



Department of Economics

Macroeconomic Policies and Agent Heterogeneity

Charles Gottlieb

*Thesis submitted for assessment with a view to obtaining the degree of
Doctor of Economics of the European University Institute*

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Abstract

This thesis contributes to the understanding of macroeconomic policies' impact on the distribution of wealth. It belongs to the strand of literature that departs from the representative agent assumption and perceives agent heterogeneity and the induced disparities in wealth accumulation, as an important dimension of economic policy-making. Within such economic environment, this thesis analyses the impact of three macroeconomic policies, namely monetary policy under the form of inflation targeting, fiscal policy under the form of asymmetric transfers, and finally retirement policies by shedding light on how household allocate their financial wealth over the life cycle.

The first chapter of this thesis explores whether a higher inflation target induces more households to hold real assets rather than money holdings, thereby leading to a higher aggregate capital stock. It shows that a higher inflation target can lead to welfare improvements, when the economy is parametrized to US data. Such policy shows to be welfare improving, as the higher stock of aggregate capital reduces the real interest rate, which improves the welfare of indebted households.

The second chapter of this thesis is joint work with A. Fagereng and L. Guiso. It provides novel empirical evidence on the life cycle patterns of the extensive and the intensive margin of stock market participation over the life-cycle. Also we provide a model that replicates the life cycle patterns of the conditional risky share and the participation rate, by introducing a fixed per period cost friction and a limited trust friction.

In the third chapter, co-authored with M. Froemel, we analyse whether asymmetric transfer policies can be a pertinent short run policy instrument to overcome distortions arising from the lack of insurance opportunities for households due to financial market incompleteness. We show that asymmetric transfers can improve welfare, when transfer programs are pro-borrowers rather than lump-sum or pro-lenders.

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Introduction

Can a higher inflation target improve welfare? How do households allocate their financial wealth over the life-cycle? Can an asymmetric transfer policy generate greater welfare than a lump-sum transfer policy? This thesis contributes to the literature by providing answers to these three questions in the following three chapters.

Chapter 1 shows that an increase in the anticipated inflation rate can improve welfare due to redistribution through the interest rate. Therein I investigate the distributive effects of inflation in an incomplete markets economy with heterogeneous households who can choose to smooth consumption with either interest bearing real assets or money. Based on empirical evidence, I assume a fixed per-period cost to participate in financial markets which endogenously segments the asset market. In this model, money is a return-dominated asset, but also a costless mean to smooth consumption for households who do not participate in financial markets. The contribution of this chapter is twofold. First, I show numerically that higher welfare can be achieved by increasing permanently the rate of anticipated inflation: A higher inflation rate transfers resources from creditors to debtors via the real interest rates, which improves risk sharing, in spite of the greater welfare loss implied by a higher participation rate. Second, this chapter generates an endogenous distribution of the welfare cost of inflation via its impact on the extensive margin of households' decision to participate in financial markets.

Chapter 2, joint work with Andreas Fagereng and Luigi Guiso, delivers novel insights into the life cycle pattern of households' portfolio allocation. So far, models of life cycle portfolio decisions with labor income uniformly predict that investors should reduce their portfolio share in stocks as they age because human capital, which acts a bond, becomes a smaller component of total household wealth. Despite the fact that the prediction rests on an undisputed fact - the shrinking pattern of human wealth over the life cycle - it has not yet found empirical support. We study the life cycle portfolio allocation using a random sample of 75,000 households drawn from the Norwegian Tax Registry followed over 14 years which contains exhaustive and error-free information on all components of households' investments.

We find that both participation in the stock market and the portfolio share in stocks have important life cycle patterns. Participation is limited at all ages but follows a hump-shaped profile which peaks around retirement; as households retire and begin decumulating wealth, they start exiting the stock market. The share invested in stocks among the participants is high and flat for the young but investors start reducing it slowly as retirement age gets closer. Our data suggest a double adjustment as people age: a rebalancing of the portfolio away from stocks as they approach retirement, and stock market exit after retirement. Existing calibrated life cycle models can account for the first behavior but not the second. We show that extending the models in Gomes, Kotlikoff, and Viceira (2008) and Gomes and Michaelides (2003) to incorporate reasonable per period participation costs can generate a joint pattern of participation and the risky asset share over the life cycle similar to the one observed in the data. In addition, if we add a small perceived probability of being cheated when investing in stocks, the model predicts a share in stocks much closer to the one observed in the data.

Chapter 3, joint work with Maren Froemel, studies the welfare effects of a 'redistribution policy' that takes the form of targeted transfers in an infinite horizon economy with exogenously incomplete markets and heterogeneous agents. The fiscal instrument is asymmetric and targeted in the sense that it is contingent on the asset position of the household, and differentiates between positive and negative asset holders only. We numerically assess the welfare effects of such redistribution policy, and in particular how effective imperfectly state contingent policy instruments are in alleviating distortions arising from incomplete financial markets. We show that this policy instrument can bring the economy closer to the complete market allocation, when transfer programs are pro-borrowers rather than lump-sum or pro-lenders. By crowding out the precautionary motive for holdings assets the distortions from market incompleteness are reduced. Also, we show that only a pro-borrower transfer program leads to an increase in aggregate welfare. Lastly, the effect of the redistributive policy instrument on the equilibrium interest rate and the shares of agents with positive and negative asset holdings in the population is non-monotonic.

Chapter 1

On the distributive effects of inflation

1.1 Introduction

In his paper “Inflation and Welfare” (Lucas 2000), Lucas argues that the results from the literature on the welfare cost of inflation might be flawed. He suggests that so far, the theories used to account for households’ management of cash holdings at low interest rate levels are inadequate.¹ In particular, he stresses that the extensive margin, the household’s decision to enter/exit financial markets, may be important enough to cancel out potential welfare gains from reducing inflation. In fact, a lower inflation rate reduces the cost of holding money and makes real interest bearing assets relatively less worthwhile.²

In this chapter, I address precisely this flaw and show numerically that accounting for the endogeneity of households’ decision to participate in financial markets overturns the traditional monetary policy wisdom, whereby lower inflation rates are necessarily welfare improving.

¹“There are indications, however, that theory at the level of the models I have reviewed in this paper is not adequate to let us see how people would manage their cash holdings at very low interest rates.” (Lucas 2000)

²“Recent work by Mulligan and Sala-i Martin (1996) assumes that there is a fixed cost of holding positive amounts of interest bearing securities, and that households who hold only cash do not incur this cost. In this case, if a monetary policy driving interest rates to zero were implemented, more and more households would decide not to incur this fixed cost, which is to say that fewer and fewer households would be using resources to economize on cash holdings. The presence of such cost might be undetectable in aggregate time series, yet important enough to completely negate any welfare gain from reducing interest rates from, say, 1.5 percent to zero.” (Lucas 2000)

Empirical Evidence

Empirical evidence from the household finance literature documents the low participation rates of households in financial markets across OECD economics (See Table 1.1). Mulligan and Sala-i Martin (2000) and Guiso (2003) estimate that 59% and 48% respectively of the US population hold no interest-bearing financial assets. Attempts to rationalize the low participation rates of households in asset markets have found empirical support for the fixed per-period cost hypothesis rather than the variable cost hypothesis or the fixed entry cost hypothesis (Vissing-Jorgensen 2002). Estimates of \$US 260 per year are found to be high enough to explain the non-participation of 2/3 of the non-participants. This evidence shows that the low percentage of households' participation in financial markets is a salient feature of the data and suggests that the extensive margin of households' financial decision is key to understanding the heterogeneity in portfolio holdings and thereby the welfare cost of inflation.

Table 1.1: Proportion of households investing in stocks

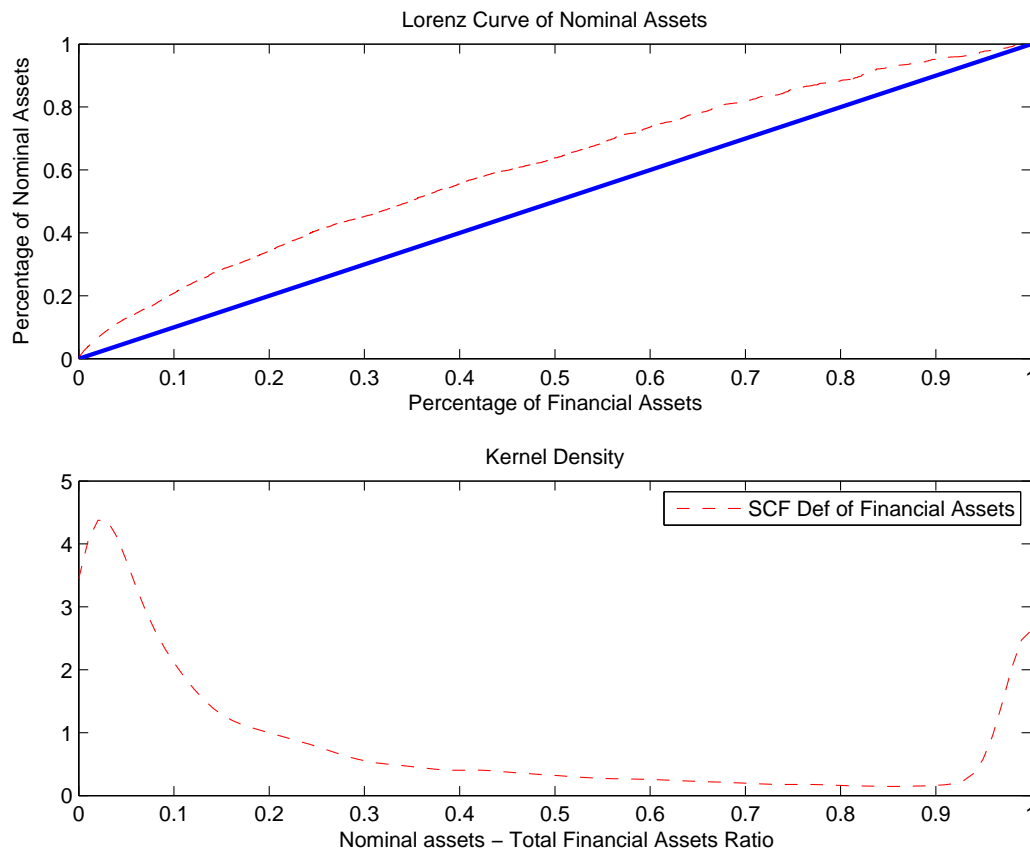
% of population	FR	DE	IT	NL	SWE	UK	US
Direct Participation	14.4	14	4	17.2	40.8	21.6	19.2
Direct and Indirect Participation	26.2	22.9	8.2	24.1	66.2	31.5	48.9

Source: Table 1 in Guiso, Sapienza, and Zingales (2008)

Beyond the low degree of participation of households in financial markets, empirical evidence suggests substantial cross-sectional heterogeneity in portfolio holdings. Based on the Survey of Consumer Finance 2007 (SCF 2007), the empirical evidence presented herein shows that the fraction of nominal assets held by households decreases with their financial wealth. Figure 1.1 shows a Lorenz curve for nominal assets, where the cumulative density function of wealth is plotted against the cumulative density function of nominal assets. The bottom 10% of households in terms of financial wealth hold 20% of the total amount of nominal assets, suggesting a higher than average holding of nominal assets. Symmetrically, the top 20% of households in terms of financial wealth hold around 10% of the total amount of nominal assets. This suggests that the exposure of households to inflation, which can be understood as a tax on nominal assets, is more than proportional for households at the bottom of the wealth distribution and less than proportional for households at the top of the wealth distribution. This observation goes along with most of the existing literature on

the distributive effect of inflation, as they usually reach the conclusion that inflation is a tax on the poor (Erosa and Ventura (2002) and Albanesi (2007)).

Figure 1.1: Empirical Evidence - Lorenz Curve of nominal assets, and Kernel Density of nominal assets to wealth ratios.



The lower graph in Figure 1.1 plots a kernel density of the ratio of nominal assets³ to financial assets for households based on the SCF 2007. The density function is bimodal, suggesting that households either hold all their financial wealth in nominal assets or very little of it. This distribution strengthens the argument in favour of the importance of fixed per-period costs to participating in financial markets. A rational household will, in an environment with a fixed cost and 2 assets (one strictly dominating the other but requiring a fixed cost), allocate all his wealth in the return-dominating asset once the fixed cost is sunk. This behaviour seems a reasonable approximation of the data, as either households do not participate in financial markets and have a high nominal asset to financial wealth ratio

³Nominal assets = Money market accounts [MMA]+Checking accounts [CHECKING]+Savings accounts [SAVING]+Call accounts [CALL]

(right mode), or they have a low nominal asset to financial wealth ratio (left mode) and hold their wealth in the return dominating asset.

In this chapter, I develop a monetary growth model that is consistent with the evidence on the heterogeneity of portfolio holdings, participation rates in financial markets and the exposure to the inflation tax across individuals. Households can choose between two assets (money and interest-bearing real bonds) with different returns and transaction cost structures to self-insure against idiosyncratic uncertainty on labor income. Money is a return-dominated asset, nevertheless a fraction of households will hold money because they do not find it worthwhile to pay the fixed per-period cost of participating in financial markets. However, with increasing wealth, the benefits of asset market participation outweigh the participation cost. Symmetrically, households have the possibility to participate in financial markets to borrow if they pay the fixed cost. An attractive by-product of the fixed cost assumption is that wealthier individuals have access to a higher net per-unit return than less wealthy individuals. The key innovation of this chapter is that the distribution of the welfare cost of inflation arises endogenously. Further, when the economy is parametrized to US data, I show numerically that raising permanently the anticipated inflation rate from say, 2 to 4 %, improves average welfare. Interestingly, I can also disentangle winners and losers from this permanent policy change as a function of their individual wealth.⁴

Related literature

The literature on the impact of transaction cost on the conduct of monetary policy was an active one in the 1990s. So far the literature on the redistributive effects of inflation focused mostly on the effects of inflation when credit is an alternative means of payment to money in economies with representative households (Aiyagari, Braun, and Eckstein 1998). In a similar environment, but allowing for agent heterogeneity, Erosa and Ventura (2002) show that the distributive effects of inflation are guided by the non-linear nature of the inflation tax: Inflation operates as a regressive consumption tax, as the exposure to the inflation tax is dependent on the level of cash purchases. Their result depends on the parametrization of the transaction technology (responsiveness of money demand to changes in the rate of inflation) and on the existence of economies of scale in the credit sector. In their environment, wealth-poor individuals are more than proportionally affected by a higher inflation rate. Albanesi (2007) builds on a similar framework to argue that low income households have

⁴All results so far ignore transitions. As far as I am aware of, there is no paper that has yet evaluates the welfare cost of inflation taking into account the transition when households are endogenously heterogeneous.

a weaker bargaining position in the determination of government policies. In equilibrium, higher inequality increases the relative vulnerability to inflation of low income households and determines a further weakening of their bargaining position, thereby reinforcing income inequality.

Imrohoroglu (1992) quantifies the welfare cost of inflation in an endowment economy, where non interest-bearing nominal assets are the only liquid assets available for self-insurance. She finds that in such an environment the welfare cost of inflation are four times higher than in environments where the welfare cost of inflation are approximated by the area under the empirical money demand curve. Algan and Ragot (2009) show that long run anticipated inflation has real effects in an incomplete market economy when agents face idiosyncratic shocks and occasionally binding constraints. They identify a hump-shaped relationship between inflation and the aggregate capital stock. On the one hand, inflation leads to increased precautionary savings by constrained households which fosters capital accumulation, on the other hand this effect is counter-acted by the redistribution of the inflation tax, which crowds out the precautionary motive.

A major flaw of the approach taken by the literature is the lack of consideration of a portfolio choice, because, as the empirical evidence outline above shows, the intensive as well as the extensive margin are key determinants of the cross-sectional distribution of portfolios.

Ragot (2010) addresses this issue and identifies key frictions that allow to reproduce the joint distribution of money, consumption and financial assets. He combines a standard Cash-In-Advance friction, and a Baumol-Tobin friction, meaning that agents incur a cost to adjust their financial portfolio, and will therefore hold money in excess of their consumption level. Ragot (2010) quantifies that the transactional motive generates 15% of total money demand whereas the Baumol-Tobin friction accounts for 85%. Whereas he focuses on the cost of adjusting a financial portfolio, this chapter focuses on per-period participation cost as suggested by the micro-econometric evidence delivered by the household finance literature (Vissing-Jorgensen 2002). Furthermore, we relax the assumption of no-borrowing, given that empirical evidence suggest that 24% of households are debt (Ábrahám and Cárceles-Poveda 2010).

This chapter motivates money solely as a financial asset and focuses on quantifying the channel of redistribution resulting from inflation via its impact on the decision to participate in financial markets. To answer this question, I embed a portfolio choice problem à la Chatterjee and Corbae (1992) into a stochastic growth model with incomplete markets.

Preview of results

The numerical results of this study show that higher inflation has three direct effects on the allocation: a distributive effect on households' wealth, via the lump-sum transfers and the inflation tax, and on the participation margin of households. As a consequence of these effects, a general equilibrium effect is triggered via the capital market clearing, and inflation fosters capital accumulation. This general equilibrium effect operates mostly through the effect of inflation on households' asset market participation threshold. In a nutshell, higher inflation lowers the wealth threshold of asset market participation which crowds-in capital via the participation margin, thereby lowering the equilibrium interest rate. The lower equilibrium interest rate reduces interest payments of debtors and lowers the return on capital of creditors. Given the technology assumptions, lower interest rates induce higher equilibrium wages which benefits on average all households, given that labor supply is inelastic. A quantitative exercise shows that at certain levels of participation cost, higher average welfare can be reached with higher inflation. This depends mostly on the wealth distribution of the economy, as indebted households are net winners of higher inflation rates, whereas creditors as well as households outside financial markets are worse-off. I find that the burden of inflation is higher for individuals at the top of the wealth distribution than for those at the bottom.

The remainder of this chapter is organized as follows. Section 1.2 presents the model economy and defines the equilibrium. In section 1.3 I parametrize the model to US data and assess its quantitative performance. Section 1.4 discusses the results and section 1.5 concludes by outlining future research.

1.2 Model

The outlined monetary growth model consists of many, ex-ante identical, infinitely lived households. Asset markets are incomplete and households self-insure against an idiosyncratic productivity risk by holding money, or interest-bearing real bonds if they pay a fixed per-period participation cost. In equilibrium, in spite of the fact that money is dominated in return, a mass of households will hold money, as long as the participation cost is positive. Conditionally on paying the participation cost, households face an economic environment identical to Aiyagari (1994). Households have an endogenous outside option from participating in asset markets as they may smooth consumption through money holdings as in Imrohoroglu (1992).

1.2.1 Preferences and Technology

At any given time, there is a unit mass of ex-ante identical, infinitely lived households. Households differ in their labor efficiency $s_t \in S = [s_{min}, s_{max}] \subset \mathbb{R}_+$ and in their cash-on-hand $x_t \in X = [x_{min}, x_{max}] \subset \mathbb{R}$. They independently draw their labor efficiency from a stochastic process defined on a measurable space with transition function given by the Markov matrix Γ .

There is one composite good produced according to an aggregate production function $F(K_t, N_t)$, where K_t is the aggregate capital stock that depreciates at rate δ and N_t is the aggregate labor in efficiency units. The composite good can either be used for consumption or for investment purposes and technology is guided by the following assumptions.

Assumption 1.1 *For all $K_t, N_t \geq 0$, F satisfies (i) constant return to scale (ii) diminishing marginal returns with respect to the two factors, (iii) $\partial^2 / \partial K_t \partial N_t > 0$, (iv) Inada Conditions hold.*

The preferences of a household are given by the expected value of the discounted sum of utility derived from consumption.

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^i)$$

where $0 < \beta < 1$ is the discount factor and c_t^i individual consumption level at time t . I make the following assumption on preferences.

Assumption 1.2 *For any given c_t^i , $U(\cdot)$ is strictly increasing, concave and differentiable.*

1.2.2 Central Bank

The Central Bank sets μ_t the growth rate of the nominal money stock, which is denoted by \tilde{M}_t . It is assumed that the central bank has perfect control over the inflation rate. The law of motion of the aggregate nominal money stock reads:

$$\tilde{M}_{t+1} = (1 + \mu_t) \tilde{M}_t$$

Seigniorage revenues are redistributed in a lump-sum fashion to all households. Furthermore, it is assumed that government spending G_t amounts to nil. The government budget constraint expressed in real terms reads as follows.

$$G_t = -\tau_t + \frac{\tilde{M}_{t+1} - \tilde{M}_t}{P_t} = 0$$

After rearrangements, we get the following expression for lump sum transfers.

$$\tau_t = \frac{\mu_t}{1 + \pi_t} M_t$$

where M_t denotes the real money stock.

1.2.3 Markets

Factor markets are competitive, the rental rate on capital is denoted by r_t and the real wage per efficiency unit by w_t .

The purchase of an interest-bearing real asset in period t of value a_{t+1} means that the household entered into a financial contract with a firm which promises $a_{t+1}(1+r_{t+1})$ in period $t+1$. For the financial agency to take place and repayment to be assured, it is assumed that a fixed per period cost q is levied onto the household. This is independent on whether she is lending or borrowing.

Alternatively, households can store their wealth in money. If households decide in period t to hold an amount m_{t+1} of money holdings, they are exposed to an inflation tax, as in period $t+1$ the real value of the real wealth transfer is $\frac{m_{t+1}}{1+\pi_t}$, where π_t denotes the inflation rate.

1.2.4 Decision Problems

The timing of the economy is as follows. (i) idiosyncratic shocks s_t are drawn, (ii) capital and labor are rented, and production takes place, (iii) household decide on asset market participation and on borrowing/savings decisions, and (iv) consumption of the composite good takes place. In the following, I will focus on steady state equilibria, where $w = w_t$, $r = r_t$ and $\pi = \pi_t$.⁵

Households

The households' budget correspondences $\mathbb{B}_{x,s,1'}$ depend on the exogenous state s , on the endogenous state x and on endogenous aggregate prices r, w . Moreover, it depends on the decision to participate in the asset market $\mathbf{1}'_{a \neq 0} = \{0, 1\}$, where $\mathbf{1}'_{a \neq 0} = 1$ denotes the decision of the household to participate in the asset market, and $\mathbf{1}'_{a \neq 0} = 0$ the decision to remain outside the asset market.

⁵For the sake of notational clarity the following recursive formulation of households' decision problem denotes any period t variable x_t by x and any period $t+1$ by x' .

