Essays on households' consumption and saving decisions

By

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A Thesis submitted for the degree of

Doctor of Philosophy (Ph.D.) in Economics

School of Economics and Finance

University of London

Queen Mary

April 2014

AUTHOR'S DECLARATION

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ABSTRACT

In this thesis I contribute to the applied study of households' consumption and saving behaviour. In the first chapter I introduce and explain why it is relevant to understand how households react to income shocks in terms of their consumption and saving decisions.

The second chapter is inspired by a recent paper by Krueger and Perri (2011), who argue that the observed response of household wealth to income shocks, which is smaller over long periods, provides evidence in favour of the classic permanent-income model with perfect financial markets. Whether a model with financial market imperfections, however, such as the standard incomplete-markets model with liquidity constraints, can also generate such a wealth response crucially depends on the importance of precautionary wealth accumulation. I structurally estimate a model with a precautionary-savings motive and show that it can generate the observed wealth responses in the data. I further show that the wealth responses to income shocks do not allow us to rule out financial market imperfections.

In the third chapter I extend the analysis, studying empirically what can be learned from international evidence on the way in which households react to income. I use detailed panel data from newly available surveys of Chile, Spain and the United States. Although it compares three different countries with dissimilar levels of development in their financial markets, the evidence suggests that the amount of precautionary savings in these economies is low and that household behaviour is not strongly influenced by the presence of borrowing constraints. The structural estimation for all countries suggests a low target level of wealth resulting from high levels of impatience or low levels of risk aversion.

In the fourth chapter I extend the analysis to the real estate properties owned by the households. I revisit the Italian data, building on Kaplan and Violante (2014) who have argued that a substantial fraction of wealthy households with illiquid wealth, such as real estate, behave as hand-to-mouth consumers. In exploring the data, I find that, in the Italian sample, households which adjust their illiquid wealth show responses to income shocks like permanent-income consumers. Instead households which do not adjust their illiquid wealth, and whose behaviour in general can thus not be characterised by the first order conditions, show responses to income shocks which suggest a stronger precautionary-saving motive, such as wealthy hand-to-mouth consumers might be expected to show.

The fifth chapter provides the conclusions of the thesis.

ACKNOWLEDGEMENT

I have not been alone in this experience and my gratitude goes to all the people who helped to make this project possible. First, I would like to thank my supervisors, Winfried Koeniger and Giulio Fella, for their guidance and support in doing this thesis.

I am also very grateful to the School of Economics and Finance at Queen Mary. I truly appreciate the help received from the academics and staff and for the financial support given.

I would like to thank my family, in particular, my parents, Cristina and Hugo, for teaching me from the very first to follow my dreams, persevere and be patient. I hope that one day I can support my sons half as well as you have supported me.

I would like to thank Carlitos, for encouraging me to do this, a long time before it was a possibility - this is for you, wherever you are. Likewise, I do not forget Mamama, who taught me to fly.

I would like to thank my friends, the old ones and the new; I am grateful to this adventure for bringing you into my life. All of you played a role in this process.

Finally, I want to thank my beloved wife, Verónica, who stood by my side and without whom I would not have finished this thesis. She was a great partner on this journey; she was always there, when one year in the end turned into six, when two went out and four returned; as you see, I did not teach you math, but you taught me love. I want to dedicate this thesis to you, Benja and Matías. My time now is yours.

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Chapter 1

Introduction

This thesis contributes to the empirical literature which studies households' consumption and saving behaviour. The thesis aims to discover whether we can learn about the motives for saving from consumption and wealth accumulation decisions in the aftermath of income shocks. In particular, I use these decisions to infer the strength of the precautionary-savings motive relative to the standard consumption-smoothing motive in the permanent-income theory.

Precautionary-saving behaviour depends on financial market imperfections such as borrowing constraints. Thus, the strength of the precautionary-saving motive can be assessed to indicate whether financial market imperfections, in the form of borrowing constraints, play a role in households' savings decisions.

Quantifying the amount of precautionary savings in the data has been challenging for the literature. In this thesis I provide evidence on the strength of the precautionary-savings motive which is very important for policy purposes. For instance, any policy measure aimed to meet the needs of social security system should consider the relevance of precautionary savings: whether households use such savings to self-insure, which households do it and to what extent.

In a seminal paper Krueger and Perri (2011) use unique Italian panel data on consumption, wealth and income to analyse the predictions of wealth responses to income shocks. They test the predictions of workhorse models and conclude that the permanent-income model describes the data best. In this, the wealth response to income shocks declines if measured over longer time horizons. In particular, Krueger and Perri (2011) argue that the wealth responses to income shocks allow us to figure out whether and to what extent financial market imperfections matter for households decisions.

In Chapter 2, to study the response of consumption and wealth accumulation to income shocks, I contrast the predictions of two leading models: the permanent-income model and the precautionary-saving incomplete-markets model.

I summarise the contribution of this chapter as follows. With respect to the permanent-income model, I generalise the results of Krueger and Perri (2011) and find that high levels of income persistence are needed to obtain decreasing responses of wealth over time. With respect to the precautionary-savings model I provide a non-trivial example in which this model also generates a declining wealth response over time. Furthermore, I structurally estimate the model and find that once the precautionary-savings model matches the sample mean and median net worth, to quantitatively discipline the strength of the precautionary motive, the wealth profile is decreasing over time and contributes to a better fit of the model.

Overall, I show that the declining wealth responses to income shocks over time may not be considered as evidence for the classic permanent-income model with perfect capital markets, and thus as evidence against the existence of borrowing constraints.

To what extent the strength of precautionary savings motives is strong enough to generate an increasing, or decreasing, profile of wealth to income shocks over time is an empirical issue. In Chapter 3 I explore what can be learnt from the international evidence in this regard. Using data for Chile, Spain and the United States I estimate the consumption and wealth responses, applying the same selection criteria as in Chapter 2.

This is a valid question, since these three countries exhibit different levels of development in their financial markets. A priori, I expect that this heterogeneity may have implications for the observed responses. For instance, in less developed countries households may face higher levels of uncertainty in the economy, in terms of institutions, income, or economic conditions. These characteristics, jointly with a public welfare system which provides less support, may imply different saving behaviour from households in less developed economies.

I construct panel data on income, consumption and wealth for Chile, Spain and the United States. For each country I estimate the households' responses to income shocks and then estimate a precautionary-saving incomplete-markets model. As far as I know, this is the first research to structurally estimate this kind of model for Chile or Spain using a relatively new and rich dataset.

My results are as follows. I find that the wealth responses for the three countries predicted by the model qualitatively, and quantitatively in some cases, replicate the decreasing wealth responses over time in the data. As in the case of Italy, in all three countries the predicted wealth profile improves the fit of the model. Moreover, the model implies a low target level of wealth, given the estimated levels of impatience and risk aversion for the households. Surprisingly, the results suggest that the heterogeneity in financial development across the considered countries is not as important as expected a priori.

Considering only households which do not own real estate, as in Krueger and Perri (2011), may imply selection biases for the results. In fact Kaplan and Violante (2014) argue that there is a sizeable fraction of households which behaves as if liquidity constrained, even though they have positive net worth due to homeownership. These are the households which for instance have not recently adjusted their housing stock, but this is illiquid and thus compels non-durable consumption behaviour, which is similar to that of liquidity constrained consumers.

In Chapter 4 I revisit the Italian dataset used in the second chapter of the thesis and extend the analysis to include households with real estate properties. Using the framework of Kaplan and Violante (2014) and Kaplan, Violante, and Weidner (Forthcoming), I apply a new strategy to identify those households which adjust their housing stock. I also characterise the fraction of these households which comprises hand-to-mouth consumers. I compare the behaviour of these households with those households which did not adjust their housing stock.

My results are as follows. The group of households that adjusted its housing stock exhibits a decreasing profile of wealth to income shocks over time, whereas this profile is increasing for those households which did not adjust. Furthermore, I characterise the households according to their portfolio positions and find a higher proportion of hand-to-mouth consumers in the group of households which did not adjust its stock of durables. These results encourage the interpretation that the upward sloping profile of wealth may be the outcome of precautionary-saving behaviour, because these households are relatively more constrained. This evidence supports the hypothesis proposed by Kaplan and Violante (2014).

In summary, this thesis contributes to the literature by showing how the slope of wealth responses to income shocks over time is influenced by both precautionary-savings and permanent-income behaviour. The evidence that I present in the different chapters supports the strategy of identifying precautionary-savings or permanent income behaviour by looking at whether the wealth response to income shocks over time increases or decreases. Chapter 5 draws some conclusion and contains the closing remarks of the thesis.

Chapter 2

Financial market imperfections and the response of household wealth to income shocks

2.1 Introduction

The two workhorse models of consumer behaviour are the classic permanent-income model and the precautionary-savings incomplete markets model. A key difference between these models is the degree of access to financial markets. Whereas the permanent-income model allows consumers to freely borrow against future earnings, the incomplete-markets model imposes a borrowing constraint. The occasionally binding borrowing constraint, reinforced by the usual assumption of prudence for household preferences, implies that consumers hold precautionary savings to insure against uninsurable shocks.

This chapter is inspired by work with Giulio Fella and Winfried Koeniger.

The degree of financial market imperfection is hard to observe directly but of crucial importance for the welfare effects of social insurance policies. Thus, previous research has tried to exploit different predictions of the two models for observable variables in order to draw inferences about the constraints that consumers face in financial markets (see the literature surveyed by Deaton (1992), Attanasio and Weber (2010), and references in Krueger and Perri (2011)). Such inferences are more easily made the more information about household decisions is available so that the emergence of panel data with information about income, consumption and wealth over a sufficiently long period have allowed me to construct new statistical data to test the permanent-income model against the precautionary-savings incomplete-markets model.

Using the Italian Survey of Household Income and Wealth (SHIW), which is unique for its panel information about household consumption, income and wealth since 1987, Krueger and Perri (2011) have documented that the observed response of household wealth to income shocks declines over the time horizon considered. They argue that this provides evidence in favour of the classic permanent-income model without borrowing constraints. I show that whether models with financial market imperfections, such as the standard incomplete-markets model with liquidity constraints, can generate such a wealth response crucially depends on the importance given to precautionary wealth accumulation. This is a quantitative issue which I address by structurally estimating a standard incomplete-markets model by the simulated method of moments, including the observed median and mean net household worth of the SHIW sample considered by Krueger and Perri (2011). My findings illustrate that in general a model with precautionary savings is able to match the declining wealth response to income shocks observed in the data. Moreover, when I quantitatively evaluate it for this Italian sample, the wealth profile contributes to a better fit of the model.

The rest of the paper is structured as follows. In Section 2.2 I present predictions of the permanent-income model and show a precautionary-savings incomplete-markets model for the consumption and wealth responses to income shocks. In Section 2.3, I briefly discuss the SHIW data which I then use to estimate the responses of wealth and consumption to income shocks. In Section 2.4 I calibrate and estimate the two models to assess whether they can explain the data. I conclude in Section 2.5.

2.2 Theoretical predictions for responses to income shocks

Compared with the previous literature, Krueger and Perri (2011) use the responses of consumption *and* wealth to income shocks in order to test the permanent-income model against the precautionary-savings incomplete-markets model. In this section I thus present the predictions of the two models regarding these responses.

Consumers have an infinite horizon, derive utility from consumption c_t and discount the future with factor β. In each period t they decide how much to consume c_t and how many assets a_{t+1} to hold in the next period. The assets earn a given interest r in the small-open economy.

The recursive problem of the agent is

$$v(a_t, y_t) = \max_{a_{t+1}} \left\{ u(\underbrace{(1+r)a_t + y_t - a_{t+1}}_{c_t}) + \beta E_t v(a_{t+1}, y_{t+1}) \right\} \tag{2.1}$$

subject to

$$a_{t+1} + c_t = (1+r)a_t + y_t, \tag{2.2}$$
$$\lim_{T\to\infty} \left(\frac{1}{1+r}\right)^T a_{T+1} = 0 \text{ a.s.},$$

where the No-Ponzi-Game condition ensures that the intertemporal budget constraint holds with equality.

The problem has two state variables: the endogenous asset position a_t and the exogenous stochastic income y_t which matters for expectations due to the persistence of income shocks. The consumer's stochastic labour income y_t follows the process

$$y_t = z_t + \varepsilon_t, \tag{2.3}$$
$$z_t = \rho z_{t-1} + \eta_t,$$

where $\varepsilon_t \sim \mathcal{N}(0, \sigma_\varepsilon^2)$ is a transitory income shock and $\eta_t \sim \mathcal{N}\left(0, \sigma_\eta^2\right)$ is an income shock with persistence $0 < \rho \leq 1$.[1] The shocks ε_t and η_t are assumed to be uncorrelated with each other in each period t and i.i.d. over time.[2]

[1] Krueger and Perri (2011) assume a permanent income shock, i.e. $\rho = 1$. I also solve the model for $\rho = 1$ which requires normalization of all variables by permanent income in the recursive formulation and the further assumption of a finite time horizon T to keep distributions stationary in the simulations. The main insights do not change if I consider $\rho = 1$ instead of values of ρ very close to unity; for simplicity I focus on persistence $0 < \rho < 1$, but I elaborate the case for $\rho = 1$ when relevant.

[2] In the calibrated precautionary-savings incomplete markets model below the process is specified for the logarithm of income since the income distribution in the data is skewed. The specification of the process in income levels allows for simple analytic char-

2.2.1 Permanent-income model

To derive the predictions of the permanent income model I assume a quadratic period utility function $u(c_t) = -\frac{1}{2}(\overline{c} - c_t)^2$. The recursive problem (2.1) implies that the intertemporal allocation of resources at an interior optimum is characterised by the standard Euler equation

$$u'(c_t) = \beta(1+r)E_t u'(c_{t+1})$$

which, for the assumed quadratic utility function, simplifies to

$$c_t = (1 - \beta(1+r))\,\overline{c} + \beta(1+r)E_t c_{t+1}. \tag{2.4}$$

The purest version of the permanent-income model abstracts from the tilting of the consumption profile and assumes $\beta(1+r) = 1$. Under these assumptions, I describe how consumption, wealth and income change after transitory and persistent shocks. The proof, as for the other analytic results in this section, is provided in the appendix.

Remark 1. *In the permanent-income model with $\beta(1+r) = 1$ and income process (2.3), consumption, wealth and income changes are given by*

$$\begin{aligned}
\Delta c_t &= \frac{r}{1+r}\varepsilon_t + \frac{r}{1+r-\rho}\eta_t \ , \\
\Delta a_{t+1} &= \frac{\varepsilon_t}{1+r} + \frac{1-\rho}{1+r-\rho}\left(\rho z_{t-1} + \eta_t\right) \ , \\
\Delta y_t &= \Delta\varepsilon_t + \eta_t + (\rho - 1)\, z_{t-1} \ .
\end{aligned}$$

The responses of consumption and wealth to the shocks in Remark 1

acterization of the consumption and wealth response in the permanent-income model.

are well known and hence I comment on them only briefly. Consumption changes by the annuity value of the transitory shock ε_t and wealth bears the remaining impact of that shock on resources. Consumption increases more after the persistent shock η_t and indeed this shock affects only consumption and not wealth if it is permanent ($\rho = 1$).

Obviously, the panel data which I are going to use do not contain direct information about transitory and persistent income shocks so that, as a next step, I use the results in Remark 1 to derive predictions for changes of wealth and consumption after changes in observed income. I compute the predictions of the model for changes over N periods, since I will exploit the SHIW data, as do Krueger and Perri (2011), to compute consumption and wealth responses to changes in labour income over two, four and six years. I show in Section 2.4 how these predictions are affected if income shocks are measured with error.

Remark 2. *If consumers behave according to the permanent-income model with* $\beta(1+r) = 1$ *and observed income follows the process (2.3), the response of consumption and wealth to changes in income over* N *periods is given by*

$$\beta_c^N = \frac{cov(\Delta^N c_t, \Delta^N y_t)}{var(\Delta^N y_t)} = \frac{\frac{1-\rho^N}{1-\rho}\frac{r}{1+r-\rho}Q + \frac{r}{1+r}}{\left(\frac{(\rho^N-1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho}\right)Q + 2}$$

$$\beta_a^N = \frac{cov(\Delta^N a_{t+1}, \Delta^N y_t)}{var(\Delta^N y_t)} = \frac{\frac{1-\rho^N}{1+\rho}\frac{1}{1+r-\rho}Q + \frac{1}{1+r}}{\left(\frac{(\rho^N-1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho}\right)Q + 2}.$$

with $Q \equiv \sigma_\eta^2/\sigma_\varepsilon^2$.

Remark 2 makes explicit how consumption and wealth responses to observed income changes depend on the relative importance of the persistent shock Q as well as on the periods N over which the change is measured.[3] The following corollary states how these responses change with N.

Corollary 1. *If consumers behave according to the permanent-income model with $\beta(1+r)=1$ and $0<Q<\infty$:*

- *the response of consumption to income shocks increases in the number of periods ($\partial\beta_c^N/\partial N>0$) if $\rho=1$ or $\rho<1$ is sufficiently large and $Q<Q_c^*$;*
- *the response of wealth to income shocks decreases in the number of periods N over which the response is measured ($\partial\beta_a^N/\partial N<0$) if $\rho=1$ or $\rho<1$ and $Q>Q_a^*$, where $Q_a^*<Q_c^*$.*

These results are intuitive. Consider first the case with a permanent income shock, $\rho=1$. As the number of periods N increases, the wealth and consumption response to income changes depends more on the cumulative permanent shock rather than on the transitory shocks: the independently distributed transitory shocks offset each other over a longer horizon, while the permanent shocks accumulate. Therefore the consumption response increases and the wealth response decreases in N.

If the component z_t in the labour income process (2.3) is not permanent but only persistent, the consumer changes his asset holdings to smooth consumption after changes in z_t. The effect of the change becomes weaker over time: ρ^N decreases in N for $0<\rho<1$. Thus, the effect of changes in the persistent income component z_t on consumption and wealth decreases

[3]Note that Remark 2 nests the results of Krueger and Perri (2011) for $\rho=1$ since by L'Hôpital's rule $\lim_{\rho\to1}\frac{1-\rho^N}{1-\rho}=\lim_{\rho\to1}\frac{-N\rho^{N-1}}{-1}=N$ and $\lim_{\rho\to1}\frac{(\rho^N-1)^2}{1-\rho^2}=\lim_{\rho\to1}\frac{1-2\rho^N+\rho^{2N}}{1-\rho^2}=\lim_{\rho\to1}\frac{-2N\rho^{N-1}+2N\rho^{2N-1}}{-2\rho}=0$.

in N ceteris paribus. Clearly, the importance of this effect for the profile of the consumption and wealth response across N is less if persistence ρ is greater. Corollary 1 shows that for a persistent enough $0 < \rho < 1$ there exists $Q \in (Q_a^*; Q_c^*)$ so that the consumption response increases in N while the wealth response decreases in N.

Table 2.1 shows the behaviour of the consumption and wealth response as a function of N for different ρ, using parameter values $r = 0.02$ and $Q = 0.34$ as in Krueger and Perri (2011), Tables 6 and 7, where the value for Q is based on estimates for σ_η and σ_ε from Jappelli and Pistaferri (2006). For these plausible parameter values, the consumption response to income shocks increases in N and the wealth response decreases in N, for all considered values of persistence ρ. For very persistent shocks ($\rho = 0.9995$ or $\rho = 0.995$), the wealth response falls more strongly and the consumption response increases more strongly in the number of periods N. The wealth and consumption response are flat, as one would expect, if the shock has very low persistence ($\rho = 0.2$).

Table 2.1: Persistence and the wealth response to income shocks over different numbers of periods N.

	Consumption response			Wealth response		
		β_c^N			β_a^N	
Number of years (N)	2	4	6	2	4	6
Persistence						
0.9995	0.255	0.4	0.497	0.369	0.297	0.249
0.995	0.210	0.327	0.403	0.391	0.332	0.292
0.95	0.078	0.112	0.132	0.454	0.427	0.405
0.8	0.028	0.033	0.036	0.471	0.446	0.428
0.2	0.011	0.011	0.011	0.480	0.477	0.477

Source: Author's calculation. Note: The parameter values are $r = 0.02$, $Q = 0.34$.

2.2.2 Precautionary-savings incomplete-markets model

I contrast the predictions of the permanent-income model with the precautionary-savings incomplete-markets model. I assume a CRRA period utility function $u(c_t) = \left(c_t^{1-\alpha} - 1\right)/(1-\alpha)$, $\alpha > 0$. Compared with the classic permanent-income model, the precautionary-savings incomplete-markets model does not have a closed form solution and thus analytic results on the response of wealth and consumption to income changes are not available.[4] Appendix C provides details and references for the solution and simulation of this standard model.

