

Pension Uncertainty and Household Portfolio Choices

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Abstract

Recent theory suggests that idiosyncratic non-tradable risks can be important determinants of asset allocation decisions. I empirically assess this proposition focusing on the background risk of uncertain public pension benefits. When contributions to the social security system are mandatory and benefits tied to future labor income realizations, pension risk stemming from unexpected earnings variations is largely uninsurable and hard to diversify. To identify the causal effect of pension risk on portfolio composition, I exploit the exogenous changes in expected pension benefits and degree of pension uncertainty introduced by the Italian social security reforms of the 90's. The legislative intervention made pension entitlements less generous and less volatile and differently affected different observable groups and cohorts of individuals, creating an ideal quasi-experimental framework for the purposes of this study. Besides, as the overwhelming majority of Italian workers is exclusively covered by the social security program and only a negligible fraction contributes to private and occupational plans, public pension risk reflects almost entirely sampled individuals' uncertainty about retirement income. I find statistical evidence of substitutability between background risk and financial risk taking. The estimates indicate that, for a given level of expected pension benefits, an amelioration in background risk equivalent to a 1000 euros decrease in the standard deviation of annual benefits increases the share of risky assets on household financial wealth by 2.4 percentage points. This is a sizeable effect, as risky asset holdings amount, on average, to less than 25% of household financial wealth.

1 Introduction

There is wide consensus in both the economics and finance literature about the fact that household portfolio choices are influenced by sources of uncertainty other than rate-of-return uncertainty. More precisely, when markets are incomplete, idiosyncratic uninsurable and non-diversifiable risks may optimally induce more prudent investment strategies and cause individuals to hold safer portfolios so to attain the desired total exposure to risk. Households are typically endowed with non-tradable background risks such as unexpected earnings variations, unpredictable changes in health status and out-of-pocket medical expenditures, retirement income uncertainty, and the possibility of credit or liquidity constraints. The importance of each

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one of these sources of uncertainty can be different at different stages in the life cycle. Accordingly, individuals should optimally change their asset allocation over time and choose portfolios that best hedge their personal risks. This paper investigates whether and how the background risk of uncertain pension provisions affects household portfolio choices.

The lack of relatively large household panel data on both income and asset holdings makes it difficult to analyse the effect of idiosyncratic background risks on individual portfolio decisions without relying on imputation techniques or combination of different data sources. Also, in the absence of exogenous variation in background risk, the bias in cross-sectional estimates may be severe because of unobserved heterogeneity in household investment behaviour. In this study I overcome both problems by means of a very rich dataset, containing detailed information on household characteristics, income and portfolio composition, and a credible source of exogenous variation in background risk. Besides, I contribute to the existing literature by considering the variability of expected pension benefits as a background risk. Even though investing for retirement is one of the main purposes of household wealth allocation strategies, the role of pension uncertainty has been neglected when studying the optimal individual portfolio composition over the life cycle.

Since I regard pension uncertainty as a background risk, I only refer to public pension provisions. This is because private pension risk can be, to a great extent, endogenously controlled and affected by the individual's investment decisions. The data set used in this study also provides an empirical justification for this choice. The overwhelming majority of the surveyed households, in fact, is exclusively covered by the public social security programme, and only a negligible fraction expects to receive some benefits from private or occupational plans.

There exist several reasons why individuals might be uncertain about the amount of resources available after retirement through the social security programme and not consider their future pension entitlements as a risk-free asset. Defined benefit (DB) pensions, often characteristic of public schemes, greatly reflect earnings uncertainty, particularly when the pension award formula averages earnings over a short period of final years. This is less of an issue in notional public defined contribution (DC) schemes, where pension provisions are proportional to contributions paid throughout the working career and, therefore, labour income shocks can be more easily smoothed out over time. DC allowances, however, are subject to rate-of-return risk, as their value is determined by the proceeds on account holdings. Pensions are vulnerable to inflation risk too, both when the entitlement is calculated and during retirement. The sustainability of the social security system and the possibility of pension reforms are further sources of uncertainty about public pensions (Butler, 1999). If people believe that the system will not be able to fulfil its promises, they will not consider the present discounted value of social security benefits as net wealth.

Within the framework of a life cycle model, public pension uncertainty is, whatever its form or origin, a factor bound to influence the investment behaviour of forward looking individuals. The sources of unpredictable public benefit variations are usually beyond the agent's control. Thus, public pension uncertainty is largely an exogenous risk. The goal of this paper is to investigate the relationship between this background risk and individuals' incentives to hold risky assets in their portfolios. As numerous OECD countries have recently undergone or are currently undergoing pension reforms, such an exercise is relevant for the design of policies that

are being considered and for the study of the implications of the ones already implemented. Different institutional features of the social security programme can indeed imply different degrees of pension uncertainty and account for different patterns in household stock market participation and stock holdings. Also, variation in pension risk could help explain some of the observed cross-sectional variation in household portfolio composition.

The theory of portfolio choice with background risk builds on the seminal contributions of Pratt and Zeckhauser (1987), Kimball (1993) and Gollier and Pratt (1996), who show that, under fairly general conditions on preferences, there exists substitutability between exogenous and endogenously controlled risks. When confronted with a deterioration in background risk, investors with such preferences will behave in a more risk-averse manner and reduce their exposure to avoidable financial risks by choosing a relatively safer portfolio. Using a two period model of consumption and asset allocation, Elmendorf and Kimball (2000) demonstrate that, when preferences exhibit decreasing absolute prudence, labour income risk increases precautionary savings and reduces incentives to invest in risky assets. Koo (1998, 1999) and Viceira (2001) provide similar conclusions in extended dynamic settings with finite or infinite horizon.

Several empirical studies have attempted to back these theoretical predictions. Overall, background risks have proved helpful in explaining non-participation in the stock market and some of the considerable heterogeneity in individual portfolio composition.¹ Guiso *et al.* (1996) find that Italian households facing higher income variability and higher probability of being liquidity constrained tend to keep a lower proportion of their financial wealth in risky assets. Using the American Panel of Individual Tax Return Data, Heaton and Lucas (2000b) relate business income risk to equity holdings, while Vissing-Jørgensen (2002b) studies the relationship between earnings variance and stock market participation in the Panel Study of Income Dynamics. Souleles (2003) shows that in the Consumer Expenditure Survey individuals with more volatile consumption hold relatively fewer stocks. Conversely, Alessie *et al.* (2002) and Hochguertel (2003) do not find evidence of a significant role of earnings uncertainty on Dutch households' demand for risky assets. Massa and Simonov (2006) observe that Swedish investors tend to hold stocks correlated to their labour earnings rather than hedging against non-financial income risk.

The empirical analysis in this paper uses microeconomic data drawn from the Italian Survey of Household Income and Wealth (SHIW). I refer to pension risk as uncertainty about future social security benefits stemming from unexpected earnings variations. I estimate the degree of pension risk at the individual level and I relate it to the demand for risky assets. The available waves (1989-2006) span over a period featuring a massive shift towards stock holdings and dramatic changes in the Italian social security system that made pension provisions both less generous and less volatile. The differential variation in pension risk introduced by the reforms across groups and cohorts of workers allows me to identify the effect of pension uncertainty on household portfolio decisions. The study is carried out in two steps.

In a first step, I specify a model for earnings determination that separates labour income shocks into idiosyncratic transitory and persistent components and I estimate the degree of earnings variability for different job categories and education groups. Using these estimates, I construct, for each labour income recipient, measures of the level and riskiness of future pension

¹Campbell (2006) and Curcuru *et al.* (2006) provide extensive surveys on household finance.

entitlements, exploiting the benefit formula as the channel through which unexpected earnings variations translate into pension benefit uncertainty. The estimation procedure implies that pension risk varies across individuals according to their sector, education, age and length of the retirement horizon and crucially depends on the computation arrangement for granting benefits.