1. If a household has productivity s and has been outside the asset market $\mathbf{1}_{a \neq 0} = 0$ and decides to remain outside the asset market $\mathbf{1}'_{a \neq 0} = 0$, then

$$\mathbb{B}_{x,s,0}(r, w) = \{c \in \mathbb{R}_+, m' \in \mathbb{M}, a' = 0 : c + m' \leq sw + \frac{m}{1 + \pi} + \tau\} \quad (1.1)$$

2. If a household has productivity s and has been outside the asset market $\mathbf{1}_{a \neq 0} = 0$ and decides to enter the asset market $\mathbf{1}'_{a \neq 0} = 1$, then

$$\mathbb{B}_{x,s,1}(r, w) = \{c \in \mathbb{R}_+, m' \in \mathbb{M}, a' \in \mathbb{A} : c + q + a' + m' \leq sw + \frac{m}{1 + \pi} + \tau\} \quad (1.2)$$

3. If a household has productivity s and has been participating in the asset market $\mathbf{1}_{a \neq 0} = 1$ and decides to remain in the asset market $\mathbf{1}'_{a \neq 0} = 1$, then

$$\mathbb{B}_{x,s,1}(r, w) = \{c \in \mathbb{R}_+, m' \in \mathbb{M}, a' \in \mathbb{A} : c + q + a' + m' \leq sw + (1 + r)a + \frac{m}{1 + \pi} + \tau\} \quad (1.3)$$

4. If a household has productivity s and has been participating in the asset market $\mathbf{1}_{a \neq 0} = 1$ and decides to exit the asset market $\mathbf{1}'_{a \neq 0} = 0$, then

$$\mathbb{B}_{x,s,0}(r, w) = \{c \in \mathbb{R}_+, m' \in \mathbb{M}, a' = 0 : c + m' \leq sw + (1 + r)a + \frac{m}{1 + \pi} + \tau\} \quad (1.4)$$

Define \mathbb{Y} to be all possible $(a, m, s, \mathbf{1})$ tuples. Given that only households participating in the asset market can hold debt, and that money can only be held in positive amounts, then $\mathbb{Y} \equiv \{A \times M \times S \times \mathbf{1} = 1\} \cup \{0 \times M \times S \times \mathbf{1} = 0\}$, where $A \in [a_{\min}, \infty)$, $M \in \mathbb{R}_+$, and a_{\min} is an exogenous borrowing limit.

Setup of household's decision problem

Let $v_{x,s}(r, w)$ denote the expected lifetime utility of a household with cash-on-hand x and productivity s , that faces prices r, w and let $v(r, w)$ be the vector $\{v_{x,s}(r, w) : (x, s) \in S \times X\}$ in the set \mathbb{V} of all continuous functions $v : S \times X \rightarrow \mathbb{R}$.⁶

I reformulate the household optimization problem in terms of a vector-valued operator $(TV)(r, w) = (TV)(x, s; r, w) : (x, s) \in S \times X$, which yields the maximum lifetime utility achievable.

Dwasefinition 1.1 For $v \in \mathbb{V}$, let $(TV)(x, s; w, r)$ be defined as follows:

⁶For details on the state space reduction, see Annex 1.6.2.

1. For $X \in X^{out}$ and $\mathbb{B}^{out} \equiv \mathbb{B}_{x,s,0}(r, w) \cup \mathbb{B}_{x,s,1}(r, w)$ (See household decision problem 1.2 and 1.1),

$$(Tv^{out})(x^{out}, s) = \max_{c, x' \in \mathbb{B}^{out}} U(c) + \beta \int v(x', s') \Gamma(s, s') \quad (1.5)$$

2. For $X \in X^{in}$ and $\mathbb{B}^{in} \equiv \mathbb{B}_{x,s,0}(\pi, r, w) \cup \mathbb{B}_{x,s,1}(r, w)$ (See household decision problem 1.3 and 1.4),

$$(Tv^{in})(x^{in}, s) = \max_{c, x' \in \mathbb{B}^{in}} U(c) + \beta \int v(x', s') \Gamma(s, s') \quad (1.6)$$

3. For $X \in X^{out}$ and $\mathbb{B}^{out} \equiv \mathbb{B}_{x,s,0}(\pi, r, w) \cup \mathbb{B}_{x,s,1}(r, w)$

$$(Tv)(x, s) = \max_1 ((Tv^{in})(x, s); (Tv^{out})(x, s)) \quad (1.7)$$

The household decision problem involves a discrete choice and $T(v^*)$ delivers the optimal policy correspondence instead of a function. The measurable selection theorem (Theorem 7.6, Stokey, Lucas, and Prescott (1989)) guarantees the existence of measurable policy functions for consumption $c(x, s)$, asset holdings $a'(x, s)$, real money holdings $m'(x, s)$, and the participation decision $\mathbf{1}_{a \neq 0}(x, s)$. The policy functions can be mapped from the wealth policy function $x'(x, s)$ given the participation thresholds.

The optimal policy correspondence P for the participation decision can be derived as follows.

$$\mathbf{1}_{a \neq 0} = \begin{cases} 1, & \text{if } \bar{x} \in X_p, \\ 0, & \text{otherwise.} \end{cases} \quad (1.8)$$

where $X_p \equiv \{\bar{x} : V_{\bar{x},s}^{in} > V_{\bar{x},s}^{out}\}$.

Firms

The representative firm faces a static optimization problem and maximizes profits. The necessary conditions for profit maximization imply the following prices for capital and labor.

$$w = F'_L(K, \bar{L})$$

$$r + \delta = F'_K(K, \bar{L})$$

where w , and r denote the real wage and real interest rate.

1.2.5 Equilibrium definition

Dwasefinition 1.2 *Given a borrowing limit a_{min} , a positive fixed cost q and an exogenous money growth rate $\mu \in \Pi$, a stationary monetary competitive equilibrium is a set of strictly positive prices w, r , strictly positive quantities of aggregate capital K and aggregate real money M , decision rules $a'(x, s), m'(x, s), \mathbf{1}_{a \neq 0}(x, s)$ and a probability distribution $\lambda(x, s)$ such that:*

1. *The prices (w, r) satisfy the static optimization problem of the representative firm.*
2. *The policy functions $c(x, s), a'(x, s), m'(x, s), \mathbf{1}'_{a \neq 0}(x, s)$ solve the household's maximization problem.*
3. *The probability distribution $\lambda(x, s)$ is a stationary distribution s.t.*

$$\lambda(x', s') = \int_s \int_x \lambda(x, s) \Gamma(s, ds')$$

4. *The asset market clears.*

$$\int_x \int_s \lambda(x, s) \mathbf{1}_{a \neq 0}(x, s) a'(x, s) = K$$

5. *The money market clears.*

$$\int_x \int_s \lambda(x, s) (\mathbf{1} - \mathbf{1}_{a \neq 0}(x, s)) m'(x, s) = M$$

6. *The commodity market clears.*

$$K + C + q \int_s \int_x \mathbf{1}_{a \neq 0}(x, s) \lambda(x, s) = F(K, L) + (1 - \delta)K$$

7. *The Central bank budget constraint is satisfied.*

$$\tau = \frac{\pi}{1 + \pi} M$$

By Walras law, the commodity market will clear when the money and capital markets are in equilibrium.

The existence of a steady state is given under some restrictions on prices. Since K is strictly positive, the measure of asset market participants needs to be non-empty. For this to be always true, a lower bound on the steady state inflation is necessary.

Lemma 1.1 *For a steady state to exist such that $K > 0$, given that $q > 0$, the choice set of the Central Bank needs to be restricted. By applying a no-arbitrage argument, equilibrium existence requires $\pi_{min} > -\frac{r-q/x'}{1+r-q/x'}$.*

Henceforth, the Friedman Rule $-\frac{r}{1+r}$ can by construction not be implemented in this model. In other words, for a monetary equilibrium to exist in accordance with definition 1.2, the Central Bank's set of inflation rate has to be restrained so as to exclude inflation rates generating an empty set of households not-participating in financial markets.

1.3 Benchmark Economy

The following section justifies the choice of parameters, compares steady states and exposes the key mechanisms of the model. The strategy to parametrize the economy is to calculate equilibria for a combination of fixed cost and inflation rate. Amongst those equilibria, the benchmark economy is the one that best matches the wealth distribution, the household debt structure and participation rates, with the stylized facts mentioned in Section 1.1.

1.3.1 Parametrization

The time period of the model is assumed to be one year. The time discount rate β is chosen so as to generate an annual real interest rate around 4%. Preferences are of the CRRA type $U(c_t) = \frac{(c_t^i)^{1-\sigma}}{1-\sigma}$ with a risk aversion parameter of $\sigma = 2$. The production function is assumed to be of the Cobb-Douglas type. The technology parameter α is chosen so as to match the labor share of 0.64 in the US data. The depreciation rate δ and the discount factor β are set to match the annual investment to capital ratio of 3. These parameters are standard in the macroeconomic literature. Finally, inflation is set to 3%, close to the post World War II average of US inflation.

Table 1.2: Technology and preference parameters

β	σ	α	δ	ρ	σ
0.96	2	0.36	0.08	0.6	0.2

The process guiding idiosyncratic labor productivity shocks is taken from Diaz, Pijoan-Mas, and Rios-Rull (2002). It is an AR(1) process with an autocorrelation of 0.6 and a

coefficient of variation of the normally distributed error term of 0.2. The process is discretized using the Tauchen (1986) method.

Table 1.3: Baseline parametrization for a 1 year model period

Variable Description	Source	US Data	Model
Unsecured debt to Income ratio	Hurst and Willen (2007)	36%	31%
Share agents in debt	Ábrahám and Cárceles-Poveda (2010)	24%	22%
Non-Participation rate	Vissing-Jorgensen (2002)	50%	7%
M2 / GNP	FRED II Database 2007	44%	.6%
Fixed cost / mean total income	own calculation	.5%	2%
Asset Gini Index	Ríos-Rull, Corbae, and Chatterjee (2007)	.78	.73
Wealth Gini Index	Díaz-Giménez, Quadrini, and Rios-Rull (1997)	.80	.72
Financial sector (%GNP)			1.5%

Table 1.3 shows the quantitative performance of the model. The model matches relatively well the Gini indices for wealth and asset holdings. These results are in contrast to the Gini indices usually obtained in Bewley economies. Usually these models deliver a Gini of wealth of around .4 (.38 in Aiyagari (1994)). This could be explained by the fact that, in contrast to Aiyagari (1994), this model allows for borrowing. It could also be understood as the importance of the extensive margin to account for wealth inequalities. Moreover, the heterogeneity in returns net of fixed cost is, I presume, also an ingredient behind the good match of the wealth inequality. Disentangling which one of these assumption drives this result seems a promising alley of research. I leave this point out for further research.

In addition, the model performs well in matching the debt structure of the household sector, in particular the amount of unsecured debt relative to income. Using 1999 PSID data, Hurst and Willen (2007) report that the mean of unsecured debt held by households amounts to 36% of their average income. The model should therefore capture well the impact of a change of anticipated inflation on households' wealth and consequently the distributive effects of inflation.

The model does not match the empirical evidence on asset market participation well: compared to the 48% of financial market participation in the US data (see Table 1.1), the benchmark model delivers an asset market participation rate of 92%. Moreover, this is achieved with a fixed cost that is four times higher than the empirical evidence. For the fixed cost, I take the estimate of Vissing-Jorgensen (2002) of \$US 260 and divide it by annual median annual household income in the US which amounts to \$52,000.⁷ According to Vissing-

⁷Source: 2008 dollar, U.S. Census Bureau, <http://www.census.gov>

Jorgensen (2002), this level of fixed cost explains 2/3 of non-participation. With a cost four times as high of approximately \$1000 she explains the whole non-participation observed in US data. Under this baseline calibration, the model can only explain just under a fifth of non-participation, as defined in the micro-econometric literature. However, it is important to note that the household finance literature considers only households with positive net wealth. In the above model, as we try to discern real from nominal assets, households who borrow unsecured debt are accounted for as asset market participants, which is not the case in the household finance literature (see Vissing-Jorgensen (2002) for example). This point will be discussed further in section 1.3.2.

The purpose of this chapter being to assess the redistributive effects of inflation, it is essential to map the measure of households' asset demand into the corresponding monetary supply counterpart. Table 1.4 compares money stocks, as defined by the Fed, with the measure of liquid assets, as measured in the SCF 2007.

Table 1.4: Money measure defined

	Federal Reserve data			SCF data
	M0	M1	M2	Liquid assets [LIQ]
Notes and currency	+	+	+	
Demand deposits at commercial banks		+	+	+
Other checkable deposits		+	+	
Savings deposits			+	+
Small denominations time deposits			+	
Balances in retail money market fund			+	+

Source: Federal Reserve Statistical Release H.6. Money Stock Measures (2010) & Survey of Consumer Finances (2007)

The appropriate money supply measure seems to be M2 for two reasons. Firstly, this chapter looks at the store of value motive for holding money (savings deposits and demand deposits) which is not captured in M0 and only partially in M1. Secondly, this chapter tries to understand how the intensive margin of the asset market participation decision matters for the measure of the welfare cost of inflation. Asset market participation amounts to holding assets which bear/or cost interest payments and mostly pay-out in real terms (in particular equity, or unsecured debt), in contrast with return-dominated deposit, which pay-out in nominal terms. The M2/GNP ratio in Table 1.3 is computed using the FRED II database. Under this calibration, money for sole store of value purposes accounts for 0.6% of GNP. This

model only motivates money for its store of value, therefore the ambition is not to match the monetary aggregates, as the model disregards other key motives for holding money, in particular the transaction motive.

Overall, the model performs well in mimicking the debt structure of the economy and the heterogeneity of household financial wealth and asset holdings, however it fails to generate enough money demand so as to match statistics on monetary aggregates. In the next section, I show that accounting for the way asset market participation is defined in this model environment and matching it with the data from the SCF 2007, the model outcomes improve substantially and lie quite close to cross-sectional evidence.

1.3.2 Robustness of parametrization

In the following subsection, I show how robust the crowding-in effect and the Tobin effect are for different combinations of fixed cost and inflation rate.

Asset Market Participation

Figure 1.2 plots the share of agents remaining outside the financial market, who smooth consumption with real money holdings, for various levels of participation cost and inflation rate. When the participation cost is high, a higher equilibrium inflation rate crowds households into the asset market leading to a crowding-in of savings. Thereby, the increase in the tax rate, here inflation, crowds investment into the production sector, via the extensive margin. For higher inflation rates, the threshold of participation as a function of cash-on-hand is lower, inducing a higher mass of household to bear the participation cost. This crowding-in effect is stronger, the higher the participation cost.

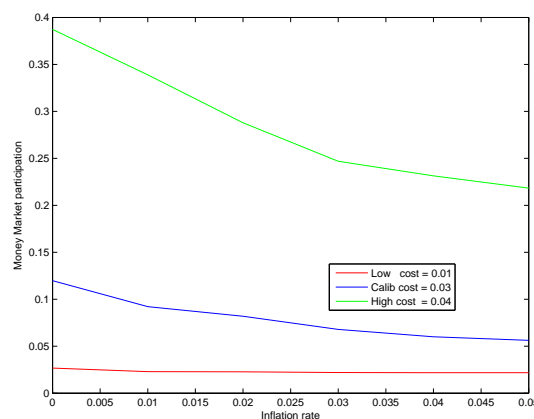


Figure 1.2: Non participation rates

In the household finance literature and in particular in Vissing-Jorgensen (2002) asset market participants are defined as households with positive financial asset holdings who hold directly bond or equity. To evaluate the performance of the model with regard to the extensive margin, it is important to assess whether the findings of the household literature are robust to the model definition of asset market participation. In this model, asset market participants are allowed to borrow, and households are not required to hold assets directly, but what matters is their holding of assets which pay out in real terms. I adjust the wealth measure given by the SCF to include unsecured debt and a wider notion of asset holdings (direct and indirect). The bi-modal behaviour of the density function and the shape of the Lorenz curve from Figure 1.1 are robust to the model definition of financial wealth. In addition, the steady state statistics of asset market participation are closer to the empirical evidence. Based on the SCF 2007, Table ?? documents evidence on asset market participation as defined in the above model: asset market participants are households who either hold financial assets beyond liquid assets, and/or hold some unsecured debt.

Table 1.5: Cross-sectional Statistics for Asset Market Participation (% population)

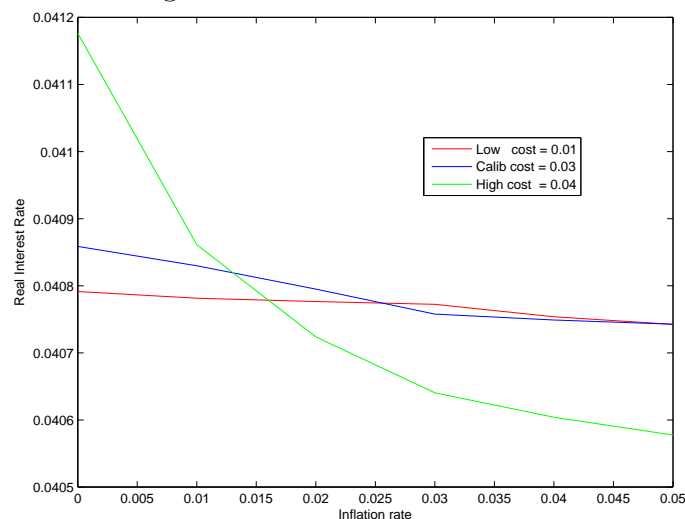
Description	<i>Data</i>		<i>Model</i>
	Literature	Model	Outcome
Asset Market Participants	44	88	93
Participants (Unsecured debt)		66	
Participants (Non liquid financial assets)		72	
Non-Participants	56	12	7

Source: Survey of Consumer Finances (2007)

Contrasting the above figure of 88% of asset market participation with the model outcome of 92%, shows that the match of asset market participation is actually quite good. Hence with a fixed cost, amounting to 2% of annual income, I can generate an asset market participation rate in line with cross-sectional evidence.

Tobin effect

Figure 1.3: Mundell-Tobin effect



The existence of participation cost gives rise to the Mundell-Tobin effect, via the extensive margin of the asset market participation decision. As Figure 1.3 shows, an increase in the equilibrium money growth rate crowds agents out of the money market, and consequently raises the share of agents incurring the participation cost. Rather than smoothing consumption with a government supplied financial instrument, a share of households switches and smooths consumption with a privately supplied financial instrument that is used to finance production. The crowding-in effect of monetary policy leads to an increase in capital supply, which lowers the return on capital.

When comparing steady states, one result of this chapter shows that "anticipated inflation is likely to raise (lower) the money rate of interest by less than the rate of inflation (deflation) itself" (Mundell 1963). The failure of the Fisher equation to hold at the aggregate level implies that monetary policy affects the equilibrium allocation. As emphasized by Tobin (1965), in this model, "[t]he equilibrium interest rate and the degree of capital intensity are in general affected by monetary supplies and portfolio behavior, as well as technology and thrift" (Tobin 1965), implying that the classical dichotomy does not hold.

1.4 Results

In this section, I present findings on the aggregate and individual effects of inflation, and focus on the welfare impact of permanently modifying the long term inflation rate.

1.4.1 Positive role of inflation

At the aggregate level, raising the inflation rate has positive effects on the capital stock and output (see Figure 1.4). The key mechanism is the extensive margin of asset market participation. In an environment with higher inflation, the wealth threshold for which households are indifferent between participating and not participating is lower, because of a higher inflation tax. Hence households are more willing to pay to enter financial markets and to hedge against this tax. Resources are thereby channelled into production, which in equilibrium lowers the economy wide interest rates, and raises wages.

The general equilibrium effect of inflation are illustrated via four policy experiments in Table 1.6. Taking as benchmark inflation rates 2 and 3 %, the table shows how the equilibrium allocation is affected by a permanent change of inflation (+/- 2%). A lower inflation target has greater quantitative impact than a higher inflation rate. Changing the inflation rate from say, 2 to 4 %, crowds households in financial markets (.01%), thereby lowering the amount of money held (-33%), and leading to a higher steady state level of capital (.025%).

Table 1.6: Aggregate effects (% change) of changes in monetary policy

$\Pi_{Benchmark}$	Π_{Policy}	ΔK	ΔY	$\Delta \mathbf{1}$	ΔM	$\Delta \Upsilon$
3	5	0.025	0.009	0.012	-33.434	0.046
3	1	-0.277	-0.100	-0.024	86.304	-0.268
2	4	0.023	0.008	0.022	-47.955	0.137
2	0	-0.185	-0.067	-0.038	115.663	-0.100

The desirability of policies is evaluated based upon a Utilitarian welfare criterion that measures ex-ante welfare.

$$\Upsilon = \int_x \int_s V(x, s) d\lambda(x, s) \quad (1.9)$$

where Υ denotes the expected value function of households. Following this criterion, raising the inflation target from 3 to 5% increases welfare by .046% and from 2 to 4% by .137%.

Figure 1.4: Welfare across steady states

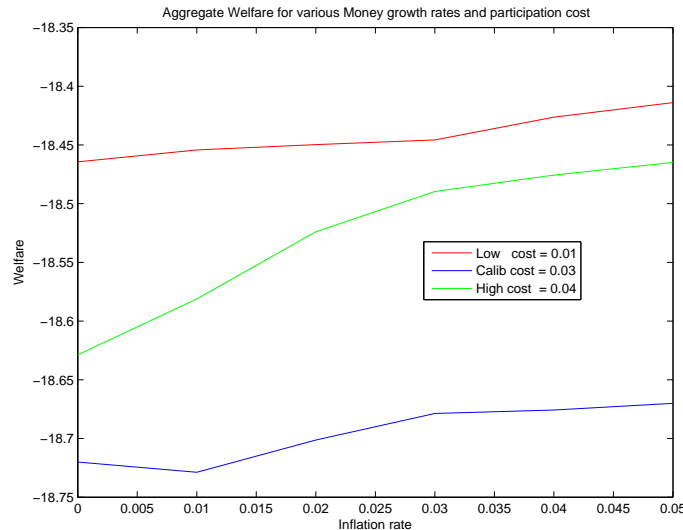


Figure 1.4 shows the robustness of the result, and strengthen the result according to which monetary policy improves welfare for basically all level of fixed cost considered, and that the magnitude of its impact increases with the level of the participation cost.

Overall, accounting for the extensive margin of households portfolio allocation overturns the conventional theoretical wisdom according to which low inflation is welfare improving.⁸ This result suggests the model presented in the chapter gives some foundations to the point raised by Lucas Lucas.

1.4.2 Distributive effects of inflation

In the model economy, the extent to which households are affected by inflation depends on their wealth and on whether they participate in the asset market. Households remaining outside the asset market are affected directly via the inflation tax on their inter-temporal wealth transfer. Households participating in financial markets are only indirectly affected via equilibrium prices for capital and labour.

⁸This result has to be nuanced by the fact that we do steady state comparison and do not take into account transitional dynamics. However, transitional dynamics for monetary in models with heterogeneous agents, is an uncharted field of research, as explained in the conclusion.

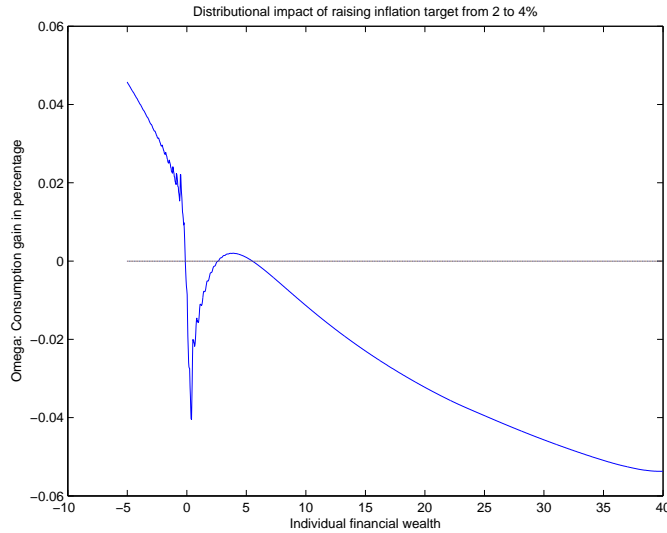
I calculate the variation in consumption that makes households indifferent between the economy defined by the proposed monetary policy and the benchmark economy. The variation in consumption is denoted by ω :

$$\omega(x) = \left(\frac{\int_s V_{policy}(x, s) d\lambda_{policy}(s)}{\int_s V_{benchmark}(x, s) d\lambda_{benchmark}(s)} \right)^{\frac{1}{1-\sigma}} - 1$$

where $V_{policy}(x, s)$ is the value function prevailing at the equilibrium with the new inflation rate, $V_{benchmark}(x, s)$ is the value function prevailing at the equilibrium with the initial inflation rate, and $\lambda_{policy}(x, s)$, $\lambda_{benchmark}(x, s)$ denote the respective stationary distribution of wealth for both equilibria.