The recursive problem of the agent changes compared to the permanent-income model since solvency now implies a borrowing constraint $a_{t+1} \geq \underline{a}$. The existence of this occasionally binding borrowing constraint results in a precautionary saving motive which, for the commonly assumed CRRA utility function, loses strength if the agent is wealthier. Indeed, if the agent has abundant net worth relative to the borrowing limit $\underline{a}$ so that the constraint is binding with probability close to zero, the predictions of this model are identical to those of the classic permanent-income model.

I now provide an intriguing example in which most consumers have *little* net worth and the precautionary-savings incomplete markets model is nonetheless able to generate wealth and consumption responses to income changes that are qualitatively similar to the classic permanent-income model. This is not obvious since, as Krueger and Perri (2011) have con-

[4]The special case of CARA utility without borrowing constraints, for which closed form solutions are available, is not interesting for my purposes. Its predictions for the consumption and wealth responses are identical to the permanent-income model because the precautionary motive does not depend on the amount of resources available to the agent.

vincingly argued, a key difference between the models is that even permanent shocks are partially insured in the precautionary-savings incomplete-markets model and thus affect wealth holdings. Since the impact of these shocks on asset holdings increases over time, the wealth response to income shocks may increase in the number of periods N, as illustrated in the examples provided by Krueger and Perri (2011).

If this prediction of the precautionary-savings incomplete-markets model were robust, it would allow for an easy test of the classic permanent-income model against the precautionary-savings incomplete-markets model. Researchers would compute the wealth response to income shocks for a different number of periods N. If the wealth response to income shocks fell with N in the data, this would be supporting evidence for the permanent-income model (under the conditions spelled out in Corollary 1) but not for the precautionary-savings incomplete-markets model. Note that both models have instead the same qualitative prediction that the consumption response to income shocks will increase in N.

I want to add to the findings in Krueger and Perri (2011) by providing an alternative example for the precautionary-savings incomplete-markets model. Strikingly, in this example the precautionary-savings incomplete-markets model with liquidity constraints, $\underline{a} = 0$, delivers a wealth response to income shocks which decreases in N. Thus, observing such a wealth response in the data is not necessarily inconsistent with the financial market imperfections implied by occasionally binding liquidity constraints.

The first row of Table 2.2 displays the consumption and wealth response for my example with parameter values $\rho = 1$, $\beta = 0.91$, $r = 0.02$, $\alpha = 1.1$, $\underline{a} = 0$ and $Q = 0.34$ based on the estimates of Jappelli and Pistaferri

Table 2.2: Consumption and wealth response to income shocks over different number of periods

	Consumption response			Wealth response		
		β_c^N			β_a^N	
Number of years (N)	2	4	6	2	4	6
Coefficients	0.547	0.653	0.713	0.168	0.151	0.131
Coefficients for different quartiles of the wealth distribution						
1st quartile	0.628	0.705	0.755	0.103	0.088	0.066
2nd quartile	0.537	0.645	0.711	0.088	0.080	0.071
3rd quartile	0.511	0.626	0.696	0.110	0.091	0.080
4th quartile	0.442	0.575	0.647	0.168	0.139	0.122

Source: Author's calculation. Notes: Median regression estimates for the selected samples. The parameter values are $\rho = 1$, $\beta = 0.91$, $r = 0.02$, $\alpha = 1.1$, $\underline{a} = 0$ and $Q = 0.34$.

(2006). The parameter values are plausible where not surprisingly, given my previous findings in Table 2.1 the permanent (or even very persistent) income shock gives the model a chance to generate a wealth response to income shocks which decreases in N.

Figure 2.1 plots the policies as a function of net worth for some selected income states, together with the stationary distribution of net worth implied by the model.[5] Remarkably, the liquidity constraint is binding for more than 45% of the agents. As will become clear when I present the data, this incidence of the constraint is not implausible for the sample of households that I focus on, following Krueger and Perri (2011).

Figure 2.1 raises the question how a wealth response to income shocks which decreases in N is generated by the model despite the fact that median net worth is very low at 0.02, and many consumers are at, or close to, the liquidity constraint. In the simulations, most of these consumers are

[5] As I am presenting the solution for the model with $\rho = 1$ the plotted variables are normalised by the permanent income level.

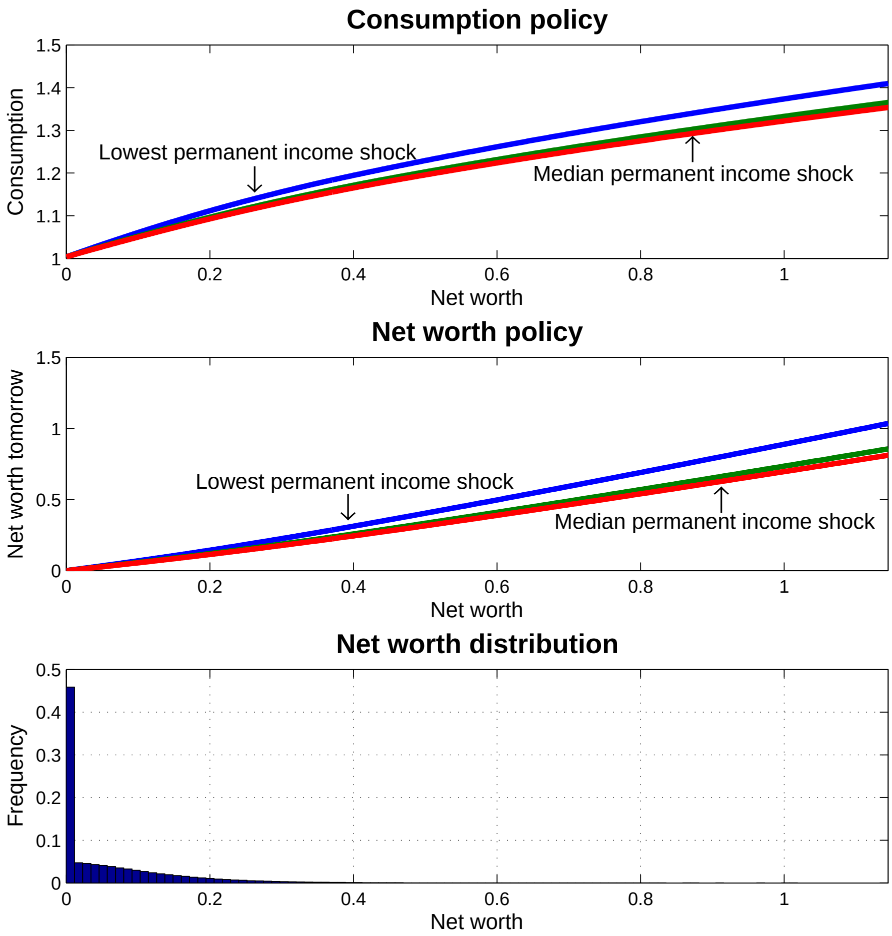

Figure 2.1: Policy functions for selected income states and the net worth distribution. Source: Author's calculation. Note: All variables are normalised by the level of the permanent income. The parameter values are $\rho = 1$, $\beta = 0.91$, $r = 0.02$, $\alpha = 1.1$, $\underline{a} = 0$ and $Q = 0.34$.

in the bottom half of the income distribution. For these income levels the policy functions are already fairly linear close to the liquidity constraint since the discount factor $\beta = 0.91$ implies a low target level of wealth. Put differently, most consumers do not save much for precautionary reasons close to the liquidity constraint for these values of income. Thus, the motive for precautionary wealth accumulation is not strong enough for these impatient consumers to dominate the effect of N on the wealth response predicted by the permanent-income model.

The lower part of Table 2.2 provides supporting evidence showing the wealth and consumption response across different quartiles of the net worth distribution. These responses are obtained by adding dummies for each but the first net worth quartile to the median regression and by interacting these dummies with the respective changes in income. I assign observations to a quartile of the net worth distribution at the time when the consumer makes the first decision over an N period horizon. For example, the income changes and wealth responses over six years are classified according to the net worth at the beginning of the period. Table 2.2 shows that the consumption response increases across all quartiles while the wealth response decreases for consumers in all quartiles of the net worth distribution. Thus, the precautionary saving for all agents is small.

I provide an example which shows that a wealth response to income shocks which decreases in N is consistent with financial-market imperfections in the form of occasionally binding liquidity constraints if the motive for precautionary wealth accumulation is not too strong. I now elaborate on this finding and confront the permanent-income model and precautionary-savings incomplete-markets model more seriously with the data, estimating the latter model by a simulated method of moments. In doing so, I target median and mean net worth which imposes discipline on the incomplete-markets model, since the amount of precautionary wealth needs to match the net worth observed in the data.

2.3 Data

Having presented the predictions of the permanent-income and precautionary-savings incomplete-markets model, which I want to confront with data, in this section I discuss the most important characteristics of the data I use. Since I follow Krueger and Perri (2011) when constructing my sample, I refer to Appendix B and their paper for further details.

The Italian Survey of Households Income and Wealth (SHIW) is a unique panel data set which contains comprehensive information about household income, consumption and wealth over a long period. Since 1987 the SHIW has a panel dimension covering around $8,000$ households which form a representative sample of the Italian population (Jappelli and Pistaferri (2010)). The survey is conducted every two years with the exception of a three-year gap between 1995 and 1998.

Krueger and Perri (2011) show that income shocks co-move with shocks to real estate and business wealth in the SHIW. Thus, I follow their strategy to isolate the effect of income shocks on household behaviour by selecting only those households for my sample which have no members in self-employment or entrepreneurial activities and which do not own real estate. Thus, households in the selected sample have less net worth and income than the average population, as shown in Table B.1 with summary statistics in Appendix B. After cleaning the data, as described in Appendix B, this leaves me with a sample of 554 households for which I observe the wealth and non-durable consumption responses to after-tax and transfer labour income changes after two, four and six years in the time period 1987 to 2010. As in Krueger and Perri (2011), I convert the data into equivalent units per adult using the OECD equivalence scale to control for differences in household size.[6]

I also follow Krueger and Perri (2011) by purging changes in after-tax labour income, consumption and wealth from those changes which are predictable. I thus regress the observed changes on a quartic polynomial of the age of the household head, on education, time and regional dummies as well as the age-education interaction dummies. I then use the residuals of these regressions as my measure of shocks, where I take into account that income shocks are measured with error.

Since there are some outliers for observations on wealth in the data, even after cleaning the data, I report all estimation results for median regressions which minimise absolute deviations and thus are robust to outliers.

2.4 Results

This section assesses whether calibrated versions of the permanent income and of the precautionary saving model match the consumption and wealth responses to income changes in the SHIW data for different values of N. I reproduce in Table 2.3 Krueger and Perri's estimate for the 1987-2008 sample. The response of consumption is increasing in N while the wealth response is decreasing in N.

[6]The results are robust if I consider the household as a decision unit.

As noted in the data section, income changes observed by the econometrician are measured with error. I thus allow for measurement errors in my calibration and derive consumption and wealth responses under the assumption that the econometrician observes the true income process y_t in Equation (2.3) with error:

$$\widetilde{y}_t = y_t + \gamma_t, \tag{2.5}$$

where $\gamma_t \sim \mathcal{N}\left(0, \sigma_\gamma^2\right)$ is a classical measurement error and is assumed to be i.i.d. over time and uncorrelated with the income shocks ε_t and η_t.

Table 2.3: Consumption and wealth response to income shocks in the permanent-income model and in the data.

Results of Krueger and Perri (2011)

	Consumption response β_c^N			Wealth response β_a^N		
Number of years N	2	4	6	2	4	6
Responses in the permanent-income model	0.23	0.37	0.47	0.17	0.14	0.12
Responses in the SHIW data	0.23	0.25	0.27	0.17	0.07	0.09

Source: Krueger and Perri (2011), Table 5. Parameter values: $\rho = 1$, $r = 0.02$, $Q = 0.29$, $M = 0.55$.

2.4.1 Permanent-income model

Before calibrating the permanent-income model, I briefly discuss how measurement error affects the theoretical predictions of the model.

Remark 3. *If consumers behave according to the permanent-income model with $\beta(1+r) = 1$ and observed income follows the process (2.5), the response of consumption and wealth to changes in income over N periods is given* *by*

$$\beta_c^N = \frac{cov(\Delta^N c_t, \Delta^N \widetilde{y}_t)}{var(\Delta^N \widetilde{y}_t)} = \frac{\frac{1-\rho^N}{1-\rho}\frac{r}{1+r-\rho}Q + \frac{r}{1+r}(1-M)}{\left(\frac{(\rho^N-1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho}\right)Q + 2} \tag{2.6}$$

$$\beta_a^N = \frac{cov(\Delta^N a_{t+1}, \Delta^N \widetilde{y}_t)}{var(\Delta^N \widetilde{y}_t)} = \frac{\frac{1-\rho^N}{1+\rho}\frac{1}{1+r-\rho}Q + \frac{1}{1+r}(1-M)}{\left(\frac{(\rho^N-1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho}\right)Q + 2}. \tag{2.7}$$

with

$$Q \equiv \frac{\sigma_\eta^2}{\sigma_\varepsilon^2 + \sigma_\gamma^2} \textit{ and } M \equiv \frac{\sigma_\gamma^2}{\sigma_\varepsilon^2 + \sigma_\gamma^2} \ .$$

Remark 3 makes explicit how the response of consumption and wealth to observed income changes depends on the relative importance of measurement error M. I summarise the effect of measurement error on the responses in the following corollary.

Corollary 2. *If consumers behave according to the permanent-income model with $\beta(1+r) = 1$ and income shocks are measured with error according to (2.5), measurement error affects the responses of wealth and consumption to observed income shocks in the following way:*

- *The response of wealth to income shocks is reduced more by measurement error than the response of consumption if the interest rate r is smaller than unity ($\partial\beta_a^N/\partial M < \partial\beta_c^N/\partial M < 0$).*
- *The effect of measurement error on the responses, in absolute terms, decreases in the number of periods N ($\partial^2\beta_a^N/\partial M\partial N > 0$, $\partial^2\beta_c^N/\partial M\partial N > 0$).*

Measurement error, as the transitory shock, matters more for smaller N since the measurement error is also independently distributed over time.

Table 2.4: Persistence and the wealth response to income shocks over different numbers of periods N.

	Wealth response β_a^N		
Persistence ρ \ Number of periods N	2	4	6
0.9995	0.174	0.144	0.124
0.995	0.193	0.176	0.164
0.95	0.250	0.263	0.268
0.8	0.268	0.279	0.280
0.2	0.2757	0.2762	0.2762

Source: Author's calculation. Note: The parameter values are $r = 0.02$, $Q = 0.29$, $M = 0.55$

Since the consumption response is *smaller* and the wealth response is *larger* if measured over a smaller number of periods N, the stronger attenuation bias for smaller N affects in different ways the profile of the wealth and consumption response over the number of periods. Measurement error reduces and may even reverse the negative sign of $\partial\beta_a^N/\partial N$; the derivative $\partial\beta_a^N/\partial N < 0$ becomes smaller in absolute terms and may even become positive. Measurement error instead increases the positive sign of the effect of the number of periods on the consumption response.

Table 2.4 shows how measurement error affects the behaviour of the wealth response as a function of N compared with Table 2.1 in Section 2.2.1. For illustration purposes I set $Q = 0.29$, $M = 0.55$ as in the calibration of the permanent income model in Krueger and Perri (2011).

The wealth response to income shocks no longer decreases consistently in the number of periods N. The wealth response falls in N only for very high levels of persistence ($\rho = 0.9995$ or $\rho = 0.995$) and is nearly flat (as one would expect) if the shock has low persistence ($\rho = 0.2.$). Yet, for intermediate values of $\rho = 0.8$ or $\rho = 0.95$ the wealth response

Table 2.5: Consumption and wealth response to income shocks in the permanent-income model and in the data.

	Consumption response β_c^N			Wealth response β_a^N		
Number of years N	2	4	6	2	4	6
Responses in the permanent-income model	0.23	0.35	0.43	0.17	0.15	0.14
Responses in the SHIW data	0.23	0.25	0.27	0.17	0.07	0.09

Source: Author's calculation. Parameter values: $\rho = 0.995$, $r = 0.02$, $Q = 0.40$, $M = 0.60$.

increases in N. These results show that, for plausible parameter values, the permanent-income model can generate a wealth response which decreases in N, $\partial\beta_a^N/\partial N < 0$, only if income shocks are extremely persistent. In other words, a wealth response to income shocks which decreases in N imposes tight restrictions on ρ in the permanent-income model with measurement error. I thus choose a high level of persistence $\rho = 0.995$ and calibrate the relative importance of the variance of the persistent shock Q and the measurement error M in expressions (2.6) and (2.7), following Krueger and Perri (2011). Namely, I choose Q and M so that the permanent-income model exactly matches the two-year responses of wealth and consumption to income shocks (see Appendix C for further details). I do this while maintaining the assumption $\beta(1 + r) = 1$ in the permanent-income model with $r = 0.02$ as before.

The model responses are reported in the first row of Table 2.5, and in the second row Krueger and Perri's empirical estimates are reproduced. The model matches the two-period responses of consumption and wealth of the SHIW exactly for the empirically plausible values $M = 0.60$ and $Q = 0.40$.

Allowing for income persistence in the calibration implies that, for a level of $\rho = 0.995$, the profile of the consumption response over different periods N increases less, and the wealth response decreases less, compared with the profile in the calibration of Krueger and Perri (2011) with $M = 0.55$ and $Q = 0.29$ in the first row of Table 2.3.

Quantitatively, Table 2.5 shows that the permanent-income model predicts that the consumption response will increase more strongly in N than in the data, and the wealth response decreases less strongly in N than in the data for the values of Q and M necessary to match my estimates for $N = 2$ in Table 2.5.

One may wonder how the difference between $M = 0.60$ and $Q = 0.40$ in my calibration and the values $M = 0.55$ and $Q = 0.29$ in Krueger and Perri (2011) affects the results of the permanent-income model. If I change only M relative to Krueger and Perri (2011) so that $M = 0.60$ and $Q = 0.29$, the wealth responses are $\beta_a^2 = 0.17$, $\beta_a^4 = 0.16$, $\beta_a^6 = 0.15$. This shows that the higher value for M in my calibration compared with Krueger and Perri (2011) makes it more difficult for the permanent-income model to match the wealth response in the data which decreases in N. However, the higher value of Q compared to Krueger and Perri (2011), which turns out to be more important for the consumption responses for the considered parameter values, contributes obtaining a flatter profile of consumption over time.

2.4.2 Precautionary-savings incomplete-markets model

I showed in Section 2.2.2 that an incomplete-markets model with liquidity constraints may generate the qualitative profile observed in the data of the way in which consumption and wealth responses to income shocks depend on N. I now confront the model more seriously with the data to assess whether the qualitative and quantitative predictions of the precautionary-savings incomplete-markets model differ from those of the permanent-income model for parameter values for which the model matches the net worth holdings in the data. This is important since matching the amount of net worth imposes discipline on the strength of the motive for precautionary wealth accumulation, which is key to the predictions of the model regarding the wealth response and its dependence on N.

I proceed to structurally estimate a subset of the model parameters after choosing the other parameters on the basis of external estimates. In particular, I set $Q = 0.34$ and the variance of the observed income $\sigma_y^2 = 0.32$ based on estimates for the SHIW income data by Jappelli and Pistaferri (2006) and Jappelli and Pistaferri (2010) respectively.

I set persistence $\rho = 1$ because, as I previously showed, a high level of persistence is required for the model with measurement error to have a chance to match a wealth response which decreases in N as in the data. Finally, I set the borrowing limit to $\underline{a} = 0$, which is the natural borrowing limit for the lognormal income process in Equation (2.3).

I then estimate the parameters β, α and the variance of the measurement error σ_γ^2 for which the model generates moments which minimise the weighted sum of the squared deviations from the following eight data moments: the mean and median of net worth, and the responses of consumption and wealth to income shocks over years $N = 2, 4, 6$, in turn. The weighting matrix is the variance-covariance matrix of the model moments, thus taking into account the model's predictions about the precision with which the data moments are estimated. The properties of the response to income shocks receive less weight in assessing the validity of the model if the model predicts that these properties are less precisely measured in the data.

For the estimation with the simulated method of moments, I compute the model solution on the parameter grid $\beta = 1/(1+\delta) \in [0.90, 0.98]$ with distance 0.0025 between adjacent gridpoints of the discount rate δ, $\alpha \in [0.80, 2.8]$ with distance 0.05 between adjacent gridpoints and $\sigma_\gamma^2 \in [0, 0.0375]$ with distance 0.0025 between adjacent gridpoints. I then perform a search for the parameter combination on this grid that minimises the distance between the model generated moments and the moments obtained from the SHIW. See Appendix C for further information on the model solution and estimation.