I focus on the changes in the pension award formula introduced in Italy by two main social security reforms in 1992 and 1995. The pension legislation in the post-reform regime features a gradual replacement of the traditional DB public pension scheme with a notional DC one. As a result, pension benefits are awarded averaging earnings realizations over a longer career span. This in turn implies less generous provisions on one hand (a drop of 12% on average), but also a considerably lower degree of pension uncertainty for workers before retirement on the other (an average reduction of 50% in the standard deviation of annual benefits). More importantly, the reforms differently affected different categories and cohorts of individuals, introducing discontinuities depending on the sector and on the number of years of contribution. Observing some of these groups in both the pre and the post-reform regimes and assuming that the changes in the pension formula were not fully anticipated, the reforms created an ideal quasi-experimental framework for the purposes of this study.

In a second step, I relate, in a difference-in-difference regression framework, the share of risky assets on household financial wealth to the degree of pension uncertainty. I therefore exploit the differential effect of the reforms on different groups' entitlements to identify the causal effect of background risk on individual investment strategies. The estimates statistically support the proposition that lower uncertainty about future pension benefits is associated with riskier portfolios. The results suggest that, given the expected level of pension benefits, an amelioration in background risk, equivalent to a 1000 euros decrease in the standard deviation of annual benefits, increases the share of risky assets by 2.4 percentage points. This is a quite sizeable effect if one considers that, on average, risky asset holdings represent less than 25% of household financial wealth. The estimates also indicate that the share of risky assets is an increasing function of household disposable income. The estimated relationship is consistent with utility functions that exhibit decreasing absolute prudence. As in previous studies, I find evidence of a hump-shaped age profile for stockholding. Since it may imply higher chances of facing out-of-pocket medical expenditures, being in poor health reduces the demand for equities. Conversely, contributing to a private pension fund and holding a life insurance policy are both positively correlated with financial risk taking.

The rest of the paper proceeds as follows. In section 2, I first sketch a simple model that provides a theoretical framework for the empirical analysis. Next, I introduce the econometric specification and discuss the identification strategy and the estimation procedure. In section 3, I estimate the variance of the permanent shocks to earnings for different job and education groups and I use it to obtain measures at the individual level of expected pension benefits and the degree of pension uncertainty. Section 4 gives some institutional details of the Italian social security legislation before and after the reforms of the 90's. It also presents a quantitative assessment of the differential effects of the changes in the benefit formula on different groups' pension entitlements. In section 5, I briefly analyse recent trends in household portfolio composition and stock market participation in Italy. The empirical results are presented and discussed in section 6. Section 7 concludes.

2 Optimal Portfolio Allocation and the Background Risk of Uncertain Retirement Income

This section introduces a simple two-period model of consumption and portfolio choice where agents hold a non-tradable risky asset, specifically the right to receive an annuity at retirement whose payment stream is uncertain. The model solution is informative about the relationship between optimal portfolio composition and retirement income risk. It also provides a theoretical justification for the econometric specification that I will use to empirically study the effect of pension uncertainty on household portfolio decisions.

2.1 Portfolio problem with a non-tradable risky asset

Starting with an initial wealth W_t , the agent decides optimal consumption and asset allocation at time t in order to maximize next-period return on wealth. At time $t + 1$, the agent receives the realization of a non-negative random variable, B_{t+1} , that cannot be borrowed against to finance current consumption and investment decisions. In other words, B_{t+1} is a non-tradable risky asset that promises an uncertain flow of future income whose risk cannot be insured and diversified away.

In a life cycle perspective, one can think of time t as the period during which the individual works, receives labour income and pays contributions to the social security system, acquiring the right to claim pension benefits at retirement. Thus, W_t can be regarded as cash-on-hand, including initial wealth and labour income net of social contributions. At time $t + 1$, the individual retires and claims pension benefits. The variable B_{t+1} can be thought of as uncertain retirement income, available for consumption only at the end of the working career. Along this line, the model can be used to gain some insight on how, and under what circumstances, individual asset allocation responds to changes in the expected value of future pension benefits and variations in the degree of pension uncertainty.

There are two tradable assets in the economy: a risk-free asset with a constant gross return, R_0 , and a risky asset with a stochastic gross return, $R_{1,t}$. Denoting with a lower case letter the log of the gross return, the log premium on the risky asset is

$$r_{1,t+1} - r_0 = r^p + e_{t+1},$$

with e_{t+1} assumed to be normally distributed with mean zero and variance σ_e^2 . The return promised by the non-tradable asset is lognormal:

$$b_{t+1} \equiv \log(B_{t+1}) \sim N(b, \sigma_b^2),$$

and uncorrelated with $r_{1,t+1}$.²

Assuming that preferences are described by a CRRA utility function with coefficient of relative risk aversion γ , and indicating with β the subjective discount factor, the agent solves the following maximization problem by choosing current consumption, C_t , and the share of

²If one interprets B_{t+1} as uncertain DB pension benefits, then this assumption seems reasonable to maintain.

tradable financial wealth held in the risky asset, α_t :

$$MAX_{C_t, \alpha_t} \left\{ \frac{C_t^{1-\gamma}}{1-\gamma} + \beta E_t \left[\frac{W_{t+1}^{1-\gamma}}{1-\gamma} \right] \right\} \quad (1)$$

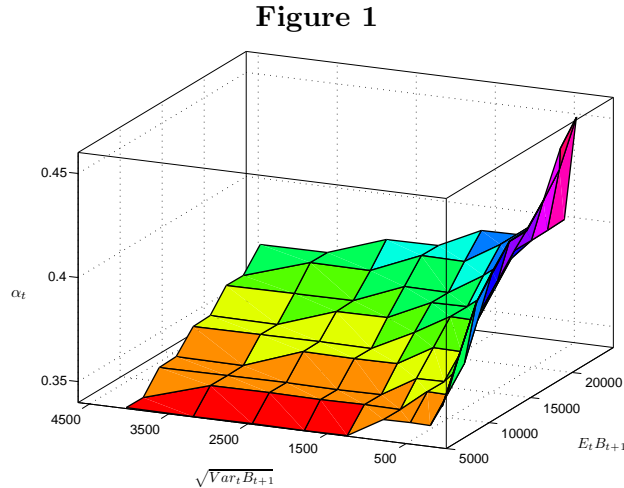
subject to

$$W_{t+1} = R_{t+1} (W_t - C_t) + B_{t+1}, \quad (2)$$

and the next-period gross return on financial wealth

$$R_{t+1} = \alpha_t R_{1,t+1} + (1 - \alpha_t) R_0. \quad (3)$$

Despite its apparent simplicity, the model does not have a closed form solution. An analytical approximate solution for the optimal investment policy α_t can be found in section A of the Appendix. In order to ease the intuition, I use here the numerical solution and draw a 3-dimensional graph of the optimal portfolio weight as a function of the expected value and variance of the return on the non-tradable risky asset. Figure 1 below shows that the optimal share of risky assets, α_t (Z-axis), increases with $E_t(B_{t+1})$ (X-axis) and decreases with $\sqrt{Var_t(B_{t+1})}$ (Y-axis).³



The former is a wealth effect: the higher the expected stream of income promised by the non-tradable asset in $t + 1$, the more willing the investor is to take up financial risks in the current period. The latter can be interpreted as the effect of a mean-preserving increase in the variance of B_{t+1} . As B_{t+1} is non-tradable and its risk uninsurable and non-diversifiable, an increase in $Var_t(B_{t+1})$ represents a deterioration in background risk to which a prudent agent will react by rebalancing his or her portfolio towards a safer position. This is consistent with the