Figure 1.5 plots the Consumption Equivalent ($\omega(x)$) effect of raising anticipated inflation from 2 to 4 percent as a function of individual financial wealth. Households with negative net wealth benefit most from an increase in the inflation rate, via the indirect effect on the real interest rate. Households who remain outside financial market are directly affected by the inflation tax, and are worse-off when the inflation rate is raised. Finally, creditors are also indirectly affected by the change in inflation rate via the equilibrium interest rate which is lower. The wealthier the household lending to firms, the more his consumption is lowered, the higher his consumption equivalent loss of welfare.

Figure 1.5: Consumption Equivalent effect of increasing inflation target from 2 to 4 percent



Beyond the individuals effects of inflation mentioned via the interest rates, a higher inflation rate also redistributes wealth from households whose wealth depends highly on returns to capital (creditors), to households whose income is mostly composed of wage income

(debtors). Given that labor supply is exogenous in this framework, each households benefits in absolute terms equally from the wage increase, but in relative terms household with high labor income to wealth ratio are net winners. Therefore in this model, higher inflation reduces wealth inequalities.

1.5 Conclusion and Way forward

This model provides new quantitative insights regarding the distributional effects of anticipated inflation. It complements the view according to which inflation acts as a tax on the poor (Erosa and Ventura 2002), and shows that inflation penalizes creditors as well as agents who do not participate in financial markets, but is a boon to borrowers. It strengthens the widely acknowledged wisdom that inflation tends to favour debtors rather than creditors.

The interaction of three effects whose impact varies along the distribution of households will determine the net effect of inflation on welfare. Firstly, inflation taxes agents who smooth consumption with nominal assets. Secondly, inflation indirectly affects asset market participants, by crowding households in the asset market, and thereby lowering (increasing) the wealth of households with long (short) positions on the asset market. Finally, the crowding-in of savings, lowers the price of capital and thereby increases wages, which benefits all agents.

To conclude, I mention my plans for future research. In order to quantitatively disentangle the mechanisms, one needs to account for welfare changes along the transition path, following a change in the money growth rate. Steady state comparisons can deliver a very misleading welfare analysis as emphasized in the fiscal policy literature by Domeij and Heathcote (2004). They have quantified the welfare implications of fiscal policy on the transition path, and identified that substantial redistribution occurs during the transition which mitigates the welfare gains traditionally associated with the elimination of capital income taxation (Chamley (1986) and Judd (1985)).

Given the evidence delivered by this chapter, similar redistribution is likely to occur after changes in monetary policy, and accounting for these effects could further offset the welfare gains from the implementation of the Friedman Rule.

1.6 Appendix

1.6.1 Algorithm

Algorithm 1.1 (H) *Exogenous inflation rate π and fixed cost q .*

Step 1: Initial guess on M_{start} and r_{start}

Step 2: Discretization of the state space $n \times X \times n$.

Step 3: Value function iteration - see graphs below.

Step 5: Track back decision rules, and obtain policy functions. - see graphs below

Step 6: Obtain ergodic distribution over (x, s) .

Step 7: Calculate capital holdings, money holdings M_n , and corresponding interest rate r_n .

Step 8: If $|r_n - r_{n-1}| < \epsilon$ and $|M_n - M_{n-1}| < \epsilon$ stop; else step 9.

Step 9: Update initial guesses for M and r with dampening.

1.6.2 Reduction of the state space

Based on the two below Lemma 1.2 and 1.3, the state space can be reduced. Let $x \in X$ denote an agent's cash-on-hand at time t .

Lemma 1.2 *It is suboptimal for asset market participants to hold money.*

Lemma 1.3 *As we disregard default and given that households can hold negative net asset positions but cannot go short on money, there exists a solvency constraint on money market participants. This solvency constraint takes the form of a wealth limit beyond which indebted asset market participants cannot exit the asset market and enter the money market. This constraint fixes the lower bound of the state space of decision problem 1.4.*

$$a_{min}^{\mathbf{1}_{a \neq 0} = 1} = -\frac{sw + \tau}{1 + r}$$

Given Lemma 1.2 and Lemma 1.3, I construct the state space for all possible (x, s) tuples. Let's define $X \equiv A \times M$ and $A_{min}^{out} \equiv [a_{min}^{\mathbf{1}_{a \neq 0} = 1}, \infty)$.

The state space of asset market participants $Y^{in} = \{X \times S \times \mathbf{1}\}$. For asset market outsiders, given Lemma 1.3 $Y^{out} = \{X^{out} \times S \times \mathbf{1}\}$.

Chapter 2

Portfolio choice over the life-cycle

With Andreas Fagereng & Luigi Guiso

2.1 Introduction

Over the past 10 years a number of contributions have re-examined the life cycle behaviour of investors' portfolio. Inspired by empirical findings from novel microeconomic data on households portfolios, several papers have provided new models of the life cycle portfolio of individual investors that go beyond the seminal models of Mossin (1968), Samuelson (1969), Merton (1969) and Merton (1971).

These earlier contributions have two sharp predictions: first, even in a dynamic setting, individuals should, at all points in their life-cycle invest a share of their wealth in risky assets. That is, independently of age, all investors should participate in the stock market - an extension of the participation principle in a static setting to a dynamic context. Second, assuming complete markets and in the absence of labor income, the share invested in the risky asset should be age-invariant. Thus, the portfolio - either described by the ownership of risky assets or by their share in total wealth - exhibits no life cycle pattern. However, the absence of rebalancing over the life cycle predicted by these earlier models is not robust to the (realistic) presence of human capital. As shown by Merton (1971), the presence of tradeable human capital in a complete market setting implies that since human capital is riskless and tradeable, it plays the same role of a large endowment in riskless bonds. Hence, it creates a strong incentive to invest in risky securities when abundant, that is early in the life cycle, and to rebalance away from stocks as people get older and their human wealth shrinks. Importantly, this basic implication carries over to more complex environments that feature

non-insurability of labor income and incomplete markets, as shown by several computational models of life cycle portfolio investments reviewed in Section 2.2 that amend the Samuelson-Merton model in one or more dimensions to add doses of realism. All these models, uniformly predict that individuals should rebalance their portfolio as they approach retirement and the driving force is the life cycle pattern of human capital. On the other hand, without specific additional assumptions, they still imply that people should participate in the stock market.

In contrast to these models, microeconomic data on household portfolios seem to show two remarkable features: first, not only participation in the stock market is limited at all ages but it tends to follow a life cycle pattern - in many instances a hump-shaped one, as documented for several countries by Haliassos, Guiso, and Jappelli (2001). Second, the share invested in stocks tends to vary little with age, though in this case the specific empirical pattern is more controversial. Summarizing evidence for several countries, Haliassos, Guiso, and Jappelli (2001) argue that the age profile of the share of risky assets conditional on participation is relatively flat, though in some instances “there does seem to be some moderate rebalancing of the portfolio away from risky securities” as people age. Thus, a reasonable characterization of the empirical findings is that participation in risky assets follows a hump-shaped profile while the share invested varies little, if at all, with age. But how solid is the evidence on which they rest? The finding that people do not rebalance their portfolio share over the life cycle sounds particularly puzzling since it is implied by an indisputable fact of life - the decrease in the stock of human capital as people age.

While the lack of participation is a robust feature of the data, there are at least three reasons to doubt the empirical patterns over age in both participation and the portfolio share. First, most of the available evidence is obtained from cross sectional data. Since in a cross section one has to compare portfolio holdings from individuals of *different* ages at a point in time, one cannot separate age effects from cohort effects and thus any pattern observed in either risky assets participation or the portfolio share may not reflect a life-cycle effect, but differences across individuals in the particular cohort they belong to. Second, most studies ignore the fact that the risky portfolio share is only defined for the participants in the risky assets markets and that participation in assets markets is an endogenous choice. A third issue is that this evidence comes primarily from household surveys which are notoriously subject to measurement problems. Most importantly, measurement and reporting error may be correlated with age giving rise to age patterns even when not present (or hide them when present) in the true data. This would arise for instance if under-reporting or non-reporting of specific assets is correlated with wealth levels which in turn are correlated with age. Furthermore, since stocks are less widely held, lying about them in surveys is more likely,

because it is more difficult to detect the lie than if one lies on safe assets. Hence, erroneous age effects may appear in the portfolio shares.

One important exception is Ameriks and Zeldes (2002). They try to circumvent these problems by using a panel data of TIAA-CREF contributors covering 13 years of data.¹ Since for each individual in their sample they have observations for many periods, they can in principle distinguish between age, time and cohort effects. The data being of administrative origin, non-reporting and under-reporting of assets in the program is not a major issue. Using a variety of identifying assumptions to separate age, time and cohort effects and distinguishing between ownership of stocks and conditional shares, they conclude that a good characterization of the portfolio life cycle is one where time and age effects play an important role, the life-cycle of stock market participation is hump shaped and the conditional share in stocks shows little action over the life cycle. Thus, in their view, most of the life cycle portfolio changes take place on the extensive margin not on the intensive margin.

While their results mark a clear progress in the literature, a number of open issues related in part to the data remain. First, TIAA-CREF reports only assets contributed to the program, not the complete portfolios of these individuals. Furthermore the part left out is not negligible - retirement assets are less than 30% of total household financial assets in the 1998 SCF - and there is no obvious reason why the portfolio allocation in pension savings should be the same as the allocation in other financial assets or follow the same age profile (indeed it is not, see Guiso and Sodini (2011)). Second, the data refer to individuals and not to households. If the asset allocation is a joint family decision, this may result in distorted estimates. Third, participants at TIAA-CREF are from a selected group of the population - typically employees at institutions of higher education - which have marked different characteristics compared to a representative population sample. Since the estimated portfolio life-cycle reflects the age pattern of portfolio-relevant household (or individual) variables, such as the age profile of human capital and that of its riskiness, if these profiles differ across groups also the profiles of their portfolios will be different. Hence, they may not be a good characterization of the average investor in a population. Finally, dynamic portfolio patterns of pension assets from a defined contribution plan such as TIAA-

¹Agnew, Balduzzi, and Sundén (2003) also use a four year panel data of about 7,000 people in a 401k retirement accounts and can thus distinguish age and time effects. They find that the portfolio share is decreasing in age. But this result is obtained restricting cohort effects to zero; in addition, since they fit a Tobit model, no distinction is made between the optimal share and the participation decision. Thus it is unclear whether the pattern stems from people exiting the market or lowering their share. Since they look at allocations in a 401k plan alone, all the issues raised about the Ameriks and Zeldes (2002) data extend to their data too.

CREF may be constrained by the rules of the plan, potentially resulting in less pronounced age patterns than in overall portfolios which reflect allocations of unconstrained financial wealth.

In this paper, we try to overcome these problems. To reach this goal, we have assembled a new database drawing on administrative data from the Norwegian Tax Registry (NTR). Since Norwegian households are subject to a wealth tax, they have to report to the tax authority all their asset holdings, both real and financial, item by item at the level of the single instrument as of the end of year. We have drawn a random sample of about 75,000 Norwegian households from the 1995 population and then followed these households for 15 years up until 2009 - the latest year for which we could obtain the data. This truly unique dataset reports the complete portfolios of Norwegian people and is similar in structure and content to the one used by Calvet, Campbell, and Sodini (2007) but spans more years - a relevant feature when studying the portfolio life cycle. Being of administrative source, measurement error is minimized. The main source of non-reporting or under-reporting should stem from incentives to evade the wealth tax, but in light of the way the wealth tax is collected, tax evasion is unlikely to be an issue in Norway as we will argue in Section 2.3. Because taxes are filed individually, information on asset holdings is at the individual level but can be aggregated at the family level since a family code is available. Finally, since the whole population of Norwegian taxpayers has to report to the NTR, there is very little attrition in the panel - the only reasons to exiting it being either divorce, death or emigration to another country.

Taking into account the endogeneity of the participation decision and modelling directly cohort effects through specific variables that capture relevant experiences in individuals formative years, we find that both participation in the stock market and the portfolio share in stocks show important life cycle patterns. As in other studies, we also find a hump-shaped life cycle profile in participation (besides limited stock market participation at all ages). But we also find that conditional shares decline significantly with investors' age. Specifically, the portfolio share is high and fairly constant in the earlier and mid phases of the life cycle at a level just below 50%. As retirement age comes within households' sight - roughly 15 years before retirement - households start rebalancing their stock market share gradually but continuously by little less than one percentage point per year until they leave the job market (around age 65). During retirement investors who remain in the market keep the share at around 30% fairly flat or slightly increasing. On the other hand, participation in the stock market rises rapidly with age when young reaching a value of around 70% at age 40 and stays roughly constant until retirement age. As soon as investors leave the labor market and retire, they start exiting the stock market as well.

Our data suggest a double adjustment as people age with a very specific timing: a rebalancing of the portfolio away from stocks *before* households reach retirement; exiting the stock market *after* retirement. Existing calibrated life cycle models can account for the first behaviour but not the second. We show that extending the models by Gomes, Kotlikoff, and Viceira (2008) and Gomes and Michaelides (2003) model to incorporate reasonable per period participation costs can generate a joint pattern of participation and the risky asset share over the life cycle similar to the one observed in the data. In addition, if we add a small perceived probability of being cheated when investing in stocks, the model predicts a share in stocks much closer to the one observed in the data.

The rest of the paper is organized as follows. Section 2.2 reviews the life cycle portfolio literature highlighting its core implications for the life cycle pattern of the participation and risky portfolio share. Section 2.3 discusses the Norwegian Registry data and presents descriptive evidence of the portfolio life cycle pattern. Section 2.4 lays down the methodology for estimating the life cycle portfolio profile and presents the estimation results. Section 2.5 shows how an extended calibrated life cycle model can account for the pattern of the portfolio that we observe in the data. Section 2.6 presents the results of this paper and Section 2.7 summarizes the contribution of this paper and draws implications for future research.

2.2 An Overview of the Literature

Inspired by empirical findings from novel microeconomic data on household finances, over the past decade several papers have provided new models of optimal portfolio rebalancing over the life cycle that go beyond the seminal dynamic framework of Merton (1969), Merton (1971), Mossin (1968) and Samuelson (1969). The Merton-Mossin-Samuelson (MMS) models generate two sharp predictions. First, individuals should participate in risky asset markets at all ages - a proposition that extends the participation principle to a dynamic context. Second, the share invested in the risky asset should not vary over the life cycle. The implications of the MMS models are in contrast both with the limited participation that we observe in the data at all ages and with the widespread advice of the financial industry practitioners to invest substantially in stocks when young and reduce the exposure to the stock market when older. Yet, these earlier contributions were not meant to provide sharp predictions about realistic features of the data but rather to establish the benchmark conditions under which a long term investor would choose “myopically” - i.e. show no life cycle pattern in his investments. As Samuelson (1969) points out, “[A] lifetime model reveals that investing for many periods does not itself introduce extra tolerance for riskiness at early, or any,

stages of life". One needs the MMS assumptions of no labor income, unpredictable stock returns, constant relative risk aversion and time-separable preferences, in addition to long time horizon, to obtain that the optimal portfolio risky share does not vary with wealth and age.

In fact, as shown by Merton (1971), adding to the model tradeable human capital in a complete market setting generates a strong rebalancing motive in the financial risky share. Since human capital is riskless and tradeable, it plays the same role as a large endowment in riskless bonds. Hence, it creates a strong incentive to invest in risky securities when human capital is abundant, that is early in the life cycle, and to rebalance away from stocks as people get older and their human wealth diminishes. The simple presence of human capital - an indisputable feature of any realistic model of household portfolio decisions - seems to be enough to provide a rationale for the practitioners' advice to rebalance the portfolio away from stocks as people age.

Merton (1971)'s result is obtained in a complete market setting with tradeable human capital; this allows him to obtain neat closed-form solutions. A new recent wave of papers has reconsidered the Merton (1971) model relaxing the assumption of complete markets and tradability of human capital (see Gomes and Michaelides (2003), Gomes and Michaelides (2005); Heaton and Lucas (1997); Gakidis (1998); Haliassos, Guiso, and Jappelli (2001); Storesletten, Telmer, and Yaron (2007); Campbell and Viceira (2001); Viceira (2001); Cocco, Gomes, and Maenhout (2005); Davis, Kubler, and Willen (2006); Benzoni, Collin-Dufresne, and Goldstein (2007); Gomes, Kotlikoff, and Viceira (2008)). Because markets are incomplete and labor income is uncertain and non-tradeable, these models do not have closed form solutions and have to be solved numerically. A representative example of this literature is Cocco, Gomes, and Maenhout (2005). They develop, numerically solve and simulate a life cycle model of consumption and portfolio choice which allows for non-tradeable and uncertain labor income as well as many other features that characterize a typical household environment such as bequest motives, mortality risk, non-standard preferences, uncertain retirement income and catastrophic labor income shocks. They calibrate the labor income process on the US PSID and estimate average consumption and assets allocation by simulating the model over 10,000 households. A robust prediction of this and all the other models in this literature is that the portfolio share invested in stocks has a strong life cycle profile. Thus, Merton (1971)'s rebalancing implication holds true not only when labor income is tradeable and certain but also when it is non-tradeable and subject to uninsurable risk.²

²A declining life cycle portfolio profile may be generated also by other features than just the life cycle human capital. For instance, Bodie, Merton, and Samuelson (1992) show that accounting for endogenous

Despite that the prediction according to which households should rebalance their portfolio as they approach retirement rests on an uncontroversial fact, namely the decline in human capital as people age, it has been hard to find it in the data, as we have argued. This is likely to be the reflection of limitations in the data that we are able to overcome using the Norwegian dataset, and we find evidence that is indeed consistent with the prediction that households should rebalance their financial risky portfolio as they approach retirement.

While the shape of the age profile of the portfolio share in stocks predicted by these models resembles the one we find in the data, there are two important differences between these models' predictions and our findings. First, the new models generate much higher shares in stocks, particularly at the beginning of the life cycle and in the middle ages, than those seen in the data among the stockholders. Second, they often do not give rise to limited participation and to exit from the stock market as people age. In particular, our evidence suggests a double adjustment as people age: as they approach retirement, they rebalance their portfolio away from stocks but continue to stay in the market; after retirement they stop rebalancing but start exiting the market. Some models have addressed the issue of limited participation among the young by allowing for a once and for all fixed cost of participation (Cocco, Gomes, and Maenhout 2005), or for long run co-integration between labor income and stock market returns (Benzoni, Collin-Dufresne, and Goldstein 2007) or for costly access to the loans market (Davis, Kubler, and Willen 2006). None of these models, however, deals with exit from the stock market as people retire. Hence they cannot explain the hump shape in participation over the life cycle and the timing of rebalancing in the optimal share and in participations that we observe in the data. In addition, these models tend to predict a far too high share in stocks among the stockholders at some point over the life cycle. To better mirror the data, we propose a simple extension of the Cocco, Gomes, and Maenhout (2005) model enriched with two ingredients: a per period participation cost and a trust friction. This model is able to generate a hump shaped pattern of stock market participation that peaks at retirement and declines thereafter. This pattern is the consequence of the hump-shaped wealth age profile: when young, wealth is typically increasing and thus gradually more and more consumers will cross the wealth thresholds that triggers entry into the stock market. After retirement, people begin to decumulate assets and at some age the level of assets left

labor supply decisions can induce the young to invest more in stocks because, enjoying greater labor market flexibility act as an insurance against financial risks. Departure from CRRA utility may give rise to a downward sloping age-portfolio profile (Gollier and Zeckhauser (2002)), life cycle patterns of risk aversion and background risk, as well as predictability of stock returns (Kandel and Stambaugh (1995); Campbell and Viceira (1999), Campbell and Viceira (2002)). These may certainly contribute to induce a life cycle rebalancing motive but none is uncontroversial as instead is the life cycle of human capital.

is too low for it to be worthwhile to pay the per period cost and remain in the market, hence they exit.³ At the same time, the age profile of the share among the stockholders is relatively high and flat at young age, but as people foresee retirement, they start rebalancing the portfolio. Limited trust - modelled as an individual specific small probability that the investor is cheated and loses the money invested in stocks - helps lower the portfolio share in stocks, bringing it closer to the one observed in the data.

2.3 Data

The empirical study of household portfolio allocations over the life cycle has formidable data requirements. Ideally, one needs data on households' complete portfolio holdings over a long time span, free of measurement and reporting errors. The NTR data that we use in our empirical analysis come very close to these requirements. Because households in Norway are subject to a wealth tax, every year they are required to report their complete wealth holdings to the tax authority for the wealth tax to be levied. We merge this information with administrative records of individual demographic characteristics and information on earnings from the same source and obtain a unique panel data set spanning between 1995 and 2009.

2.3.1 The Norwegian Administrative data

Each calendar year, before taxes are filed in April, employers, banks, brokers, insurance companies and any other financial intermediary send both to the individual and to the tax authority, information on the value of assets individuals own, as well as information on the income earned on these assets. In case an individual holds no stocks, the tax authority pre-fills a tax form and sends it to the individual for approval; if no answer is given, it is perceived as an approval of the information gathered by the tax authority. In 2009, as many as 2 million individuals in Norway (about 60% of the tax payers) belonged to this category.⁴ If the individual holds stocks then he has to fill in the tax statement - including calculations of capital gains/losses and deduction claims. The statement is sent back to the

³Some exit from the stock market after retirement may occur even without a per period participation cost if households are heavily invested in stocks and liquidate stocks to finance consumptions following retirement, that is if stock is the prominent form of liquid wealth (Alan 2006). In general, however, absent participation costs, one should see a decumulation of both stocks and bonds and very little exit.

⁴See Norwegian Tax Administration annual report:
<http://www.skatteetaten.no/Upload/annual-report-2009.pdf>

tax authority which, as in the previous case receives all the basic information from employers and intermediaries and can thus check its truthfulness and correctness.⁵ Stockholders are treated differentially only because the government wants to save on the time necessary to fill in more complex tax statements and to reduce the risk of controversy due to miscalculated deductions on capital losses and taxes on capital gains. Since the early 2000's all this is done electronically, prior to 2000 tax reports were done on paper forms. This procedure and the fact that the tax authority always receives directly from the intermediaries the information on asset holdings and relative yields, makes tax evasion very difficult and thus very likely negligible.

During the sample time period, asset markets worldwide and in Norway experienced both booms and busts, and the mutual fund industry expanded significantly making it easier for many households to participate in the risky asset market, e.g. by lowering participation costs, offering cheaper diversification opportunities and spreading information about mutual fund investments. The administrative data contains information about all individuals and their demographics. The quality of this data is similar to that in the Swedish data studied by Calvet, Campbell, and Sodini (2007). Until 2007, Sweden like Norway collected taxes on both individual income and wealth. In 2007, however, Sweden abandoned the wealth tax, leaving Norway as the only Scandinavian country with this arrangement. Tax reports on both labor income and asset holdings are filed by each individual even for married couples. Data on asset holdings are reported as of December 31 of the previous year. We focus on the financial portfolio and distinguish between bank deposits, bonds, stocks (of listed and non-listed companies), mutual funds, money market funds.⁶ Following the literature, we consider a two asset-portfolio and define risky financial assets as the sum of stock mutual funds and directly held stocks; the rest - the sum of bank deposits, money market funds and bonds - is classified as risk-free (or safe) assets. A financial market participant is one that holds some positive amount in either risky or risk-free assets at the end of the year. Since some households report very few financial assets, we set a minimum of 3000NOK (approx. 480 USD (1995)). A risky asset market participant is defined as a household holding a positive amount (minimum 1000NOK - approx. 160 USD (1995)) of either stocks or stock mutual fund at the end of the year.⁷

⁵Internet brokers tend to offer to their costumers calculations of realized returns over the previous year for free.