Table 2.6 reports the estimation results. To facilitate comparison I report the data moments from the SHIW in the last row of the table. The model estimates for β, α and σ_γ^2 are reasonable and comparable to the literature. With respect to the example provided in section 2.2.2, the discount factor in the estimated model is higher, $\beta = 0.97$. Thus, the households are more patient and thus their target level of wealth is higher than in the example. Given that Q is calibrated to 0.34 and the variance of observed income to 0.32, the estimate for the variance of measurement error $\sigma_\gamma^2 = 0.02$ implies $\sigma_\eta^2 = 0.0124$ and $\sigma_\varepsilon^2 = 0.0168$, and thus $M =$

Table 2.6: Estimation results for the incomplete-markets model.

Parameters (std.err.)	Estimation with optimal weighting of moments $\beta = 0.97$ (0.001), $\alpha = 0.90$ (0.041), $\sigma_\gamma^2 = 0.02$ (0.003)							
	Wealth		Consumption response			Wealth response		
	Median	Mean	N=2	N=4	N=6	N=2	N=4	N=6
Model moments	0.43	0.55	0.261	0.401	0.493	0.178	0.171	0.168
Standard deviation	(0.020)	(0.021)	(0.026)	(0.029)	(0.030)	(0.032)	(0.039)	(0.045)
SHIW data moments	0.29	0.59	0.23	0.25	0.27	0.17	0.07	0.09

Source: Author's calculation. Note: The other parameter values are $\rho = 1$, $Q = 0.34$, $\sigma_y^2 = 0.32$ and $\underline{a} = 0$.

$0.02/(0.02 + 0.0168) = 0.54$. The estimate for M coincides with Krueger and Perri's calibration of the permanent income model.

The estimation results in Table 2.6 show that the model essentially matches the mean net worth, 0.55 compared to 0.59, though slightly overestimating the median net worth. While the model predicts the consumption response at $N = 2$ quite precisely, then it predicts a steeper profile of responses over time compared with the data. In terms of wealth responses, the model does an excellent job of predicting the responses at $N = 2$ and capturing a decreasing profile over time, though this is not as pronounced as in the data. Interestingly, the precautionary motive for wealth accumulation, which is required for the model to match the rather low net worth holdings of the selected sample in the data, is not strong enough to prevent the model from capturing the decreasing profile of the wealth response across N observed in the data.

The model fails to pass the test for overidentifying restrictions with a test statistic of 207 where the critical value for rejection at the 1%-level is $\chi^2(5) = 15.09$. Interestingly, the main reason for rejection comes from the discrepancies predicting the median net worth and the consumption responses at $N = 4$ and $N = 6$, which worsen the performance of the model. In fact, the wealth responses contribute to the fitting of the model. The point of Krueger and Perri (2011) is that the wealth responses over time allow them to reject the precautionary-savings model. In my estimation what turns out to be true is that the wealth responses over time marginally contributes to the χ^2 statistic by only ten points, adding 3 more degrees of freedom.

2.5 Conclusions

Building on the results in Krueger and Perri (2011), I have shown that the observed response of household wealth to income shocks, which decreases if measured over a greater number of years, is consistent with the classic permanent-income model if income shocks are very persistent and income is not measured with too much error. Then I have provided an example in which a standard incomplete-markets model with liquidity constraints generates such a wealth response if the motive for accumulating precautionary wealth is small enough. Thus, it is important that the quantitative predictions of the incomplete-markets model are evaluated at parameter values for which this model matches the net worth holdings of the selected sample of consumers in the data.

My estimation results, obtained by the simulated method of moments, show that the precautionary saving motive in a model with financial market imperfections, disciplined by matching wealth moments, is not strong enough to revert to the decreasing wealth profile observed in the data. In sum, the declining wealth response to income shocks over time is not a strong statistic to consider as evidence against the existence of borrowing constraints.

Appendices

Appendix A

Proofs

Proof. **Remark 1:** I follow Deaton (1992), Chapter 3, adapting the derivations to my assumptions about the income process (2.3). The intertemporal budget constraint

$$\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} c_s = (1+r)a_t + \sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} y_s$$

holds for any realization of income and thus also in expectation:

$$\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} E_t c_s = (1+r)a_t + \sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} E_t y_s. \tag{A.1}$$

It follows from (2.4), applying the law of iterated expectations, that for $s > t$

$$c_t = E_t c_s,$$

so that

$$\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}E_t c_s = c_t\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} = \frac{1+r}{r}c_t.$$

Thus (A.1) implies

$$c_t = ra_t + \frac{r}{1+r}\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}E_t y_s. \tag{A.2}$$

Change of consumption over time

Using the lagged budget constraint (2.2) to substitute a_t, I get

$$c_t = r\left((1+r)a_{t-1} + y_{t-1} - c_{t-1}\right) + \frac{r}{1+r}\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} E_t y_s. \tag{A.3}$$

Using (A.2) lagged one period and multiplying by $1+r$ yields

$$\begin{aligned}(1+r)c_{t-1} &= r(1+r)a_{t-1} + (1+r)\frac{r}{1+r}\sum_{s=t-1}^{\infty}\left(\frac{1}{1+r}\right)^{s-t+1} E_{t-1}y_s \qquad \text{(A.4)}\\ &= r(1+r)a_{t-1} + ry_{t-1} + \frac{r}{1+r}\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} E_{t-1}y_s.\end{aligned}$$

Subtracting (A.4) from (A.3) I find

$$\begin{aligned}\Delta c_t \equiv c_t - c_{t-1} &= \frac{r}{1+r}\left\{\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t}(E_t y_s - E_{t-1}y_s)\right\}\\ &= \frac{r}{1+r}\left\{\varepsilon_t + \sum_{s=t}^{\infty}\left(\frac{\rho}{1+r}\right)^{s-t}\eta_t\right\}\\ &= \frac{r}{1+r}\varepsilon_t + \frac{r}{1+r-\rho}\eta_t,\end{aligned}$$

where $E_t y_s = y_s$ for $s \leq t$ and the second equality follows from (2.3).

Change of wealth over time

Substituting (A.2) into the budget constraint, I have

$$\begin{aligned}a_{t+1} &= (1+r)a_t + y_t - c_t\\ &= a_t + y_t - \frac{r}{1+r}\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} E_t y_s.\end{aligned}$$

Thus,

$$
\begin{aligned}
\Delta a_{t+1} &= y_t - \frac{r}{1+r}\sum_{s=t}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} E_t y_s \\
&= y_t - \frac{r}{1+r} y_t - \frac{r}{1+r}\sum_{s=t+1}^{\infty}\left(\frac{1}{1+r}\right)^{s-t} E_t y_s \\
&= \frac{1}{1+r}\left(y_t - \frac{r\rho}{1+r}\sum_{s=t+1}^{\infty}\left(\frac{\rho}{1+r}\right)^{s-t-1} z_t\right),
\end{aligned}
$$

where Equation (2.3) implies

$$
E_t y_{t+s} = \rho E_t z_{t+s-1} + E_t \eta_{t+s} + E_t \varepsilon_{t+s} = \rho^s z_t.
$$

Expanding, I get

$$
\begin{aligned}
\Delta a_{t+1} &= \frac{1}{1+r}\left(y_t - \frac{r\rho}{1+r-\rho} z_t\right) \\
&= \frac{\varepsilon_t}{1+r} + \frac{1-\rho}{1+r-\rho}\left(\rho z_{t-1} + \eta_t\right).
\end{aligned}
$$

Change of income over time

It follows immediately from the assumed income process (2.3) that

$$
\begin{aligned}
\Delta y_t &= \Delta z_t + \Delta \varepsilon_t \\
&= \left(\rho - 1\right) z_{t-1} + \eta_t + \Delta \varepsilon_t.
\end{aligned}
$$

□

Proof. **Remark 2 and 3:** I derive results for the general income process (2.5) with measurement error. The results of Remark 2 are easily obtained by setting $M = 0$ in Equations (A.8) and (A.9) below.

Remark 1 implies that the N-period changes of consumption, wealth and income are

$$\Delta^N c_t = \sum_{\tau=t-N+1}^{t} \left(\frac{r}{1+r}\varepsilon_\tau + \frac{r}{1+r-\rho}\eta_\tau \right) \ , \tag{A.5}$$

$$\Delta^N a_{t+1} = \frac{1-\rho^N}{1+r-\rho}\rho z_{t-N} + \sum_{\tau=t-N+1}^{t} \left(\frac{\varepsilon_\tau}{1+r} + \frac{1-\rho^{t-\tau+1}}{1+r-\rho}\eta_\tau \right) \ , \tag{A.6}$$

$$\Delta^N \widetilde{y}_t = \left(\rho^N - 1\right) z_{t-N} + \sum_{\tau=t-N+1}^{t} \rho^{t-\tau}\eta_\tau + \Delta^N \varepsilon_t + \Delta^N \gamma_t \ . \tag{A.7}$$

The coefficients of bivariate regressions of N-period consumption or wealth changes on N-period income changes are thus given by $cov(\Delta^N c_t, \Delta^N \widetilde{y}_t)/ var(\Delta^N \widetilde{y}_t)$ and $cov(\Delta^N a_{t+1}, \Delta^N \widetilde{y}_t)/var(\Delta^N \widetilde{y}_t)$. Equations (A.5), (A.6) and (A.7) allow us to compute these variance and covariances as

$$\begin{aligned} var(\Delta^N \widetilde{y}_t) &= \left(\frac{(\rho^N - 1)^2}{1-\rho^2} + \sum_{\tau=t-N+1}^{t} \rho^{t-\tau} \right) \sigma_\eta^2 + 2\sigma_\varepsilon^2 + 2\sigma_\gamma^2 \\ &= \left(\frac{(\rho^N - 1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho} \right) \sigma_\eta^2 + 2\sigma_\varepsilon^2 + 2\sigma_\gamma^2, \end{aligned}$$

$$cov(\Delta^N c_t, \Delta^N \widetilde{y}_t) = \frac{1-\rho^N}{1-\rho}\frac{r}{1+r-\rho}\sigma_\eta^2 + \frac{r}{1+r}\sigma_\varepsilon^2$$

and

$$
\begin{aligned}
cov(\Delta^N a_{t+1}, \Delta^N \widetilde{y}_t) &= \left(-\frac{\rho(1-\rho^N)^2}{(1+r-\rho)(1-\rho^2)} + \sum_{\tau=t-N+1}^{t} \rho^{t-\tau} \frac{1-\rho^{t-\tau+1}}{1+r-\rho} \right) \sigma_\eta^2 + \frac{\sigma_\varepsilon^2}{1+r} \\
&= \left[-\frac{\rho(1-\rho^N)^2}{1-\rho^2} + \sum_{\tau=t-N+1}^{t} \left(\rho^{t-\tau} - \rho^{2(t-\tau)+1} \right) \right] \frac{\sigma_\eta^2}{1+r-\rho} + \frac{\sigma_\varepsilon^2}{1+r} \\
&= \left(-\frac{\rho(1-\rho^N)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho} - \frac{1-\rho^{2N}}{1-\rho^2}\rho \right) \frac{\sigma_\eta^2}{1+r-\rho} + \frac{\sigma_\varepsilon^2}{1+r} \\
&= \frac{1-\rho^N}{1-\rho^2} \frac{1-\rho}{1+r-\rho} \sigma_\eta^2 + \frac{\sigma_\varepsilon^2}{1+r} = \\
&= \frac{1-\rho^N}{1+\rho} \frac{\sigma_\eta^2}{1+r-\rho} + \frac{\sigma_\varepsilon^2}{1+r}.
\end{aligned}
$$

Using the definitions $Q \equiv \sigma_\eta^2/(\sigma_\varepsilon^2 + \sigma_\gamma^2)$ and $M \equiv \sigma_\gamma^2/(\sigma_\varepsilon^2 + \sigma_\gamma^2)$,

$$
\begin{aligned}
\beta_c^N = \frac{cov(\Delta^N c_t, \Delta^N \widetilde{y}_t)}{var(\Delta^N \widetilde{y}_t)} &= r \frac{\frac{1}{1-\rho} \frac{1-\rho^N}{1+r-\rho} \sigma_\eta^2 + \frac{1}{1+r} \sigma_\varepsilon^2}{\left(\frac{(\rho^N-1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho} \right) \sigma_\eta^2 + 2\sigma_\varepsilon^2 + 2\sigma_\gamma^2} \\
&= r \frac{\frac{1}{1-\rho} \frac{1-\rho^N}{1+r-\rho} Q + \frac{1}{1+r}(1-M)}{\left(\frac{(\rho^N-1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho} \right) Q + 2} \qquad \text{(A.8)} \\
&= r \frac{\frac{1}{1-\rho} A(\rho, N) + \frac{1}{1+r}(1-M)}{B(\rho, N)}
\end{aligned}
$$

and

$$
\begin{aligned}
\beta_a^N = \frac{cov(\Delta^N a_{t+1}, \Delta^N \widetilde{y}_t)}{var(\Delta^N \widetilde{y}_t)} &= \frac{\frac{1-\rho^N}{1+\rho} \frac{\sigma_\eta^2}{1+r-\rho} + \frac{1}{1+r} \sigma_\varepsilon^2}{\left(\frac{(\rho^N-1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho} \right) \sigma_\eta^2 + 2\sigma_\varepsilon^2 + 2\sigma_\gamma^2} \\
&= \frac{\frac{1}{1+\rho} \frac{1-\rho^N}{1+r-\rho} Q + \frac{1}{1+r}(1-M)}{\left(\frac{(\rho^N-1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho} \right) Q + 2} \qquad \text{(A.9)} \\
&= \frac{\frac{1}{1+\rho} A(\rho, N) + \frac{1}{1+r}(1-M)}{B(\rho, N)}
\end{aligned}
$$

with

$$A(\rho, N) \equiv \frac{1-\rho^N}{1+r-\rho} Q \text{ and } B(\rho, N) \equiv \left(\frac{(\rho^N - 1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho} \right) Q + 2.$$

□

Proof. **Corollary 1:** I derive the results for the general case with measurement error where the results of Corollary 1 are easily obtained setting $M = 0$.

It follows from Remark 3 that

$$\frac{\partial \beta_a^N}{\partial N} = \frac{\frac{1}{1+\rho} \frac{\partial A(\rho,N)}{\partial N} B(\rho, N) - \frac{\partial B(\rho,N)}{\partial N} \left(\frac{1}{1+\rho} A(\rho, N) + \frac{1}{1+r}(1-M) \right)}{B(\rho, N)^2} \tag{A.10}$$

and

$$\frac{\partial \beta_c^N}{\partial N} = r \frac{\frac{1}{1-\rho} \frac{\partial A(\rho,N)}{\partial N} B(\rho, N) - \frac{\partial B(\rho,N)}{\partial N} \left(\frac{1}{1-\rho} A(\rho, N) + \frac{1}{1+r}(1-M) \right)}{B(\rho, N)^2}. \tag{A.11}$$

The sign of $\partial \beta_a^N / \partial N$ and $\partial \beta_c^N / \partial N$ depends on the sign of the respective numerator in (A.10) and (A.11):

$$sign\left(\frac{\partial \beta_a^N}{\partial N}\right) = \frac{1}{1+\rho} sign\left[\frac{\partial A(\rho, N)}{\partial N} B(\rho, N) - \frac{\partial B(\rho, N)}{\partial N} \left(A(\rho, N) + \frac{1+\rho}{1+r}(1-M) \right) \right]$$

and

$$sign\left(\frac{\partial \beta_c^N}{\partial N}\right) = \frac{1}{1-\rho} sign\left[\frac{\partial A(\rho, N)}{\partial N} B(\rho, N) - \frac{\partial B(\rho, N)}{\partial N} \left(A(\rho, N) + \frac{1-\rho}{1+r}(1-M) \right) \right].$$

Note that

$$\frac{\partial A(\rho,N)}{\partial N}=\begin{cases}-\frac{\rho^N\ln\rho}{1+r-\rho}Q>0 & \text{if } 0<\rho<1 \text{ and } Q>0\\ 0 & \text{if } \rho=0 \text{ or } \rho=1.\end{cases}$$

and

$$\frac{\partial B(\rho,N)}{\partial N}=\begin{cases}\frac{\rho^N\ln\rho}{1-\rho}\left(\frac{2(\rho^N-1)}{1+\rho}-1\right)Q>0 & \text{if } 0<\rho<1 \text{ and } Q>0\\ 0 & \text{if } \rho=0\\ Q>0 & \text{if } \rho=1 \text{ and } Q>0,\end{cases}$$

where L'Hôpital's rule implies $B(1,N)=NQ+2$.

The consumption response as a function of N

Substituting in the expressions for $A(\rho,N)$, $B(\rho,N)$, and their respective derivatives with respect to N,

$$\begin{aligned}
sign\left(\frac{\partial\beta_c^N}{\partial N}\right) &= \frac{1}{1-\rho}\, sign\left[-\frac{\rho^N\ln\rho}{1+r-\rho}Q\left(\left(\frac{(\rho^N-1)^2}{1-\rho^2}+\frac{1-\rho^N}{1-\rho}\right)Q+2\right)\right.\\
&\qquad\left.-\frac{\rho^N\ln\rho}{1-\rho}\left(\frac{2(\rho^N-1)}{1+\rho}-1\right)Q\left(\frac{1-\rho^N}{1+r-\rho}Q+\frac{1-\rho}{1+r}(1-M)\right)\right]\\
&= \frac{1}{1-\rho}\, sign\left[-\frac{\rho^N\ln\rho}{(1-\rho^2)(1+r-\rho)}Q\left(2(1-\rho^2)-Q\left(\rho^N-1\right)^2\right)\right.\\
&\qquad\left.-\frac{\rho^N\ln\rho}{1+r}\left(\frac{2(\rho^N-1)}{1+\rho}-1\right)Q(1-M)\right]\\
&= \frac{1}{1-\rho}\, sign\left[-\frac{\rho^N\ln\rho}{(1-\rho^2)(1+r-\rho)}Q\times\right.\\
&\qquad\left(2(1-\rho^2)-\frac{(1-\rho^2)(1+r-\rho)}{1+r}\left(\frac{2(1-\rho^N)}{1+\rho}+1\right)-Q\left(\rho^N-1\right)^2\right)\\
&\qquad\left.-\frac{\rho^N\ln\rho}{1+r}\left(\frac{2(1-\rho^N)}{1+\rho}+1\right)QM\right)\Bigg]
\end{aligned}$$

For $0<\rho<1$, the second term in square brackets is positive for $0<M\le 1$.

The first term is positive if Q is sufficiently small so that

$$2(1-\rho^2) - \frac{(1-\rho^2)(1+r-\rho)}{1+r}\left(\frac{2(1-\rho^N)}{1+\rho}+1\right) - Q\left(\rho^N-1\right)^2 > 0$$

or

$$Q < \frac{2(1-\rho^2) - \frac{(1-\rho^2)(1+r-\rho)}{1+r}\left(\frac{2(1-\rho^N)}{1+\rho}+1\right)}{\left(\rho^N-1\right)^2} \equiv Q_c^*.$$

Note that $Q_c^* \geq 0$ only for $\rho > 0$.

Let us now consider two special cases. If $\sigma_\varepsilon^2 = 0$ and $\sigma_\gamma^2 = 0$ so that $Q = \infty$,

$$\beta_c^N = r\frac{1+\rho}{(2+\rho-\rho^N)(1+r-\rho)}$$

which is decreasing in N for $0 < \rho < 1$, constant at $1/(1+r)$ for $\rho = 0$ and constant at zero for $\rho = 1$.

If $\rho = 1$,

$$\beta_c^N = \frac{NQ + \frac{r}{1+r}(1-M)}{NQ+2},$$

so that

$$\begin{aligned}\frac{\partial \beta_c^N}{\partial N} &= \frac{NQ^2 + 2Q - NQ^2 - \frac{r}{1+r}(1-M)Q}{(NQ+2)^2} \\ &= \frac{2Q - \frac{r}{1+r}(1-M)Q}{(NQ+2)^2}.\end{aligned}$$

Since $0 \leq M \leq 1$, the consumption response depends positively on N if $\sigma_\varepsilon^2 > 0$ and $\sigma_\eta^2 > 0$ so that $0 < Q < \infty$.