³To solve the model I discretize the state space using an equally spaced grid for W_t and I adopt grid search to find the optimal values for the decision variables. Interpreting B_{t+1} as uncertain social security benefits, the grids of $E_t(B_{t+1})$ and $\sqrt{Var_t(B_{t+1})}$ are chosen so to be representative of the sample mean and standard deviation of yearly public pension in Italy (see section 4 for more details). I use gaussian quadrature to approximate the conditional expectation of future utility. In the figure I plot the optimal share of risky asset corresponding to the sample mean of W_t . The preference parameters used for the numerical solution are $\beta = 0.97$ and $\gamma = 4$. The risk-free interest rate is 2%, the expected risk premium is 3% (and not the historical 5% so to take into account transaction costs). The standard deviation of the return on the risky asset is $\sigma_e = 0.15$. The model is solved under the assumption that $Cov(r_{1,t+1}, b_{t+1}) = 0$. I also experiment with moderate degrees of (positive) correlation between the shocks to $r_{1,t+1}$ and to b_{t+1} , obtaining very similar results.

analysis of Kimball (1993), who demonstrates that prudent individuals facing any risk beyond their control are less willing to bear other endogenously controlled risks, like financial ones.⁴

Interpreting B_{t+1} as public pension benefits, the model implies that, for a given level of expected retirement income, an increase in pension uncertainty will induce individuals to cut back their risky asset holdings in order to readjust the desired exposure to risk. This is because, as social security contributions are mandatory and future pension benefits non-tradable, individuals cannot directly modify the accumulation of social security entitlements in response to an increase in pension uncertainty. They will instead appropriately rebalance the composition of their tradable wealth.⁵ Figure 1 suggests that, other things being equal, prudent investors would shift towards safer (riskier) portfolios if the variability of their future pension benefits increased (decreased).

2.2 Empirical specification and identification strategy

To empirically test this prediction I relate, in a regression framework, the share of household financial wealth invested in risky assets, α_{it} , to the household head's expected value of future pension, PB_{it} , and perceived degree of pension uncertainty, PU_{it} .⁶

It is appropriate to think of the desired share of risky assets as a limited dependent variable. Given their wealth, characteristics, background risks and information, some investors will regard as optimal not to bear any financial risk at all. The selection bias caused by the fact that not all individuals own risky assets can be handled using a corner solution (Tobit) model. Thus, conforming to the standard approach in the literature, I assume the following data generating process for the demand of risky assets:

$$\alpha_{it}^* = X_{it}'\vartheta + \varphi_1 PB_{it} + \varphi_2 PU_{it} + \kappa_t + \varsigma_g + u_{it}, \quad u_{it} | X_{it}, PB_{it}, PU_{it} \sim N(0, \sigma_u^2), \quad (4)$$

$$\alpha_{it} = \max(0, \alpha_{it}^*), \quad (5)$$

where X_{it} is a vector of controls likely to affect household preferences and attitude towards risk over the life cycle, and κ_t and ς_g represent time and group effects, respectively.

The vector X_{it} includes various demographic variables such as household composition, income, net real wealth, area of residence, head's education, and indicators for a working spouse and private pension. Time effects κ_t are introduced to control for macroeconomic shocks and financial market trends, e.g. expected return and volatility of risky assets. Group dummies are also added to the regression equation to account for the possibility of systematic differences in investment behaviour across groups and cohorts due to different earnings profiles and/or preferences.

⁴This result is formalized by Kimball (1993) in the notion of *standard risk aversion*. Standard risk aversion implies that any undesirable risk increases the agent's sensitivity to independent risks. Necessary and sufficient conditions for standard risk aversion are decreasing absolute risk aversion (DARA) and decreasing absolute prudence (DAP). A CRRA utility function would, therefore, imply standard risk aversion.

⁵Suppose that social security benefits are awarded using a defined-benefit formula and that pension uncertainty stems only from unexpected earnings variations. The individual could move to a different job, promising a different degree of earnings fluctuation, so to change the degree of pension uncertainty. However, this benefit would have to be weighted against the costs associated to the move, e.g. search, mobility, loss of tenure, etc. I ignore this possibility throughout the text.

⁶It will become clear shortly how these two measures can be obtained at the individual level.

When estimating the model in equations (4)-(5) on individual data, the identification of the parameters of interest φ_1 and φ_2 is problematic because of the potential endogeneity of expected pension benefits and pension uncertainty. Selection in different occupations as well as retirement decisions are important factors affecting both PB_{it} and PU_{it} and likely to be correlated with unobservable heterogeneity in individual investment behaviour. In practice these two variables are not directly observable, but estimated according to the procedure discussed in the next sections. For the very same reasons as above, correlation between the variables used to estimate pension expectations and pension risk and the error term u_{it} in equation (4) cannot be ruled out, introducing potential bias in the estimated coefficients. Such a problem can be overcome by fitting a two-equation simultaneous model of the type

$$\alpha_{it} = \max(0, X'_{it}\vartheta + \varphi_1 PB_{it} + \varphi_2 PU_{it} + \kappa_t + \varsigma_g + u_{it}), \quad (6)$$

$$\begin{pmatrix} PB_{it} & PU_{it} \end{pmatrix}' = X'_{it}\Pi_1 + Z'_{it}\Pi_2 + \kappa_t + \varsigma_g + v'_{it}, \quad (7)$$

provided that an m -dimensional vector, Z_{it} ($m \geq 2$), of additional variables serving as instruments is available.

The source of exogenous variation used to identify the parameters of interest is the differential effect that the Italian social security reforms in the 90's had on different groups' pension wealth and pension risk. By modifying the benefit formula, these legislative interventions altered the way pension entitlements were granted and significantly changed the expected value of future benefits and the degree of pension uncertainty stemming from earnings shocks. More importantly, they differently affected different groups of individuals, introducing important discontinuities depending on the sector and the number of years of contribution. Observing some of the categories and cohorts affected by these changes in both the pre- and the post-reform regimes, I can use a difference-in-difference estimator, exploiting such differential variation in PB_{it} and PU_{it} across groups, to consistently estimate φ_1 and φ_2 . Thus, the vector of instruments, Z_{it} , includes a binary variable taking value 1 in the post-reform period and its interactions with group dummies. To maximize systematic differences in PB_{it} and PU_{it} as well as their different time evolution across different categories and cohorts of workers, groups are formed following closely the selection criteria of the reforms.⁷

Clearly the identification strategy pursued in this study is more effective the less the changes in the pension award formula brought about by the reforms were anticipated by future retirees. Although the urgency of a major intervention was apparent and several possibilities of reforming the social security system were extensively debated in the early 90's, it was very difficult for the Italian workers before 1992 to foresee which categories and generations of workers were going to be affected and to what extent. The reform of the public pension system, in fact, was part of a broader fiscal strategy aiming to tackle serious budgetary problems. The budget process and the political climate in the early 90's contributed to make the design of the pension reform quite complex, undermining individuals' ability to anticipate possible changes in the system

⁷The reforms identify workers according to their occupation - public employees, private employees and self-employed individuals - and contribution history in 1995 - old workers, with more than 18 years of contribution in 1995; middle-aged workers, with less than 18 years of contribution in 1995; young workers, who started contributing to the system after 1995. Thus, groups are defined by the interaction of occupation and cohort dummies. A more thorough discussion of the institutional details of the reforms can be found below.

and predict their implications for pension entitlements.⁸

An additional assumption that will be maintained throughout the paper is that individuals use the currently legislated pension award formula to form their expectations about future benefits. This might not be entirely correct if the system is perceived to be unsustainable and its rules likely to be modified in the short run. However, in the absence of additional information, it is extremely difficult to take into account other (unobservable) factors, besides the actual rules for granting benefits, that individuals might use to form expectations about their future pension entitlements.