⁶Some households also hold more sophisticated financial instruments, like forward contracts and options. These households are very few and do not affect the results of the analysis.

⁷About the use of selection requirements, see Calvet, Campbell, and Sodini (2007) and Brunnermeier and Nagel (2008).

In what follows, a household is defined as a married couple, and the age reported is that of the husband; we refer to this as the age of the household. The term "cohort" refers to the year of birth of the husband. In order to have the largest possible sample that is computationally manageable, we randomly draw a sample of about 75,000 households from the 1995 population of tax reports, and follow these households over the following 15 years, until 2009. There is a certain attrition as individuals die, migrate and divorce. These households are left out and are not replaced. Further details regarding our wealth data are provided in Halvorsen (2011).

Table 2.1: Descriptive Statistics - 1995

	Full Sample				Balanced Panel Sample			
	Obs	Mean	Std Dev	Median	Obs	Mean	Std Dev	Median
Demographics:								
Age Husband	74,711	51.26	14.15	50	48,928	47.96	11.73	47
Age Wife	74,711	48.54	14.02	47	48,928	45.33	11.48	45
Share Low Education	73,345	0.23			48,158	0.18		
Share High School Education	73,345	0.51			48,158	0.53		
Share College Education	73,345	0.27			48,158	0.29		
Household Size	74,628	3.22	1.17	3	48,888	3.42	1.17	3
Asset Holdings in USD:								
Financial Wealth	74,711	41,923	112,291	14,232	48,928	41,079	114,751	13,287
Stocks	74,711	14,029	96,685	0	48,928	15,210	99,654	0
Mutual Funds	74,711	1,284	4,056	0	48,928	1,350	4,106	0
Safe Assets	74,711	26,610	38,776	11,597	48,928	24,519	36,710	10,580
Net worth	74,711	120,354	143,051	97,543	48,928	122,045	145,279	99,174
Participant share:								
Risky Assets	74,711	0.40	0.49	0	48,928	0.42	0.49	0
Stocks	74,711	0.29	0.45	0	48,928	0.31	0.46	0
Mutual Funds	74,711	0.24	0.43	0	48,928	0.25	0.43	0
Risky Asset (min 160\$)	74,711	0.36	0.48	0	48,928	0.39	0.49	0
Mean share participants:								
Risky Assets	30,036	0.29	0.30	0.16	20,784	0.30	0.31	0.18
Stocks	30,036	0.21	0.33	0.13	20,784	0.22	0.31	0.04
Mutual Funds	30,036	0.08	0.16	0.08	20,784	0.09	0.14	0.03
Attrition:								
	26,253							
Share Death		0.62						
Share Migration		0.13						
Share Divorce/Separation		0.25						
Mean yearly attrition rate:		0.029	0.001					
Age at Exit		65.51	16.57					

Note: This table displays summary statistics for the main sample of married households in the first year of observation, 1995. In addition, the table provides summary statistics for the sample of households that remain in the panel throughout, until 2009. Where applicable, values are reported in 1995 USD.

Table 2.1 provides summary statistics for the household sample in 1995. The average age

of households is 51 years. Education attainment measured in 1995 is available for almost all the households. The most common educational attainment level is a high school diploma, which is obtained by 51% of the sample, while 26.5% hold a college degree.⁸ Although there is attrition in the sample at an average annual rate of 2.9%, we can track 2/3 of the households sampled in 1995 all the way until 2009. The main reason for exiting the sample is death of a spouse (62%), as suggests households' average age of 65 years when they exit from the sample. The average Norwegian household holds around 42,000 USD (1995) in financial assets. Net worth, comprising financial assets and real estate net of debt amounts to 120,000 USD (1995), of which about 2/3 is real estate.⁹ The financial portfolio of the average household is mostly composed of safe assets which account for 63% of the total average financial assets. Around 40% of the Norwegian population participates in risky asset markets. If we define as participant only a household with at least 160 USD (1995) of risky assets, the participation rate amounts to 36%. A closer look at the data, reveals that 29% of the population hold stocks directly, while 23% percent participate via mutual funds. Hence, back in 1995 mutual funds were not as widespread as direct stock-holding amongst Norwegian households. Among participants, the average of the portfolio share in risky assets is 29% while mutual funds account for 8% - a similar figure prevails in other European countries, as documented in Haliassos, Guiso, and Jappelli (2001). The right part of Table 2.1 displays summary statistics for the majority of households that do not drop out of our 15 year panel. The selection of the households present in all years have a lower average age back in 1995. Further, this group contains a lower fraction of households with less than high school education. The levels of asset holdings are similar across the two groups, although the balanced panel displays slightly higher holdings of risky assets. For the asset market participants of the two groups, the mean shares in risky asset classes differ only by 1 percentage point when it comes to stocks and mutual funds.

2.3.2 Portfolio Life Cycle Patterns by Cohort: Descriptive Evidence

Figure 2.1 plots the age participation profile in the risky asset markets for selected cohorts with intervals of 5 years, beginning with the cohort born in 1970 who are aged 25 in 1995, the

⁸These numbers are in line with official numbers from Statistics Norway. For 2010 data, see e.g. http://www.ssb.no/English/subjects/04/01/utniv_en/tab-2011-06-09-03-en.html.

⁹The real estate value is a proxy based on the reported tax values of Norwegian households, and is not updated every year. For our measure here, we use the reported tax value of real estate and divide by 0.25 to get an approximation, following the guidelines of the Norwegian Tax Authorities, stating that the tax value of real estate shall not exceed 30% of market value.

first sample year. Since we are able to follow each cohort for 15 years, we are able to provide a good picture of the life cycle portfolio pattern by just plotting the raw data. Consider the first cohort born in 1970. In 1995, they were 25 years old and only slightly more than 10% of them were participating in risky asset markets. However, in the following years the share of participants in this cohort increased significantly, and when this cohort reached the age of 30, more than 40% of the households held risky assets in their portfolio. Clearly, this pattern is consistent with a marked age effect (an increase in participation with age), with strong time effects (an increase in participation due to favourable market conditions, e.g. the boom of the mutual funds industry), as well as with a cohort specific pattern. If this were the only cohort observed, these effects would be hard to disentangle as time and age evolve in parallel and we only observe one cohort; we could not make any claim on whether the increase in participation rate is cohort-specific, a pure age effect, or if it reflects a common time trend that affects all cohorts in the years 1995-1999. The next plotted cohort - that of the households born in 1965 - shows also for these households a steep increase in the average participation during the first years of our sample. This suggests that the increase in participation is unlikely to be cohort specific. Yet it is still unclear whether this surge in participation rates is due to an age-effect, or to a common time trend. Comparing the evolution of participation across cohorts suggests that time effects are likely to be important; for instance, all cohorts experience a marked increase in participation during the first years of our sample, even those born in 1920 - who are 75 in 1995 - and thus typically exit risky asset markets. The graphical evidence given by Figure 2.1 suggests that cohort effects play an important role. In Section 2.4, we describe our empirical strategy to separate these effects and to test for the presence of cohort effects.

As a next step in the descriptive analysis of the life cycle patterns of participation, we consider two measures of entry into and exit from the stock market, as defined in table 2.2. These two measures are plotted in Figure 2.2 for the same selected cohorts. The first measure refers to entry (exit) in a given year, regardless of the household's past (future) participation pattern. The second, reports entry (exit) that was not preceded (followed) by a previous entry (a subsequent exit). In other words, the second measure captures first-time entry and permanent exit.

Figure 2.1: Participation shares in Risky Asset markets by Cohort

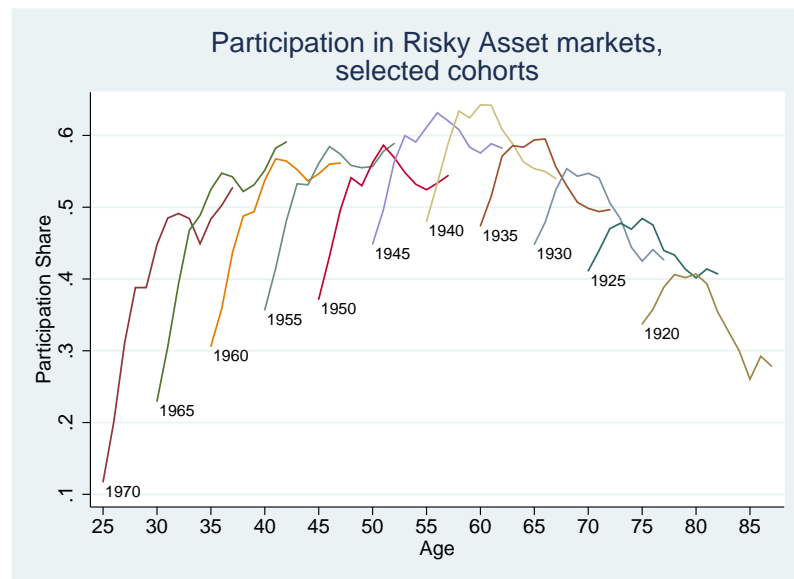


Table 2.2: Entry and Exit Definitions

Measure 1:

Entry: The fraction of households who do not hold stocks at age a that enter the risky asset markets at $a+1$.

Exit: The fraction of those who are stockholders at age a who exit the market at age $a+1$.

Measure 2:

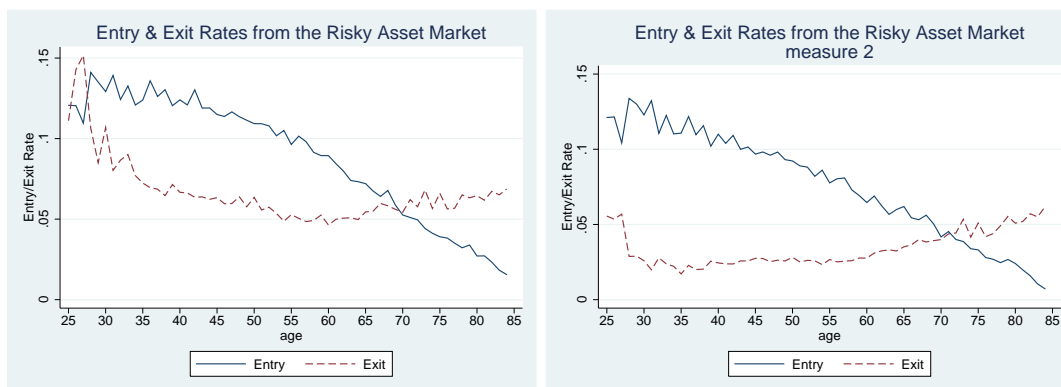
Entry: The fraction of households who **has never held any stocks** up until the age a that enter the risky asset markets at $a+1$.

Exit: The fraction of those who are stockholders at age a who exit the market at age $a+1$ and **never re-enters** the stock market.

First-time entry is very high at the beginning of the life cycle, with a peak at 13%, and drops steadily thereafter. Instead permanent exit is low at the beginning of the life cycle and increases sharply after retirement. By reporting the two measures, Figure 2.2 highlights that early in life temporary entry and exit are very common phenomena. Among households in their early 30s, 30% enter the stock market but only half of them enter for the first time. Similarly, the fraction of young households that sell all risky financial assets to

return to the stock market later in life is almost five times the fraction of households that exit permanently. These figures suggest important learning effects of early stock market experiences. Some households decide to hold stocks when young, and to exit the market permanently, after that early experience.¹⁰

Figure 2.2: Entry and Exit rates from Risky Asset Markets.



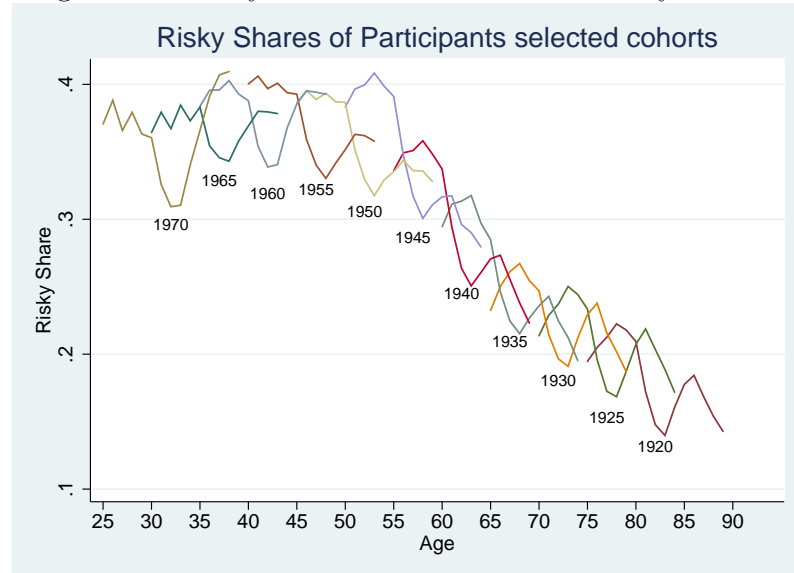
Note: This figure plots entry and exit rates into the risky asset markets. The left graph depicts entry and exit frequencies, allowing for re-entry/exits. In the right graph, entry and exit frequencies of first time entry and once for all exit are plotted.

For the same cohorts selected for Figure 2.1 and Figure 2.2, we plot in Figure 2.3.2 the risky financial share for households who participate in the stock market - that is the portfolio share conditional on participation. In what follows, we refer to it as the conditional share. To obtain a smoother picture, we have plotted centred average shares around the current age using the two adjacent years. Overall, the picture suggests that once people enter, they invest a relatively large share in risky assets and reduce it as they age. A comparison across cohorts suggests less pronounced cohort effects than the ones we observed for participation. On the other hand, comparing the pattern of the conditional share over time across cohorts reveals strong time effects. This may reflect variation in stock prices coupled with active rebalancing in response to changes in the share induced by stock price movements, as suggested by Calvet, Campbell, and Sodini (2007). Although the graphic does not give an unambiguous picture, just plotting the raw data of risky shares is quite informative in suggesting that there is substantial rebalancing over the life cycle, in particular when households approach

¹⁰Note that at low and high ages, the number of observations is limited because fewer households and of more limited stock market participation at those ages. Both in this graph and in the Figure 2.3.2 this explains the higher variability at these ages.

retirement.

Figure 2.3: Risky Share of Financial Wealth by Cohort.



Note: This figure plots the average risky shares of households' financial portfolios conditional on participation, for selected cohorts at each age they are observed. In order to smooth large market movements out of the graphs, we plot 3 years averages.

2.4 Estimation

The descriptive evidence presented so far suggests the existence of a life cycle pattern both for the participation decision, and the risky share of household's portfolio conditional on participation. Although informative for descriptive matters, we have not yet addressed the problems tied to limited stock market participation and the identification problem of age, time and cohort effects properly. In this Section, we discuss these issues, and propose a way to address them, allowing us to pin down these patterns accurately.

2.4.1 Methodology: Limited Asset Market Participation

It is a well established 'puzzle' that not all households participate in risky asset markets. Previous empirical analysis of the life cycle profile of household portfolios have ignored this issue (Ameriks and Zeldes 2002). Also theoretical models have until recently assumed that

all households participate in risky asset markets. What may cause households that “should” be in the risky asset market not to participate? Under the assumptions that households have a constant relative risk aversion (CRRA) and face some fixed cost to participate in risky asset markets, not everyone will find it worthwhile to participate.

Our empirical strategy consists in addressing this issue in a Heckman type selection model: we use a probit selection model to estimate whether or not a household participates in risky asset markets, and subsequently estimate the risky share conditional on the selection equation. We follow Vissing-Jorgensen (2002) and apply a commonly used exclusion restriction, namely households lagged net-wealth. Given CRRA preferences, higher wealth will *ceteris paribus* make a household more likely to participate in risky asset markets, as it is more likely that he can afford the participation cost, without affecting the risk aversion, thereby allowing us to observe the risky share.¹¹

2.4.2 Methodology: Proxy for cohort effects

The issue of identification of age, time and cohort effects is extensively covered in Ameriks and Zeldes (2002), but not appropriately addressed, as we argue herein. Campbell (2006) asserts that even with the perfect data set, where the researcher observes a panel of households over their entire life span, it is not possible to identify cohort, time and age effects simultaneously without further restrictions. In fact as discussed in Section 2.3, one cannot distinguish between age and cohort effects. If older people hold more stocks, it is either an age effect, or it can be due to the fact that they grew up in different times, such that they have developed different attitudes towards risk-taking (cohort effect). Given that we can observe the same household over time in a panel data setting, we can partially address this issue, but as much as it helps identifying one extra dimension, it also adds one more dimension to identify.

Berndt and Griliches (1995) solve the problem of identification in the unbreakable relationship $cohort_i = time + age_{it}$ in a non-parametric fashion, by restricting some of the age coefficients to be constant (e.g. that there is no age effect between for example age 30 to 35). In their analysis of price indexes for personal computers, this allows them to identify age, time and cohort effects separately. We build on recent research in the field of household finance which indicates that cohort effects affect individual risk taking substantially. Giuliano and Spilimbergo (2009) show that generations growing up during recessions have different socio-economic beliefs relative to generations growing up during booms. In addi-

¹¹If q is the fixed cost of participation in risky asset markets, W is a households' wealth, α is the risky share derived from the households preferences, and R^e are the excess returns of the stock market the relation $F \leq W * \alpha * R^e$ will decide if a household that period decides to participate in risky asset markets or not.

tion, Malmendier and Nagel (2011) show that households who have experienced higher stock market returns throughout their life time are more likely to participate in the stock market and, that conditional on participation, these households will invest a higher fraction of their wealth in risky assets. This evidence supports their use of the returns of S&P 500 as a proxy for cohort effects. For the purpose of our estimation, we will use stock market returns experienced during the household heads' youth as a proxy for cohort effects. In particular, we use a weighted index of the Norwegian stock market and the S&P 500 as a proxy. As we will demonstrate, these returns significantly affect both the decision to enter risky asset markets and the risky conditional share.

2.4.3 Results from estimating Life Cycle patterns

Table 2.3 reports the estimates of the selection model and shows that experienced asset market returns affect positively both the participation decision and the risky share conditioned on participation.¹² The coefficients for the age dummies of this regression are plotted in Figure 2.4.3. First, we note that these Figures represent refined versions of the raw plots of the data presented in Figures 2.1 and 2.3.2, and document a distinct hump-shaped pattern of asset market participation over the life cycle. Younger households enter risky asset markets steadily until the age of approximately 41, age at which the level of participation is stable until the age of approximately 55. From age 55 onwards, the participation rate drops almost linearly until the age of 80. The pattern for the conditional risky share is remarkably different: until age 47 the conditional risky share is stable around 39%, it then declines steadily until retirement, time at which the risky share stabilizes around 30%.

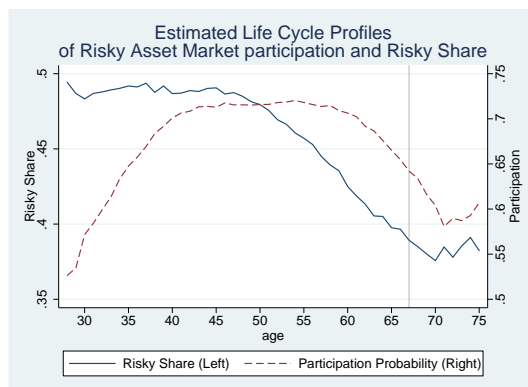
¹²In order to enable Stata to find feasible initial values, we have made a draw of 50% from our household sample to estimate the Heckman selection procedure with Maximum Likelihood. The results displayed here are those from a Heckman two-step procedure, but results are identical for both procedures.

Table 2.3: Heckman Selection Model Estimation

Risky Share (Outcome Eq):	
Youth Stock Returns	0.004 (0.002)**
Participation (Selection Eq):	
Youth Stock Returns	0.041 (0.003)***
Lag Financial Wealth	0.256 (0.006)***
athrho	
Constant	-0.503 (0.005)***
lnsigma	
Constant	-1.284 (0.002)***
Observations	418,163

Note: This table displays the estimated Heckman selection equation for asset market participation and the conditional risky share. Lagged Financial Wealth is in 100,000 USD (1995). Coefficients in the Selection Equation are calculated marginal effects from the underlying probit regression. Omitted from the table are calendar year fixed effects, whereas age dummies and marginal effects are plotted in figure 2.4.3. Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 2.4: Life Cycle Patterns of Risky Asset Market Participation & Risky Share of Financial Assets.



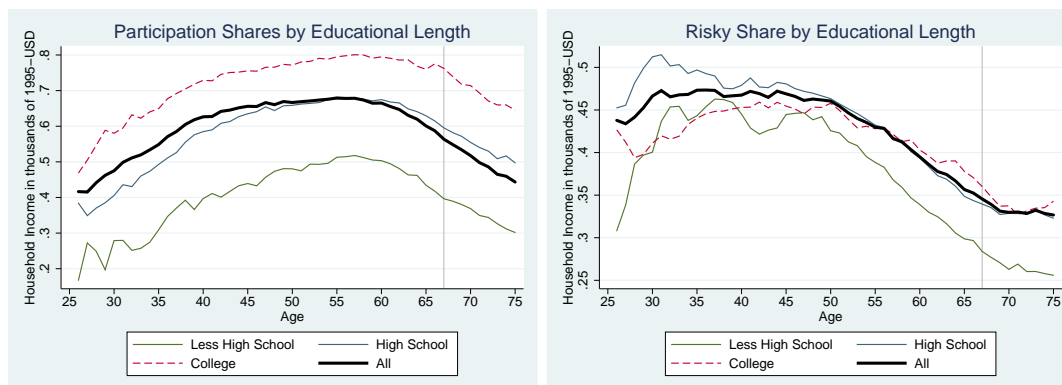
Note: This figure plots the life cycle patterns for both the Risky Asset Market Participation and the Conditional Risky Share of Financial Wealth coming from the Heckman selection equation reported in Table 2.3. For the Selection/Participation Equation, we plot the marginal values of the estimated underlying probit equation, and for the risky share, the age coefficients of the Outcome equation in the Heckman model.

Table 2.4: Heckman Selection Model by Educational Attainment

	Low	Medium	High
Risky Share (Outcome Eq):			
Youth Stock Returns	0.017 (0.006)***	-0.003 (0.003)	0.019 (0.004)***
Participation (Selection Eq):			
Youth Stock Returns	0.011 (0.005)***	0.057 (0.004)***	0.071 (0.005)***
Lag Financial Wealth	0.182 (0.002)***	0.273 (0.002)***	0.280 (0.003)***
athrho			
Constant	-0.346 (0.014)***	-0.500 (0.007)***	-0.557 (0.010)***
Insigma			
Constant	-1.397 (0.005)***	-1.280 (0.003)***	-1.253 (0.004)***
Observations	90,654	222,904	102,471

Note: The table displays the estimated Heckman selection equation for asset market participation and the conditional risky share for three levels of educational attainment. Lag Financial Wealth is in 100,000 USD (1995). Coefficients in the Selection Equation are calculated marginal effects from the underlying probit regression. Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Figure 2.5: Life Cycle Patterns of Risky Asset Market Participation by Education Level.