The wealth response as a function of N

I have

$$
\begin{aligned}
sign\left(\frac{\partial \beta_a^N}{\partial N}\right) &= \frac{1}{1+\rho}\, sign\left[-\frac{\rho^N \ln\rho}{1+r-\rho}Q\left(\left(\frac{(\rho^N-1)^2}{1-\rho^2}+\frac{1-\rho^N}{1-\rho}\right)Q+2\right)\right.\\
&\qquad \left.-\frac{\rho^N \ln\rho}{1-\rho}\left(\frac{2(\rho^N-1)}{1+\rho}-1\right)Q\left(\frac{1-\rho^N}{1+r-\rho}Q+\frac{1+\rho}{1+r}(1-M)\right)\right]\\
&= \frac{1}{1+\rho}\, sign\left[-\frac{\rho^N \ln\rho}{(1-\rho^2)(1+r-\rho)}Q\left(2(1-\rho^2)-Q\left(\rho^N-1\right)^2\right)\right.\\
&\qquad \left.-\frac{\rho^N \ln\rho}{1+r}\frac{1+\rho}{1-\rho}\left(\frac{2(\rho^N-1)}{1+\rho}-1\right)Q(1-M)\right]\\
&= \frac{1}{1+\rho}\, sign\left[-\frac{\rho^N \ln\rho}{(1-\rho^2)(1+r-\rho)}Q\times\right.\\
&\qquad \left(2(1-\rho^2)-\frac{(1+\rho)^2(1+r-\rho)}{1+r}\left(\frac{2(1-\rho^N)}{1+\rho}+1\right)-Q\left(\rho^N-1\right)^2\right)\\
&\qquad \left.-\frac{\rho^N \ln\rho}{1+r}\frac{1+\rho}{1-\rho}\left(\frac{2(1-\rho^N)}{1+\rho}+1\right)QM\right]
\end{aligned}
$$

For $0<\rho<1$, the second term in square brackets is positive for $0<M\leq 1$. The first term is negative if Q is sufficiently large so that

$$
2(1-\rho^2)-\frac{(1+\rho)^2(1+r-\rho)}{1+r}\left(\frac{2(1-\rho^N)}{1+\rho}+1\right)-Q\left(\rho^N-1\right)^2<0
$$

or

$$
Q>\frac{2(1-\rho^2)-\frac{(1+\rho)^2(1+r-\rho)}{1+r}\left(\frac{2(1-\rho^N)}{1+\rho}+1\right)}{\left(\rho^N-1\right)^2}\equiv Q_a^*.
$$

Note that $Q_a^*<Q_c^*$ for $0<\rho<1$, so that there exists $Q\in[Q_a^*;Q_c^*]$ for which the wealth response negatively depends on N while the consumption response positively depends on N.

Let us now consider again two special cases. If $\sigma_\varepsilon^2=0$ and $\sigma_\gamma^2=0$ so that $Q = \infty$,

$$\beta_a^N = \frac{1-\rho}{(2+\rho-\rho^N)(1+r-\rho)},$$

which decreases in N for $0 < \rho < 1$, constant at $1/(1+r)$ for $\rho = 0$ and constant at zero for $\rho = 1$.

If $\rho = 1$,

$$\beta_a^N = \frac{1}{1+r}\frac{1-M}{NQ+2}$$

which is unambiguously decreasing in N for $0 < Q < \infty$. □

Proof. **Corollary 2:**

Using the results of Remark 2, I find that the effect of measurement error on the wealth and consumption response is

$$\frac{\partial \beta_a^N}{\partial M} = -\frac{\frac{1}{1+r}}{B(\rho, N)}$$

and

$$\frac{\partial \beta_c^N}{\partial M} = r\frac{\partial \beta_a^N}{\partial M}$$

so that $\partial\beta_a^N/\partial M < \partial\beta_c^N/\partial M < 0$ for $-1 < r < 1$. The effect of measurement error on the responses of wealth and consumption increases in the number of periods N since

$$\frac{\partial^2 \beta_a^N}{\partial M \partial N} = \frac{\frac{1}{1+r}\frac{\partial B(\rho,N)}{\partial N}}{B(\rho, N)^2} > 0.$$

where the inequality follows from $\partial B(\rho, N)/\partial N > 0$ for $0 < \rho \leq 1$, as established in Corollary 1. $\square$

Appendix B

Data appendix

The variables used in the analysis are defined as follows:

Non-durable consumption: all expenditures but for expenditures on transport equipment, valuables, household equipment, home improvement, insurance premia and contributions to pension funds. The measure includes the effectively paid or the imputed rent.

After-tax labour income: after-tax wages and salaries, fringe benefits and transfers (pensions, arrears and other transfers).

Net-financial assets: sum of deposits, checked deposits, repos, postal savings certificates, government securities and other securities (bonds, mutual funds, equity, shares in private limited companies and partnerships, foreign securities, loans to cooperatives) net of financial liabilities (liabilities to banks and financial companies, trade debt and liabilities to other households).

Education: the categories are elementary school, middle school, high school, college degree and postgraduate education.

Regions: the regions are Northern, Centre and Southern regions (in-

Table B.1: Summary statistics for the SHIW sample of households with a head aged 25-55 observed in at least two consecutive waves, and the selected sample of these households without real estate wealth and without members in self-employment or entrepreneurial activities.

Variables	Sample of households (aged 25-55 and with obs. in consecutive waves)	Selected sample (not self-employed, no real estate)
Age of household head	43.4	41.5
	(7.691)	(8.102)
Household size	3.42	3.28
	(1.247)	(1.356)
Labour earnings (after tax/transfer)	9,747	8,063
	(6,687)	(4,892)
Standard deviation of	-	-
residual earnings: 2-period change	-	(1,251.5)
Standard deviation of	-	-
residual earnings: 4-period change	-	(506.2)
Standard deviation of	-	-
residual earnings: 6-period change	-	(436.8)
Net worth	57,774	5,614
	(67,092)	(14,197)
Non-durable consumption	8,229	6,818
	(4,314)	(3,525)
Education: none	0.01	0.02
	(0.108)	(0.132)
Education: elementary school	0.17	0.21
	(0.375)	(0.408)
Education: middle school	0.36	0.42
	(0.481)	(0.494)
Education: high school	0.35	0.29
	(0.478)	(0.454)
Education: college degree	0.10	0.06
	(0.296)	(0.230)
Education: postgraduate education	0.004	0.002
	(0.063)	(0.043)
Region: North	0.42	0.43
	(0.494)	(0.495)
Region: Center	0.20	0.16
	(0.396)	(0.363)
Region: South (incl. islands)	0.38	0.41
	(0.486)	(0.492)

Sources: Author's calculation based on SHIW data 1987-2008. Note: Standard deviation in brackets. Monetary variables are converted to Euro in 2000 and expressed in adult equivalent units. Labour earnings include income from self-employment for the sample of households with a head aged 25-55 and observed in at least two consecutive waves.

cluding islands), individually.

Sample construction:

The SHIW data between 1987 and 2008 include 87,629 observations for 54,070 households. I convert all nominal variables so that their unit is the Euro in the year 2000. I clean the sample of those households that report zero food consumption (dropping 24 observations). As Krueger and Perri (2011) I construct the sample with households which appear in consecutive waves (resulting in 43,482 observations). I select the prime-age households whose head is between 25 and 55 years old (21,835 observations) and whose members are not in self-employment or employed in entrepreneurial activities (16,796 observations) and which do not own real estate (5,487 observations for 2,515 households). Table B.1 provides summary statistics for the full cleaned sample and the selected sample of households without real estate or members in self-employment or entrepreneurial activities.

Following Krueger and Perri (2011) I construct measures for shocks to labour income, consumption and net worth by purging the changes in after-tax and transfer labour income observed in the data from the changes which are predictable. I thus regress the respective observed changes on a quartic polynomial of the age of the household head, on education, time and regional dummies as well as the age-education interaction dummies. I then use the residuals of these regressions as my measure of shocks, where I take into account that income shocks are measured with error. These changes of variables are annualised because the SHIW is a biannual survey with the exception of the three-year difference between the wave of 1995 and 1998.

I then select the households for which I observe at least the second, fourth and sixth difference of income. This leaves me with a sample of 554 households.

Appendix C

Calibration and model estimation

Calibration of M and Q in the permanent income model

The equations of Remark 3 imply that

$$M = 1 + \frac{1-\rho^N}{1-\rho}\frac{1+r}{1+r-\rho}Q - \left(\frac{(\rho^N-1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho}\right)\frac{1+r}{r}Q\beta_c^N - \frac{1+r}{r}2\beta_c^N,$$

$$Q = 2\frac{\frac{\beta_c^N}{r} - \beta_a^N}{2\frac{\rho}{1-\rho^2}\frac{1-\rho^N}{1+r-\rho} - \left(\frac{(\rho^N-1)^2}{1-\rho^2} + \frac{1-\rho^N}{1-\rho}\right)\left(\frac{\beta_c^N}{r} - \beta_a^N\right)}.$$

For $\rho = 1$, applying L'Hôpital's rule so that $\lim_{\rho\to1}\frac{1-\rho^N}{1-\rho} = N$, $\lim_{\rho\to1}\frac{(\rho^N-1)^2}{1-\rho^2} = 0$, $\lim_{\rho\to1}\frac{1-\rho^N}{1-\rho^2} = N/2$,

$$M = 1 + \frac{1+r}{r}NQ - \frac{1+r}{r}\left(NQ+2\right)\beta_c^N,$$

$$Q = \frac{2}{N}\frac{\beta_c^N - r\beta_a^N}{1-\beta_c^N + r\beta_a^N}.$$

I set $N = 2$ to match the two-period responses of consumption and wealth to income shocks.

Solution and estimation of the incomplete-markets model

The solution and estimations follow Hintermaier and Koeniger (2011) so that I mention only computational issues which are not discussed in their paper. I discretise the permanent η_t and transitory shock ε_t with the quadrature method using 12 points. The grid for the assets is triple-exponential with 1,600 points (adding 25 extra points where the policies have more curvature). I employ the endogenous-grid method (EGM) proposed by Carroll (2006) to solve the model.

I simulate the model economy for 45 periods for 25,000 consumers, drawing both the transitory and the permanent shock with the normal random number generator and interpolating the policy functions to obtain consumption and savings for the simulated values of income and net worth. I drop the first 1,000 periods and then use the remaining observations as my simulated data set for the stationary distribution. I estimate the response of consumption and wealth to income changes following the same steps as for the SHIW data (described in the data appendix).

In order to determine for which parameter values the incomplete markets model minimises the distance to the data moments, I estimate the model using the simulated methods of moments. This is implemented in a standard fashion so that I refer to the detailed description of Hintermaier and Koeniger (2011) for brevity. To compute the variance-covariance matrix I draw, with replacement, 10,000 random samples of size 554, the sample size of the data set constructed from the SHIW. I compute the data moments for each of these finite samples and their variance/covariance across the 10,000 samples.

Chapter 3

Do financial market imperfections matter for household behaviour? Evidence from Chile, Spain and the United States

3.1 Introduction

Using the framework from the previous chapter, I empirically study what can be learned from the international evidence with respect to households' reaction to income shocks and the influence of financial market imperfections on their behaviour, represented by the existence of a borrowing limit.

The international evidence on this topic raises an interesting issue, which is enhanced when the data availability is considered. I obtain a panel data on income, consumption and wealth for an heterogeneous set of countries. First, I have data for the United States, the most developed country in terms of financial markets. Second, I have Spain, a European developed country which is comparable to Italy. Finally, I have a developing country, Chile, which presents less developed financial markets.

It is an interesting set of countries because financial markets there have developed differently in the US from Spain and Chile. A priori, I expect that the additional variation from the different level of development will imply different results across these three countries. In addition, it permits me to check the robustness of the results for Italy presented in Chapter 2.

To the best of my knowledge, this is the first research that structurally estimates a standard precautionary-savings incomplete-markets model for countries such as Chile and Spain. Hence, this is the first attempt to exploit two relatively new and rich panel data surveys and try to understand empirically how relevant borrowing constraints are for a particular set of households from these economies, and also to compare the results with those of United States and the ones for Italy presented in Chapter 2.

I summarise the empirical answers to the question of how households respond to income shocks and how important are borrowing constraints derived from what I can learn from the data and from the model. First, in analysing how household consumption and saving react to income shocks I find evidence from the three countries to suggest that the financial market imperfections are not very important. Second, I structurally estimate a standard precautionary-saving incomplete-markets model for the three countries, disciplining it by matching net worth moments, mean and median, which limits the quantitative importance of precautionary savings.

As in Chapter 2, the model is able to replicate the observed downward sloping wealth profile to income shocks over time. I find that the standard model has difficulties in exactly matching some features of the net worth distribution and that it overestimates the consumption responses to income shocks. In fact the contribution of the predicted saving behaviour is the most important factor in the model fitting. The target of level of wealth is low for the sub-samples considered. The model matches this with a low level of risk aversion and high or moderate levels of impatience.

The rest of the chapter is organised as follows. Section 3.2 briefly recalls the model I introduced in Chapter 2. Section 3.3 describes the data sources used for each country, with their peculiarities. Section 3.4 presents and discusses the estimation results. Section 3.5 concludes.

3.2 The Model

As in Chapter 2, the model is based on the standard income fluctuation problem. Households have an infinite horizon; they derive utility from consumption c_t and discount the future with factor β. In each period t they receive labour income y_t and interest r from a one-period asset. With these sources of income they decide how much to consume c_t and the amount of assets to hold for the next period a_{t+1}. Households are subject to a borrowing limit $a_{t+1} \geq \underline{a}$. I am considering a small open economy so that the interest rate is exogenous.

I repeat in the following equations the recursive form of the household problem where, compared to the previous chapter, I include the borrowing constraint (Equation 3.3).

$$v(a_t, y_t) = \max_{a_{t+1}} \left\{ u(\underbrace{(1+r)a_t + y_t - a_{t+1}}_{c_t}) + \beta E_t v(a_{t+1}, y_{t+1}) \right\} \tag{3.1}$$

subject to

$$a_{t+1} + c_t = (1+r)a_t + y_t, \tag{3.2}$$

$$a_{t+1} \geq \underline{a}, \tag{3.3}$$

$$\lim_{T\to\infty} \left(\frac{1}{1+r}\right)^T a_{T+1} = 0 \text{ a.s.,}$$

where the No-Ponzi-Game condition ensures that the intertemporal budget constraint holds with equality.

The problem has two state variables: the endogenous asset position a_t and the exogenous stochastic income y_t which matters for expectations due to the persistence of income shocks. The consumer's stochastic labour income y_t follows the process

$$y_t = z_t + \varepsilon_t, \tag{3.4}$$

$$z_t = \rho z_{t-1} + \eta_{t,}$$

where $\varepsilon_t \sim \mathcal{N}(0, \sigma_\varepsilon^2)$ is a transitory income shock and $\eta_t \sim \mathcal{N}\left(0, \sigma_\eta^2\right)$ is an income shock with persistence $0 < \rho < 1$. The shocks ε_t and η_t are assumed to be uncorrelated with each other in every period t and i.i.d. over time.

As in Chapter 2, I assume that income is observed with measurement error by the econometrician. The income process observed in the data is:

$$\widetilde{y}_t = y_t + \gamma_t, \tag{3.5}$$

where $\gamma_t \sim \mathcal{N}\left(0, \sigma_\gamma^2\right)$ is classical measurement error and is assumed to be i.i.d. over time and uncorrelated with the income shocks ε_t and η_t.

The measurement error is estimated in the model with the commonly assumed utility function CRRA. Under these preferences the precautionary-savings incomplete-markets model does not have a closed form solution.[1]

Solvency in this model implies a borrowing constraint $a_{t+1} \geq \underline{a}$ which I set as the natural borrowing limit introduced by Aiyagari (1994). The existence of this occasionally binding borrowing constraint results in a precautionary saving motive which, for the commonly assumed CRRA utility function, becomes less strong when the agent is wealthier. Indeed, as I explained previously, there are situations where the predictions of this model are identical to those of the classic permanent-income model.[2] This is trivial if the agent has abundant net worth relative to the borrowing limit $\underline{a}$ so that the constraint is binding with probability close to zero. More interestingly, the behaviour of the agent is characterised well by a permanent-income model if the agent has a very low target level of wealth. In this case the precautionary saving motive is very low, even when the agent is close to being constrained. A numerical example is presented in Chapter 2.

3.3 Data Description

From an empirical perspective, it is demanding to take the model to the data since this requires information on all the components of a household's budget constraint (3.2). The ideal dataset would consist of households

[1]On Appendix C of Chapter 2 I provide details and references on ways to solve and simulate this standard model.

[2]I refer the interested reader to the first chapter, where I present more details about predictions of the precautionary-savings incomplete-markets model and insightful comparisons with the permanent income hypothesis model.

panel data with a long time dimension and with detailed information on after-tax labour income, non-durable consumption and wealth holdings.

Data sources with information on all the relevant components of the household budget constraint are scarce. In addition to the survey conducted by the Bank of Italy, which I use in the first chapter, I have identified three other accessible surveys: the *Encuesta de Protección Social* (EPS) for Chile, the *Encuesta Financiera de las Familias* (EFF) for Spain and the *Panel Survey of Income Dynamics* (PSID) for the United States. [3]

I follow the strategy of the first chapter for sample selection and exclude from the sample households with self-employed or business activities and with real estate. As Krueger and Perri (2011) show, income shocks co-move with real estate and business wealth. Thus, the response to income shocks is not well measured for households with real estate wealth.

To estimate the household behaviour in terms of consumption and saving, I first purge the series from any predictable changes. Then I use the changes in the residuals of those regressions as the shocks to estimate the responses of consumption and wealth over time.

Chile

The *Encuesta de Protección Social* (EPS, Social Protection Survey) is the first microeconomic panel data for Chile. The first wave is from 2002 and further waves exist for 2004, 2006 and 2009. The first wave represented

[3] In April 2013 the first wave of the Eurosystem's Household Finance and Consumption Survey was released. This will be a great data source for my purposes when more waves have become available in the future. Other existing panel data could be constructed using administrative records for Denmark, Finland and Norway, but the access is restricted. Finally there is the Luxembourg Wealth Study (LWS) which has harmonised micro-data at a household level for several countries but only with a cross-sectional dimension.

only the population affiliated with the pension system but the waves from 2004 onwards consider the whole Chilean population. The survey provides information on the labour and pension history of household members and their demographic characteristics, such as age, gender and other characteristics presented in Appendix E, education levels, health, transfers and wealth in particular.[4]

The EPS has some limitations worth pointing out. Compared to the other surveys used in this research, the EPS is not a financial survey by design (as is the SHIW for Italy or the EFF for Spain) although it provides information about households' asset holdings and debts for the last three waves (the financial module has been included since 2004). As I explain in Appendix G, this matters for the external estimates that I use as inputs in the model.

A further issue is that the Chilean pension system was reformed in 2008. Although this may have affected survey answers in the 2009 wave, feeding these changes into the structural model is beyond the scope of this chapter.

Spain

The Central Bank of Spain manages the *Encuesta Financiera de las Familias* (EFF, Survey of Household Finances) since 2002. It is a survey conducted every 3 years, where the last available wave corresponds to the year 2008. From the second wave onwards, the survey has had a panel component. The survey has detailed information on the income, consumption, wealth holdings and debts of the families.

[4]For more details about sample design, questionnaires and other methodological aspects see "Encuesta de Protección Social 2002-2009, Documento Metodológico" available from http://www.previsionsocial.gob.cl/subprev/?wpfb_dl=158.

For this research purposes the Spanish data's main disadvantage is its sample size, which results from two characteristics. First, the size of the panel component of the EFF constrains my selected sample: the 2008 wave has 6, 197 observations of which 1, 925 come from interviews in 2002. Second, Spain is one of the countries that has the highest home ownership rates. According to the EFF survey 80% of households own their main residence.[5] Labour income is reported gross, not after tax. I describe in Appendix E how I calibrate the labour income process for net income in Spain. Finally, unlike the other datasets, this one contains no region information and the place of birth is not reported in the survey.

Due to the small size of the total sample, the criteria for selecting the sample are imposed on the households only in the year 2002. The difference from the other countries is that in the subsequent waves some characteristics could change as a result of the households' responses to the shocks. With this approach the balanced panel sample size is 88 households instead of 42.

United States

The Panel Study of Income Dynamics (PSID) started in 1968 and thus has the longest time dimension of any household panel survey. It is conducted by the Survey Research Center of the Institute for Social Research at the University of Michigan. This dataset includes information on earnings, consumption and wealth at the household level. Originally the survey was conducted every year, but since 1998 information has been collected only every other year.

[5] The percentage of households which rent or have free use of their residence in the EFF is 14.4%.

I consider the 7 waves between 1998 and 2010, because these waves include detailed information on the household's asset holdings and a broader measure of consumption (which has been further extended since 2004). See Appendix E for further details about the variable definitions used for this research.