2.3 Econometric procedure

The two-equation simultaneous model (6)-(7) can be estimated using the two-step procedure proposed by Smith and Blundell (1986). Given the potential correlation between u_{it} and v_{it} , one can write

$$u_{it} = v'_{it}\psi + \omega_{it}. \quad (8)$$

After plugging this last expression for u_{it} in equation (6), one has:

$$\alpha_{it} = \max(0, \widetilde{\mathbf{x}}'_{it}\mathbf{b} + v'_{it}\psi + \omega_{it}). \quad (9)$$

where, in order to ease the notation, I have defined $\widetilde{\mathbf{x}}'_{it}\mathbf{b} \equiv X'_{it}\vartheta + \varphi_1 PB_{it} + \varphi_2 PU_{it} + \kappa_t + \varsigma_g$. Under the assumption that $\omega_{it}|\mathbf{x}'_{it}, v_{it} \sim N(0, \sigma_\omega^2)$, equation (9) can be estimated using the following two-step procedure:⁹

1. estimate the reduced form equation (7) by OLS and compute the residuals \widehat{v}_{it} ;
2. replace v_{it} in equation (9) with the OLS residuals \widehat{v}_{it} from the previous step and estimate

$$\alpha_{it} = \max(0, \widetilde{\mathbf{x}}'_{it}\mathbf{b} + \widehat{v}'_{it}\psi + \omega_{it}) \quad (10)$$

by standard Tobit.

The Smith-Blundell approach also delivers a test for the endogeneity of PB_{it} and PU_{it} . If u_{it} and v_{it} were uncorrelated, namely $\psi = 0$, then PB_{it} and PU_{it} would be exogenous. Thus, the typical t -statistic on $\widehat{\psi}$ after the Tobit estimation of equation (10) can be used to test the null $H_0 : \psi = 0$, that is the potential endogeneity of PB_{it} and PU_{it} . As $u_{it} = \omega_{it}$ under $\psi = 0$, the test does not require any distributional assumption on the reduced form disturbance term, v_{it} , to be valid.

When $\psi \neq 0$, the Smith-Blundell procedure does not allow to estimate the variance of u . This is a crucial parameter, required for the estimation of average partial effects. However,

⁸The complexity of the political economy of the Italian pension reform is clearly shown by the series of interventions that took place in the early and mid 90's to correct or implement further previously legislated changes.

⁹Clearly this is equivalent to assuming that $u|\mathbf{x}', v \sim N(v'\psi, \sigma_\omega^2)$. Smith and Blundell (1986) work under the more restrictive assumption of joint normality, namely: $\begin{pmatrix} u \\ v \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{bmatrix} \sigma_u^2 & \sigma'_{uv} \\ \sigma_{vu} & \Sigma_v \end{bmatrix}\right)$. In this case $\psi = \Sigma_v^{-1}\sigma_{uv}$.

it can be showed (Wooldridge, 2002) that, in this case, average partial effects are given by derivatives (for continuous variables) or differences (for discrete variables) of

$$\begin{aligned} E[\alpha|\tilde{\mathbf{x}}] &= E_v \left[\Phi \left(\frac{\tilde{\mathbf{x}}'\mathbf{b} + v'_{it}\psi}{\sigma_\omega^2} \right) \left(\frac{\tilde{\mathbf{x}}'\mathbf{b} + v'_{it}\psi}{\sigma_\omega^2} \right) + \sigma_\omega^2 \phi \left(\frac{\tilde{\mathbf{x}}'\mathbf{b} + v'_{it}\psi}{\sigma_\omega^2} \right) \right] \\ &\equiv E_v \left[\Psi_1 \left(\tilde{\mathbf{x}}'\mathbf{b} + v'_{it}\psi, \sigma_\omega^2 \right) \right], \end{aligned} \quad (11)$$

$$E[\alpha|\tilde{\mathbf{x}}, \alpha > 0] = E_v \left[\tilde{\mathbf{x}}'\mathbf{b} + v'_{it}\psi + \sigma_\omega^2 \lambda \left(\frac{\tilde{\mathbf{x}}'\mathbf{b} + v'_{it}\psi}{\sigma_\omega^2} \right) \right] \equiv E_v \left[\Psi_2 \left(\tilde{\mathbf{x}}'\mathbf{b} + v'_{it}\psi, \sigma_\omega^2 \right) \right], \quad (12)$$

where $\Phi(\cdot)$ and $\phi(\cdot)$ are the cdf and the density of a standard normal, respectively, $\lambda(\cdot) = \phi(\cdot)/\Phi(\cdot)$ is the inverse Mills ratio, and $E_v[\cdot]$ denotes expectation with respect to the distribution of v . Consistent estimates of expressions (11) and (12) can be obtained by replacing the unknown parameters, \mathbf{b} , ψ and σ_ω^2 , with the consistent Smith-Blundell estimators and averaging across individuals, namely

$$E[\widehat{\alpha|\tilde{\mathbf{x}}}] = \frac{1}{N} \sum_{i=1}^N \Psi_1 \left(\tilde{\mathbf{x}}'\widehat{\mathbf{b}} + \widehat{v}'_{it}\widehat{\psi}, \widehat{\sigma}_\omega^2 \right), \quad (13)$$

and

$$E[\alpha|\widehat{\tilde{\mathbf{x}}}, \alpha > 0] = \frac{1}{N} \sum_{i=1}^N \Psi_2 \left(\tilde{\mathbf{x}}'\widehat{\mathbf{b}} + \widehat{v}'_{it}\widehat{\psi}, \widehat{\sigma}_\omega^2 \right), \quad (14)$$

where \widehat{v}'_{it} are the OLS residuals from the first step of the Smith-Blundell procedure.

As I do not assume joint normality of (u, v) , I will not use the Smith and Blundell (1986) formulas for the asymptotic variance of the two-step estimator, nor the delta method to obtain the standard errors of the average partial effects based on expressions (13) and (14). I will instead rely on bootstrap standard errors to conduct statistical inference.

3 Unexpected Earnings Variations and Pension Uncertainty

Suppose that retirement income is entirely provided by a public pension programme. There exist several reasons why individuals may attribute some riskiness to their social security entitlements and these can vary depending on the design of the programme. In a defined benefit (DB) scheme, for example, one can think of future labour income realizations, retirement age, number of years of contribution at retirement, benefit computation arrangements, and the future structure of the pension system as uncertain variables to which benefits are tied. Additional sources of uncertainty for those workers in a pay-as-you-go notional defined contribution (DC) scheme are their future rates of contribution to the account as well as the rates of return on it.

In what follows, I focus on a DB public pension scheme and I refer to pension risk as uncertainty about future benefits stemming uniquely from unexpected earnings variations through the award formula. More precisely, suppose that pension entitlements for a generic individual i are based on the average of the last j labour income realizations:

$$(Pension\ Benefits)_i = K \left(\frac{1}{j} \sum_{s=RA-j}^j Y_{is} \right) = K\bar{Y}_i^j,$$

where Y are earnings, RA retirement age (assumed to be known with certainty), and K a factor that depends on the number of years of contribution at retirement and on the accrual rate. At age t , the individual faces uncertainty about his or her future ($RA - t$) labour income realizations and, to the extent that these realizations enter the pension formula, about his or her future pension benefits. Hence, conditional on the information available at age t , the individual will expect a certain level of future pension entitlements

$$PB_{it} = E_t [(Pension\ Benefits)_i] = K \cdot E_t [\bar{Y}_i^j], \quad (15)$$

and will have a certain degree of uncertainty about them

$$PU_{it} = Std_t [(Pension\ Benefits)_i] = K \cdot Std_t [\bar{Y}_i^j]. \quad (16)$$

Pension risk varies across individuals according to labour income variability and length of the retirement horizon. Individuals in different job categories and education groups typically experience different degrees of earnings fluctuation. This in turn makes future entitlements more or less foreseeable ex-ante. Also, workers at different stages in their lifetime have different information to predict their pensions. As retirement approaches, more and more realizations of labour income entering the pension award formula become known, reducing the ex-ante uncertainty about future social security entitlements. Finally, by changing the career span taken into account for benefit computation, different pension formulae can imply different degrees of pension uncertainty for different groups and cohorts of individuals. In the next sub-sections, I deal with the estimation of expected pension benefits and pension uncertainty as defined in equations (15) and (16).