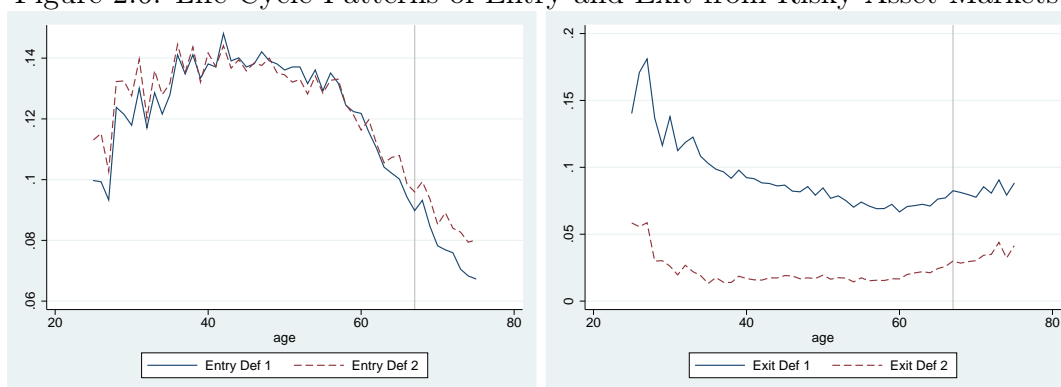
Note: These figures plot the life cycle patterns of Risky Asset Market Participation and Conditional Risky Share of Financial Wealth by educational achievement level coming from the Heckman selection equations reported in Table 2.4. The participation graphs plot the marginal values of the estimated underlying probit equations, and for the risky share it plots the age coefficients of the Outcome equation in the Heckman model.

Table 2.5: Entry and Exit Regressions

	Entry (all)	Exit (all)	Entry (first time)	Exit (forever)
Youth Stock Returns	0.009*** (0.002)	-0.005*** (0.001)	0.005** (0.002)	0.001 (0.001)
Constant	0.035 (536.209)	0.071 (518.577)	0.104 (0.086)	0.039 (384.926)
R^2	0.026	0.006	0.034	0.008
N	404,268	437,132	317,994	437,132

textitNote: This Table reports the estimates obtained from regressing the different entry and exit patterns on a set of age dummies, year dummies and a cohort proxy. Year dummies are omitted from the Table, where as the age dummies plotted in Figure 2.4.3. Standard error in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 2.6: Life Cycle Patterns of Entry and Exit from Risky Asset Markets.



Note: These figures plot the life cycle patterns of Entry and Exit, defined by two different measures in Table 2.2 used in the regressions reported in Table 2.5.

Figure 2.4.3 highlights two regimes for the age pattern of the conditional risky share. First, participating households aged between 27 and 45 hold around 40% of their financial portfolio in stocks. Second, from 64 onwards households participating in asset markets invest around 30% of their wealth in risky assets. Between the age of 45 and 64, households reduce their risky shares by about half a percentage point per year. For a matter of reference, one should bear in mind that the advice of professionals from the financial service industry to households is to reduce their exposure to risky assets by one percentage point every year. These empirical patterns are the targets of the overlapping generations model developed in

Section 2.5.

In Table 2.4, we re-ran the regression for the sample split by educational attainment, and plotted the corresponding age patterns in Figure 2.5. We note a differences in the participation probabilities, which fits well the literature on financial literacy, according to which more educated households are likely to possess also more information on risky asset markets, which will effectively reduce their cost of participation (Van Rooij, Lusardi, and Alessie 2007). However, conditional on participation, households with medium or high educational attainment have fairly similar profiles of risky asset holdings as a share of total financial wealth.

Next, we apply the same methodology to clean out year and cohort effects from the entry and exit patterns in Figure 2.2. We regress the two different measures of entry and exit of the risky asset market on age dummies, calendar year fixed effects and a proxy for cohort effects, the stock market return at ages 15-25. These regressions are reported in Table 2.5 and Figure 2.4.3. Due to the very limited sample of households participating early in life, we see that, already early in the life cycle, the exit rates (especially of the first definition) are high. Entry into the risky asset market picks up just after the age of 30, and the inflow rate remains constant up until mid life.

2.4.4 Validation of strategy

Following Berndt and Griliches (1995), we check our identification strategy of age, time and cohort effects. Studying the age profiles in Figure 2.4.3 more closely, we note that both curves have distinct plateaus. Specifically, the risky share is fairly stable around 48% until the age of 50, whereas the participation rate is stable from the age of approximately 45 to 55. We impose testable restrictions on the age effects over these periods which then enables us to replace the cohort proxy (stock market life time gains) with the original cohort dummies. One restriction is that the age patterns are stable from age 30 to 40 for the conditional risky share, and from the age 45 to 55 for the participation rate. These hypotheses cannot be rejected at the 10% level (p-value of 0.55). Using the imposed restrictions on age, we estimate the selection model including all three age, time and cohort effects, offering a candidate for resolving the issue of identification in this framework. Having inserted the restricted age patterns into the Heckman selection model, we now re-run the analysis using instead of the cohort proxies (stock market returns) the cohort dummies. Table 2.6 displays the correlation between these estimated cohort dummies and the proxies. As noted earlier for the regression including the cohort proxies, the cohort effects seem to matter more for the decision of participation than for the risky share. This is indeed confirmed here as we

see that for the participation decision the estimated cohort effects are highly correlated with the cohort proxies, whereas it is not the case for the risky share. One way to interpret this is that there are cohort components in a once and for all participation costs (which would come in addition to the per period participation cost), hence cohort proxies would affect participation but not the conditional share.

In Table 2.7 the same correlations are reported for the regressions split by education reported in Table 2.4 after imposing restrictions to the age patterns of participation and risky shares. As we see, this effect disappears for lower education groups, whereas we find it significant for households with high school or college education.

Table 2.6: Cohort Effect Correlation

	Share	Participation
Youth Stock Returns	-0.006 (0.012)	0.172 *** (0.034)
Constant	0.021 (0.012)	-1.048 *** (0.033)
N	61	61
R^2	0.004	0.304

Note: The table displays the correlation between estimated cohort proxies and the estimated cohort effects when restricting the age pattern of the model estimated in table 2.3 and figure 2.4.3. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.7: Cohort Effect Correlation, by Education

	Low		Medium		High	
	Part	Share	Part	Share	Part	Share
Youth Stock Returns	-0.009 (0.013)	-0.096 (0.067)	-0.008 (0.013)	0.236*** (0.086)	0.087 *** (0.021)	0.023 (0.091)
Constant	0.298 *** (0.012)	5.786 *** (0.061)	-0.016 (0.013)	-1.649 *** (0.085)	-0.088 *** (0.020)	5.852 *** (0.087)
N	57	57	60	60	58	58
R^2	0.009	0.036	0.007	0.115	0.233	0.001

Note: The table displays the correlation between estimated cohort proxies and the estimated cohort effects when restricting the age pattern of the models estimated by educational attainment in Table 2.4 and Figure 2.5. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

2.5 Model

Having shown evidence on the life cycle portfolio profile of Norwegian households' asset market participation and conditional portfolio share, we present in this section a life cycle model that can account for the life cycle portfolio profile along both margins. In a nutshell, we use a version of the workhorse portfolio choice model of Cocco, Gomes, and Maenhout (2005) and extend it in two ways: first, we allow for a fixed per-period stock market participation cost. This is meant to provide a motive for exiting the stock market as people age. Second, we allow for a limited trust element as in Guiso, Sapienza, and Zingales (2008) in order to avoid the “too” high conditional shares in risky assets at young and middle ages that these models typically generate. Over recent years, several cases against the biggest financial advisor firms in Norway for selling dubious products with high leverage are ongoing, for example the ongoing case against Norway's biggest commercial bank, DNBNor.¹³

2.5.1 Model Specification

Preferences

We assume that households leave no bequests and let t denote the age of the household head. Households work from age T^b until age T^w , after which households retire. Households face uncertainty in the amount of period they live (T). We model this component as Hubbard, Skinner, and Zeldes (1995) and denote p_t the probability that the household is still alive at age $t + 1$ conditional on being alive at t . Household preferences are described as follows:

$$E \sum_{t=1}^T \underbrace{\delta^t \left(\prod_{j=0}^{t-2} p_j \right)}_{=\beta_t} U(c_{i,t}) \quad (2.1)$$

where $c_{i,t}$ is the consumption of household i at age t and δ the discount factor, and β_t the age-dependent effective discount factor that takes into account the probability of death.

Market Structure

In the model economy, markets are incomplete. Households smooth consumption over the life cycle by holding a riskless asset and possibly a risky asset. The riskless asset can be

¹³<http://www.reuters.com/article/2009/04/24/dnbnor-lawsuit-idUSL013864720090424> and <http://www.risk.net/structured-products/news/1512563/norwegian-watchdog-rules-dnb-nor>

thought of as a real bond and has a time-invariant return r_f . We denote the amount of wealth the household i in bonds at age t with $B_{i,t}$. Whereas the riskless asset can be purchased and sold at no cost, we impose a fixed per-period participation cost q to hold risky assets. The risky asset has a time-dependent real return \tilde{r}_t , and a risk premium denoted r_p .

$$\tilde{r}_t = r_f + r_p + \nu_t, \quad \nu \sim \mathcal{N}(0, \sigma_r^2). \quad (2.2)$$

where ν_t is the period t innovation to stock market returns drawn from a normal distribution. The amount of risky asset held by household i at age t is denoted by $A_{i,t}$. Furthermore, we assume that households can't borrow against future labor income and that the quantities of the two assets held are positive.

$$A_{i,t} \geq 0, \quad B_{i,t} \geq 0. \quad (2.3)$$

These constraints ensure that the share $\alpha_{i,t}$ of financial wealth invested in risky assets at age t , is non-negative and $\alpha_{i,t} \in [0, 1]$. Finally, we incorporate trust as defined by Guiso, Sapienza, and Zingales (2008) into the model. Trust is defined as the probability a household attributes to the possibility of being cheated. In deciding whether to hold shares a household assesses the probability that the company is just a scam, or that the manager steals proceeds. We denote with p_{cheat} the probability that such scam occurs and that the household's investment in shares is fully lost. The complementary probability $(1 - p_{cheat})$ identifies the degree of trust an investor has in the stock market and the probability of recovering his investment with the accrued return.

2.5.2 Household Problem

Households start a period with a certain amount of cash-on-hand which is the sum of their labor income and financial wealth. Then households decide how much to consume and to save in bonds if they don't participate in the stock market, and how much to consume and save in bonds and equity, if they choose to participate in the stock market. Finally, they compare their utility in both scenarios (participation vs. non-participation) and decide whether to enter or exit the stock market.

The budget constraint of a working age household reads as follows:

$$c_{i,t} + \mathbf{1}_{i,t+1}(a_{i,t+1} + q) + b_{i,t+1} = w_t z_{i,t} + (1 + \tilde{r}_t)\mathbf{1}_{i,t}a_{i,t} + (1 + r_f)b_{i,t}, \quad t = 1, \dots, T^w \quad (2.4)$$

where $\mathbf{1}$ is an indicator function taking value 1 if the household participates in the stock market at age t and 0 if not; $w_t z_{i,t}$ stands for the age-dependent labor income which is

composed of a deterministic component of age w_t and a random walk component $z_{i,t}$ as shown in equation (2.13).

The retired households' budget constraint is as follows.

$$c_{i,t} + \mathbf{1}_{i,t+1}(a_{i,t+1} + q) + b_{i,t+1} = \phi_{ret} w_{T^w} + (1 + \tilde{r}_t) \mathbf{1}_{i,t} a_{i,t} + (1 + r_f) b_{i,t}, \quad t = T^w + 1, \dots, T \quad (2.5)$$

Equation (2.5) is isomorphic to (2.4) with the only difference that labor income is time-invariant and not subject to uncertainty. Retirement income is a fixed share ϕ_{ret} of the last working-age labor income of the household.

The problem of a household is to maximize equation (2.1) subject to the above constraints (2.2)-(2.5). In the following subsection, we formulate this problem recursively.

2.5.3 Recursive Formulation

The household problem has a set of control variables $\{c_{i,t}, a_{i,t}, b_{i,t}, \mathbf{1}_{i,t}\}_{t=1}^T$ and a set of state variables $\{t, x_{i,t}, z_{i,t}\}_{t=1}^T$, where $x_{i,t}$ denotes financial wealth and $z_{i,t}$ labor income. Let $V_t^{in}(x, z)$ be the value of the objective function of a t -year old household who participates in the stock market, has labor productivity z and financial wealth amounting to x .¹⁴

$$V_t^{in}(x, z) = \max_{c, a', b'} U(c) + \beta_{t+1} E_{z', \tilde{r}'}((1 - p_{cheat}) V_{t+1}(x', z') + p_{cheat} V_{t+1}((1 + r_f) b', z')) \quad (2.6)$$

where

$$x' = (1 + r_f) b' + (1 + \tilde{r}) a' \quad (2.7)$$

Households participating in the stock market have with probability $(1 - p_{cheat})$ the law of motion given by equation (2.7).

The Bellman equation below describes the value of the objective function of a working age household who does not bear the fixed participation cost and invests only in risk-free assets.

$$V_t^{out}(x, z) = \max_{c, b'} \{U(c) + \beta_{t+1} E_{z'} V_{t+1}(x', z')\} \quad (2.8)$$

where

$$x' = (1 + r_f) b' \quad (2.9)$$

The budget constraint of the household problem reads as follows:

$$c + \mathbf{1}'(a' + q) + b' = wz + x, \quad (2.10)$$

¹⁴We drop the indices i and t , to keep the notation light. Also x' denotes x_{t+1} .

The Bellman equation for the household problem pins down the participation decision of the household problem.

$$V_t(x, z) = \max_{\mathbf{1}' = \{1, 0\}} (V_t^{in}(x, z); V_t^{out}(x, z)) \quad (2.11)$$

The optimal policy correspondence P for the participation decision can be derived as follows.

$$\mathbf{1}' = \begin{cases} 1, & \text{if } \bar{x} \in X_p, \\ 0, & \text{otherwise.} \end{cases} \quad \text{where } X_p \equiv \{\bar{x} : V_t^{in}(x, z) > V_t^{out}(x, z)\}. \quad (2.12)$$

The maximization problem of the retired households is analogous to the above formulation with the only difference that the uncertainty with regard to the realization of the income shocks is shut down and replaced with a deterministic income that is equal to a fraction ϕ_{ret} of the last working age period labor income.

2.5.4 Parametrization

As emphasized in Section 2.2, the value of a workers' human capital (the discounted sum of future income streams) makes up a dominant part of a workers overall portfolio, and is according to the literature a key rationale for portfolio rebalancing over the life cycle. Therefore an accurate quantitative analysis of the risk structure of a workers human capital is essential for a thorough analysis of the life cycle pattern of portfolio allocation. At the onset of a career, a household has relatively low holdings of financial wealth. The human wealth is correspondingly higher, as the worker has a full career in front of him/her. To account for this, we gather income data for our sample of households over the same time span to pin down a measure of their life long labor income and of the risk related to a workers labor income. We use a broad measure of labor income: the sum of pre-tax pensionable earnings at the household level. In addition to labor income, this measure also contains sickness money, maternity leave, and benefits paid during unemployment spells. Similar to Carroll (1997), we also include all income that counts towards retirement and individuals retirement savings base. The measure is summed up for both husband and wife in the household, and we also add pension payments to pin down the within-household replacement rate.¹⁵ The official retirement age in Norway is 67 years of age, in practice however, there exists a number of arrangements for workers to retire at earlier ages.¹⁶ Our measure is then deflated using the

¹⁵Values are in 1995 US\$ - converted using the 1995 NOK/USD exchange rate.

¹⁶See e.g. http://ec.europa.eu/economy_finance/publications/publication14992_en.pdf, where the average actual retirement age in Norway is reported closer to 64.

growth in the National Insurance Scheme basic amount, which is used to adjust payments of unemployment insurance and pensions.¹⁷

For the matter of the estimation of the life cycle profile of labor income, we follow closely Carroll (1997) and Cocco, Gomes, and Maenhout (2005). The analysis of the income variance is highly dependent on low income realizations of few households. Contrary to these previous contributions, we have highly reliable data reported for tax calculations and whereas they exclude any household that has one or more observations below 80% of the within household sample mean during the observation period (after having deflated the data with the consumer price index), we use the same sample as for the portfolio analysis.¹⁸

We estimate the life cycle income profiles using the following equation:

$$\log(Y_{i,t}) = \alpha + \beta(X_{i,t}) + \gamma_t + \varepsilon_{i,t}, \quad (2.13)$$

where α is the constant, $X_{i,t}$ includes the age dummies and household size, β the corresponding vector of coefficients, γ_t the calendar year fixed effects and $\varepsilon_{i,t}$ the error term. The estimation is done for 3 different levels of educational attainment in addition to year fixed effects, in addition to the whole sample. The educational level associated with a particular household is determined by the highest achieved educational level of the husband.

The life cycle income profiles are obtained from the estimation of equation 2.7 on the full data sample from age 25 to 80 years. The age coefficients are plotted in Figure 2.7, where the solid lines represent the estimated pattern of age dummies. Table 2.8 displays the estimated 5th order polynomials that fits the income profiles best. The income profiles by educational attainment deliver evidence for the existence of an education premium for households where the husband has a college education. Furthermore, we see a drop in income prior to the official retirement age as some income earners retire prior to the age of 67, as some households retire prior to the official retirement age.

To estimate the variance components of the income process, we follow the procedure in Carroll and Samwick (1997) and Cocco, Gomes, and Maenhout (2005). We re-run the regressions from above, but deviate from the literature and cut the sample prior to retirement. As retirement income is essentially considered to be riskless and constant, including these observations will bias down our estimates of income variance.¹⁹ Based on the labor income

¹⁷See NAV <http://www.nav.no/English/Membership+in+The+National+Insurance+Scheme> for more information on Basic Amount

¹⁸We also experimented with a few exclusion thresholds as in Carroll and Samwick (1997). Results show that estimated variances vary significantly with such thresholds. We chose to use the full sample, as our data are unlikely to suffer from measurement errors as in the PSID.

¹⁹In fact, we cut the sample at the age of 65, to avoid variability in income coming from early retirement from influencing our results

polynomials, we obtain prediction errors for each observation, which allow us to calculate the variance of the d -th period income deviation from the base year (1995). We then estimate the variance using the distance from the base year as the right hand side variable.

The results of the decomposition are displayed in Table 2.9. We see that the variance of both the permanent and transitory income shocks are considerably smaller for the group of households with High school education or College relative to the ones with education less than high school. Relative to the findings in Cocco, Gomes, and Maenhout (2005), we find lower estimates of the transitory components (they find 7.38 % for High school graduates, we find 4.7%). Considering the social insurance scheme in Norway, this number is not implausible. There are however limits to how much of a comparison one can make, as the result from Cocco, Gomes, and Maenhout (2005) build on PSID surveys, and one would expect our analysis to be less prone to measurement errors.

Figure 2.7: Estimated labor income processes by educational level

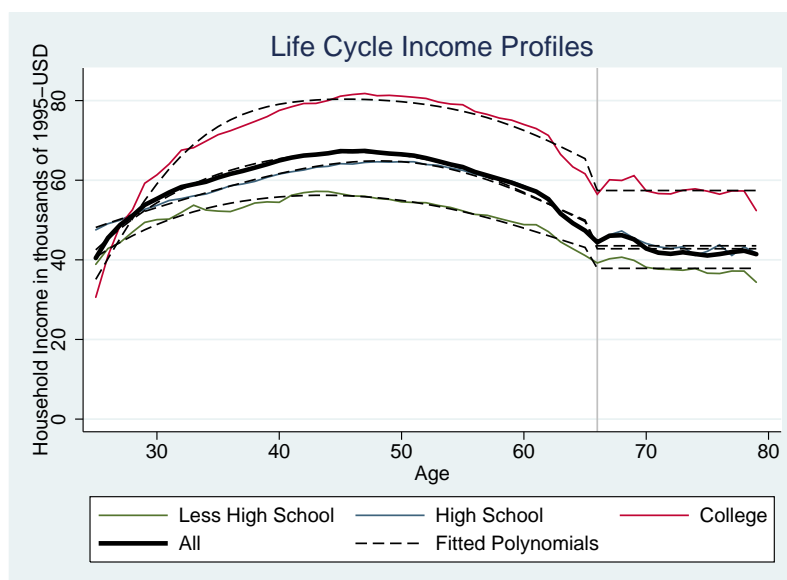


Table 2.8: Age polynomials for labor income process

	Low	Medium	High	All
Age	0.0563 (6.58)	0.0236 (2.99)	0.172 (11.74)	0.0769 (10.09)
Age2	-0.00344 (-3.71)	-0.000761 (-0.89)	-0.0121 (-7.63)	-0.00501 (-6.08)
Age3	0.000118 (2.85)	0.0000423 (1.10)	0.000433 (6.07)	0.000192 (5.21)
Age4	-0.00000238 (-2.93)	-0.00000158 (-2.10)	-0.00000772 (-5.53)	-0.00000408 (-5.62)
Age5	1.86e-08 (3.22)	1.66e-08 (3.11)	5.28e-08 (5.32)	3.24e-08 (6.30)
Constant	3.653 (149.03)	3.851 (170.05)	3.397 (80.78)	3.678 (168.57)
Observations	55	55	55	55
r2	0.976	0.978	0.954	0.986

Note: The table shows the coefficients of a 5th order polynomial describing labor income as a function of age. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.9: Income variance decomposition and correlation with stock return

	Less High School	t	High School	t	College	t	All	t
Transitory	0.079	13.3	0.047	17.4	0.028	10.7	0.049	27.4
Permanent	0.048	24.94	0.027	32.8	0.024	30.5	0.031	57.5
Stock Market	0.017	0.48	0.045	0.34	0.005	0.75	0.008	0.50

Note: The table reports estimates of the variance of permanent and transitory labor income shocks. The estimation is based on the error terms from estimating the labor income process in Figure 2.7. The procedure is based on the method in Carroll and Samwick (1997), which is also used in Cocco, Gomes, and Maenhout (2005).

Finally, we also computed the correlation between labor income and stock market returns on the Norwegian stock market. A correlation here would represent a hedging opportunity for the households, as argued in Bodie, Merton, and Samuelson (1992). Table 2.9 shows that the correlation indeed tends to be negative but that it is not significant at the 10% level. This confirms the results in Cocco, Gomes, and Maenhout (2005) for the United States.²⁰

Table 2.10: Parameter choice

Variable Name	Variable	Value	Source
Discount factor	δ	.96	yearly data
Risk aversion (CRRA)	γ	6	
Participation Cost (1995 US\$)	q	500	
Probability of scam	p_{cheat}	0.0175	
Retirement age	T^r	67	Norwegian Law
Variance of transitory shocks		0.047	Data - table 2.9
Variance of persistent shocks		0.027	Data - table 2.9
Risk free return	r_f	.02	Literature
Risk premium	r_p	.04	Literature
Std deviation stock return	σ_r	0.231	Data - Oslo Stock Exchange
Income share of retired HH	ϕ_{ret}	.9058	Data - Table 2.8
Shape of Pareto Distribution for x_0	μ	0.4521	Data
Scale of Pareto Distribution for x_0	σ	5711.7	Data

Table 2.10 reports the benchmark parameter values. The retirement age is set to 67 for all households in accordance with Norwegian law. The discount factor is set to 0.96 as we aim at matching yearly data, and the coefficient of relative risk aversion is set at 6. As in the literature on the equity premium puzzle, we set the risk free rate at 2% and the equity premium at 4%. The standard deviation of the innovation to the risky return is set to 0.231, the standard deviation of returns on the Oslo Stock Exchange. The conditional survival probabilities are taken from the population tables of Statistics Norway. We used the survival estimates for both sexes to calculate the conditional survival probabilities p_j for $j = 1, \dots, T$.²¹ For the simulations, we draw households' initial financial wealth from a Pareto

²⁰The same holds for a combined measure of returns from the S& P 500 and the Oslo stock exchange.