I use the data between 1998 and 2010 to calibrate an income process for the sub-sample considered in this research and the last 4 waves to exploit the extended consumption information and estimate household behaviour. Since the PSID reports labour income before tax, I update the Stata codes for the TAXSIM model developed by Feenberg and Coutts (1993) to obtain each household's labour income net of taxes.[6]

Since the time period for which data are available for each country constitutes another source of heterogeneity, I provide information about the macroeconomic environment for each country in Appendix D.

3.3.1 Selected sample

I apply the same sample selection procedure for the three countries considered (except for the modifications due to the small sample size in Spain mentioned above). I present in Appendix E more details on the steps taken to construct the sample and variables for each country . To summarise, I select the households which are renting, whose head is between 25 and 55 years old, non-retired and which does not have other real estate properties or any business. To exploit the panel dimension of the data I focus on the households which appear consecutively in all the available waves for Chile and Spain and for the United States for the time period considered.

[6]The Stata codes for the PSID can be downloaded from the NBER website http://users.nber.org/~taxsim/ and were developed by Eric Zwick.

In Table 3.1 I present the summary statistics for the selected samples of the three countries. The monetary variables correspond to adult equivalent units and are expressed in 2010 dollars.

Note first that the Spanish figures differ from those of the other countries because I also relax the sample selection criteria to increase the number of observations. In particular, I include households which can own real estate, or become self-employed, or have businesses, from the second or third wave in which they are observed. This explains the higher age of the head and the greater net worth values that the households hold. If I consider in all the years those households which are renting or freely using their residence (as in the other samples), there are only 69 Spanish observations in the three waves. In this case the age of the average households' head is 42.0 years and the average net worth is $11,260.5$ dollars of 2010, figures that are closer to those observed for the other countries.

Second, Chilean statistics for income, consumption and wealth are lower than those in the other countries. While Chile is a developing economy, this is also due to the bigger average household size. Households in Chile are almost twice the size of households in Spain and the United States, which affects the figures in adult equivalent units.

Table 3.1 shows that the selected sub-samples correspond to middle-aged households which are slightly younger than the whole sample population (Chile 46.9, Spain 59.3 and United States 44.6), and with similar numbers of household members as in their sample population (Chile 4.9, Spain 2.8 and the United States 2.8). I report in the table the labour earnings for the head and spouse in the household. Compared with the averages for the whole sample, the earnings for Chile and Spain are similar (6.6%

Table 3.1: Summary statistics for the selected samples

	Chile	Spain	United States
Age of household head	39.3	52.2	39.0
	(6.916)	(14.258)	(7.582)
Household size	5.1	2.8	2.8
	(2.105)	(1.461)	(1.639)
Labour earnings	2,360.3	8,487.2	19,727.6
	(2,895.6)	(11,620.9)	(19,278.5)
Labour earnings plus transfers	2,408.0	14,578.9	20,185.3
	(2,342.3)	(10,777.2)	(14,020.6)
Non Durable consumption	1,694.9	7,526.5	6,192.4
	(1,742.0)	(4,547.8)	(3,446.8)
Net worth	-110.1	22,079.6	9,273.0
	(1,569.3)	(66,260.2)	(163,977.7)
Observations	702	264	1,520

Source: Author's calculations. Note: Monetary variables are in 2010 dollars. I use the OECD equivalence scale to convert the data into adult equivalent units. The results are robust if I consider the household as the unit of analysis. Labour earnings correspond to the head and spouse of the household. Standard errors in parentheses.

and 8.3% higher than the averages for the whole sample). The selected American households have 34.3% lower labour income than the mean for the PSID households in the years under review.

The size of the transfers are most important for Spain. The transfers for all three countries reduce the observed inequality.

Finally, the differences between the economies are manifested most clearly in terms of wealth. The households in the selected sample for Chile have no net worth, while net worth is highest in Spain, because some households own real estate in the second or third wave. Chilean households with mean net worth are in the second decile of the EPS net worth distribution, the selected Spanish households are in the fifth decile of the EFF and the American households in the sixth decile of the PSID net worth distribution.

3.3.2 Empirical evidence

The objective is to obtain estimates of the way in which household consumption and saving behaviour respond to unpredictable changes of income over time.

The first step is to obtain the shock components of the variables of interest by removing any deterministic predictability. To do so I regress the income, consumption and wealth of the households on a set of observables: demographic variables of the head of the household (a quartic polynomial of the age, education level, gender and interactions between education and age) and time and regional variables. When available, more information on the set of regressors and the construction of the shocks is provided in Appendix F.

Next I use these residual series to construct changes of consumption, income and wealth over N period horizons. Due to the different periodicity and availability between the three considered surveys, the time horizons for each country are different. For Chile I construct two and five year differences, for Spain three and six year differences and for the United States two, four and six year differences.

I regress these residual changes in consumption and wealth for different time periods on the corresponding residual changes of income to see how consumption and savings react to income shocks over time. I present the estimates in Table (3.2). For robustness to outliers I report the results of median regressions.

Table 3.2: Consumption and wealth response to income shocks in the data

	N	**Consumption** β_c	**Wealth** β_a	**Wealth** **Mean**	**Median**	**Sample size**
Chile	2	0.136	0.013	-0.096	0.000	234
		(0.031)	(0.009)			
	5	0.332	0.003			
		(0.033)	(0.013)			
Spain	3	0.127	0.459	1.390	0.798	88
		(0.068)	(0.292)			
	6	0.186	0.123			
		(0.071)	(0.310)			
USA	2	0.068	0.164	0.482	0.038	380
		(0.029)	(0.058)			
	4	0.092	0.131			
		(0.023)	(0.066)			
	6	0.184	0.159			
		(0.020)	(0.091)			

Source: Author's calculation. Note: Median regression estimates. β_c (β_a) are regression coefficients of the N-period changes in consumption (wealth) over N-period changes in observed income. Standard errors in parentheses.

The model estimates reported in the table correspond to changes of the variables specified in levels. Thus the coefficients show how changes in consumption or wealth react to a one monetary unit change of income. Table 3.2 shows that the consumption responses have an increasing profile in N for all countries with all the estimates being significantly different from zero (only the coefficient for Spain at $N = 3$ comes close to being rejected with a $p - value$ of 6.5%). The non-durable consumption profile over time for Chile is the steepest and the 6 year responses are similar between Spain and the United States. However, when we consider the estimated wealth responses the situation is different. First, the wealth profiles are more noisily estimated; for instance, only the responses at $N = 2$ and $N = 4$ for the United States are significantly different from zero. Second, wealth responses are qualitatively different across countries: the wealth profile over time decreases markedly for Spain and seems flat for the US and Chile.

In spite of the sample for the three countries being constructed as consistently as the data allow, the final selected samples show substantial heterogeneity across countries. The wealth distribution is very different, exhibiting high levels of debt in Chile where half the sample is indebted, a very skewed distribution in the US with a mean-median ratio of 12.7, and relative wealthy households in Spain. Replicating these different net worth distributions will represent a challenge for the standard precautionary-saving incomplete-markets model in the next section.

3.4 Results

In this section I present the estimates of a precautionary-savings incomplete-markets model for the countries considered. The objective is to assess if this model can match the consumption and wealth responses to income shocks replicating at the same time the observed mean and median of the wealth distribution.

3.4.1 Estimation method

I apply the simulated methods of moments to estimate the discount factor β, the coefficient of risk aversion α, and the variance of the measurement error σ_γ^2 for all three countries. In addition, for Chile I estimate the levels of transfers Tr.

I need to select some parameters and to do so I use external estimates coming from different data sources. I set outside the model Q and the variance of observed income σ_y^2. I detail below the sources and the strategy for calibrating these parameters.

I simulate the model for 45 periods. I am considering a small-open economy so I set the interest rate $r = 0.02$.

I solve the model for $\rho = 1$ which allows the normalization of all variables by permanent income in the recursive formulation to reduce the number of state variables and simplify the model solution. As discussed in the previous chapter, the main insights do not change if I consider $\rho = 1$ instead of values of ρ very close to unity and, moreover, the non-increasing wealth profile estimated in the data suggests that shocks are permanent or with high levels of persistence.

The income process calibration is key to determining the model's results. As explained above, I allow for the presence of measurement error (γ) for income. Given the variance of measurement error (σ_γ^2), I calibrate the variance of permanent (σ_η^2) and transitory shocks (σ_ε^2) to match the observed residual variance of household income (${\sigma_y}^2$) and the ratio Q of permanent shocks over the temporary components (transitory shocks plus measurement error). I present more details about the income process calibration in Appendix G.

I am disciplining the model to generate the variance in the income process observed in the data. For this external estimate I consider the residual household earnings variance from a regression of a log-earnings measure over deterministic observables which are consistent with a structural equation of labour income that is used in the literature. For Chile and the United States I estimate the corresponding variances.[7] In the case of Spain I use the average residual variance of net household earnings estimated by Pijoan-Mas and Sanchez-Marcos (2010). The authors use the *Encuesta Continua de Presupuestos Familiares* (ECPF, Household expenditure survey) between 1985 and 1996.

The other parameter that I need to calibrate the income process is Q, which is the ratio of the variance of permanent shocks to the sum of the variances of the transitory shocks and the measurement error. The best inputs for constructing a measure of Q would come from estimating an income process decomposition in the permanent and transitory components for the data used. This is only possible for the United States, for which I estimate a $Q = 0.6511$. For the two other countries there are not enough waves to decompose the income process. In the case of Chile I calibrate $Q = 0.4991$ by re-scaling the estimates from Huneeus and Repetto (2005). The authors use a different survey: *Encuesta Suplementaria de Ingresos* (ESI, Supplement income survey) which was run between 1990 and 2000 and construct a synthetic panel to estimate the income decomposition. For

[7] I discuss the estimation procedure in Appendix F.

Spain I calibrate $Q = 0.6762$ following Pijoan-Mas and Sanchez-Marcos (2010) and using an average of the estimates from the ECPF.

I present a summary of the external estimates that I use in the estimation in Table 3.3 and provide more details about the income calibration in Appendix G.

Table 3.3: External estimates used in the income process calibration

	Chile	**Spain**	**USA**
Earnings variance	0.4779	0.4557	0.3337
Q	0.4991	0.6762	0.6511

The estimation strategy used for the simulated methods of moments is the following. I solve the precautionary-savings incomplete-markets model numerically over a grid of the parameters of interest: time discount rate δ, coefficient of relative risk aversion α and variance of the measurement error σ_γ^2. For each grid-point I compute the wealth moments (mean and median) and the consumption and wealth responses to income shocks for the relevant time horizons N. Finally the estimates are those which minimise the distance between the model generated moments and the data moments. I refer to Appendix C of Chapter 2 for details about the model solution and estimation.

The three-dimensional grid is constructed as follow. For the discount factor $\beta = 1/(1+\delta) \in [0.90, 0.98]$ with distance 0.0025 between adjacent points of the discount rate δ, the coefficient of relative risk aversion $\alpha \in [0.40, 3.20]$ with distance 0.05 between adjacent grid-points. Finally, the grid for σ_γ^2 varies for each country. As I present in Appendix G, the highest amount of measurement error allowed depends on the variance of the earning process, the ratio Q and the nature of the shocks (permanent or persistent). I am presenting the results for the model with permanent shocks, so the maximum measurement error variance for Chile is 0.0383, for Spain it is 0.0275 and for the United States it is 0.0209.

3.4.2 Model results

I report the estimation results for Spain in Table (3.4). The estimated set of parameters is plausible. The discount factor β is 0.969. The estimated coefficient of relative risk aversion is 0.90, suggesting that the felicity function for Spain is close to logarithmic. Finally, the model estimates no measurement error, which implies that the variance of the permanent (σ_η^2) and transitory shocks (σ_ε^2) are 0.0186 and 0.0275 respectively.

In the last row I reproduce the data moments from the EFF. The model performance is mixed in terms of generating the targeted moments for the estimated parametrization. In terms of net worth, the model overestimates the median and underestimates the mean. Qualitatively, the model is able to capture the decreasing wealth profile over time to income shocks. However, quantitatively the intercept of the wealth response over time (N=3) is overestimated and the slope is flatter than the data. For the consumption responses the model struggles the most: the model intercept is four times the one observed in the data and the generated slope is 2.5 times bigger.

In Table (3.5) I reproduce the model estimation for the United States. The parameter estimates are reasonable. The coefficient of relative risk aversion $\alpha = 0.65$, is slightly smaller than 1. The discount factor β is 0.973 and the variance of measurement error (σ_γ^2) is 0.01. The estimated size of σ_γ^2 implies a variance of the permanent shock of 0.0136 and a variance of

Table 3.4: Model estimation for Spain.

Parameters	$\beta = 0.969$ (0.006), $\alpha = 0.90$ (0.314), $\sigma_\gamma^2 = 0.00$ (0.015)					
	Wealth		Consumption Response		Wealth Response	
	Median	Mean	$N = 3$	$N = 6$	$N = 3$	$N = 6$
Model	0.949	1.202	0.480	0.628	0.295	0.264
	(0.096)	(0.115)	(0.079)	(0.075)	(0.145)	(0.186)
Data	0.798	1.390	0.127	0.186	0.459	0.123

Source: Author's calculation. Note: Standard errors in parentheses. Since the estimation of measurement error is at the bound, I compute the standard error for a value of $\sigma_\gamma^2 = 0.001$.

the transitory shock of 0.0109.

The targeted moments for the United States are difficult to match for the standard precautionary-savings incomplete-markets model. The observed net worth distribution presents high levels of skewness even though the households have low levels of wealth. The estimated mean net worth is one third lower than that observed in the data and the median is 6 times higher. These moments of the distribution are very precisely estimated. The model predicts a slightly decreasing response of saving to income shocks. The level of the responses is in line with the data estimates. In terms of the consumption responses, the model does not obtain good results. The predicted responses of consumption to income shocks are much stronger in the model and the slope of responses over time is twice that observed in the data.

As I highlighted in the data section, the data for Chile presents a challenge for the structural estimation, since half of the selected sample is indebted and the mean net worth is about -10% of mean income. To allow the model to capture this feature I add transfers to the households and allow them to have debt, imposing the solvency constraint at the borrowing

Table 3.5: Model estimation for the United States.

Parameters	$\beta = 0.973(0.002)$, $\alpha = 0.65(0.124)$, $\sigma^2_\gamma = 0.01(0.002)$							
	Wealth		Consumption Response			Wealth Response		
	Median	Mean	N=2	N=4	N=6	N=2	N=4	N=6
Model	0.252	0.331	0.410	0.569	0.657	0.171	0.155	0.149
	(0.015)	(0.017)	(0.036)	(0.037)	(0.035)	(0.036)	(0.041)	(0.044)
Data	0.038	0.482	0.068	0.092	0.184	0.164	0.131	0.159

Source: Author's calculation. Note: Standard errors in parentheses.

limit. I estimate the levels of transfers as another parameter of the model. I report the model estimation for Chile in Table (3.6). All the parameters present plausible values and are inside the grid. Households present high levels of impatience ($\beta = 0.905$) and low levels of risk aversion ($\alpha = 0.90$). The estimation implies no transfers and the estimated variance of measurement error is 0.025. Under this specification the variance of permanent shocks is 0.0191 and the variance of the transitory shock is 0.0133.

The parameter estimates entail a low target level of wealth compatible with what is observed in the data. Given the precision of the median estimates, the simulated method of moments assigns more weight to the median than the mean. The median net worth is matched exactly, but as expected the standard precautionary-savings incomplete-markets model is not capable of generating a negatively skewed wealth distribution and thus the model mean net worth is positive. The model predicted wealth responses over time match those in the data. Moreover, as for the other countries, the model-implied consumption responses to changes in income are much higher than the ones observed in the Chilean sample.

Analysing the data estimates presented in Table 3.2 with the structural model, I provide some intuition about the income process and relevance of

Table 3.6: Model estimation for Chile.

Parameters	$\beta = 0.905(0.001)$, $\alpha = 0.90(0.001)$, $Tr = 0(0.008)$, $\sigma_{\gamma}^{2} = 0.025(0.0001)$					
	Wealth		Consumption Response		Wealth Response	
	Median	Mean	N=2	N=5	N=2	N=5
Model	0.000	0.018	0.496	0.662	0.013	0.005
	(1.5e-05)	(0.003)	(0.050)	(0.050)	(0.012)	(0.008)
Data	0.000	-0.096	0.136	0.332	0.013	0.003

Source: Author's calculation. Note: Standard errors in parentheses. Since the estimation of transfers is at the bound, I compute the standard error for a value of $Tr = 0.001$.

the borrowing constraints. Chile's small wealth responses to income shocks suggest the very low importance of the transitory shocks and imply that income is mainly driven by permanent shocks. This evidence is in line with the results obtained by Huneeus and Repetto (2005), who find very low variance of transitory shocks; I report these results in Table G.1 of Appendix G. In all the samples the consumption responses are significantly smaller than one, suggesting the existence of precautionary saving motives and possibly the presence of measurement error. Moreover, the fact that wealth profiles are non-increasing, even though noisily estimated, suggests that the strength of the precautionary motive is moderated and the financial market imperfections such as borrowing constraints are not important for the household consumption behaviour in the three samples.

3.4.3 Robustness and model evaluation

It is clear from the tables presented above that the standard precautionary-savings incomplete-markets model is having difficulties in matching some of the data moments for each country. As I estimate more moments than parameters I can test the model performance using the test of overidentifying restrictions. For all the three countries, the model is easily rejected when the eight moments are targeted.

One particular feature of the data is the high level of skewness of the net worth distribution. This can be seen by the high mean-median ratios which for Spain is 1.7 and for the United States is 12.7. This is a feature of the wealth distribution data which is hard for the model to match. One possibility in future research would be to improve the model in line with Krusell, Smith, and Jr. (1998) who assume preferences heterogeneity allowing for different discount factors.

The other feature that the standard model is unable to match is the level of consumption responses to income shocks. The model-implied consumption responses are greater than those observed in the data. Increasing the amount of measurement error might help to generate lower consumption responses. However this direction is not promising, for two reasons. First, the maximum amount of measurement error is limited in the calibration (see Appendix G). Second, as explained in Chapter 2, a higher measurement error will make the wealth responses flatter or even increasing, which would worsen the fit of the model. An alternative to lowering the level of the consumption responses is to reduce the persistence of the income shocks. If income shocks become less persistent, households start to save a higher fraction of the shocks. This is a tension, however, with the higher level of wealth responses which become greater in N when shocks are less persistent. In Chapter 2 I show, for the permanent-income model, how a wealth response to income shocks which decreases over time requires high levels of income persistence in the model. Although there are no closed form solutions for the precautionary-savings model the intuition is similar.[8]

To better understand which feature of the data is difficult for the model to generate, I estimate it using different subsets of the data targets. I have found that when one of the net worth moments and the wealth responses over time are targeted, the model fit significantly improves. Since I am estimating the level of transfers as another parameter for Chile, I conduct this restricted model exercise only for Spain and the United States. The results are reported in Table (3.7).

In the restricted estimation for Spain, the model has the same number of parameters and moments, so that there are no overidentifying restrictions to test. I present the results for Spain in Panel (a) of Table (3.7). The two estimated sets of parameters fit the corresponding targeted net worth moment, median or mean very well. Concerning the wealth profile, both parametrizations predict very similar results, which are lower and somewhat flatter than the profiles observed in the data; but in both cases the data moments are inside two standard deviations of the estimated response. Interestingly the estimated parameters are almost the same when the mean is targeted, and when the full model with eight moments is estimated.

For the United States, abstracting from one net worth moment and the consumption responses significantly improves the fit of the model. The estimated parameters and their predictions are displayed in Panel (b). For these restricted models, which target median or mean net worth and the asset responses at three horizons $N = 2, 4, 6$, I can run a test of the overi-

[8] Allowing for persistent shocks implies that I cannot reduce the state space by normalizing variables by the permanent income. With two state variables the model becomes more computationally intensive to solve. I have estimated the model for Spain and the United States for values of ρ between 0.97 and 0.995 and the resulting wealth profiles are increasing.

dentifying restrictions. When the mean net worth is targeted along with the wealth responses, the model is comfortably accepted (it has a p-value of 49.8%). Instead when the median net worth is targeted, the fit of the model worsens (the restrictions have a p-value of 5.1%). When the restricted model which targets mean net worth is estimated, the set of parameters obtained is very similar to the full model estimation.

The empirical data estimations of the way that net worth holdings react to changes in income over time suggest that precautionary motives are not very strong in the sub-samples considered for the three countries. For all three countries, the wealth responses over time to income shocks are non-increasing. As I discuss in the second chapter, following the argument of Krueger and Perri (2011), if agents had a strong precautionary savings motive, wealth responses should increase.