3.1 A model for earnings determination

In this paper pension uncertainty is the result of the accumulation of unpredictable earnings shocks through the award formula. A measure of earnings variability for different groups of workers is therefore necessary to estimate the degree of pension uncertainty at the individual level. For this purpose, I estimate a model of earnings determination that separates labour income shocks into idiosyncratic transitory and permanent components (Meghir and Pistaferri, 2004).

I estimate the model for six occupation-education groups, using microeconomic data drawn from the Italian Survey of Household Income and Wealth (SHIW), run by the Bank of Italy every two years. The available data consist of 10 waves, from 1987 to 2006 (with a 3-year gap between 1995 and 1998). The survey contains detailed information about individual and household characteristics, labour supply, household wealth and saving, including portfolio composition. About 8000 households are interviewed in each wave. Approximately 45% of the sample is interviewed in at least 2 waves, and 13% is followed for 5 or more periods. I rely on the longitudinal dimension of the survey to carry out the econometric analysis below. Further details about the survey and the sample selection criteria are provided in section B of the Appendix.

The model for the conditional mean of log-earnings is

$$\log Y_{it} = \delta_0 + \delta_1 age_{it} + \delta_2 age_{it}^2 + w_i' \phi + \eta_{it}, \quad (17)$$

where w_i is a vector of individual characteristics, constant over time, and η_{it} an error term given by the sum of a permanent component and a transitory shock that includes measurement error, namely

$$\eta_{it} = p_{it} + \varepsilon_{it}. \quad (18)$$

The process for the permanent component is assumed to be a random walk

$$p_{it} = p_{it-1} + \xi_{it},$$

with $\xi_{it} \sim \text{i.i.d. } N(0, \sigma_\xi^2)$ and $E[\xi_{it}\varepsilon_{it}] = 0, \forall i, t$.

I separately estimate equation (17) for 6 sub-samples of active workers aged 25-60. Groups are defined by the interaction of job sectors - public employees, private employees and self-employed - and education achievement - individuals with compulsory education and individuals with more than compulsory education. The estimation of the conditional mean process of log-earnings is carried out by OLS. The vector of individual characteristics, w_i , contains indicators for sex, marital status, area of residence and year-of-birth cohort.

Given the available data, I can observe the 2-year and 3-year rates of growth of earnings. Accordingly, I define the unexplained component of the rate of growth of earnings as

$$\Delta^l \eta_{it} = \eta_{it} - \eta_{it-l} = (\varepsilon_{it} - \varepsilon_{it-l}) + \sum_{j=1}^l \xi_{it-j+1}, \quad (19)$$

with $l = 3$ when the year of observation is $t = 1998$, and $l = 2$ otherwise.

I then use the residuals from the regressions of equation (17) in the place of η_{it} to form

$$\Delta^l \hat{\eta}_{it} = (\hat{\eta}_{it} - \hat{\eta}_{it-l}), \quad (20)$$

and replace theoretical moments with sample analogues to study the stochastic properties of labour income.

As it is not possible to disentangle the effect of the variance of measurement error from the one of purely transitory shocks, I will focus thereafter on the estimation of σ_ξ^2 and consider only the degree of pension uncertainty stemming from permanent shocks to earnings. Even though this choice imposes some limitations to the analysis, it avoids confounding uncertainty due to transitory shocks, likely to induce the type of economic response investigated in this paper, and noise due to imperfect data.¹⁰

¹⁰Samwick and Skinner (2004) adopt a similar strategy and ignore transitory shocks to earnings in their simulations of DB and DC plans. It should be noticed that the omission of transitory shocks may result in the underestimation of the degree of pension uncertainty associated with DB plans. The typical DB formula, in fact, averages earnings realizations over a very short period at the end of the worker's career. In this case, the role of transitory shocks for pension uncertainty may not be negligible.

3.2 Identification and estimation of the variance of permanent shocks

Using equations (17) and (19) it follows that

$$Cov(\Delta \log Y_{it}, \Delta \log Y_{it-s}) = \begin{cases} Var[\Delta^l(\eta_{it})] = l\sigma_\xi^2 + 2\sigma_\varepsilon^2 & \text{for } s = 0 \\ Cov(\Delta^l\eta_{it}, \Delta^2\eta_{it-s}) = -\sigma_\varepsilon^2 & \text{for } s = l \\ Cov(\Delta^l\eta_{it}, \Delta^2\eta_{it-s}) = 0 & \text{for } s > l \end{cases}. \quad (21)$$

The variance of the shock to the permanent component σ_ξ^2 is therefore identified by the correspondence

$$\sigma_\xi^2 = \frac{1}{l} \left[Var(\Delta^l\eta_{it}) + 2Cov(\Delta^l\eta_{it}, \Delta^2\eta_{it-2}) \right], \quad (22)$$

with $l = 3$ when $t = 1998$ and $l = 2$ otherwise.¹¹

The estimation of the variance of the permanent shock is performed for each of the 6 job-education groups mentioned above by Equally Weighted Minimum Distance (Altonji and Segal, 1996). Standard errors are computed using block bootstrap, so to take into account arbitrary serial correlation and/or heteroskedasticity. The results are reported below.

Table 1: Variance of the Shock to the Permanent Component of Earnings

	Pooled Sample	Public Employees		Private Employees		Self-Employed	
		Low Ed.	High Ed.	Low Ed.	High Ed.	Low Ed.	High Educ.
σ_ξ^2	0.0130** (0.002)	0.0063** (0.003)	0.0074** (0.002)	0.0055** (0.003)	0.0090** (0.002)	0.0262** (0.013)	0.0196** (0.009)

Block bootstrap standard errors in parentheses (1000 replications). ** indicates 5% significance; * indicates 10% significance.

Low Ed. refers to the group of individuals with compulsory education. High Ed. refers to the group of individuals with more than compulsory education.

Overall, the estimated variances of the permanent shock to earnings are in line with the ones found earlier in the literature.¹² Lower values than in US panel data studies likely reflect differences in the features of the Italian and American labour markets. A striking aspect of the results in Table 1 is the substantial difference in the estimated values of σ_ξ^2 between employees and self-employed individuals. A higher labour income variability for self-employed individuals is not surprising, though.¹³

Public and private employees typically hold long-term contracts with compensations fixed by law or union bargaining. In addition, the lack of lateral and vertical job mobility in the Italian labour market could explain the relative smoothness of the average employee's earnings profile. Starting from the early 90's, however, changes in labour market legislation introduced

¹¹Notice that $Cov(\Delta^2\eta_{it}, \Delta^3\eta_{it-s}) = -\sigma_\varepsilon^2$, if $s = 2$, and $Cov(\Delta^2\eta_{it}, \Delta^3\eta_{it-s}) = 0$, if $s > 2$. This case is equivalent to the case when $l = 2$ in equation (21).

¹²Guiso, Jappelli and Terlizzese (1992) and Guiso, Jappelli and Pistaferri (2002) use subjective measures of earnings uncertainty elicited by the SHIW. They find that perceived income uncertainty in Italy is significantly lower than in the US.

¹³Similar evidence can be found in Carroll and Samwick (1997) and Campbell *et al.* (1999).

temporary or short-tenure contracts that might have increased earnings instability for these categories of workers. On the other hand, self-employed individuals tend to engage in short-term contracts and are subject to highly varying rates. This certainly generates greater degrees of earnings volatility both at a permanent and at a temporary level. Interestingly, the estimated degree of earnings uncertainty faced by Italian self-employed individuals is comparable to that of US employees and considerably lower than that of self-employed workers in the US. Table 1 also shows that the variance of the shock to the permanent component tends to be higher for better educated workers. Individuals with more education typically experience higher returns at a cost of more frequent and/or larger unexpected earnings variations.