²¹Table 5 - Life tables http://www.ssb.no/english/subjects/02/02/10/dode_en/tab-2011-04-14-05-en.html

distribution that is fitted to the initial wealth of households with age 25 from our sample.

2.5.5 Solution Method

The problem is solved by backward induction. Given the terminal condition, the policy functions are trivial: households consume all their wealth, and the value function equals to the utility function. We substitute this value function in the bellman equation and compute the policy functions one period backward. We do this for 75 periods, from $T = 100$ to age $T_b = 25$. We discretize the state space for cash-on-hand state variable and iterate on the value function. The density function for the labor income process as well as for the risky return is approximated using Gaussian quadrature. Finally, we simulate 10,000 agents. In the next section, we present and discuss the policy functions and the simulation results of the model.²²

2.6 Results

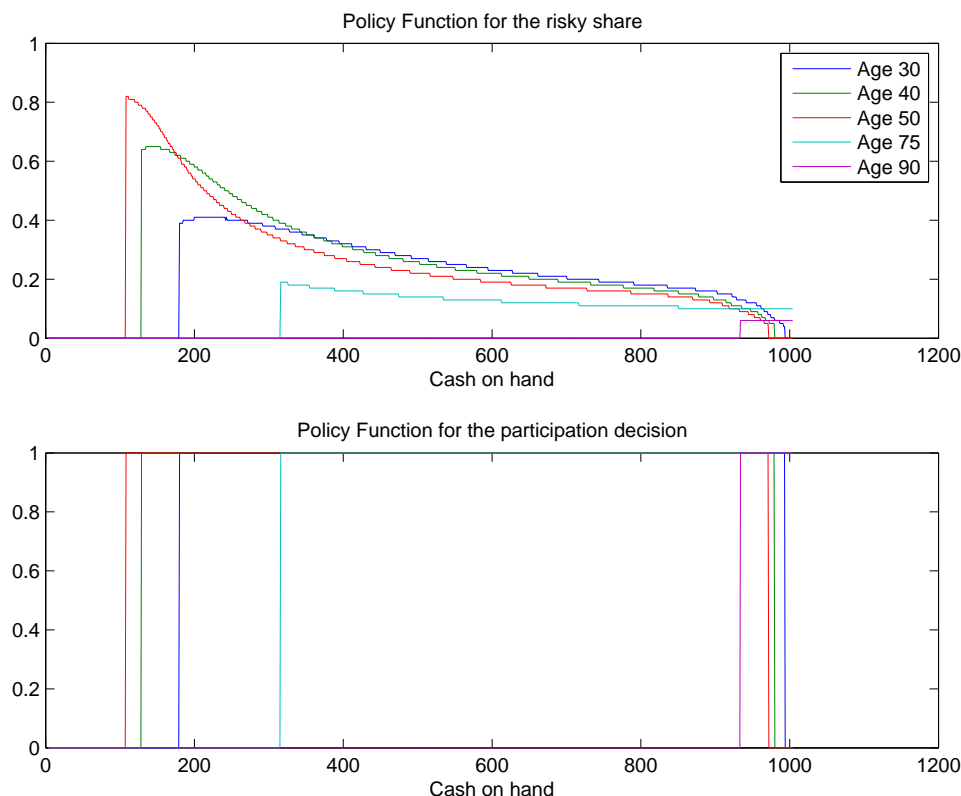
2.6.1 Model Solution

The upper panel of Figure 2.8 plots the optimal portfolio share invested in risky assets conditional on participating as a function of cash-on-hand at a given age. The optimal portfolio rule is decreasing with both cash on hand, and age, a pattern that is consistent with Cocco, Gomes, and Maenhout (2005). The inclusion of a per-period participation cost and limited trust have two distinct effects on the policy functions. The participation cost introduces an age and wealth dependent entry threshold, and lowers the risky share conditional on participating. The trust friction further reduces the conditional risky share as emphasized in the stylized model presented in Guiso, Sapienza, and Zingales (2008).

Also in a model with incomplete markets and uninsurable labor income risk, the optimal share invested in risky assets is decreasing with cash on hand because it is driven by the importance of human capital relative to accumulated wealth, as in for example Merton (1971). During working age, since shocks to labor income are uncorrelated with stock market returns, the deterministic component of labor income mimics the pay-off of a risk free asset. Therefore, for a given level of human capital, households with low levels of financial wealth have a relatively large amount of future income from risk free assets (relative to their financial wealth) and thus invest more aggressively in stocks than wealthier households. A higher

²²For comparison with the data, we cut the simulation results at age 75.

Figure 2.8: Policy Functions



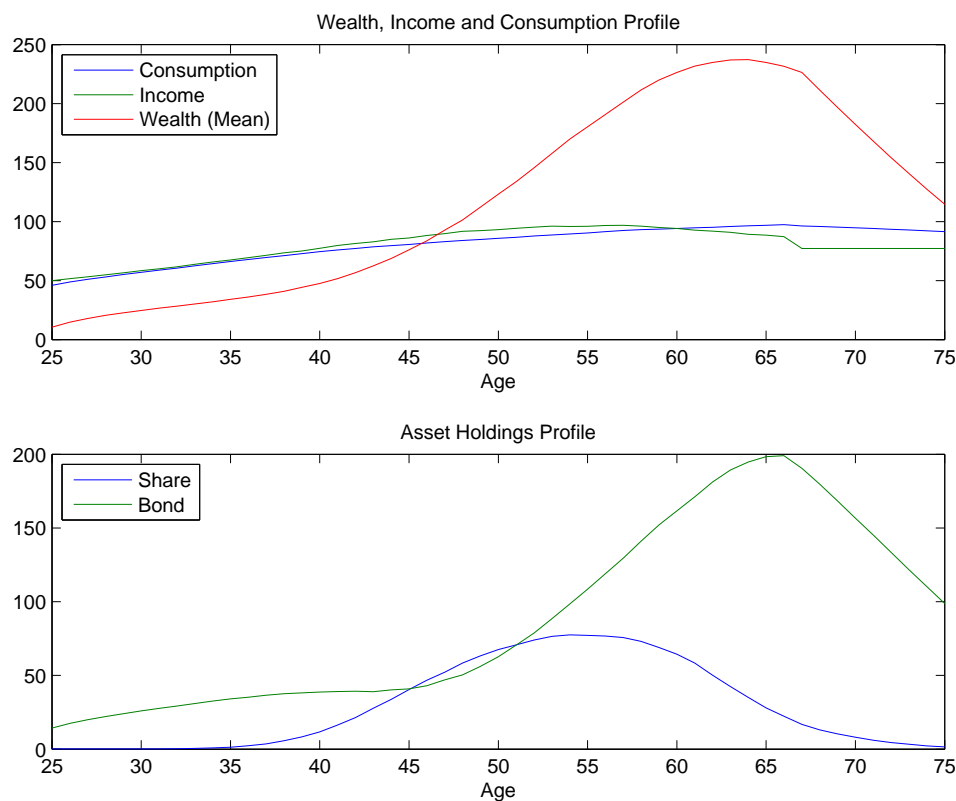
level of financial wealth reduces the relative importance of the safe human capital and leads households to rebalance their portfolio by investing less in stocks relative to their wealth level. A similar logic applies after retirement. As for the negative correlation with age, this follows from the same logic. The portfolio rule is less aggressive when agents grow older because the capitalized value of labor income drops with age, and households compensate for this drop in bond-like wealth by reducing their relative holding of risky assets.

The lower panel of Figure 2.8 plots the cash-on-hand thresholds beyond which households find it optimal to participate in the stock market at a given age. The wealth threshold of risky asset market participation is decreasing with age until age 50, age at which average labor income peaks. Prior to age 50, the participation cost is, relative to average labor income, getting smaller with increased working age. However, above age 50, when households are approaching retirement the trajectory of their labor income profile is declining, and the participation threshold shifts rightward with increased age. From then onwards, household seek to diversify away from stocks, and shift towards risk free assets in order to compensate for the reduction of risk free labor income.

It is also important to notice that the model delivers a counter-factual behaviour, in the sense that it is optimal for some working age household with very high levels of cash on hand to exit risky asset markets. This is a by-product of the downward sloping optimal portfolio rule; above a certain wealth threshold, it is optimal for household to hold a very low share of equity. However, the low-level of the optimal share does not justify incurring the fixed cost, thereby making the outside option of not participating more worthwhile, even for wealthy households.

2.6.2 Simulations

Figure 2.9: Wealth, Income and Consumption



The upper panel of Figure 2.9 plots the mean of the simulated panel of labor income, wealth and consumption. The profile of the mean consumption follows closely the income level, suggesting that a fair share of households are borrowing constrained. With increasing age, the average wealth increases so that households can smooth consumption over the life-cycle. This behaviour persists until around age 60, age at which survival probabilities are

substantially lower and reduce the effective discount factor. The lower discount factor and the drop in labor income incites household to reduce their investments. While wealth decumulates rapidly, the consumption path remains contained and the standard hump-shaped consumption profile of life cycle model comes forth.

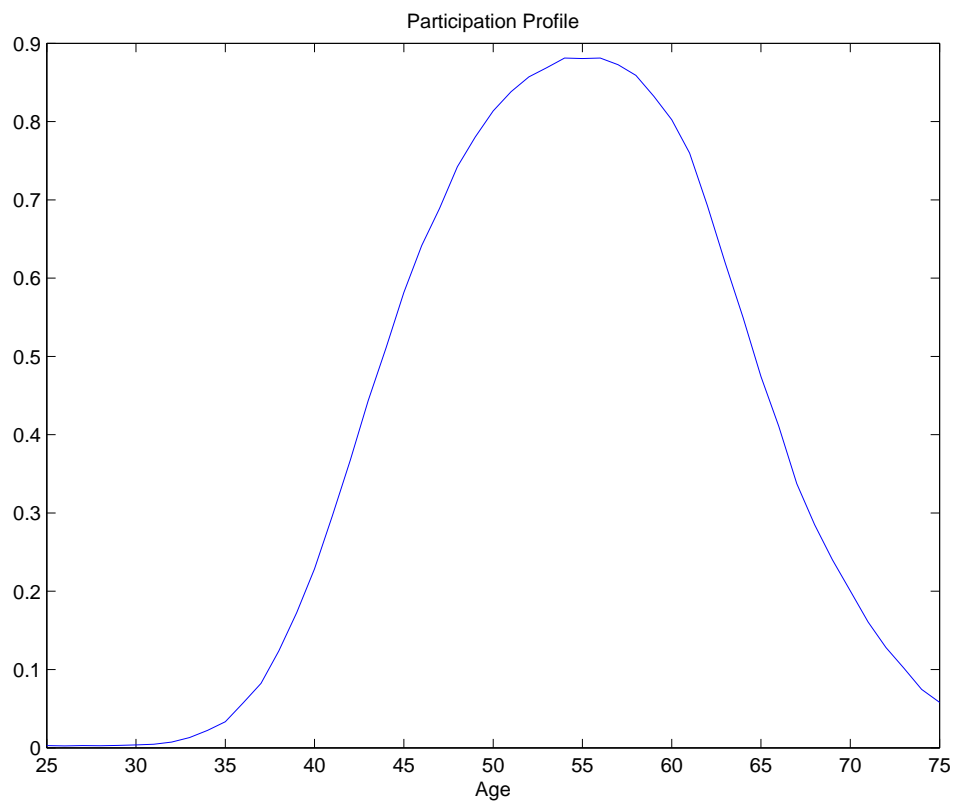
The lower panel of Figure 2.9 depicts the mean of the simulated panel of stock and bond holdings. Three phases emerge. At first, household hold only risk free portfolios until age 35 and build a stock of financial wealth so that they can privately insure against labor income risk and smooth consumption. After age 35, they start accumulating assets beyond the precautionary motive and can afford the participation cost and they invest in the risky asset. Interestingly, while households continue to accumulate stocks up until retirement they start decumulating stocks much earlier. This decrease in the average level of risky asset coincides with the peak of the average labor income. From then onwards, households prepare for retirement and shift their allocation towards risk-free asset, once again to compensate for the reduction of their risk-free labor income. Finally, at age 70 the average portfolio consists only of bonds, which is imputable to the consumption smoothing motive, and the low effective discount factor.

Figure 2.10 plots the mean stock market participation rate. Households start participating in the equity market at age 31. The participation rate increases rapidly when young and peaks at age 54; at the peak 88% of the households hold stocks. After the peak households exit the risky asset market, initially gradually and more rapidly after retirement. At age 80 all households have exited the stock market.

2.6.3 Model performance relative to data

Figure 2.11 compares the simulated portfolio conditional share in our model with the conditional share from Cocco, Gomes, and Maenhout (2005) (which for them is also the unconditional share as no participation cost is allowed for). In our model the conditional share in stocks is substantially lower than in Cocco, Gomes, and Maenhout (2005). This is mostly due to the presence of limited trust in our model. Imposing full trust would produce a profile for the conditional share that is very similar to Cocco, Gomes, and Maenhout (2005), that is a financial portfolio share in stocks very close to 1: this is one of the puzzling features of calibrated life cycle portfolio models (see Guiso and Sodini (2011) for a review). The introduction of a (very low) probability that an investments in stocks is a scam substantially reduces the mean conditional share to levels that are much closer to those observed in the data (see Figure 2.12). Risk averse households are very concerned with the possibility for extreme losses even though this is a very unlikely event, as emphasized in Jagannathan and

Figure 2.10: Participation Decision

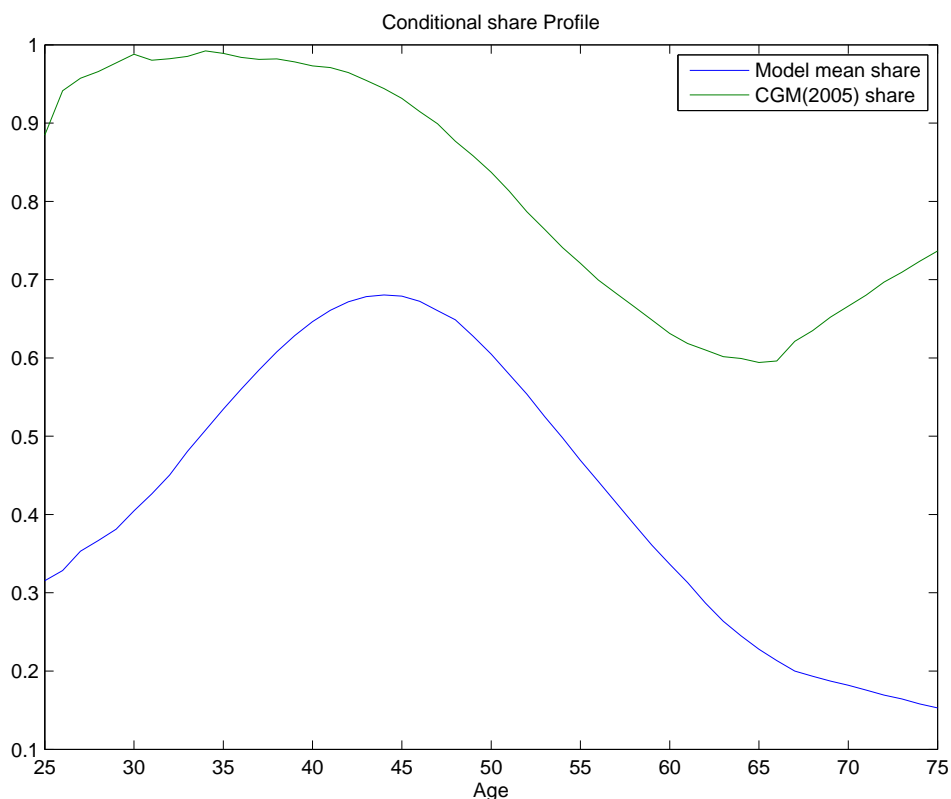


Kocherlakota (1996) and more recently by Barro (2006) in relation to the equity premium debate.

The ability of our model to match the empirical estimates from Section 2.4 can be best appreciated in Figure 2.12. One feature that our model replicates well is the joint pattern of life cycle rebalancing and exit. A key finding in the Norwegian data is that households *first* start reducing the conditional share starting from age 45 onwards, and *later* they begin exiting the stock market (from age 57 onwards). Our model replicates this pattern well: the reduction of the conditional share begins at around age 45 and households start to exit the stock market around age 55. This qualitative ability of the model to reproduce the empirical timing of the double adjustment is the main contribution of this Section of the paper.

In quantitative terms the model performance has potential for improvement. Households exit the stock market too rapidly compared to the empirical evidence. With regard to the entry pattern the model performance is also unsatisfactory. Households enter stock market too late compared to the empirical evidence. However, in terms of quantitative performance of the conditional share at entry the model is close to the the observed share at entry (around

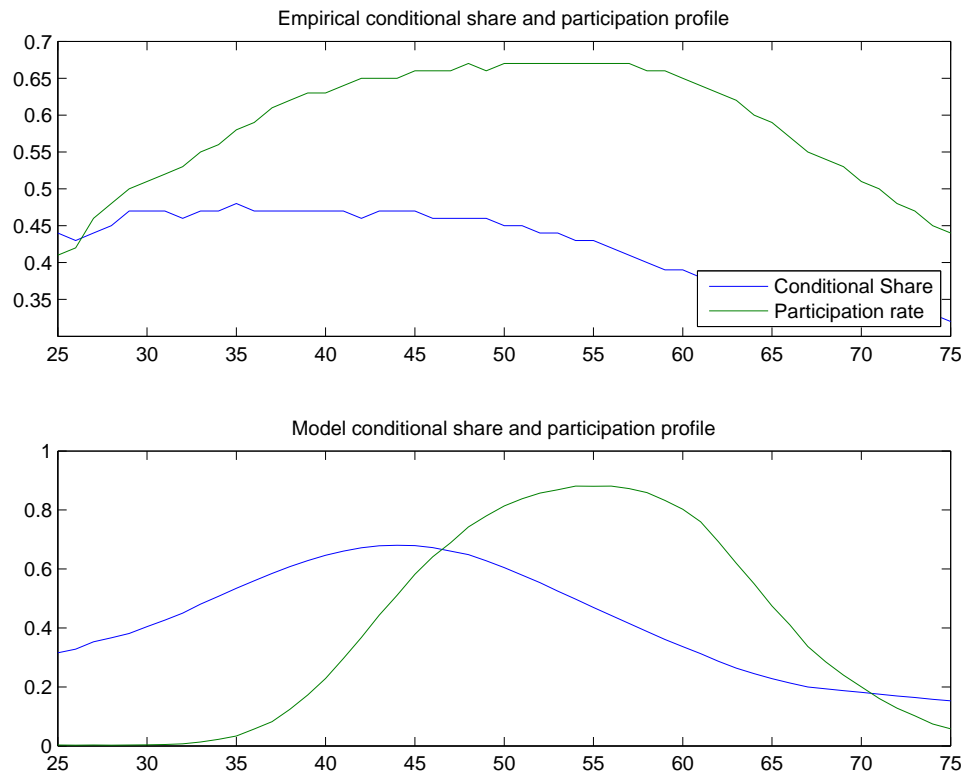
Figure 2.11: Conditional share profile - Our model vs CGM (2005)



40%-50%).

Finally, we evaluate the model's ability to match the pattern of entry and exit over the life-cycle. In Figure 2.13, we document households' entry and exit profiles according to the definition of entry and exit presented in Table 2.2, but note that the entry and exit rates are regressed on time and cohort effects. Comparing this entry and exit rates to those generated by our model shows that the model is not yet able to generate the diversity of entry and exit patterns observed in the data. For instance, we are not able to explain first time entries at late age as can be seen in the upper left panel of Figure 2.13. We also fail to explain the intensity of early entry pattern as measured by both definitions. However, qualitatively our model is relatively close to the data, in particular when looking at the exit pattern given by both definitions.

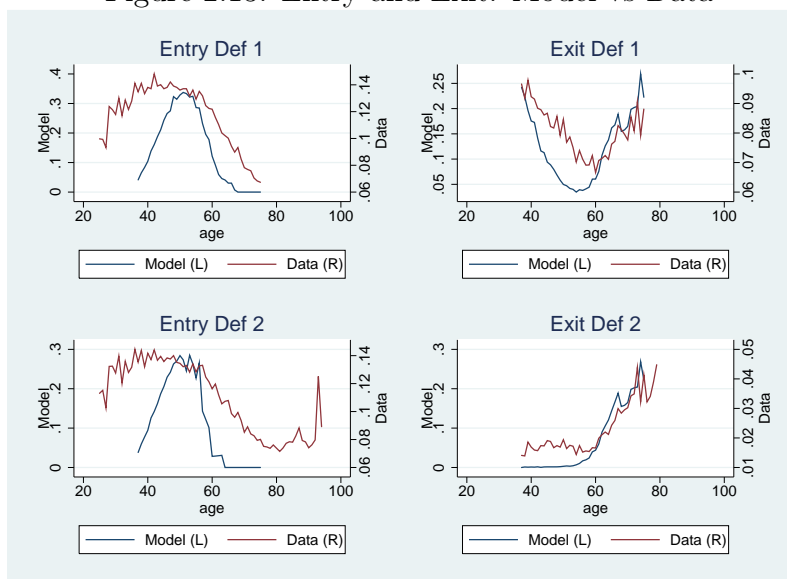
Figure 2.12: Upper Panel - Empirical conditional share and participation profile ; Lower Panel - Conditional share and participation profile of model



2.7 Conclusion

Over the past decade many scholars have used calibrated models to study life cycle portfolio allocations, departing from the simplifying assumptions of early generations models and adding realistic features of households environments. Among them, uninsurable income risk, non-tradeable human capital and imperfect borrowing markets. Despite these (and other) complications, these models uniformly predict that households should at a certain point before retirement start lowering exposure to the stock market in order to compensate for the decline in the stock of human wealth as people age, which in this models acts mostly as a risk-free asset. Finding empirical evidence in support, however, has been hard. We argue that this is likely to be due to data limitations, both because a proper treatment of the issue requires long longitudinal data and because the information on assets needs to be exhaustive, free of measurement error. Combining administrative and tax registry data from Norway we are fulfilling these requirements and find that households do indeed manage their portfolio

Figure 2.13: Entry and Exit: Model vs Data



over the life cycle in a way that is consistent with models predictions. We find that they adjust their financial portfolios along two margins: the share invested if they participate in the stock market and the decision whether to stay or leave the market altogether. They tend to enter the stock market early in life as they accumulate assets and tend to invest a relatively large share of financial wealth in stocks. As they start foreseeing retirement, they rebalance their portfolio share, reducing it gradually. Around retirement they start adjusting on the other margin, exiting the stock market. Extending that this double adjustment pattern along the intensive and extensive margin with its clear timing cannot be explained by none of the available life-cycle portfolio models; but a simple extension of these models to allow for a per period participation cost, and a trust friction, is able to qualitatively reproduce the data.

Our next step will be to try estimate the key parameters of the model - the households discount factor, the risk aversion parameter, the per-period participation cost and the probability of being cheated so as to best match model and data life cycle patterns of the conditional share and the participation rate as well as the entry and exit patterns.

