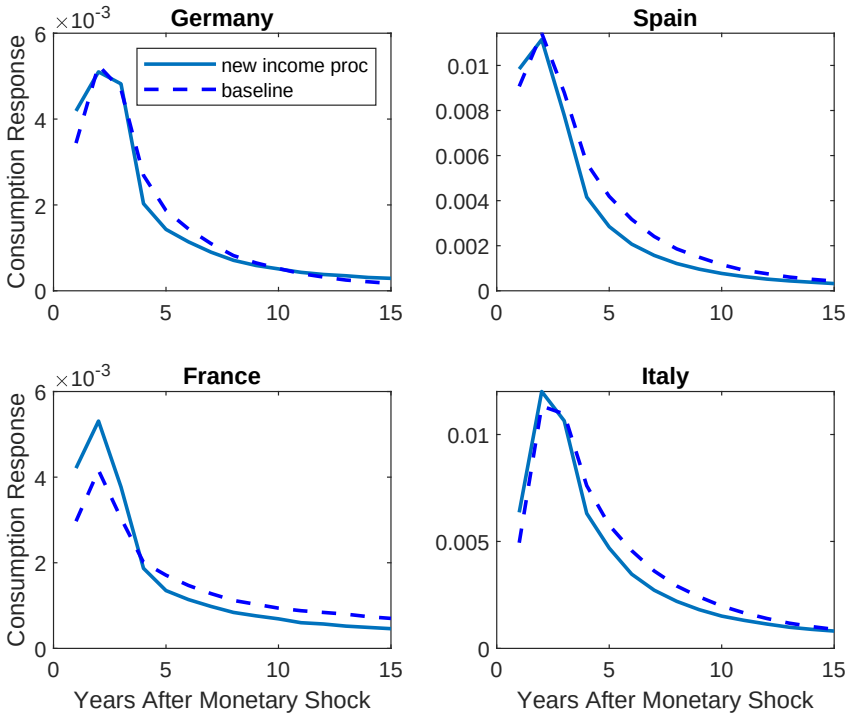
In the baseline model we have estimated income processes where government transfers are included in the household's income. We check how excluding the transfers affects our quantitative results.

With government transfers excluded, household income faces more uncertainty. As shown in table 23, compared with the baseline income processes, the new income processes features large variances of transitory and permanent income shocks.

We re-simulate the model based on the new income process, using the same parameter values estimated in

the base case. Compared with the base case, the new income processes generate higher wealth-income ratios, lower stock market participation rates, and slightly higher stock share in wealth. Figure 14 compares dynamic consumption responses based on the new income processes relative to those generated from the base case. As the figure shows, the dynamic consumption responses exhibit time series patterns and cross country comparisons that are very similar to those generated from the base case.

Figure 14: Dynamic Consumption Response (New Income Process)



This figure compare the dynamic consumption responses to a monetary shock of 100 basis points using the new income processes to those from the baseline model.

Table 22: 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
FR: 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
FR: 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
FR: 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
DE: 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
DE: 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
DE: 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
IT: 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
IT: 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
IT: 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
ES: 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
ES: 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
ES: 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

Table 23: Comparison of Income Processes

	Baseline			New Process		
	ρ	σ^2_ϵ	σ^2_η	ρ	σ^2_ϵ	σ^2_η
DE						
No College	0.895	0.022	0.016	0.906	0.022	0.031
College	0.937	0.02	0.011	0.933	0.024	0.018
ES						
No College	0.951	0.092	0.016	0.966	0.135	0.014
College	0.986	0.058	0.004	0.987	0.008	0.004
FR						
No College	0.971	0.031	0.006	0.969	0.047	0.01
College	0.941	0.023	0.018	0.958	0.026	0.02
IT						
No College	0.944	0.072	0.02	0.92	0.117	0.039
College	0.921	0.029	0.022	0.956	0.08	0.016

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