3.3 Measuring pension uncertainty

In order to compute individual pension benefits and a measure of their riskiness, I should observe the entire earnings profile of each worker in the sample. Such information is obviously not available for active workers before retirement. To carry out the analysis I have to predict forward individual earnings. For this purpose, I exploit the error structure of the log-earnings process to find a tractable expression for future earnings as a function of current earnings, age and accumulated permanent shocks.¹⁴ Specifically, referring to equation (17) and ignoring temporary shocks, one has:

$$\log Y_{it+s} = \log Y_{it} + s(\delta_1 + 2\delta_2 age_{it} + s\delta_2) + \sum_{k=1}^s \xi_{it+k}. \quad (23)$$

Thus, conditional on the information available at time t , the logarithm of earnings at time $t + s$ is a deterministic function of age and depends on the accumulated permanent shocks from time $t + 1$ to $t + s$. Observing current earnings and age for individual i and exploiting the distributional assumption for ξ_{it} , one can project the agent's future earnings using equation (23). For the same individual i , log-earnings at time $t - s$ can, instead, be deterministically computed using

$$\log Y_{it-s} = \log Y_{it} - s(\delta_1 + 2\delta_2 age_{it} - s\delta_2), \quad (24)$$

In this fashion, it is possible to recover the entire earnings profile of an individual, from the time he or she began work until retirement age. The most important aspect of this construction is that it resembles the individual's perspective about past and future labour income realizations. Conditional on the information set available at time t , past realizations are deterministically known, whereas future realizations are uncertain and subject to unpredictable variations. Repeatedly drawing permanent shocks from the hypothesized distribution, different earnings profiles can be simulated for each active worker in the sample. These profiles will be identical up to time t , when the individual is observed, and will differ afterwards due to the random draws of ξ . Given the legislated pension formula, each of these profiles will imply different levels of pension benefits. The mean and the standard deviation of these pension benefits will

¹⁴Clearly, individuals can change their marital status and/or their area of residence over time. However, it would be quite hard to take this aspect into account while obtaining a tractable expression for future earnings. Thus, I assume that the vector of individual characteristics w_i in equation (17) only contains constant variables. After all, very few individuals in the sample are observed to actually change their marital status and/or their area of residence over time.

then measure the expected level and riskiness of future pension provisions, respectively. Notice that pension uncertainty will be larger the larger labour income variability, and will decrease as the individual approaches retirement, since more and more earnings realizations entering the pension formula become known.

In practice, I first assign each worker in the sample to one of the six job-education groups defined above. Next, I plug in equations (23) and (24) the observed individual age and earnings and the group-specific estimated age coefficients $\widehat{\delta}_1$ and $\widehat{\delta}_2$ from the OLS regressions of equation (17).¹⁵ I then draw permanent shocks to earnings from

$$\xi_{it} \sim N\left(0, \widehat{\sigma}_\xi^2\right), \quad (25)$$

using the group-specific estimated variance $\widehat{\sigma}_\xi^2$. For each individual I simulate 1000 earnings profiles and figure out the corresponding pension entitlements according to the relevant benefit formula. I finally compute the mean and the standard deviation of these 1000 pension benefits to obtain estimates of PB_{it} and PU_{it} as defined in equations (15) and (16).

Given the crucial role of earnings projections in this procedure, in Figure 2 below I present the results of an external validation exercise, where I compare features of the actual and simulated cross-sectional distributions of earnings at different ages. In particular, I select all the 40-year-old sampled workers in each of the six job-education groups. For each one of them I simulate 1000 earnings profiles. I then compare the mean and standard deviation of the simulated earnings profiles in each group at age 50, 55 and 60 with their sample counterparts. While the sample means are very close to the ones of the simulated profiles, the standard deviation of simulated earnings often underestimates the actual one. This is plausibly due to the omission of transitory shocks and/or measurement error in equation (23).

4 The Italian Pension System Reforms of the 90's

In this section, I first provide some of the institutional details of the Italian social security system reforms of the 90's. Using estimates of PB_{it} and PU_{it} , I then document the differential effect of the reforms on different groups' pension entitlements.

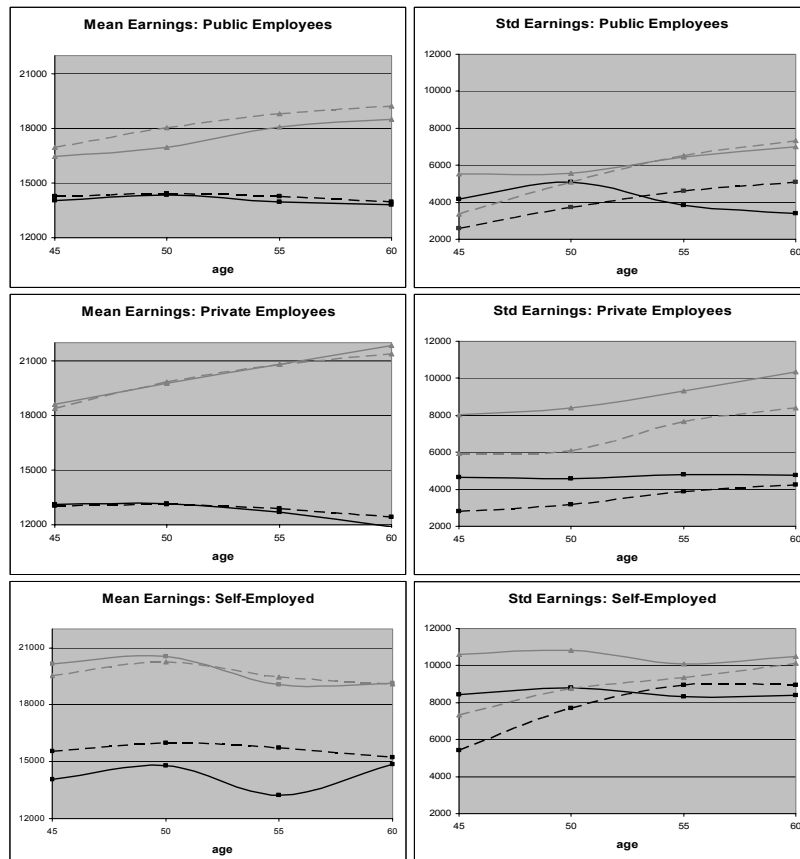
4.1 Institutional details

At a time of serious budgetary problems, in the early 90's the Italian government enacted a series of pension reforms intended to reduce the generosity of the social security system. These reforms were part of broader fiscal packages, primarily aiming to improve the critical situation of the public finances and help the country meet the criteria set by the Treaty of Maastricht to join the European Monetary Union (among them a national budget deficit not exceeding 3% of GDP and a public debt not exceeding 60% of GDP or steadily decreasing).

From 1975 to 1995, Italy experienced a dramatic growth in total public expenditure, largely driven by increasingly unsustainable pension expenditures. The ratio of pension expenditure to GDP passed from 8.4 in the mid 70's to 14 in the early 90's. The two major pension reforms of

¹⁵The group-specific estimated age coefficients from the OLS regressions of equation (17) are reported in section B of the Appendix.

Figure 2: Mean and Standard Deviation of Earnings: Actual vs. Simulated Distribution



Grey lines with triangles refer to individuals with more than compulsory education.

Black lines with squares refer to individuals with compulsory education.

Continuous lines refer to sample quantities, whereas dashed lines refer to simulated quantities.

1992 and 1995, and their minor refinement in 1997, represent a coherent attempt at redesigning the social security programme and reducing its public cost.