Chapter 3

Asymmetric transfers

With Maren Froemel

3.1 Introduction

In this paper, we assess the desirability of targeted transfers that are contingent on the asset position of households. Most of the literature on fiscal policy has studied the impact of tax reforms and lump sum transfers on the allocative efficiency of production factors, but overlooked the effect of targeting transfers by making them contingent on households' observable characteristics. Our numerical exercise focuses on understanding whether such a redistribution policy is a useful instrument to complete markets in an environment with exogenously incomplete asset markets. Given that the asset position of households is an observable characteristic, we argue that such a redistributive policy is easily implementable for short-term policy purposes.

We address this question using an exogenously incomplete markets economy as developed by Huggett (1993) where households are ex ante identical, but differ ex post with respect to their wealth due to uninsurable idiosyncratic labor productivity risk. We choose this economic environment for two reasons. First, Domeij and Heathcote (2004) emphasize that incorporating heterogeneity dramatically changes the welfare implication of tax reforms. Second, we require an economic environment that generates trade among households in equilibrium to analyze the impact of introducing transfers that target households according to their asset holdings. Given that households can only borrow up to an ad hoc limit, we also ask whether transfers policies have non linear effects on the allocation and aggregate welfare depending on the tightness of the borrowing constraint.

In this class of economy with incomplete financial markets, households cannot insure themselves perfectly against idiosyncratic income risk. Given the market structure, they use both trade in financial assets and labor supply to smooth consumption. Households with low productivity work more and households with high productivity less than in an economy with perfect risk-sharing. Furthermore, households tend to accumulate assets over the long run due to the precautionary motive, such that the allocation differs from the allocation under complete markets and welfare losses are incurred. In this paper, we will focus on the inefficient supply of labor as highlighted in Pijoan-Mas (2006) and of private insurance as in Huggett (1993). We do so because targeted transfers policies are mostly implemented with short term effects in mind, and we claim that labor supply decision are more responsive to transfers than capital in the short run.

We show numerically that the introduction of targeted transfers that are contingent on households' asset holdings leads to aggregate welfare improvement with respect to uniform transfers when the redistribution policy favors agents with a negative asset position, henceforth 'borrowers'. Moreover, only a 'pro-borrower' transfer program makes the majority of the population better off.¹ In this economy, a subsidy to agents with negative asset holdings increases welfare mostly because it subsidizes low productivity agents, reducing the misallocation of labor supply. This results from a wealth effect which induces low productivity agents to partly lower their labor supply for a given level of assets, and to reduce borrowing simultaneously in order to smooth consumption and maximize welfare. The more the policy favors borrowers, the higher is their overall share in the stationary distribution, due to the decrease in the precautionary motive of saving. This explains why the share of low productivity agents in the population of borrowers increases as well. Finally, the redistributive policy implies a higher interest rate in order for the asset market to clear. On the contrary, in an economy with complete asset markets, all agents with positive asset holdings, henceforth called savers, are currently undergoing a low productivity spell.

This paper is related to the literature that studies the welfare effects of tax reforms in incomplete markets environments. Aiyagari (1995) studies the optimal capital income tax in a model with incomplete markets without borrowing and shows that in contrast to Chamley (1986) and Judd (1985), the optimal long run capital income tax is always strictly positive. Domeij and Heathcote (2004) further show that eliminating capital tax can be welfare improving in the long-run, but that it reduces welfare on the transition path.

¹This welfare exercise compares steady states and does not yet take transitions into account. We are aware that conclusions could well be reversed when we take into account transition dynamics, as in Domeij and Heathcote (2004).

However both studies disregard the issue of borrowing and endogenous labor supply, which will be the focus of our analysis. Ábrahám and Cárceles-Poveda (2010) endogenize the borrowing limit and show that this assumption can be critical when assessing the welfare effects of tax reforms. They show that the endogenous nature of borrowing constraints further qualifies the conclusions drawn by this strand of literature. In particular, when assessing the desirability of replacing capital income taxation by a more progressive labor taxation, the effect on the equilibrium interest rate also affects the desirability to default and thereby the borrowing limit. For instance, increasing the progressivity of labor taxation induces a higher interest rate, making default more desirable which leads to tighter borrowing limits. In equilibrium, this generates less poor households at the borrowing limit, and thereby higher welfare. To summarize, Domeij and Heathcote (2004) find that eliminating capital income taxes and increasing linear labor taxes decreases aggregate welfare, when taking into account transition dynamics. Ábrahám and Cárceles-Poveda (2010) allow for borrowing and show that aggregate welfare can be increased if the elimination of capital income taxes is financed by more progressivity in the labor tax schedule.

Also this paper contributes to the literature on endogenous labor supply decisions in models of limited insurance. Alonso-Ortiz and Rogerson (2010) extend a standard Aiyagari model to evaluate the aggregate effects of tax and transfer programs. In particular, they focus on the effect of assistance programs on labor supply decisions. Their analysis of a simple labor tax that finances lump-sum transfers highlights two key findings that are closely related to this chapter. First, they show that moving from a low tax environment to a high tax environment when markets are incomplete and households heterogeneous, the implied welfare losses are reduced by a factor of 3 compared to the standard complete markets scenario. Second, tax and transfer programs have a substantial positive impact on output, leading the authors to argue that the productivity catch up of European countries relative to the US could be a mere reflection of the differences in tax systems. Our paper differs from theirs due to our focus on borrowing, on privately traded assets (no capital and zero net aggregate supply), and the contingency of the lump-sum transfer program.

Marcet, Obiols, and Weil (2007) show that endogeneizing the labor supply decision of households can overturn the Aiyagari-Huggett effect.² They show that if leisure is a normal good, market incompleteness introduces an ex-post wealth effect which reduces labor supply. For some plausibly calibrated economies, this ex-post wealth effect can dominate the Aiyagari-Huggett effect, such that the level of aggregate capital and output is actually lower

²In production economies with exogenous labor supply, uninsurable productivity risk gives rise to a precautionary motive and higher individual savings, which due to fix labor supply leads to higher output.

under incomplete market than under complete markets.

Pijoan-Mas (2006) shows that the welfare cost of market incompleteness are substantially higher when one accounts for the endogeneity of labor supply decision. Whereas under complete markets, households can substitute leisure across states, under incomplete markets asset-poor households with low-productivity levels supply many hours due to their high marginal utility of consumption. The reverse holds for a share of asset-rich households, who will supply less hours. The aggregate allocation is then associated with high work effort and a low labor productivity. Our paper features the same inefficiency, and we show the inefficient provision of labor supply can be partially undone by implementing a transfer program that favors borrowers to the detriment of savers.

Kaplan and Violante (2011) enquire consumption responses to recent fiscal stimuli, in particular tax rebates, in an incomplete market life cycle model that features two assets with different return-liquidity features. Most of the literature concludes that the marginal propensity to consume out of transfers is negligible on aggregate. This type of model generally shows that only constrained households respond substantially to such anticipated transitory transfer policies. The share of constrained household observed in data is not sufficient to match aggregate responses observed in empirical research. Kaplan and Violante (2011) bridge this gap by rationalizing so called ‘wealthy hand-to-mouth’ households, who hold substantial amount of illiquid assets but a low level of liquid assets and therefore have a high marginal propensity to consume (due to the existence of transaction costs to convert illiquid asset into liquid ones). They further confirm that households with such type of portfolio allocation are numerous in the data, suggesting that they are, jointly with households at the borrowing limit, generating a response to tax rebates that matches the ones obtained in empirical research.

Our paper is also related to a recent strand of literature that focuses on the impact of transfers in models with nominal rigidities. Oh and Reis (2011) investigate the multiplier of targeted lump-sum transfer in a model with nominal rigidities due to informational frictions and incomplete markets. Their contribution is to highlight the existence of two transmission channels of fiscal policy via targeted transfer policies, namely a neoclassical channel and a keynesian channel. The redistribution of wealth from high salary households to low salary households raises the incentive to work of the marginal household, and boosts employment as well as output - this is what they call the neo-classical channel. The keynesian channel arises from the positive impact of targeted transfers on aggregate demand, via the effect of transfers on households with high marginal propensities to consume, which in the presence of nominal rigidities leads to higher output. Their paper consists mostly of a qualitative

assessment of these effects, as they obtain a very low aggregate multiplier for government transfers. Contrary to our paper, they use exogenous state variables of the household (health and labor productivity) as a contingency for the transfer program, which we believe is hard to implement compared to our contingency on the asset holdings of a households. Furthermore, their mechanism works via the extensive margin of labor supply that is steered with social (medical transfers), which yet bears no empirical counterpart in their paper. Lastly, they disregard two aspects which we believe are important: the interplay between transfer programs and labor taxation, as well as borrowing. Contrary to Oh and Reis (2011), an increase in output in our model does not necessarily imply higher aggregate welfare across stationary equilibria, for us the inefficiency can go both ways.

Monacelli and Perotti (2011) argue that a differentiated fiscal policy targeting borrowers is neutral, and that the heterogeneous marginal propensities to consume are irrelevant in a flexible price environment without capital accumulation. The present paper challenges this point and strives to argue that this result is contingent on the exogenously fixed wealth distribution, and the lack of consideration given to occasionally binding borrowing constraints, which is essential to model explicitly when one looks at the redistributive effects of transfers.

The rest of this paper is organized as follows. In the next section, we document the quantitative importance of lump-sum transfers as a component of government budgets. In section 3.3, we describe the model economy. Section 3.4 presents the parameter choice, the solution method and discusses the results. Section 3.5 concludes.

3.2 Stylized facts on government transfers

This section highlights two stylized facts on the evolution of the importance of discretionary transfers as a policy instrument.

1. A compositional shift towards transfers in US government expenditure has occurred.
2. Transfers have become the most important fiscal tool in the US.

Figure 3.1 plots government consumption, transfers, and government investment as shares of total U.S. Government Expenditures, and the shaded areas plot the recessions as defined by the NBER. It shows the compositional shift undergone in the government budget of the US over the past 20 years. Government investment has been strongly reduced whereas transfer policies³ have become the most prominent fiscal policy tool. Notable is also the decreasing

³Transfers are defined as the sum of social benefits, subsidies and capital transfers.

importance of government consumption, yet it was less stark than the one observed for government investment. As of 2011, transfers amount to 43% of total government spending, although up until 2008, the share was still around 40% and back in 1990, it was just above 30%.

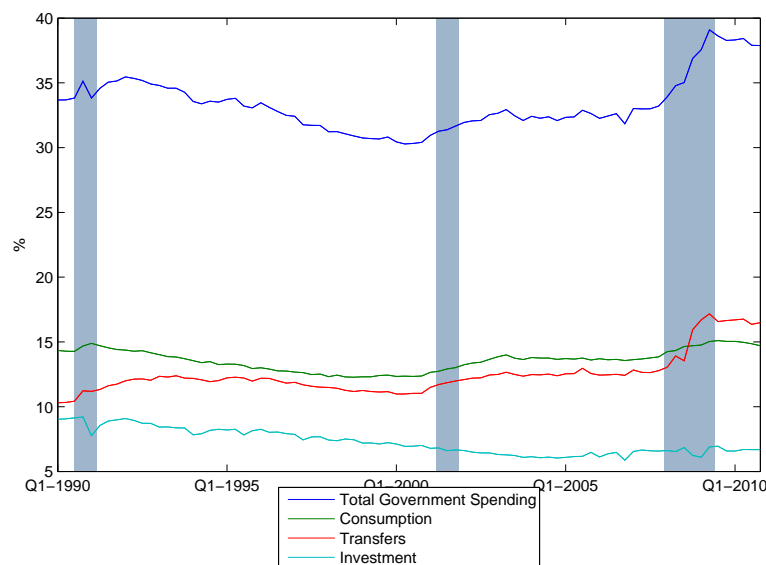
Figure 3.1: Decomposition of U.S. Government Expenditure (1990-2010)



Contrasting the increased importance of transfers with the occurrence of recessions, one can observe that recessions accelerated the compositional shift of government spending towards transfers. This policy activism seems intuitive as transfers are mostly thought of as short-term alleviations of welfare losses incurred in recessions. Further, the fact that these transfers programs have not been scaled back when recessions resumed is robust, yet puzzling.

To complete the analysis on the importance of fiscal transfers as a policy instrument, we plot in Figure 3.2 the fiscal policy instruments as ratios of GDP, in order to highlight their magnitude and dynamics in relation to the economy.

Figure 3.2: Fiscal instruments over GDP ratio (1990-2010)



We observe that transfers have been increased at a faster pace than GDP over the past two decades, in contrast to government consumption which mostly grew as fast as GDP, and government investment, which has been reduced relative to GDP. Government transfers and consumption now amount to 17 and 15 % of GDP respectively. Over the past 20 years, transfers have grown by 7 % point more than GDP, further reinforcing the importance gained by this fiscal tool.

This section highlighted the empirical relevance of fiscal transfers as a policy tool, and therefore the need to better understand its impact on allocation and welfare. Furthermore, it begs to the question as how to design such transfers programs. In the following sections, we question whether introducing a contingency to such transfer programs is a welfare improving policy.

3.3 The Economy

The economy is populated by three types of agents: households, a government and firms. Households supply labor elastically to firms and consume a homogeneous good, and hold risk-free assets. They face idiosyncratic shocks to their labor productivity against which they attempt to insure themselves by borrowing and lending the bond and by supplying labor. We assume that households only trade among themselves, i.e. the net-aggregate supply of bonds must equal zero in equilibrium.

The government finances a transfer program and some government consumption by levying a flat tax on labor income. For the purpose of the analysis of the impact of redistribution policies on equilibrium allocation, we will hold government consumption to output ratio constant throughout the analysis, as well as the tax rate, because government consumption is linked to output via public salaries and pensions, but more importantly because we are interested in understanding the effects of different distributional rules for a given share of transfers in total expenditure.⁴ The government is passive and its policies are not derived from any optimization problem. We focus here on the impact of policies on the allocation.

Firms combine labor supply by households and produce the final good. They operate with a constant returns to scale production function and there is free entry in the market.

In what follows, we give a formal description of the economy.

3.3.1 Households

There exists a continuum of ex-ante identical agents of mass 1 in the economy. Households derive utility from consumption (c_t^i) and disutility from supplying labor (n_t^i). We assume that instantaneous utility is additively separable in consumption and leisure. Households maximize expected life time utility which is given by

$$E_{-1} \sum_{t=0}^{\infty} \beta^t [u(c_t^i) - g(n_t^i)], \quad (3.1)$$

where β is the subjective discount factor, subject to the infinite sequence of period by period budget constraints,

$$c_t^i + b_{t+1}^i = (1 - \tau)w_t \epsilon_t n_t^i + (1 + r_t)b_t^i + \mathbf{1}_{b_t > 0}^i T_s + \mathbf{1}_{b_t < 0}^i T_b \quad (3.2)$$

$$b_{t+1}^i \geq \underline{b} \quad (3.3)$$

In each period, households choose their consumption (c_t^i), labor supply (n_t^i) and bond holdings (b_{t+1}^i). Households receive transfers from the government that can depend on whether they are savers ($\mathbf{1}_{b_t > 0} = 1$) or borrowers ($\mathbf{1}_{b_t < 0} = 1$) **upon entering the period**, T_s and T_b , respectively. Finally, households have a net labor income which depends on their labor supply choice, their productivity realization (ϵ_t), the labor income tax (τ), and

⁴The results are robust, in the sense that qualitatively the results hold in the model where G is left constant across transfer policy rules. In that case however, we observe hardly any effects which is due to the secondary reinforcing effect that G has on output.

the aggregate wage rate, w_t . r_t denotes the market clearing level of interest rate.⁵

New borrowing is constrained by an exogenous debt limit \underline{b} , which is identical for all agents. We make this choice in order to focus on transfer programmes in economies that exhibit a given degree of market imperfection, parametrized by \underline{b} . We do not seek to explain the emergence of constraints from commitment problems, nor do we want to derive the equilibrium level of hence endogenous constraints.

Denote by μ_t^i the multiplier on the borrowing constraint. The first order conditions to the household problem are:

$$\frac{g'(n_t^i)}{u'(c_t^i)} = (1 - \tau)w_t \epsilon_t \quad (3.4)$$

$$u'(c_t^i) = \beta \mathbb{E}_t [u'(c_{t+1}^i)(1 + r_{t+1})] + \mu_t, \quad \mu_t \geq 0. \quad (3.5)$$

Whenever the borrowing constraint is binding and the multiplier is positive, ceteris paribus current marginal utility from consumption increases and consumption is lower than when the constraint does not bind. The value of the multiplier depends crucially on how much the household uses labor supply to smooth consumption, that is the relative curvature of the utility from consumption and leisure.

We follow Monacelli and Perotti (2011) in parametrizing the instantaneous utility function:

$$u(c) - g(n) = \frac{c^{1-\gamma}}{1-\gamma} - \chi \frac{n^{1+\psi}}{1+\psi}, \quad \gamma > 0, \quad \chi > 0, \quad \psi > 0 \quad (3.6)$$

In this model, since households are ex ante identical, the solution to household i 's optimization problem is characterized by her vector of idiosyncratic state variables (b_t, ϵ_t) , that is, we can aggregate agents over the two-dimensional distribution.

3.3.2 Technology

Labor is the only input of production and aggregate output is defined as:

$$Y_t = A \int_b \int_\epsilon n(b_t, \epsilon_t)^\alpha \epsilon_t \lambda(b_t, \epsilon_t) db_t d\epsilon_t, \quad (3.7)$$

⁵In the analysis, we will focus throughout on stationary equilibria, that is $r_t = r$, $\forall t$.

where A is a scaling factor and α is workers' labor share in total income. We assume away feedback effects from changes in aggregate labor supply via a change in the wage rate by focusing on the case $\alpha = 1$.⁶

Given that we assume competitive markets for goods and labor, wages equal marginal productivity of each worker, $A(1 - \tau)\epsilon_t$.

3.3.3 Government

The government spends an exogenous amount G which is assumed to be unproductive and is not valued by neither firms nor households, and distributes transfers to households. All expenses are financed by imposing a flat tax τ on the labor income of households.

$$G + \int_b \int_\epsilon T_s \mathbf{1}_{b>0} \lambda(b, \epsilon) db_t d\epsilon_t + \int_b \int_\epsilon T_b \mathbf{1}_{b<0} \lambda(b, \epsilon) db_t d\epsilon_t = \tau w \int_b \int_\epsilon n(b, \epsilon) \epsilon \lambda(b, \epsilon) db_t d\epsilon_t. \quad (3.8)$$

The novelty of this paper is the specification of the transfer program, which is summarized by the policy parameter ϕ_{rule} . This policy parameter determines the transfer borrower receive relative to lenders ($T_b = \phi_{rule} T_s$). We introduce a form of targeted transfers that refers to one observable household characteristic, the financial position. Further, these transfers are not fully state contingent as the household's state is characterized by the pair of asset holdings and labor productivity. As we document below, this is due to the incompleteness of financial markets, thus, if a full set of state contingent assets were available, transfers would be state contingent.⁷ We use this specification to investigate how effective imperfectly state contingent policy instruments are in alleviating the distortions arising from incomplete markets.

3.3.4 Recursive Formulation of Household Problem

There is no aggregate uncertainty in this economy. The combination of bonds b and productivity state ϵ characterize a household fully in the stationary distribution. Let $V(b, \epsilon)$ denote the value function of a household with bond holdings b and productivity ϵ . The bellman equation reads:

⁶This simplifies the analysis by circumventing the question of distribution of profits for decreasing returns to scale without introducing entrepreneurs. The case studied in Monacelli and Perotti (2011) attributes all profits to agents with positive asset holdings, which induces an unrealistic wealth effect obscuring the more interesting impact of transfer policies.

⁷Of course, they would also be redundant and not change the allocation of consumption, labor and aggregate output but only influence asset flows.

$$V(b, \epsilon) = \max_{c, n, b'} \left[u(c) - g(n) + \beta \int_{\epsilon' \in E} V(b', \epsilon') dF(\epsilon' | \epsilon) \right] \quad (3.9)$$

$$c + b' = (1 - \tau)w\epsilon n + (1 + r)b + \mathbf{1}_{b \geq 0}T_s + (1 - \mathbf{1}_{b \geq 0})T_b \quad (3.10)$$

$$b' \geq \underline{b}. \quad (3.11)$$

Definition 3.1 *Given a borrowing limit \underline{b} , a government policy G, τ and a transfer allocation rule ϕ_{rule} , a stationary competitive equilibrium is a set of positive prices w, r , a positive quantity of aggregate labour supply Y , time invariant decision rules $n(b, \epsilon), b'(b, \epsilon)$ and a probability distribution $\lambda(b, \epsilon)$ such that:*

1. *The price r clears the bond market s.t.*

$$\int_{\epsilon} \int_b \lambda(b, \epsilon) b'(b, \epsilon) db d\epsilon = 0 \quad (3.12)$$

2. *The policy functions $c(b, \epsilon), n(b, \epsilon), b'(b, \epsilon)$ solve the household maximization problem.*

3. *The probability distribution $\lambda(b, \epsilon)$ is a stationary distribution s.t.*

$$\lambda(b'(b, \epsilon), \epsilon') = \int_{\epsilon} \int_b \lambda(b, \epsilon) dF(\epsilon' | \epsilon) \quad (3.13)$$

4. *The government budget constraint (3.8) is satisfied with equality.*

3.3.5 The allocation under complete markets

We want to assess how much borrowing constraints and market incompleteness contribute to welfare losses in this economy. An analogous 'first-best' economy is not available in this case, so we confront several configurations to the outcome with incomplete markets. In particular, we want to assess the ability to replicate complete markets with non state-contingent targeted transfers.

We assume that households have access to a full set of state-contingent assets. They are born without initial asset holdings and all maximize the same objective function:

$$\mathbb{E}_{-1} \sum_{t=0}^{\infty} \beta^t [u(c_t^i) - g(n_t^i)]. \quad (3.14)$$

subject to the budget constraint

$$c_t^i + \int_{\epsilon} p_t^{\bar{\epsilon}} b_{t+1}^{\bar{\epsilon}} d\bar{\epsilon} = b_t^s + (1 - \tau)\omega\epsilon n_i + T_i \quad (3.15)$$

where $\int_0^1 T_i di = T = x \int_0^1 \epsilon_i n_i di$. p_t^{ϵ} is the price in period t for the value ϵ of labor productivity in the next period. As with incomplete markets, transfers are targeted if the values of T differ across agents with respect to the 'sign' of their asset holdings.

The passive government's budget constraint reads:

$$G + T = \tau Y.$$

Note that we do not remove the assumption of distortionary taxes τ , which the government imposes to finance its expenditures.

In equilibrium, the level of consumption, labor supply and output do not depend on the level of transfers; consumption is independent of current labor productivity, and there is no history dependence for assets and labor supply either. Because markets are complete and agents ex-ante identical, transfers are redundant and impact only on the equilibrium level of asset holdings. Thus, all agents that are less productive than the (unconditional) average work less and have net negative assets, while the relatively more productive agents are net savers, which captures the insurance mechanism. In terms of the actual asset holdings, agents save against the risk of low productivity, and go short for the case in which they are productive. Thus, with complete markets the set of relatively unproductive agents coincides with the set of agents with positive asset holdings. In this case, transfers are not only targeted but implicitly contingent on labor productivity too, since the (productivity, asset position) distribution is degenerate. For more than 2 realizations of labor productivity, asset positions would differ across agents, hence targeted transfers would not state contingent in complete markets either.