The estimation of a standard precautionary-savings incomplete-markets model for three different countries shows that the precautionary saving motives are not very strong. After estimating a structural model for the three countries, in which the size of precautionary-savings is disciplined by matching observed moments of the net worth distribution, I find that the predicted wealth profile is decreasing in the horizon N. The estimated levels of patience and risk aversion for the households are low, suggesting the existence of a low target level of wealth. Hence, households do not exhibit strong precautionary saving motives, even though they have low net worth and may be close of the borrowing constraints.

The structural estimation of a partial equilibrium model allows me to compare the parameters for the three considered countries. Let me discuss what may drive these different estimates. First, some differences come from

Table 3.7: Estimation targeting one net worth moment and the wealth responses over time

Panel (a): Spain

	Median	Mean	N=3	N=6
Data	0.798	1.390	0.459	0.123

Targets: median net worth, wealth responses over time

Parameters	$\beta = 0.948(0.004)$, $\alpha = 1.70(0.124)$, $\sigma_\gamma^2 = 0.000(0.011)$			
Model	0.819		0.307	0.285
	(0.083)		(0.137)	(0.171)

Targets: mean net worth, wealth responses over time

Parameters	$\beta = 0.971(0.002)$, $\alpha = 0.80(0.132)$, $\sigma_\gamma^2 = 0.000(0.022)$			
Model		1.403	0.294	0.265
		(0.133)	(0.156)	(0.210)

Panel (b): United States

	Median	Mean	N=2	N=4	N=6
Data	0.038	0.482	0.164	0.131	0.159

Targets: median net worth, wealth responses over time

Parameters	$\beta = 0.964(0.006)$, $\alpha = 0.50(0.156)$, $\sigma_\gamma^2 = 0.005(0.002)$				
Model	0.038		0.187	0.163	0.141
	(0.005)		(0.025)	(0.026)	(0.024)
Test of overidentifying restrictions:					3.802

Targets: mean net worth, wealth responses over time

Parameters	$\beta = 0.957(0.001)$, $\alpha = 1.55(0.031)$, $\sigma_\gamma^2 = 0.01(0.002)$				
Model		0.481	0.171	0.152	0.147
		(0.022)	(0.038)	(0.046)	(0.050)
Test of overidentifying restrictions:					0.458
10% critical value of chi-sq (1):					2.706
5% critical value of chi-sq (1):					3.841
1% critical value of chi-sq (1):					6.635

Source: Author's calculation. Note: Standard errors in parentheses. Since the estimation of measurement error for Spain is at the bound, I compute the standard error for a value of $\sigma_\gamma^2 = 0.001$.

the fact that the same sub-sample of households could react diversely given the different stages of development in their financial markets. Households in Chile or Spain, with access to less developed financial markets than the ones in the United States, may have more difficulties in sharing risk and insuring themselves against earnings fluctuations or may have more chances to be subject to borrowing constraints. Second, the households are subject to different levels of earnings inequality, which affect the levels of income uncertainty and thus the way in which households take their insurance decisions. Third, the support provided by the public welfare system is different, so households are subject to unequal social insurance levels, which can affect their behaviour. Last, some considerations related to data availability should be highlighted. Although there are overlapping periods in the countries' surveys there are important data limitations for the analysis: the data for Chile and Spain cover more recent time periods and thus have fewer waves and the frequency and last period covered are not the same across countries. For instance, the recent global financial crisis is not captured in all data sets: data for Spain are available until 2008, for Chile until 2009 and for the United States until 2010. Furthermore, the impact of the crisis has varied for these economies.

3.5 Conclusion

In this chapter I explore what can be learned from international evidence on households' consumption and saving decisions in their reaction to income shocks. Furthermore, I analyse what implications about financial imperfections can be derived from their behaviour.

I construct the required data for Chile, Spain and the United States, for which panel data exist with information on consumption, wealth and income. Even though the households' net worth distribution is different across the analysed sub-samples, the empirical evidence shows consumption responses which are increasing over time, have similar levels, and are significant and precisely estimated. This is not the case for the estimated wealth responses to income shocks. The wealth profiles are less precisely estimated, in particular for Spain, due to a small sample size. The point estimates present a non-increasing profile for all three countries, which can be interpreted as evidence suggesting that the household behaviour for these economies is not affected by the presence of borrowing constraints.

I structurally estimate a standard precautionary-savings incomplete-markets model for each of the three countries. With the objective of disciplining the amount of precautionary-savings I target the median and mean of the net worth distribution and the consumption and wealth responses to income shocks over time. The obtained results are mixed. On the one hand, the wealth responses over time qualitatively, and, in some cases quantitatively, replicate the decreasing pattern observed in the data. On the other hand, the model-implied net worth moments and the predicted consumption responses do not match the data precisely. Formally, using the test of overidentifying restrictions the model is rejected for each of the countries. Analysing the contributions of each moment to the model fit, I find that the consumption responses and the skewness of the wealth distribution make the test reject the model. I estimate a restricted model which ignores the consumption responses and consider only one of the net worth moments plus the wealth profiles as targets. For this restricted model the statistic of the test of overidentifying restrictions improves significantly.

The model estimates imply moderate levels of impatience and a low level of risk aversion which imply that the households in the three countries have a low target level of wealth. Furthermore, the parametrizations in the full and restricted model imply that, after accounting for precautionary savings, the wealth profile over time is decreasing. This evidence, in line with the data, suggests that the risk of being constrained for the households in the sub-samples is not important. To some extent this is surprising since it suggests that financial markets across all countries are not very different in terms of development.

Appendices

Appendix D

The macroeconomic situation in each of the countries

Macroeconomic situation

The effects of the global financial crisis were different in the three analysed countries. The GDP in the United States contracted over 2008-2009. In real terms the activity fell by a cumulative 3.1%, with unemployment peaking at 10% by the end of 2009. Since 2010 the economy has started to show weak signs of recovery.

The effect of the crisis in the Euro area were stronger and recovery in the region is proceeding at a slower pace. The Spanish economy has been severely affected, GDP fell by 4.0% between 2009 and 2010, and the activity declined even further in 2012 (1.6%) after showing no growth in 2011 (0.1%). Labour market conditions deteriorated and unemployment rose by 7 percentage points to reach 18% in 2009. In the following years the employment conditions worsened and unemployment continued to grow,

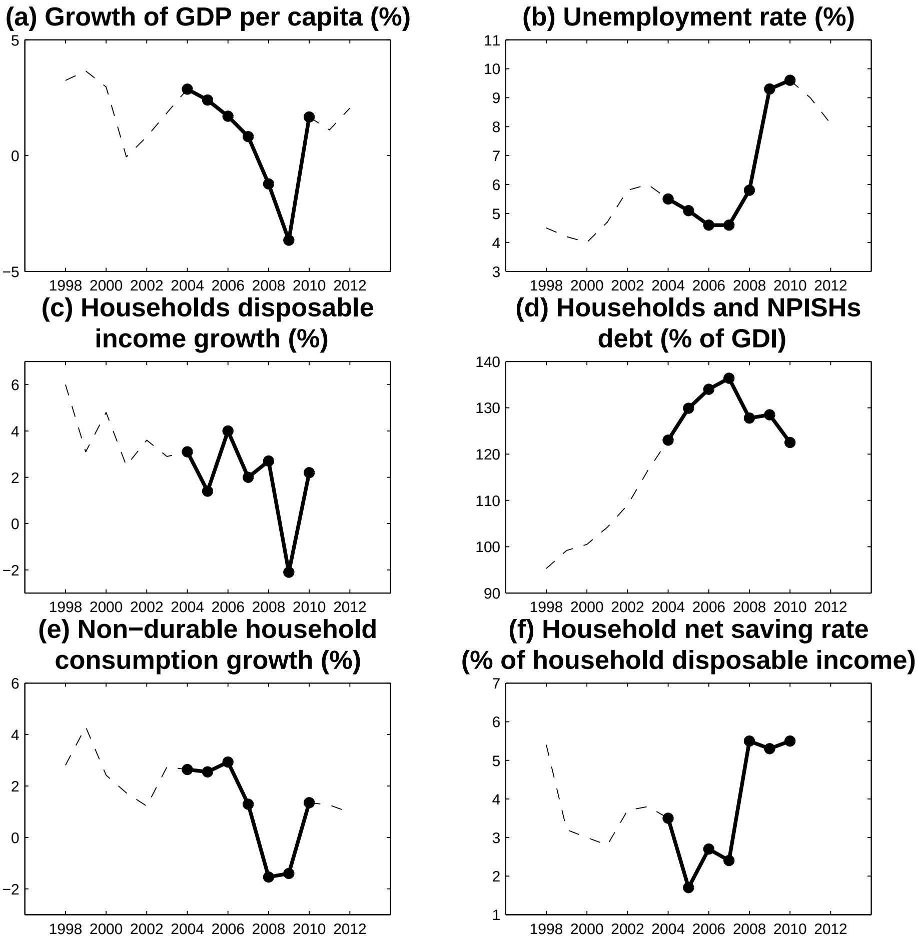

Figure D.1: Macroeconomic situation in the United States. Source: OECD. Note: The thick line highlights the period covered by the PSID used in the chapter.

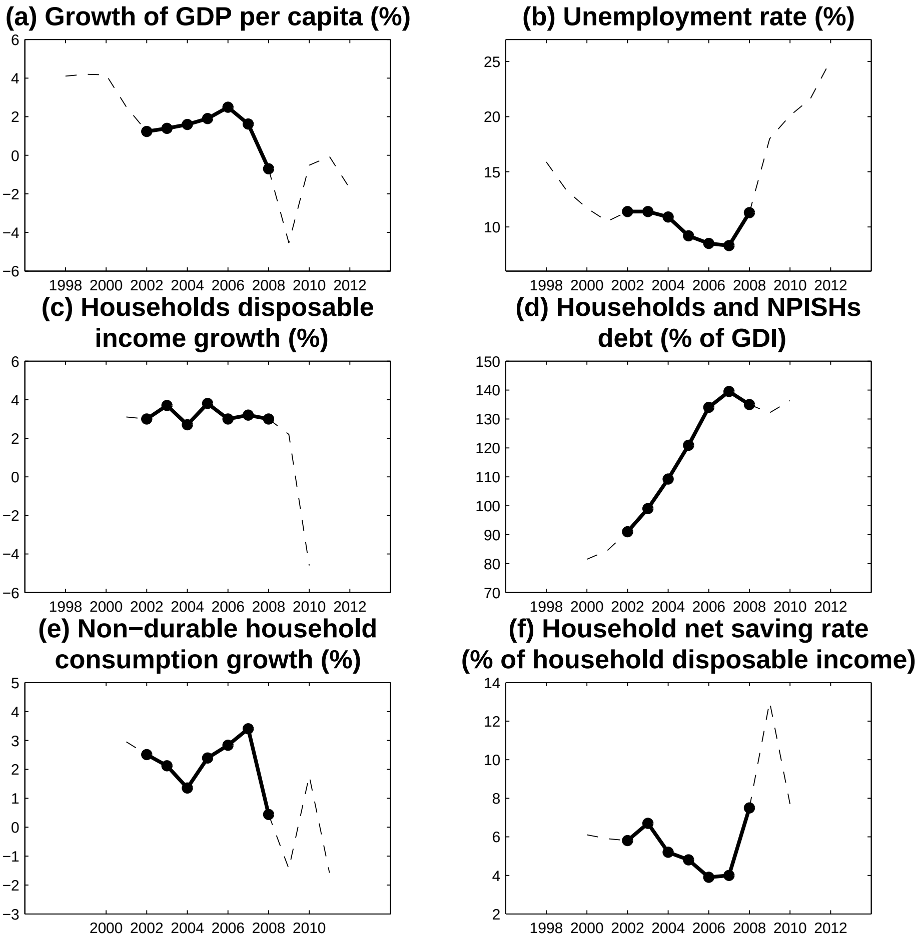

Figure D.2: Macroeconomic situation in Spain. Source: OECD. Note: The thick line highlights the period covered by the EFF used in the chapter.

reaching 25.1% in 2012.

In the developing economies the effect of the crisis and the recovery pattern was different: the impact of the crisis was not so severe and in general these economies experienced solid growth rates. In particular, economic activity in Chile contracted only during 2009. Real GDP dropped by 1.0% and recovered one year later, growing by 5.8% and surpassing its pre-crisis level. Before being hit by the crisis, unemployment levels in the Chilean economy had a decreasing trend, falling from 10% in 2004 to 7.1% in 2007. During 2009 unemployment rose to 9.7% but afterwards declined again.

Households behaviour

In each country households adjusted their consumption and saving behaviour during the crisis.

In the United States, real households' non-durable consumption dropped by 1.5% and the net saving rate increased by 3.1 percentage points, amounting to 5.5% of the household disposable income. In 2009, when the economic activity contracted, households' disposable income fell by 2.1% and non-durable consumption was reduced further (1.4%). After a decade of increasing household debts in terms of disposable income (44% between 1998 and 2007) mainly driven by mortgages, households reduced their indebtedness levels by 10% between 2008 and 2010.

Although the Spanish economy contracted in 2009, household income did not fall until 2010. In fact during 2008 and 2009, while the GDP growth was slowing down or even negative, households' real disposable income increased. Household consumption was almost stable in 2009 (0.44%) and decreased in 2010 (-1.44%).

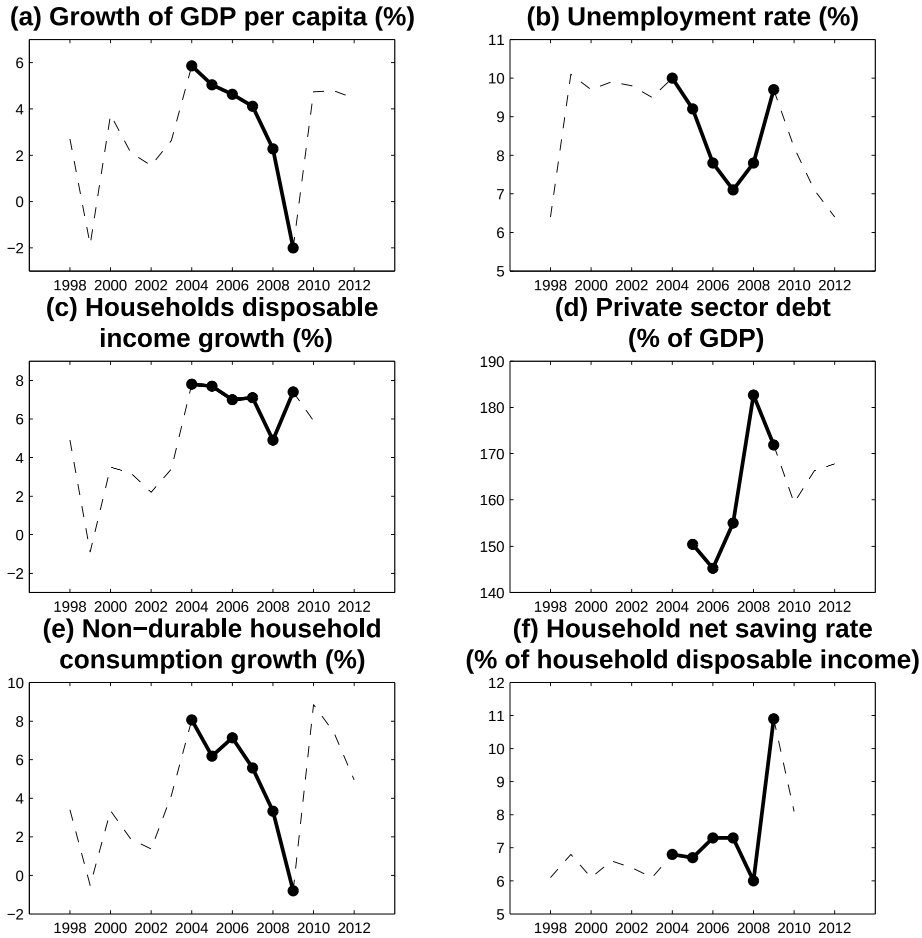

Figure D.3: Macroeconomic situation in Chile. Source: OECD. Note: The thick line highlights the period covered by the EPS used in the chapter.

Chilean households were less affected by the crisis. Their real disposable income always showed positive growth rates despite the 2009 GDP contraction. In fact it was only in that year that household non-durable consumption dropped by 0.80% and their savings as a fraction of their disposable income almost doubled (from 6.0% to 10.9%). During 2010 the recovery of the Chilean economy was faster than that of the world economy. Household consumption increased 8.9% and the savings rate of households diminished to 8.1% of disposable income.

Appendix E

Sample Construction

E.1 Chile

The Social Protection Survey (EPS) can be downloaded at http://www.proteccionsocial.cl/index.asp. There are four waves available corresponding to the years 2002, 2004, 2006 and 2009. The first wave includes only current and former members of the social security system and it does not include information about household wealth so I do not consider it in the investigation.

Variable definitions

The EPS does not provide a consolidated measure of non-durable consumption. I aggregate reported expenditures on goods and services as follows: food, clothing, utilities, transport, education, domestic services, health (care services, hospitalizations, controls, immunizations, medicines, lenses, prosthesis, etc..) and insurance (this includes life, car, fire, theft, complementary health and other insurance). To make this variable compatible with those of the other countries I do not include housing services.

For labour earnings I consider head and spouse labour income plus transfers. The EPS provides information on after tax labour income. I consider earnings from the principal, secondary and other jobs; as well payments in kind, bonuses and royalties.

To construct households' net worth I aggregate their real estate value net of debt (main dwelling and other properties), means of transport, machinery (equipment, terrain, animals, agricultural facilities and others), business wealth and financial wealth net of debt. Financial wealth includes: savings (current account, fixed deposits, housing savings and voluntary pension savings), mutual funds holdings, stocks or corporate bonds, loans to third parties and other savings (cash holdings, foreign currency, "mattress money", etc.). Debt includes: owed money (current account debt, credit card debt, educational debt, and other debt) and credit taken (bank credit, commercial house micro credit, financial house consumer credit, automotive credit, social credit, friends or family loans and money lender credit).

Sample construction

For the three waves I consider (2004, 2006 and 2009) the EPS has $47,633$ observations corresponding to $18,807$ households. I remove from the dataset those observations which report zero food consumption ($1,918$ observations)and zero labour income ($8,072$ observations). I remove as well those households which appear in one wave only ($4,056$ observations).

I find an issue with the Chilean data which is not documented. Certain questions of 2006 report answers which have extremely high values when compared to the same question for the same household in the two other waves.[1] These answers do not correspond to "no answer" or "don't know" or missing values, because they are coded differently. I discard the possibility that they could correspond to any way of top coding. Besides, I find no kind of pattern across households for that wave to explain these values. As this kind of response appears in one component of the aggregate variables that I construct, I recode them to zero so as not to lose the observation and further reduce the final sample size.

When I impose the sample selection criteria (head of the household is between 25 and 55 years old, dependent worker, there are no members in the household with business, the household is renting or freely using the dwelling and has no other real estate property), the number of observations reduces to $4,636$ (I drop $28,951$ observations). Home ownership is the reason why the sample reduces so dramatically when imposing the selection criteria. Of the cleaned sample only $7,118$ (21.2%) observations correspond to those who are renting or freely using the home. Furthermore, $21,7\%$ of those renting or freely using housing are not in the prime age group (25 to 55 years old).

In order to have a balanced panel when computing the two year and five year differences I keep those who were interviewed in all three waves. This is another heavy restriction, since only 837 observations out of $4,636$ correspond to households which were interviewed in all waves. Finally I remove income outliers (135 observations).[2]

Cleaning the sample and imposing the sample selection result in a final sample with 702 observations corresponding to 234 households observed

[1] For different questions the figures can be $1.00e + 08$, $1.00e + 09$ or $1.00e + 10$.

[2] I define income outliers with similar criteria to those adopted by Blundell, Pistaferri, and Preston (2008): those household with an income growth higher than 500% or below -80%.

between 2004 and 2009.

E.2 Spain

The Survey of Household Finances (EFF) can be downloaded at http://www.bde.es/bde/en/areas/estadis/Otras_estadistic. For each available wave the Bank of Spain provides five multiple imputation versions of the missing original data.[3] In the analysis I use the data with no imputations which can be constructed from a file with the original status of each variable.

Variable definitions

The variable that I construct for consumption includes all non-durable household expenses, which the survey reports as an aggregate (question 9.1), plus insurance services. I exclude housing services from this measure.

I generate labour income as the sum of head and spouse labour earnings plus transfers. The labour earnings reported by the EFF are before tax. This is a difference from the variable that I use in the other countries, for which I manage to construct an after tax measure. From the data estimation perspective considering gross labour earnings has two implications. First, the income moments, mean and variance, will be higher than the after tax moments. This matters for the income process calibration. Second, it can affect the estimation of the way in which changes in consumption and wealth react to changes in income shocks. If the marginal tax rate is locally constant, there are no impacts on the estimation of income shocks

[3] Description of the multiple imputation method that the institution uses can be found on its website.

before or after tax and thus no effects over the estimation of the household behaviour.