Put together, the reforms increased the state retirement age and the number of years of contribution for eligibility, modified the basic rules for granting benefits to future retirees, abolished seniority pensions and changed the indexation of benefits from nominal wages to prices. Here I restrict attention to the changes in the pension award formula. The reason is that I am interested and I model pension uncertainty as a background risk stemming from unexpected earnings variations, and this crucially depends on the computation arrangement for granting benefits. Indeed, by changing the way entitlements are calculated, different pension formulae not only imply different expected levels of annual benefits, but also different degrees of pension risk for individuals at different stages in their working career. I examine this aspect by comparing the pension award formulae in the pre-1992 and in the post-1995 regimes.¹⁶

The post-reform system distinguishes individuals in three job categories: public employees, private employees, and self-employed individuals. Within each category, it also identifies three

¹⁶The three reforms introduced distinctive measures and acted on particular aspects of the system, among them the benefit granting rules. It is therefore convenient to put together the new features and consider the post-1995 pension formula as the result of repeated interventions during the reforming process. A similar strategy is adopted by Bottazzi, Jappelli and Padula (2006) in their recent study about retirement expectations in Italy.

different cohorts of workers: old workers (individuals with at least 18 years of contribution in 1995), middle-aged workers (individuals with less than 18 years of contribution in 1995) and young workers (individuals who start working after 1995). For the remaining part of the paper, I will refer to this distinction and I will form groups following the reforms' selection criteria. As these groups were differently affected by changes in the benefit formula, this will allow me to maximize the differential variation in expected pension wealth and pension risk across job sectors and cohorts. Table 2 summarizes the benefit granting rules in the pre- and post-reform regimes.

Table 2: The Italian Pension System Reforms: Changes in the Pension Award Formula

		Public Employees	Private Employees	Self-employed
Pre-reform	All <i>Earnings Formula</i>	$[2.2\%, 2.5\%] \times \Gamma \times \bar{Y}^1$	$2\% \times \Gamma \times \bar{Y}^5$	$2\% \times \Gamma \times \bar{Y}^{10}$
Post-reform	Old <i>Earnings Formula</i>	$2\% \times \Gamma \times \bar{Y}^{10}$	$2\% \times \Gamma \times \bar{Y}^{10}$	$2\% \times \Gamma \times \bar{Y}^{15}$
	Middle-Aged <i>Pro-rata Formula</i>	$\Upsilon [Earnings Formula] + (1 - \Upsilon) [Contribution Formula]$		
	Young <i>Contribution Formula</i>	$\zeta(RA) \times \sum_{t=L}^{RA} \tau Y_t \iota_t$		

Legend. Γ : number of years of contribution at retirement; RA : retirement age; L : age began work; Y_t : earnings at time t ; \bar{Y}^j : average of the last j years of earnings; τ : contribution rate (33% for public and private employees, 20% for self-employed individuals); ι_t : accrual rate based on a 5-year moving average of GDP growth rate; $\zeta(RA)$: conversion coefficient fixed by law; Υ : fraction of years of contribution paid before 1995.

Old refers to individuals with more than 18 years of contribution in 1995. Middle-aged refers to individuals with less than 18 years of contribution in 1995. Young refers to individuals who start working after 1995.

For old workers the pension formula is entirely earnings-based, before and after the reforms. In the post-reform regime, though, the career span taken into account for benefit computation is significantly longer for all employment categories. In particular, for public employees pre-reform benefits were based on the last labor income realization, while post-reform pensions depend on the last 10 years of earnings before retirement. For private employees and self-employed, the career span taken into account for benefit computation changes from 5 to 10 years and from 10 to 15 years, respectively.

The young cohort, who starts working after the reform, acquires contribution-based pension benefits. In practice, this means that each worker has a notional public pension account credited each year with a fraction of his or her gross earnings. The balance in the account earns interest at a rate equal to a 5-year moving average of the GDP growth rate. Pension benefits, in this case, are proportional to the contributions paid throughout the working career. The account balance is transformed into an annual allowance using a conversion coefficient $\zeta(RA)$, set by the legislator, that depends on retirement age and life expectancy and should guarantee the actuarial equilibrium of the system. Simulation studies suggest that this system is always more generous than the earnings-based one for an average GDP growth rate bigger than 1%. Should

the poor performance of the Italian economy in the last 25 years continue, it is likely that the young cohort of workers will receive significantly less generous pensions. Also, given that the contribution rate is 33% for public and private employees and 20% for self-employed individuals, the latter will receive substantially lower benefits than employees in any future scenario.

A *pro-rata* arrangement applies to middle-aged workers, those with less than 18 years of contribution in 1995. Their pension benefits are computed using an earnings-based formula for the working years before 1995 and a contribution-based formula afterwards.

Overall, young and middle-aged workers are the cohorts most affected by the legislative intervention. Among the old, public employees experience the most significant change in their pension award formula through both a reduction of the accrual rate and an increase in the career span taken into account for granting benefits.

4.2 The differential effect of the reforms across workers

Using the pre-reform benefit granting rules for individuals observed before 1992 and the post-reform ones for those observed after 1995, I can quantitatively assess the effects of the changes in the pension formula on the expected value and riskiness of individual pensions.

In what follows, I regard the pooled 1989-1991 sample as the pre-reform period and the pooled 1998-2000 sample as the post-reform period.¹⁷ I only select active workers who report to be head of the household and I distinguish workers according to the same criteria adopted by the reforms. Thus, I use three employment categories - public employees, private employees, and self-employed individuals - and three cohorts of workers - old, middle-aged, and young - depending on the number of years of contribution in 1995. Old and middle-aged workers are observed in both the pre- and the post-reform regimes. The youngest cohort (those who start working after 1995) is only observed in the post-reform period. For these individuals no comparison with the pre-reform scenario is possible. They are therefore dropped from the data set and ignored for the rest of the paper.¹⁸

For each individual in the selected sample I compute annual pension benefits PB_{it} and the degree of pension uncertainty PU_{it} . In doing so I fix individual retirement age at the age workers expect to retire, elicited by the SHIW.¹⁹ I also calculate pension wealth as a measure of total resources expected after retirement, defined as

$$PW_{it} = PB_{it} \times \sum_{h=RA_t}^D \left(\frac{1}{1+r} \right)^{h-RA_t} p(h|RA_t), \quad (26)$$

¹⁷Notice that the first survey available after 1995 is the one of 1998. The post-reform regime can therefore be considered as inclusive of the minor intervention that took place in 1997. This refinement, however, did not affect the pension award formula.

¹⁸Further details about the sample selection criteria and the variables used in this part of the study are provided in the Appendix (see Sample 2 in section B).

¹⁹Dominitz and Manski (2006) review the pension expectations questions that have been asked in micro surveys and discuss how to use the elicited measures to study the impact of different pension plans on household decisions for retirement. It should be noticed that the Italian pension reforms of the 90's also increased legal retirement age. For the selected sample used in the empirical analysis, only old and middle-aged private employees were concerned with a progressive increase of the legal retirement age. I assume that these households revised their expectations accordingly and that the legislated changes were assimilated by the reported retirement ages. Bottazzi *et al.* (2006) provide empirical evidence that household revised their retirement expectations in the direction suggested by the reforms.

where RA_t is planned retirement age reported at time t , D is the last period of the life span, r is a constant real interest rate, $p(h|RA_t)$ is the probability of surviving age h conditional on being alive at age RA_t , and PB_{it} are expected annual pension benefits, assumed to stay constant in real terms.

The simplifying assumptions made throughout the text to estimate individual pension benefits, pension wealth and pension risk may be considered restrictive and subject to various criticisms. As stressed before, the identification strategy in this study relies on the differential variation in pension expectations and pension uncertainty across groups induced by the reforms. For the purpose of this exercise, it is therefore crucial to unbiasedly estimate such differential changes, rather than expected value and riskiness of individual pensions *per se*.²⁰

The results in Table 3 show that the pension reforms of the 90's implied significantly less generous and less volatile pension provisions for old and middle-aged workers. The degree of pension uncertainty, measured by the standard deviation of future benefits, falls on average by 50% in the post-reform regime because of the longer career span taken into account for benefit computation. An example can clarify this point. Take the case of public employees with at least 18 years of contribution in 1995. In the pre-reform regime their pension was tied to the last labour income realization. Consequently, any unexpected earnings variation during the last year of work would have been completely reflected in the amount of pension benefits. In the post-reform regime, even though still earnings-based, the pension formula takes into account the last 10 years of the worker's career. This reduces ex-ante uncertainty about future benefits, as labour income shocks are more likely to be smoothed out over a longer time span. Accordingly, the estimated average standard deviation of annual pension benefits for old public employees reported in Table 3 more than halves after the reform. The relatively smaller reductions in pension risk for old private employees and self-employed reflect the fact that the reforms increased by less the career span considered for benefit computation.