We consider the scenarios of (a) No transfers to households, only government consumption: $x = 0$, (b) uniform transfers $T_b = T_l$, and (c) targeted transfers $T_b = \phi_{Rule} T_l$. Because labor supply does not depend on the policy rule for transfers, total output does not change if the financing rule is varied. Neither do the level of government consumption and total transfers. Consequently, welfare is the same under scenarios (b) and (c) and the only difference between them, is the level of assets that agents hold. Welfare and the allocation in (a) depend on the value of the tax rate. If the tax rate is the same as in (b) and (c), output will be the same, but consumption and welfare will be lower because government consumption

is higher accordingly.

We derive the following equation determining equilibrium labor supply:

$$\frac{g'(n_t^j)}{g'(n_t^i)} = \frac{\epsilon_t^j}{\epsilon_t^i}, \quad \forall i, j, i \neq j. \quad (3.16)$$

Using the aggregate resource constraint and the first order condition, we can solve for the optimal allocation.

With $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$ and $g(n) = \frac{n^{1+\psi}}{1+\psi}$, we have

$$\frac{n^i}{n^j} = \left(\frac{\epsilon^i}{\epsilon^j} \right)^{\frac{1}{\psi}}. \quad (3.17)$$

Assuming two different values for labor productivity, labor supply for the type 1 equals:

$$n_1 = \left(\left(\lambda_1 \epsilon_1 + \lambda_2 \epsilon_2 \left(\frac{\epsilon^2}{\epsilon^1} \right)^{\frac{1}{\psi}} \right) \left(1 - \frac{G}{Y} \right) (\epsilon_1 (1 - \tau))^{\frac{1}{\gamma}} \right)^{-\frac{\gamma}{\psi + \gamma}}, \quad (3.18)$$

where λ_i are the shares of agents of type i in the population. Restricting our attention to stationary Markov chains, these shares are the unconditional probabilities of being in that particular state since we can apply the law of large numbers.

Furthermore,

$$c^i = c = \int_0^1 \lambda(\epsilon^i) \epsilon^i n^i di - G.$$

And transfers can be computed from $\lambda_1 T_l \phi_{Rule} + (1 - \lambda_1) T_l = xY$:

$$T_l = \frac{x}{1 + (\phi_{Rule} - 1)\lambda_1} \int_0^1 \epsilon_i n_i di.$$

We will compare the welfare losses due to incomplete markets and borrowing constraints as well as those that are due to the introduction of transfers and a redistributive policy. An approximate decomposition can be made by comparing results from (a) and (b) with those from the model with incomplete markets. The parameter values will be the same, as we describe in the next section.

3.4 Numerical Illustration

In this section, we first discuss the parameter choice and the solution method for the benchmark economy in Section 3.4.1. The discussion of the results follows in Section 3.4.2.

3.4.1 Choice of parameters and Solution Method

For the purpose of the numerical illustration, we take standard parameters from the literature, so as to have a model period of one year.

Table 3.1: Parameters and Targets

α	A	β	σ	ψ	χ	\bar{b}	τ
1	1	0.96	2	1	1	-15	0.28

The risk aversion parameter is set to 2, as is standard in the literature. The inverse of the Frisch elasticity of labor supply (ψ) is set to 1 as in Monacelli and Perotti (2011), as well as the scaling factor for the disutility of labor (χ) in the instantaneous utility function. In our benchmark calculations, we set the borrowing limit to -15 which is a very lax borrowing constraint, given that we normalize average annual labor income to unity. Thus, the borrowing limit is not too far from the natural borrowing limit $-\frac{w\epsilon(1-\tau)}{r}$. All along Section 3.4.2, we will contrast our results with substantially tighter borrowing limits, and show that results are robust to a tightening of the exogenous borrowing limit. This serves also our aim to assess the impact of transfer policies on the effective easing of borrowing constraints. Finally, we set the level of labor taxation to 0.28 as suggested by Ábrahám and Cárceles-Poveda (2010).

The stochastic process for labor productivity is assumed to be lognormally distributed and follows a stable autoregressive process of order one.

$$\log \epsilon_t = \rho \log \epsilon_{t-1} + \eta_t, \quad \text{where} \quad \eta_t \sim N(0, \sigma_\eta^2) \quad (3.19)$$

There is a wide range of estimates in the literature. We will base our values for the autocorrelation (ρ) and for the coefficient of variation (σ_η) of the normally distributed error term on Diaz, Pijoan-Mas, and Rios-Rull (2002) who suggest 0.6 and 0.2, respectively. The process is discretized using the Rouwenhorst method as suggested in Kopecky and Suen (2010). We assume two values for labor productivity.

In order to close the government budget constraint, we fix the government to output ratio of $\frac{G}{Y} = 0.17$ as suggested by Ábrahám and Cárceles-Poveda (2010). This gives a fraction of total transfers to output of 11 %.

The household problem is solved using a combination of policy function iteration and value function iteration with endogenous grid points. The general equilibrium is found using

both bisection for the equilibrium interest rate and for the equilibrium level of transfers.

3.4.2 Results

The economic experiment we have performed compares allocations between steady states of an incomplete markets economy for various 'redistribution policies' (ϕ_{rule}). We model the policy regime, or policy rule as a proportional relationship between the amount of transfer distributed to borrowers and the transfer given to savers. In order to shed light on the mechanisms, we assess the impact of moving from a uniform / lump-sum transfer policy ($\phi_{rule}=1$) to targeted transfer policies which either favor borrowers ($\phi_{rule} > 1$) or savers ($\phi_{rule} < 1$).

Labor supply misallocation and type misallocation

We characterize the allocation of the economy by focusing on two inefficiencies: A labor supply misallocation and a type misallocation. Finally, we will show how introducing the contingency of net-asset position affects those inefficiencies, and the allocation relative to the complete market allocation derived in Section 3.3.5.

The misallocation of labor supply is best illustrated in Table 3.2. Low productivity households supply more hours worked than under complete markets to facilitate consumption smoothing, whereas high productivity households have an ex-post wealth effect, and reduce their hours supplied below the 'efficient' level. This result is well-known in the incomplete markets literature with idiosyncratic productivity risk as in Pijoan-Mas (2006) and Marcet, Obiols, and Weil (2007) for example. We can see that this misallocation becomes more pronounced the tighter are borrowing constraints, since labor supply becomes the dominant means to smooth consumption. In contrast, the misallocation by asset position is alleviated when borrowing constraints become tighter, that is, borrowers work relatively less and savers relatively more than with slack constraints. This is a consequence of the absence of poor agents with high debt levels as well as the efficacy of assets used as insurance instrument. The latter leads to a lower equilibrium interest rate which discourages agents from saving more and working less.

Table 3.2: **Aggregate hours worked by productivity** - Complete markets allocation compared to stationary equilibria.

	Low productivity	High productivity	Borrowers	Savers
Complete Markets	0.365	0.601	0.601	0.365
Model with $\underline{b} = -1$				
$\phi_{rule} = 0.5$	0.459	0.532	0.604	0.387
$\phi_{rule} = 1$	0.449	0.538	0.571	0.416
$\phi_{rule} = 2$	0.440	0.545	0.564	0.420
Model with $\underline{b} = -5$				
$\phi_{rule} = 0.5$	0.412	0.571	0.616	0.367
$\phi_{rule} = 1$	0.406	0.574	0.586	0.393
$\phi_{rule} = 2$	0.401	0.577	0.589	0.388
Model with $\underline{b} = -15$				
$\phi_{rule} = 0.5$	0.409	0.595	0.649	0.355
$\phi_{rule} = 1$	0.404	0.594	0.620	0.378
$\phi_{rule} = 2$	0.400	0.594	0.625	0.368

Market incompleteness due to idiosyncratic labor risk not only leads households to supply labor inefficiently, but also gives rise to inefficient bond holdings decisions. We denominate this inefficiency a 'type misallocation'. In fact, whereas households with low/high productivity realization should hold positive/negative assets (respectively), Table 3.3 shows that in the case of uniform transfers depending on the borrowing constraint only between 52 and 63 % of households hold negative assets when they are hit by a low productivity shock, and between 52 and 66 % of households hold positive assets when facing a high productivity shock. In the case of perfect risk sharing, both shares should amount to zero.

Table 3.3: **Type Misallocation:** Share (%) of households with negative asset holdings (borrowers) and positive asset holdings (savers) by productivity status versus complete market benchmark.

	Low productivity Borrowers	High productivity savers
Complete Markets	0	0
Model with $\underline{b} = -1$		
$\phi_{rule} = 0.5$	0.6109	0.6465
$\phi_{rule} = 1$	0.6327	0.6624
$\phi_{rule} = 2$	0.6402	0.6757
Model with $\underline{b} = -5$		
$\phi_{rule} = 0.5$	0.5370	0.5470
$\phi_{rule} = 1$	0.5483	0.5584
$\phi_{rule} = 2$	0.5544	0.5706
Model with $\underline{b} = -15$		
$\phi_{rule} = 0.5$	0.5169	0.5184
$\phi_{rule} = 1$	0.5216	0.5228
$\phi_{rule} = 2$	0.5276	0.5322

The combination of the labor supply misallocation and the type misallocation lead to a deviation in aggregate quantities (and prices) from the complete market allocation as documented in Table 3.4. The high level of aggregate labor supply, between 1.16 and 3.98 % above the efficient level of aggregate level supply, translates into an aggregate output that is between -1.5 and 2.46% around the efficient level of output. Also the type misallocation leads to market clearing interest rate levels that are below the first-best scenario, indicating bond over-accumulation for the purpose of private insurance, as in Huggett (1993).

Table 3.4: Complete market (CM) allocation compared to incomplete market (IM) allocation for different redistribution policy (ϕ_{rule}) and borrowing limits (\underline{b}).

	r	C	Y	N	U
CM Allocation	4.17	0.88	1.06	0.97	-40.88
-	r	ΔC	ΔY	ΔN	ΔU
IM/CM-1 (%) - $\underline{b} = -1$					
$\phi_{rule} = 0.5$	2.46	-1.49	-1.48	2.18	-1.29
$\phi_{rule} = 1$	2.51	-1.46	-1.50	2.00	-0.78
$\phi_{rule} = 2$	2.75	-1.42	-1.40	2.57	-0.42
IM/CM-1 (%) - $\underline{b} = -5$					
$\phi_{rule} = 0.5$	3.93	-0.21	-0.22	1.16	-2.03
$\phi_{rule} = 1$	3.92	-0.35	-0.34	1.21	-1.50
$\phi_{rule} = 2$	3.97	-0.39	-0.35	1.52	-1.17
IM/CM-1 (%) - $\underline{b} = -15$					
$\phi_{rule} = 0.5$	4.14	1.32	2.46	3.98	-5.89
$\phi_{rule} = 1$	4.13	0.91	1.97	2.83	-4.90
$\phi_{rule} = 2$	4.15	0.69	1.66	3.14	-4.16

Note: r stands for the interest rate, C for aggregate consumption, Y for aggregate production, N for average hours worked, and U for welfare.

Table 3.4 also shows that average welfare worsens with the level of the borrowing limit relative to the welfare reached under complete markets. Whereas production is lower in the two first cases inspite of higher amount of labor supply, in the scenario with the laxest borrowing limit, a higher output is reached, at the expense of a substantial rise in labor supply above the efficient level. In terms of welfare, this makes households worse off, as the compensation in terms of consumption above the first-best equilibria is not sufficient to compensate for the disutility due to additional labor supply. This effect can be attributed to the poor households who have to work relatively more and who do not exist in an economy with tight borrowing constraints. Furthermore, aggregate welfare is lower with slacker borrowing constraints, and here as well the poor agents are worst off. This is consistent with the results from Abraham & Carceles-Poveda (2010), who demonstrate that the substantial welfare gains come from reforms that reduce borrowing limits (in their model endogenously). This effect is at work in our model, because a higher ϕ_{rule} translates into fewer poor households at the borrowing

limit. However, our results are to be taken with caution as we have so far ignored the welfare cost of implementing the targeted transfer program along the transition path.

Making transfers contingent on the households' asset holding position

In terms of policy, the redistribution policy is in all three scenarios welfare improving when the target transfer policy favors borrowers relative to savers. In particular, in the scenario with the tightest borrowing limit, the average household has a welfare only 0.42% below the complete markets scenario, when targeted transfers are twice higher for borrowers than savers.

We measure the improvement in terms of aggregate welfare that is due to targeted transfers as the percentage difference between aggregate welfare when transfers are non-targeted and when $\phi_{rule} = 2$. However, we need to qualify our results as we should distinguish between the effect of targeted transfers on the allocation from the effect of market incompleteness. To do so, we compare average welfare to an economy where all tax revenues are used for non-valued government spending as depicted in Table 3.5. With respect to uniform transfers in Table 3.4, we can infer that in the case of tight borrowing constraints, the distance to the complete market welfare is 5 % lower, while it is 6 % and 5.1 % lower with intermediate level of constraint and lax constraints, respectively, compared to an economy without transfer programs. Overall, the two tables tell us two distinct messages: First, the welfare loss from incomplete markets and borrowing constraints is very low in this economy, which is mostly due to our simple setup, that is, linearity assumptions and the lack of risk regarding the properties of the stochastic process for labor productivity. Second, the bulk of welfare loss stems from the lack of financial instruments, not from distortionary taxation. Given these points, we can conclude that although our welfare improvements and changes in the allocation are quantitatively small, they are not negligible relative to the dynamics that the setup can deliver: By doubling the transfers targeted to the agents with negative asset holdings, the welfare gap can be reduced by 46%, 22% and 15% for tight, intermediate and lax borrowing constraints, respectively.

Table 3.5: Welfare difference (%) to complete markets allocation from model without transfers ($\tau = \frac{G}{Y} = 0.28$).

$\underline{b} = -1$	$\underline{b} = -5$	$\underline{b} = -15$	close to NBL
-0.82	-1.59	-5.15	-7.73

Table 3.6 reveals that the implementation of the redistributive policy $\phi_{rule} = 2$ reduces the inefficient labor supply allocation. Due to higher lump-sum transfers, indebted households, who are mostly households with low productivity, reduce their supply of labor relative to the scenario with uniform transfers, such that the over-provision of labor supply is reduced. Symmetrically, saving households, who consist mostly of households with high productivity, raise their labor supply with increased ϕ_{rule} to compensate for lower lump-sum transfers, thereby reducing the labor misallocation.

Table 3.6: Change (%) in average hours worked by quintile of financial wealth relative to $\phi_{rule} = 1$ ($\underline{b} = -15$).

Policy	0-20	20-40	40-60	60-80	80-100
$\phi_{rule} = 0.5$	3.39	3.43	-0.57	-2.11	-5.08
$\phi_{rule} = 2$	-2.92	-2.10	-1.50	6.69	1.18

Figures 3.3 and 3.4 show the effect of the redistribution policy on the type misallocation. By increasing the amount of lump-sum transfers distributed to borrowers, the share of low productivity borrowers increases leading to a higher demand for bond holdings, which in equilibrium requires a higher equilibrium interest rate for the bond market to clear. When the redistribution policy favors savers, the precautionary motive of borrowers is crowded-in and they compensate for the lower level of transfers, by increasing their labor supply and level of borrowing. However, savers' precautionary motive is reduced, leading to a reduction in bond supply, which leads to a higher equilibrium interest rate. Higher transfer to savers crowds savers in up until some threshold value $\bar{\phi}_{rule}$, point at which the share of lenders decreases.

All in all, a redistribution policy favouring lenders worsens the labor supply inefficiency but reduces the type misallocation.

Figure 3.3: Equilibrium Interest Rate as a function of distribution rule and borrowing constraint.

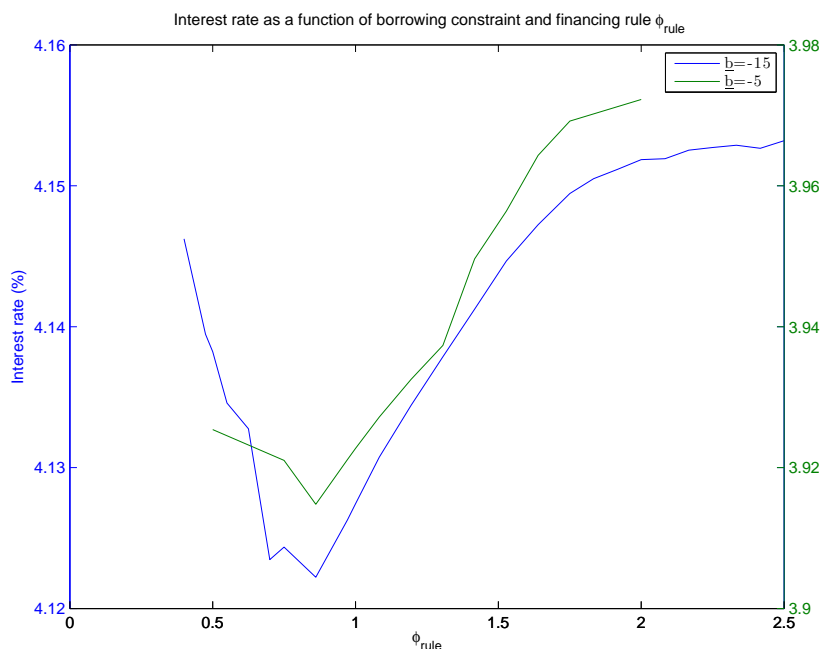
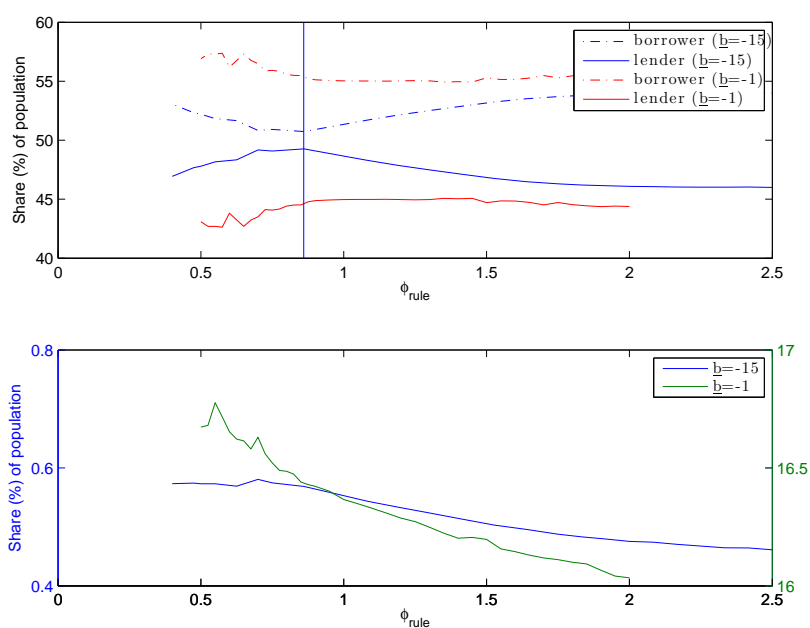


Figure 3.4: Upper panel: Share of borrowers and lenders for various ϕ_{rule} . Lower Panel: Share (%) of borrowing constrained households for various ϕ_{rule} .



Targeted Lump-sum transfers as a reform

In the following section, we analyze the desirability of introducing the proposed distributive policy as a policy reform. In a similar vein to Aiyagari (1995), we compute the share of households in favour of implementing the distribution policy. All the results presented herein don't account for potential welfare gains or losses incurred along the transition, they are mere steady-state comparison. Hence we are not yet able to track households across steady-states.

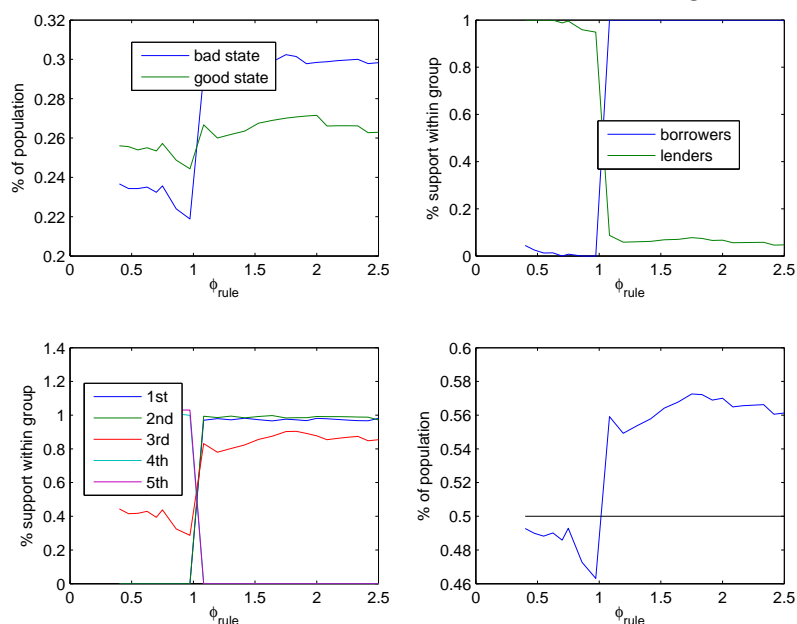
Table 3.7: Changes (%) in average welfare by quintile of bond holdings relative to $\phi_{rule} = 1$.

Policy	0-20	20-40	40-60	60-80	80-100
$\phi_{rule} = 0.5$	-3.89	-3.56	0.58	1.61	4.06
$\phi_{rule} = 2$	3.36	2.16	1.50	-6.14	-0.75

Table 3.7 decomposes the welfare gains of moving from a uniform transfer program to redistribution policy in favor of borrowers ($\phi_{rule} = 2$) and a policy in favor of lenders ($\phi_{rule} = .5$) by quintile of the financial asset distribution. Unsurprisingly the lower two quintiles all support redistributive policies targeting borrowers, and the upper two quintiles favour a policy targeting lenders.

Notable is however, the fact that on average the third quantile supports both policies but gains on average most from a pro-borrower transfer program. Figure 3.5 reveals that the increase in support of a pro-borrower policy comes from households with a bad productivity realization, that are borrowing and within the 3rd quintile of the financial asset distribution. Two effects compound to lead to the welfare gains from implementing a pro-borrower transfer program within this quintile. First, savers within this group gain insurance in the case they have to borrow next period, which is quite likely in this quintile. Second, savers within this quintile gain from higher equilibrium interest rate. The upper right panel of figure 3.5 shows that around 10% of lenders support pro-borrower policies.

Figure 3.5: Share of households that are better off - according to various criteria.



3.5 Conclusion and Future Work

So far the fiscal policy literature focused on the analysis of tax reforms and lump sum transfers on the allocative efficiency of production factors, but overlooked the effect of targeting transfers, and more particularly the redistribution channel of fiscal policy. Recent empirical evidence suggests that the role of government consumption as a fiscal policy tool is fading to the benefit of government transfers, which has lead to a renewed interest in understanding the impact of transfer programs on allocations. In this chapter, we have highlighted channels through which targeted transfer programs have redistributive effects, due to the existence of two inefficiencies coming from a labor supply misallocation and a type misallocation. More precisely, we have shown that transfer programs should target borrowers rather than lenders, for them to be welfare improving. Finally, we conducted a first step towards understanding issues related to the implementability of target transfer programs, and concluded that only pro-borrower policies would be politically sustainable.

Our plan for future work will focus on the analysis of the welfare effects of such policies taking into account the transition implied by policy changes. This includes the question of whether economies with more developed financial markets gain less from such transfer program than economies where borrowing is more restricted. Also the analysis of the incentive compatibility problems related to such transfer program could deliver interesting valuable

insights on the applicability and effectiveness of such targeted transfer programs.

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