I construct the wealth of the household as the sum of financial assets net of debt plus the value of real assets (household appliances, vehicles and valuables) and the present value of the pension scheme or other future pension provision. Financial assets include balances in current and term accounts (including house-purchase saving account), shares in listed and unlisted companies, participations in mutual funds and other portfolio investment institutions, public or private fixed income securities and other financial assets (options or loans to third parties).

Sample construction

From the three waves available (2002, 2005 and 2008) the EFF consist of $17,302$ interviews and $10,755$ households. In order to obtain a balanced panel when computing the three year and six year differences, I keep the households which were interviewed in the three waves (I drop $7,445$ observations corresponding to households which participated in one or two waves only). I remove those households without information on education (13 observations) and those which report zero food consumption (418 observations). I do not clean the sample from income outliers as I do for the other countries due to sample size restrictions which I explain below.

As I mentioned before, I need to relax the selection criteria for Spain in order to obtain a sample with a minimum acceptable size to estimate household behaviour. Spain is a country with one of the highest levels homeownership. If I consider the balanced panel sample of households which are renting or have free use of the dwelling, it represents 11.7% of the total. In addition, of those 1,304 observations corresponding to renters or free users in the balanced panel, 28.6% own other properties, 13.0% are self-employed and 23.6% are retired. Consequently if I apply the same sample criteria used in the other countries (head of the household between 25 and 55 years old, no self-employed members, renting or freely using their homes and without any other real estate properties) the sample size is 126 observations corresponding to 42 households.

I use a different approach for Spain so as to increase the sample size. In particular I relax the sample selection criteria for the second and third wave so I impose the sample requirements on the household only the first time it is observed. As a result of the shocks received between the first and second wave and the first and third wave, the household might make decisions which changed its eligibility (become self-employed, buy a real estate property, etc.). What is important is the timing and whether, when the household is first observed, it fulfils the selection criteria.

When I impose these relaxed sample selection criteria for Spain, I end up with 264 observations corresponding to 88 households observed between 2002 and 2008.

E.3 United States

The PSID data can be downloaded at `http://psidonline.isr.umich.edu/`. For the variables related to consumption, labour earnings and all relevant demographic household information I use the "PACKAGED DATA". The wealth related variables from 1998 to 2006 are provided as special files.[4] For the last two waves (2008 and 2010) I construct the equivalent

[4]The wealth supplement is also available for the years 1984, 1989 and 1994.

supplement files from the "PACKAGED DATA".

The PSID labour earning questions are retrospective; for example, in 2011 the interviewees reported their 2010 labour earnings. I consider this element when working with the sample (e.g. correcting the age of the head of the household or using the appropriate timing when deflating nominal variables).

As mentioned before, I consider households which appear in consecutive waves. Every time the head of the household changes I consider it as a different household.

Values are in constant dollars; to deflate nominal variables I use the Consumer Price Index for all urban consumers and all items. Moreover, I report values in adult equivalent units using the OECD scale. Finally all relevant variables are expressed in annual terms.

Variable definitions

The interviews of the PSID had limited information about non-durable consumption but this has improved since the end of the 1990s. From 1968 the non-durable consumption variables gathered by the PSID are food expenditure at and away from home (since 1994 this includes food delivered). Thus to study consumption in the United States the most-widely used dataset is the Consumer Expenditure Survey (CEX). In 1999 the PSID included new questions about outlays in health care, transportation and education. Furthermore since 2005 the survey has included questions about expenditure on clothing, trips and vacations, recreation and entertainment. According to Charles, Danziger, Li, and Schoeni (2006) with the expanded consumption questions the PSID covers more than 70 percent of the consumption expenditure measured by the CEX.

I consider two definitions of non-durable consumption which depend on data availability. A narrower one that can be constructed from 1998 includes food consumption, utilities expenditure (electricity, heating, water and other utilities), transportation expenditure (car repairs and maintenance, gasoline, parking, bus and train fares, taxi expenses, other transportation cost and other vehicle expenditures), education expenses and child care. A broader definition is available from 2004 and adds to the narrower measure outlays on clothing, trips and vacations, recreation and entertainment (movies, sporting events, performing arts and hobbies, reading materials) and telecommunication (telephone, cable or satellite TV, internet service).

I construct the labour income of the household as the sum of the head and spouse after tax labour income plus transfers. The PSID reports gross labour income so I use the TAXSIM model from the NBER to estimate the amount of Federal and State taxes that the household has to pay.

The PSID provides wealth supplement files which include imputed variables containing information on the assets and debts of the households. The wealth measure that I consider for this research is the imputed wealth of the household without the value of the home equity. This variable, which is net of debts, includes seven asset categories: farm or business wealth, savings, real estate, stocks (including mutual funds or investment trusts), vehicles, other assets (bond funds, life insurance, valuables) and private annuities or individual retirement accounts. When imposing the sample selection some categories of this wealth aggregate variable are zero.

Sample construction

The PSID data between 1998 and 2010 includes 56,113 observations for 13,322 households. I clean the sample of those households without information on education (1,320), race (640 observations), consumption (28 observations) and region (5 observations). In addition, I remove the households which report zero food consumption (956 observations). I impose the condition that the interviewed units should appear in at least two waves and in consecutive spells (drop 4,832 observations). Following Blundell, Pistaferri, and Preston (2008), who also work with the PSID, I clean income outliers from the sample (drop 7,055 observations).[5] The first stage of the sample cleaning leads to 41,305 observations for 8,670 households.

Next that I impose the other sample requirements: the head of the household should be an active worker in the prime age (between 25 and 55 years), none of the household members are self-employed or entrepreneurs, the household is renting or freely using the dwelling and it does not have any other real estate property.

Finally I construct the sample such that the household is observed consecutively since 2004 and thus can construct the second, fourth and six differences for consumption, income and wealth. These steps give me a balanced panel consisting of $1,520$ observations corresponding to 380 households.

[5]Households' outliers with respect to income are those with an income growth higher than 500%, below -80% or with less than \$100 a year.

Appendix F

The construction of shocks

In order to construct measures for income, consumption and wealth shocks, I remove the predictable component from those variables. I regress the respective series on a quartic polynomial of the age of the household head, time dummies and a set of other demographic potentially relevant characteristics. For this set I consider: education, gender, race, working sector, civil status of the head, region of residence and interactions between education dummies with age and age squared.

One issue to consider is that the information reported by the different surveys is not homogeneous, which limits the covariates that I can use in the first set of OLS regressions to construct the shocks. Below I provide more information about the variables used for each country. In addition, I use Wald tests to assess which set of covariates to include in the regressions for each analysed country.

In the case of Chile I identify some under-reporting problems in the EPS. The average household labour income in the EPS for the year 2006 is about 40% less than the reported value of the *Encuesta de Presupuestos Fa-*

miliares (Survey of Family Budget) conducted in 2006-2007 by the National Institute of Statistics which is specifically designed to study the income and spending of the Chilean families.[1]This is an issue that is not a problem for my estimations as long as it implies only level effects across all waves, and thus changes in income still identify income shocks correctly.

For Chile I include as covariates: a quartic polynomial of the age of the household head, educational dummies and interaction between education and age, and regional and time dummies. I find that gender, civil status, working sector and interactions between age squared and education do not contribute significantly to the model.

In the case of Spain the covariates that I consider are: a quartic polynomial of the age of the household head, educational dummies and the interaction with age, and gender of the head of the household. The Spanish survey do not provide any information about race or region of residence.

Finally for the United States I regress the variables of interest on: a quartic polynomial of the age of the household head, educational dummies and the interaction with age, race and gender of the head of the household and region of residence. The interaction between educational dummies and age squared is not statistically significant.

[1]More evidence about potential EPS data problems can be found in de Mesa, Bravo, Behrman, Mitchell, and Todd (2006) who report discrepancies between self-report pension variables in the EPS and administrative records.

Appendix G

Calibration of the income process

An important step in the model is the calibration of the income process. First, I describe the strategy followed to calibrate the model income process. Second, I provide more details of the way in which I implement it for each country.

G.1 Calibration strategy

I reproduce here the income process (3.5) that I specify for the model, which includes measurement error:

$$\widetilde{y}_t = y_t + \gamma_t,$$

where $\gamma_t \sim \mathcal{N}\left(0, \sigma_\gamma^2\right)$ is classical measurement error and is assumed to be i.i.d. over time and uncorrelated with the transitory (ε_t) and permanent (η_t) income shocks.

When I calibrate the income process for different countries the objective is to match two features of the data. One is the earnings inequality, which I measure as the residual variance of a regression of logarithmic head and spouse earnings on predictable components, usually demographics of the household and the regional and time dummies selected as described in Appendix F. The other feature to match is the ratio Q, the relative importance of the permanent (or persistent) shocks over the temporary shocks, which are formed by the transitory shocks plus the measurement error.

In the case of the shocks which are permanent, $\rho = 1$ in Equation (3.4), the system of equations that I use to calibrate the amount of permanent shocks (σ_η^2), transitory shocks (σ_ε^2) and measurement error (σ_γ^2) is:

$$\begin{cases} \frac{\sigma_\eta^2}{\sigma_\varepsilon^2+\sigma_\gamma^2} & = Q \\ \sigma_\varepsilon^2 + \frac{(T+1)}{2}\sigma_\eta^2 + \sigma_\gamma^2 & = \sigma_{log(Y)}^2, \end{cases}$$

and if I allow income shocks to become persistent, $0 < \rho < 1$ in Equation (3.4), the system becomes:

$$\begin{cases} \frac{\sigma_\eta^2}{\sigma_\varepsilon^2+\sigma_\gamma^2} & = Q \\ \sigma_\varepsilon^2 + \frac{\sigma_\eta^2}{1-\rho^2} + \sigma_\gamma^2 & = \sigma_{log(Y)}^2, \end{cases}$$

where $\sigma_{log(Y)}^2$ is the residual variance of earnings.

When solving the model for each country, Q and $\sigma_{log(Y)}^2$ come from external estimates. Therefore in each point on the parameter grid, for a given amount of measurement error (σ_γ^2) I can obtain the values for the transitory and permanent (or persistent) shocks from the following expressions. For the permanent income case:

$$\sigma_{\varepsilon}^{2} = \frac{\sigma_{log(Y)}^{2}}{1 + \frac{T+1}{2}Q} - \sigma_{\gamma}^{2},$$

$$\sigma_{\eta}^{2} = Q(\sigma_{\varepsilon}^{2} + \sigma_{\gamma}^{2}),$$

and for the persistent income case:

$$\sigma_{\varepsilon}^{2} = \frac{\sigma_{log(Y)}^{2}}{1 + \frac{Q}{1-\rho^{2}}} - \sigma_{\gamma}^{2},$$

$$\sigma_{\eta}^{2} = Q(\sigma_{\varepsilon}^{2} + \sigma_{\gamma}^{2}).$$

With this strategy I can be sure that the model is replicating the observed variance of residual earnings and the ratio of persistent (or permanent) to temporary shocks to match the amount observed in data.

I highlight two implications from the calibration strategy described above. First, the equation for transitory shocks explicitly sets the maximum amount of measurement error permitted, since the variance of the transitory shocks has to be positive. However, for this restriction, this is a flexible calibration strategy, since the system of equations that I use to calibrate income is undetermined. For given values of the residual variance and Q, and an assumption about income persistence ρ, there exist an infinite number of combinations of σ_{η}^{2}, σ_{ε}^{2}, and σ_{γ}^{2} which solve the system of equations.

G.2 Calibration implementation

Ideally the earnings inequality and the ratio Q to calibrate used in the model would come from the data that generate the moments which I am trying to match with the model.

A possible method used in the literature to obtain the income decomposition is the one proposed by Blundell, Pistaferri, and Preston (2008). It uses covariances of growth income rates at one lag to identify the variance of the transitory shocks. Then the variance of the permanent shock can be obtained by subtracting the current and previous transitory variance from the income growth covariance between two periods. These expressions need to be modified to account for the fact that the surveys are carried out every two or three years. Using this methodology implies that at least 4 waves are needed to be able to identify the permanent and transitory variance.

Following this methodology I am able to estimate the income decomposition but only for the United States. So far only 3 waves have been released for the Chilean and Spanish Surveys, so there are not enough data to estimate the permanent and transitory variance. Thus, I use external estimates based on other surveys to obtain the required inputs. There are some drawbacks to using the external estimates for Chile and Spain. For instance, the time span and surveys used in these estimates differ from the ones used in my investigation. Moreover, the variables used in those studies do not match exactly the ones I employ. Up to the time of this research these sources have been the most reliable and these issues will be resolved when new waves become available. In the next subsections I detail the implementation that I follow for each country.

Chile

The fourth wave of the EPS corresponding to the year 2012 was scheduled for the second semester of 2013 but it was not available in time for this research. To calibrate Q, I rescale estimates from Huneeus and Repetto (2005) using the log-residual variance of earnings from my data estimates.

In the Chilean study Huneeus and Repetto (2005) use the *Encuesta Suplementaria de Ingresos* (ESI, Supplement income survey) which ran between 1990 and 2000. Given that it is a cross-sectional survey the authors build a synthetic panel to estimate the income decomposition between transitory and permanent shocks. This methodology has potential implications for the estimated variances, since it uses cohort heterogeneity to proxy the individual heterogeneity. The authors acknowledge this issue. To assess it they apply the same pseudo panel methodology to the PSID data, which they then compare with the estimation using the PSID panel component.

I reproduce the findings of Huneeus and Repetto (2005) on the first three rows of Table G.1. Their results suggest the presence of a negative bias when estimating the variances using the pseudo panel. This bias is stronger in the case of the transitory shocks. I compute the ratios of the estimations using individual over cohort information for the PSID and report them in the fourth row. If it is assumed that the different income variances are at cohort level, so individuals are exposed to the same amount of permanent or transitory shocks, I can extrapolate the Chilean cohort data using the above mentioned ratios as scaling factors and obtain a proxy for the variances at an individual level. I report these figures in the last row of Table G.1. The value Q of the relative importance of permanent over transitory shocks is

0.4988.

Table G.1: Income decomposition for Chile

	Permanent variance	**Transitory variance**
(I): ESI, cohorts	0.00303	0.00030
(II): PSID, cohorts	0.01181	0.00080
(III): PSID, individuals	0.08150	0.11173
(IV): Scaling factor (III)/(II)	6.90	139.66
(V): ESI, rescaled (I)*(IV)	0.02091	0.04190

Source: Huneeus and Repetto (2005) and author's calculations.

One drawback to consider is that the earnings measure used by Huneeus and Repetto (2005) corresponds to the labour earnings of the head of the household, whereas I use head and spouse labour earnings. However, their results are robust enough to include transfers in income and to make different income specifications.[1]

Finally, with respect to log-residual earnings I use my estimates which were constructed following the procedure described in Appendix F. I set $\sigma^2_{log(Y)} = 0.4988$. First, I opt to use this figure because Huneeus and Repetto (2005) do not report it. Second, using my estimates I make sure that the residual earnings match the period and variable definitions used to estimate the consumption and wealth response of the households to income shocks. Although I recognise that the Q comes from another survey and time period, it is the best estimate until the next wave of the EPS becomes available.

[1] They consider a permanent or a persistent component and the transitory shocks that are i.i.d. or have a MA(1) structure.

Spain

The fourth wave of the EFF, corresponding to the year 2012, was not available at the time this research was done. Thus I cannot estimate an income decomposition between permanent and transitory shocks due to a lack of information. To overcome this issue I obtain the inputs to calibrate the income process from Pijoan-Mas and Sanchez-Marcos (2010), who use the *Encuesta Continua de Presupuestos Familiares* (ECPF, Household expenditure survey), a panel from 1985 to 1996.

When studying income inequality the authors regress net annual equivalised household earnings over an age polynomial and time, education and family composition dummies. From this regression they obtain the residual variance. I take the average over the 12 years to calibrate the residual earnings variance for Spain: $\sigma^2_{log(Y)} = 0.4557$. The estimation procedure followed by Pijoan-Mas and Sanchez-Marcos (2010) has several points in common with the methodology that I use: very similar labour earnings definition, the same OECD equivalence scale to normalise the variables and a comparable set of covariates. However there are two issues worth mentioning. The first one is related to the time period used in their estimation and the second one to the fact that the ECPF provide earnings after tax. Although having this measure is the best option, as I highlight above, the EFF reports before tax earnings.

The authors estimate as well the income process for the household's net labour earnings. I use the average of these estimations to construct a measure for Q which I set equal to 0.6762. The average variance of permanent shocks (σ^2_η) is 0.0407 and the average variance of transitory shocks (σ_ε) is 0.0602. The only issue to highlight is that the ECPF data is reported quarterly, because the survey follows 3,600 households for up to 8 consecutive quarters. When the authors estimate the income process, which is specified as a permanent component plus a transitory one, they use quarterly data, so they can use up to 7 observations per household. This is a potential problem for quarterly data, as it may result in residual income autocorrelations of a higher order than the one included in the permanent component. The authors acknowledge this issue but proceed without aggregating in annual terms, in order to have a larger number of observations.

United States

As I detail in the data section, for the United States I am using the PSID survey from 1998 to get more detailed information on consumption and wealth. Those 7 waves allow me to estimate the inputs required for the income calibration from the same data that I use to estimate the household consumption and saving behaviour.

To get estimates for the observed income variance I follow the estimation procedure detailed in Appendix F. Although I estimate the household behaviour using data from 2004 to 2010 (the period with the broadest consumption definition), for the residual earnings variance calibration I consider the estimation which uses all waves, since it implies the highest amount possible of observations. I set the residual earnings variance $\sigma^2_{log(Y)} = 0.3337$.

After generating the residual earnings by removing the predictable component from the head and spouse labour earnings I fit a stochastic process in order to identify the permanent and transitory variance. I follow the methodology proposed by Blundell, Pistaferri, and Preston (2008). To implement it I adapt the code provided by Heathcote, Perri, and Violante (2010) to consider the variable definitions and time period that I use. I set $Q = 0.6511$ corresponding to a estimated permanent variance (σ_η^2) of 0.0356 and a transitory variance (σ_ε^2) of 0.0547.

Chapter 4

Wealthy hand-to-mouth consumers

4.1 Introduction

In the two previous chapters I have considered the sample of non homeowners in analysing how consumption and wealth responses are correlated with income shocks.

According to Kaplan and Violante (2014), there is a substantial fraction of the sample which owns a home but behaves as liquidity constrained hand-to-mouth consumers, even though it has positive net worth due to its homeownership.

I thus extend the results of the previous chapters to consider homeowners. Durables, like homes, not only provide consumption services, but are also a means of insurance, since households may liquidate their durable stocks in response to certain shocks. Thus, I expect a priori that households' wealth responses to income shocks over time may differ according to the level and composition of their net worth. In particular, I re-examine the Italian data used in the first chapter and analyse households' behaviour according to their durable adjustment.

I summarise the main results as follows. On the one hand, wealth responses to income shocks over time are downward sloping for the group of households that adjusts its durable stock. On the other hand, the responses are upward sloping for those households which do not adjust their durable stock. This suggests that households which do not adjust have stronger precautionary saving motives. In line with those results, the consumption responses increase more steeply for the households which do not adjust compared to those which do.

I interpret these results as support for the hypothesis of Kaplan and Violante (2014). The results also support the strategy applied in previous chapters of identifying the strength of precautionary saving versus permanent income behaviour in the data by looking at the slope of the wealth and consumption responses.

The rest of the chapter is organised as follows. Section 4.2 briefly presents the conceptual framework that I use in the chapter. Section 4.3 describes the data used, the sample selection process and the estimation strategy before presenting the results. Section 4.4 discusses the estimation results. Section 4.5 concludes.

4.2 Conceptual framework

Kaplan and Violante (2014) formalise a consumption model in which households can have two kind of assets, one liquid and one illiquid and subject to transaction costs. In this chapter I apply their modelling framework to analyse how homeownership affects the households' responses to income shocks.

The argument of Kaplan and Violante (2014) may be summarised as follows. If the household owns illiquid assets and has not recently adjusted them, then the behaviour of non-durable consumption is approximately characterised by the behaviour of a liquidity constrained consumer, also called a "wealthy" hand-to-mouth consumer by Kaplan and Violante (2014). Instead, if the household has adjusted the illiquid assets, it has re-optimised by adjusting its durable stock and thus its consumption behaviour is less affected by the illiquidity of the second set of assets.

The empirical strategy I use is thus the following. I use information in the SHIW to identify those households which adjust their consumption of durables and then compare whether their consumption and wealth responses are systematically different from those households which do not adjust their consumption of durables.

Not convinced by the work of Bertola, Guiso, and Pistaferri (2005) and Alvarez, Guiso, and Lippi (2012), who use the *value* of durables reported in the SHIW to identify adjustment in the durable stock, I adopt a different strategy. I consider changes in the quantity of durables to identify the adjustment, since this procedure is robust to changes in values driven by price changes. The SHIW is an excellent dataset to use; it allows me to trace adjustments in quantity while considering, among other things, the amount of square metres of the main residence. In the next section I provide more details of the way in which I empirically identify the adjustments.

4.3 Descriptive analysis

4.3.1 Data

I use the SHIW dataset which I have described in Section 2.3, including the last wave in 2012, so that the period considered is between 1987 and 2012.

Besides the main advantage of covering a long time span, this extended dataset has detailed information about the real estate owned by the households. I consider the type of property, surface area (i.e. footprint) in square metres, time of ownership and mode of acquisition.

4.3.2 Sample selection

I select those households whose head is between 25 and 55 years old, which have members who do not own business wealth and are not self-employed, and have been observed for at least 4 consecutive waves. With respect to the selected sample that I use in Chapter 2, the households may own real estate. Therefore the households' real assets are formed by valuables and real estate properties.

In terms of housing status, the households could rent (have no properties), own the main residence and possibly own other properties. The historical dataset of the SHIW, a dataset provided by the Bank of Italy which homogenises and aggregates the information collected each wave, provides information on the way that the household acquired the ownership of the property, detailing if it was purchased, inherited or received as a gift, or built. Unfortunately there is no specific information on whether the main residence was bought with a mortgage, or from savings or a family loan. The historical dataset provides information on mortgages, but it is not sufficiently detailed. An analysis of each wave's questionnaires is needed, with the drawback that the information is not homogeneous. I discuss this problem below.

Durables adjustment

As mentioned above, the strategy is to identify those households which adjusted their consumption of durables and compare them with those which did not adjust it. I focus on housing, which is the largest durable good for most households.

As adjustment criteria I consider the region of residence, years of possession of the dwelling and reported square metres. I identify those households which do not adjust their housing stock if in 4 consecutive waves: they have always rented their dwelling, or if they owned their main residence they did not change the region, reported a consistent amount of time spent at the same address and the same amount of square metres. Furthermore, if they have another real estate property, I select those households which own the same number of properties in all waves.

To construct the sample of households which adjusted their housing stock, I select those households which during the observed period (at least 4 consecutive waves) reported at least one period without owning the main residence. In other words, this criterion selects households which acquired the main residence or, for example, as a result of a shock had to sell it and became renters. The complement of this group, which I am excluding, is formed by households which adjusted their consumption of durables, but always reported having ownership of the main residence. In Table H.1 of

Appendix H I report some statistics to highlight the differences between these two groups in terms of property ownership. Households which always own their main residence also own more dwellings for rent or agricultural land for rent.

Hand-to-mouth consumers

To complement the analysis and further characterise the behaviour of those households which adjusted or did not, I also analyse the fraction of hand-to-mouth consumers in those groups. When identifying the hand-to-mouth households I follow as closely as possible the benchmark definitions in Kaplan and Violante (2014) and Kaplan, Violante, and Weidner (Forthcoming). In particular, Kaplan, Violante, and Weidner (Forthcoming) estimate the amount of hand-to-mouth consumers for Italy by using the Household Finance and Consumption Survey (HFCS) between 2008 and 2010. While the SHIW does not have the same information as the HFCS, I follow their approach as closely as possible.

For *liquid assets* I consider various definitions. As a baseline I consider the net financial wealth reported by the historical dataset of the SHIW. This asset category consists of deposits in current and savings accounts, certificates of deposit, repos, government securities, bonds, mutual funds, equity, shares, foreign securities and loans to cooperatives. All these assets are net of financial liabilities: with banks, financial companies, other households and trade debt. This measure of liquid wealth is the closest to Kaplan, Violante, and Weidner (Forthcoming) that can be built with the historical dataset of the SHIW. The main difference is that I do not have information on cash holdings, such as the HFCS reports. The results presented are, however, robust to alternative definitions which consider different asset components.

In terms of *illiquid assets* I adopt the baseline definition of Kaplan, Violante, and Weidner (Forthcoming) which is net real estate wealth and then consider other broader measures by adding valuables, vehicles and other durables such as furniture, furnishings and appliances.

Like Kaplan, Violante, and Weidner (Forthcoming), I identify hand-to-mouth consumers considering average liquid balances. Therefore I consider poor hand-to-mouth households as those households with no positive illiquid wealth and net liquid wealth smaller than or equal to half their monthly labour earnings. Wealthy hand-to-mouth households are defined using the same restriction in terms of liquid wealth, but hold positive net illiquid wealth. Given the very low levels of indebtedness of the Italian households, it is irrelevant to consider alternative definitions of borrowing constraints by different thresholds of net liquid wealth. Finally I check the results when alternative definitions of total net worth are considered, in order to identify hand-to-mouth households.

4.3.3 Empirical findings

Portfolio adjustment

I estimate how changes in consumption and wealth react to changes in income following the empirical strategy that is explained in Chapter 3. The only changes are in the first step when I construct the shock components of the variables of interest. When I remove the deterministic predictability of the variables, I add the observables related to homeownership compared with the regressions for the sample of non-homeowners detailed in

Appendix F of the previous chapter. In particular I include dummies to capture the ownership of the main residence and the number of other properties owned by type of property: dwelling, other building, agricultural land and non-agricultural land.

In Table 4.1 I present the consumption and wealth responses to income shocks over N periods for those households which adjusted and did not adjust their owned main residence. I consider total net worth as a measure of wealth. I report all estimation results for median regressions which minimise absolute deviations and thus are robust to outliers.

Table 4.1: Total net worth: consumption and wealth responses to income shocks.

	Adjusted		Non-Adjusted	
N	β_c^N	β_a^N	β_c^N	β_a^N
2	0.272	0.875	0.181	0.265
	(0.022)	(0.248)	(0.027)	(0.094)
4	0.281	0.662	0.274	0.333
	(0.025)	(0.274)	(0.031)	(0.146)
6	0.369	0.643	0.342	0.484
	(0.025)	(0.317)	(0.029)	(0.151)
Sample size	962		650	

Source: Author's calculations. Standard errors in parentheses.

The estimated wealth responses for those households which adjusted their consumption of durables is decreasing in N and, conversely, increasing in N for those which did not adjust. In both cases the estimates are significantly different from zero. In terms of consumption responses to income shocks, they are increasing and can be more precisely estimated than the wealth responses for both groups of households. Those households which did not adjust their main residence have a lower consumption response at $N = 2$ and exhibit a steeper consumption profile over time.

It is relevant to consider in particular liquid wealth for Italy, notably its financial assets, which, given the above mentioned characteristics, are the most probable kind of asset that the household will adjust. The reason is that Italy has high levels of home ownership (74.1% in 2012 according to Eurostat) with low levels of development in the mortgage market. Thus, savings and transfers (or loans) from family and friends are the most common ways of acquiring homeownership. Hence, I present in Table 4.2 the estimation results when the value of real estate is excluded from the wealth measure.

Table 4.2: Financial net worth: consumption and wealth responses to income shocks.

	Adjusted		Non-Adjusted	
N	β_c^N	β_a^N	β_c^N	β_a^N
2	0.272	0.383	0.181	0.115
	(0.022)	(0.093)	(0.027)	(0.047)
4	0.281	0.191	0.274	0.209
	(0.025)	(0.108)	(0.031)	(0.063)
6	0.369	0.088	0.342	0.253
	(0.025)	(0.111)	(0.029)	(0.067)
Sample size	962		650	

Source: Author's calculations. Standard errors in parentheses.

The estimation results when only net financial wealth is considered as the measure of wealth confirm the results presented above. Wealth responses are decreasing in N for those households which adjusted their stock of durables, and increasing in N for those which did not adjust. The level of wealth responses is smaller, an observation which I plan to investigate further in future research.

In Table 4.3 I report moments of the net worth distribution normalised by labour income in adult equivalent units. When total wealth is considered, the differences are obvious, given the higher level of ownership in the group of households that adjusted. It is more interesting to note what happens with net financial wealth holdings between the two groups under review. The bottom part of the net financial assets distribution is very similar for both groups of households, suggesting that the differences in terms of wealth responses may be driven by the households in the top of the distribution.

Table 4.3: Net worth moments of households according housing adjustment and wealth definition.

		Total wealth			
	Sample size	1^{st}quartile	2^{nd}quartile	mean	3^{rd}quartile
Adjusted	962	0.95	3.66	5.04	7.02
Non-Adjusted	650	0.09	0.34	2.05	1.49
		Financial wealth			
		1^{st}quartile	2^{nd}quartile	mean	3^{rd}quartile
Adjusted	962	-0.04	0.23	0.37	0.85
Non-Adjusted	650	0.06	0.23	0.50	0.59

Source: Author's calculations.

To summarise, analysing total wealth or financial wealth alone, the wealth responses are downward sloping over time for the households which adjusted and upward sloping for the households which did not adjust. Furthermore, in line with this saving behaviour, the consumption responses are more steeply increasing for the households which did not adjust than for those which adjusted.

The results obtained suggest the following interpretation. If the household adjusted its stock of housing, it exhibits a behaviour similar to a permanent-income consumer. If the household did not adjust, it behaves more like a precautionary-saving consumer. In other words, the households which adjust have the possibility of liquidating their housing wealth and thus they respond to the income shocks differently from the households which did not adjust.

To consider households which adjusted their housing stock by relaxing any of the above defined criteria, for example the number of square metres or the number of other properties owned, has selection implications. For instance, this strategy will include in the same group first time home buyers and households buying a vacation home, or buying a second or third property to rent. I report the estimation results for the households which adjusted their durables and always own their main residence in Table H.2 of Appendix H.

Hand-to-mouth households

Up to this point I have characterised the households in terms of their ways of adjusting their wealth portfolio. In order to further understand the estimated responses, I now characterise the households in terms of their portfolio positions.

In Table 4.4 I present the fraction of hand-to-mouth households among those which adjusted their housing and those that did not. To identify them I use the methodology presented in Section 4.3. In the table, net financial assets are defined as liquid wealth. In the first column of the table I define illiquid wealth as net real estate wealth, computed as the difference between the value of the properties reported by the household and mortgages. The columns to the right use broader definitions of illiquid wealth.

Table 4.4: Percentage of hand-to-mouth (h-t-m) households in the sample.

	Net real estate wealth (Baseline) (I)	(I) + valuables net worth (II)	(II) + vehicles net worth (III)	(III) + other durables net worth (IV)
Adjusted				
Poor h-t-m	5.4%	1.7%	0.4%	0.1%
Wealthy h-t-m	10.4%	14.1%	15.4%	15.7%
Net worth h-t-m	5.3%	2.6%	0.1%	0.1%
All net worth h-t-m	2.5%	2.5%	2.5%	2.5%
Non-Adjusted				
Poor h-t-m	18.5%	5.5%	1.5%	0.3%
Wealthy h-t-m	2.6%	15.5%	19.5%	20.8%
Net worth h-t-m	18.3%	9.8%	2.5%	0.6%
All net worth h-t-m	8.9%	8.9%	8.9%	8.9%

Source: Author's calculations. To compute liquid wealth I consider all the financial assets net of debts. Net worth hand-to-mouth households are computed using the sum of the definitions of liquid and illiquid wealth. All net worth hand-to-mouth households are computed using the aggregate net worth reported in the SHIW, which includes net financial wealth and real assets.

In the baseline case, when illiquid wealth is net real estate (column I) and net worth is constructed by adding liquid and illiquid wealth, the proportion of hand-to-mouth consumers is 18.3% among those which did not adjust and 5.3% among those which adjusted. This result is driven by the higher fraction of households without real estate in the class of households which did not adjust.

Considering wealth liquidity to classify households allows me to identify the wealthy hand-to-mouth households which otherwise are not identified when aggregate measures of wealth are considered. Besides, as is confirmed in the table, when broader measures of illiquid wealth than housing are taken into account (moving from left to right), the composition changes in favour of wealthy hand-to-mouth households, since some positive net worth is held in other real assets.

Adding up poor and wealthy hand-to-mouth households, the proportion is 15% in the group which adjusted its durables and 22% among those who did not, supporting the result obtained with aggregate measures which indicates a higher fraction of constrained households in the group of households which did not adjust.

As a robustness check I compute the fractions of hand-to-mouth households using all SHIW data. The proportion of poor hand-to-mouth is 9.6% and of wealthy hand-to-mouth is 13.2%. These levels are compatible with the results of Kaplan, Violante, and Weidner (Forthcoming), which by using HFCS in the baseline case report 8.3% of poor and 15.5% of wealthy hand-to-mouth households.

Furthermore, in Table I.1 of Appendix I, I reproduce the computations considering financial wealth as the sum of deposits in current and savings accounts, certificates of deposit and repos. With this narrower but more liquid wealth definition the results are very similar, mostly because these are the most important asset components of financial wealth.

Another interesting dimension of the data is the incidence of mortgagors in the sub-samples. Cloyne and Surico (2014) study the effect of tax changes on consumption for the United Kingdom. They classify British households according to their housing tenure and find that the aggregate consumption responses are driven by the responses of mortgagors, which react more to income movements due to tax changes than social renters and home owners. Analysing their wealth holdings, they find that mortgagors are wealthy hand-to-mouth consumers, given that they hold mostly illiquid rather than liquid assets.

For Italy I find that the incidence of mortgagors among the households which adjusted their durables is 25.8% and 4.5% in those which did not. If I consider the whole SHIW the fraction of households with mortgages is only 10.4%.

As explained above, the housing debt market in Italy is not as developed as, for instance, the United Kingdom's. It may be the case that those with access to mortgages, have a better credit rating or access to better credit conditions. These types of household are predominant in the sub-sample that adjusted its stock of durables. Their saving behaviour could be closer to that of a permanent-income consumer. Further research is needed in this area.

I can summarise the results as follows. First, the proportion of hand-to-mouth households in Italy is about 20%, a figure in line with the literature. Second, the results show a higher proportion of hand-to-mouth consumers in the group of households which did not adjust its stock of durables. These results are robust to different definitions of the type of assets considered.

This exploration of hand-to-mouth households facilitates the interpretation of the wealth responses estimated before. The figures suggest a relatively larger proportion of hand-to-mouth households among those which did not adjust durables, in fact, more wealthy hand-to-mouth, when I use broader measures of illiquid wealth. The upward sloping profile of wealth over time for these households may result from a precautionary-saving behaviour because these households are relatively more constrained.

This evidence not only supports Kaplan and Violante (2014), but also the hypothesis of the way in which the slope of wealth to income shocks over time is influenced by precautionary-savings and permanent-income behaviour.

4.4 Discussion

The work conducted in this chapter needs further effort to make results more robust and improve the understanding of the evidence.

One criticism is related to the problem of endogeneity when including households with real estate in the estimated regressions of the way that wealth reacts to income shocks. The shocks on housing wealth may be systematically correlated with income shocks. This is why Krueger and Perri (2011) exclude home owners from their sample.

Another criticism is related to the strength of the presence of hand-to-mouth households in each group. Although there are different proportions of financially constrained households between those which adjusted and those which did not, data sources imply that the difference is not very great. Recall that the SHIW, as opposed to the HFCS, does not report cash holdings. While there is more detailed information in the SHIW annual datasets than in the historical databases, the drawback is that the data series are less consistent over time.

4.5 Conclusion

In this chapter I have revisited the question of households' reactions to income shocks in terms of consumption and savings. I have investigated whether households' behaviour is affected by their level of net worth and its composition, in particular in terms of liquid and illiquid.

I find that households which adjust their housing stock show responses of wealth to income shocks which decrease over time. Conversely, those households which did not adjust exhibit an increasing profile of wealth responses over time.

This evidence can be interpreted as follows. Those households which adjusted their housing stock, re-optimise their wealth portfolio and thus react differently from those households which did not adjust and are more affected by the illiquid nature of their wealth. When I analyse the liquidity of the wealth of the two groups I find a higher incidence of hand-to-mouth households in the sub-sample which did not adjust. This evidence, though preliminary, supports Kaplan and Violante (2014) and the strategy used in previous chapters of the thesis, to identify precautionary-savings or permanent income behaviour by looking at the wealth responses to income shocks over time.

Appendices

Appendix H

Households which adjusted their housing stock

Table H.1: Comparison of households with respect to adjustment of their owned main residence

	Bought/sold main resid.		Always owned main resid.	
	Mean		Mean	
	Uncond.	Cond.	Uncon.	Cond.
Total properties	0.68	1.25	1.58	1.58
Other properties	0.14	1.32	0.58	1.71
Dwellings	0.17	1.11	0.32	1.36
Other building	0.03	1.06	0.08	1.25
Agricultural land	0.05	1.13	0.17	1.28
Non-agric. land	0.02	1.10	0.03	1.12
Real Estate Wealth	79,485	143,383	186,337	186,337

Source: Author's calculations. Note: Conditional means are computed with respect to owning the type of property mentioned in the description. For instance, regarding other properties, the average number of other properties for all the households which bought or sold the main residence is 0.14, but among those which have other properties the average is 1.32. Real estate wealth is expressed in Euros of year 2000.

Table H.2: Consumption and wealth responses of households which adjusted their durable consumption and always owned their main residence

	Consumption	Total Wealth	Financial Wealth
N	β_c^N	β_a^N	β_a^N
2	0.266	1.238	0.266
	(0.018)	(0.251)	(0.055)
4	0.280	1.440	0.289
	(0.018)	(0.253)	(0.070)
6	0.290	1.466	0.324
	(0.018)	(0.265)	(0.074)
Sample size		1749	

Source: Author's calculations.

Appendix I

Hand-to-mouth consumers: a narrower definition of liquid assets

Table I.1: Fraction of hand-to-mouth (h-t-m) households in the sample: narrower definition of financial wealth.

	Net real estate wealth (Baseline) (I)	(I) + valuables net worth (II)	(II) + vehicles net worth (III)	(III) + other durables net worth (IV)
Adjusted				
Poor h-t-m	6.1%	1.7%	0.5%	0.1%
Wealthy h-t-m	12.3%	16.7%	17.9%	18.3%
Net worth h-t-m	6.1%	2.7%	0.1%	0.1%
All net worth h-t-m	2.5%	2.5%	2.5%	2.5%
Non-Adjusted				
Poor h-t-m	18.8%	5.7%	1.5%	0.3%
Wealthy h-t-m	2.6%	15.7%	19.8%	21.1%
Net worth h-t-m	18.6%	10.0%	2.5%	0.6%
All net worth h-t-m	8.9%	8.9%	8.9%	8.9%

Source: Author's calculations. To compute liquid wealth I consider deposits in current and saving accounts, certificate of deposits and repos, net of financial debts. Net worth hand-to-mouth households are computed using the sum of the definitions of liquid and illiquid wealth. All net worth hand-to-mouth households are computed using the aggregate net worth reported in the SHIW, which includes net financial wealth and real assets.

Chapter 5

Conclusion

This thesis has studied how households respond to income shocks by analysing their consumption and saving behaviour over time. The main objective has been to understand what we can learn from households' saving decisions, in particular about the importance of precautionary-savings and consumption-smoothing motives.

In Chapter 2 I have shown that the two leading theoretical models for studying consumption and saving decisions, the permanent-income model and the precautionary-saving incomplete-markets model, may both generate a decreasing wealth profile over time. With reference to Krueger and Perri (2011), I show that decreasing wealth responses over time do not allow us to rule out the presence of borrowing constraints. Moreover, I have illustrated that the slope of the wealth responses to income shocks identifies the strength of the precautionary-saving motives relative to permanent-income motives.

In Chapter 3 I have extended this research by providing international evidence. I have structurally estimated a precautionary-saving incomplete-markets model for Chile, Spain and the United States. Surprisingly, I have found that, despite the dissimilar financial development of the considered countries, the household behaviour and estimated parameters are quite similar, suggesting that the financial market differences between the countries are not very important.

Finally in Chapter 4 I have extended the analysis to include homeownership. Following Kaplan and Violante (2014), I have classified households into two groups according to whether or not they adjusted their housing stock and whether they are constrained in terms of liquid assets. Working with the Italian dataset that I used in the first chapter, I find support for the hypothesis of Kaplan and Violante (2014) and the strategy to identify households that exhibit precautionary saving motives according to the slope of their wealth response to income shocks over time.

The results of the thesis confirm the adopted empirically strategy to identify the relative strength of the precautionary-savings motive and the consumption-smoothing motive by analysing how the wealth responses to income shocks evolve over time.

The next step in my research agenda is to formulate a structural model which incorporates housing, as in Chapter 4. The estimation of the size of precautionary-savings with such a model will allow me to further test the robustness of the results in this thesis.

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