Consistently with this argument, the reduction for middle-aged workers is more sizeable. In the new regime, in fact, their pension is calculated pro-rata: earnings-based benefits for working years before 1995 and contribution-based benefits afterwards. Thus, part of the annual benefits is proportional to the contributions paid throughout the entire working life. As a consequence, earnings shocks can be better smoothed out over time, while several labour income realizations entering the pension formula are known for workers at this stage in their career. These two effects result in a generalized lower degree of pension variability. For this cohort of workers, the estimated reductions in pension uncertainty range from 50% to 58%.

Besides any induced variation in pension uncertainty - of central interest for this exercise - the changes in the pension award formula significantly altered the amount of expected entitlements at retirement. Again, the reforms differently affected different categories and cohorts of workers.

²⁰It is not possible to compare the simulated quantities with actual individual pension expectations, as the latter are not observed. The SHIW, however, contains some information about expected replacement rate in three of the waves considered in this study, 1989, 1991 and 2000. I use this information to construct approximate measures of pension expectations as follows: I select individuals with non-missing observations in these three waves and I compute expected pension benefits by multiplying current earnings by expected replacement rate. For each individual I compute the mean and the standard deviation of expected entitlements over these three observations. Due to the very limited sample size, I cannot separate workers in different cohorts or distinguish between the pre- and the post- reform periods. Expected pension benefits and the corresponding standard deviation are 13,453 and 4,493 for public employees, 13,339 and 4,503 for private employees, 12,404 and 7,705 for self-employed, respectively. These magnitudes are in line with those reported in Table 3.

In general, the middle-aged cohort experiences the most substantial reduction in its expected pensions. In particular, benefits for middle-aged public employees and self-employed drop by 20% and 25%, respectively. The expected loss for middle-aged private employees is instead less sizeable at around 8%. Pensions of old private employees were untouched, while the ones of old self-employed were only marginally affected by the new computation arrangements. Old public employees, whose accrual rate was noticeably reduced, lost roughly 20% of their allowances.

On the whole, the Italian social security system reforms of the 90's made public pension provisions less generous, but also reduced the background risk of benefit uncertainty stemming from unexpected earnings variations. Figures showing the induced shift to the left in the distributions of pension benefits, pension risk and pension wealth are provided in section C of the Appendix.

Table 3: Pension Outcomes Before and After the Reforms

	Pre-reform regime 1989-1991	Post-reform regime 1998-2000
	Expected Pension Benefits - (Pension Wealth)	
Public Employees		
<i>Old</i>	15.85 - (264.37)	12.81 - (216.17)
<i>Middle-Aged</i>	16.40 - (280.04)	13.01 - (209.59)
Private Employees		
<i>Old</i>	12.27 - (206.67)	12.43 - (212.08)
<i>Middle-Aged</i>	12.99 - (220.48)	11.85 - (188.278)
Self-employed		
<i>Old</i>	14.32 - (221.62)	13.83 - (210.99)
<i>Middle-Aged</i>	15.16 - (245.77)	11.15 - (165.14)
	Pension Uncertainty	
Public Employees		
<i>Old</i>	4.35	1.89
<i>Middle-Aged</i>	6.22	2.60
Private Employees		
<i>Old</i>	3.11	1.91
<i>Middle-Aged</i>	5.09	2.47
Self-employed		
<i>Old</i>	4.56	2.51
<i>Middle-Aged</i>	7.23	3.27

Individual expected pension benefits and pension uncertainty computations are based on equations (15) and (16), respectively. Pension wealth computations are based on equation (26). Reported quantities are group averages in thousands of 2000 euros. For each individual the number of years of contribution at retirement is $Planned\ Retirement\ Age - Current\ Age + Current\ Years\ of\ Contribution$. In the contribution-based formula I use a constant GDP growth rate of 0.08% per year (the average Italian GDP growth rate from 1980 to 2005). For pension wealth computations I assume $D = 100$ and $r = 2\%$. Survival probabilities, by age and gender, are taken from the Italian life tables for the year 2002 (Italian Statistical Annex, ISTAT, Rome 2002).

5 Portfolio Composition and Stock Market Participation in Italy

The SHIW collects detailed information about household real and financial wealth. This allows me to follow the dynamics of stock market participation, financial wealth and portfolio composition in Italy over the 90's. These were years of intense reforms and important structural changes in the Italian economy. In the previous section, I discussed the implications of the measures introduced by a series of social security reforms for the expected value and riskiness of individual pension entitlements. Before embarking in a more formal analysis, where I relate the background risk represented by pension uncertainty to individual financial decisions, I describe here the characteristics of the Italian household portfolios over the period considered in this study.

Although still relatively few Italian households invest in the stock market and housing and other real assets constitute by far the largest share of their wealth, there has been a rapid increase in stock market participation during the last decade. At the same time, the composition of financial assets has changed dramatically. The share of government bonds has more than halved, while corporate bonds have significantly increased. The most striking aspect, however, is the increase in the share of stocks, either held directly or indirectly through mutual funds. The importance of foreign assets has also increased steadily over the 90's, even though Italian households seem to strongly prefer domestic investments.

Overall, the portfolio of Italian households has become much more risk-oriented than it was before. This can be partly related to the relatively higher returns paid by risky assets and partly to some institutional developments that have increased the incentive to invest in the stock market. Some numbers can give a clearer idea of this phenomenon. In 1991, 12.8% of the surveyed households have postal deposits, 24.2% hold government bonds and 6.7% other assets. In 2000, 18.8% have postal deposits, 7.4% hold government bonds, 11.9% corporate bonds and investment fund units and 7.2% Italian shares and other equities.

The characteristics of the individuals investing in risky assets are in line with what has been observed in other OECD countries. Middle-aged and better educated people tend to be more exposed to financial risks. Also, the values of financial wealth and risky assets vary significantly with geographical areas. In the year 2000, for example, household financial wealth in the South is roughly 1/3 the one in the North and 1/2 the one in the Centre of Italy. Remarkably, the share of risky assets on financial wealth in southern regions is only 1/7 the one observed in the North.

Table 4 shows the evolution of the share of risky assets on household financial wealth and stock market participation over the 90's. I use two different definitions for risky assets, a narrow definition and a broad one. The former includes corporate bonds, investment fund units and equities. The latter also considers long-term government papers. The idea is that households may regard as risky an investment that guarantees a safe return at maturity, but requires money to be locked for a long time period (10 years or more). Such an investment is, in fact, highly illiquid, vulnerable to inflation risk (unless the bonds are inflation-indexed) and could imply considerable transaction costs. Also, in view of Italy's very large stock of public debt, investors may consider, as a further source of risk, the possibility of government's default on long-term

Table 4: Risky Share and Stock Market Participation in the Italy over the 90's

Year	% of Individuals with non zero financial wealth	Narrow Definition of Risky Assets		Broad Definition of Risky Assets	
		% <i>holding risky assets</i>	<i>risky share</i>	% <i>holding risky assets</i>	<i>risky share</i>
1989	73	8.4	2.6	12.8	5.3
1991	84	8.5	3.7	14.2	7.0
1993	88	12.6	6.6	17.6	10.7
1995	89	13.9	6.7	20.4	12.5
1998	93	23.5	14.4	25.9	16.8
2000	87	28.2	20.0	30.6	22.1

Narrow Definition: risky assets = corporate bonds + investment fund units + equities.

Broad Definition: risky assets = corporate bonds + investment fund units + equities + long-term government bonds.

bonds.²¹ The share of risky assets is defined as the ratio of the value of risky assets to financial wealth.

Besides the constantly growing percentage of sampled households with non-zero financial wealth, the effect of the increasing trend in stock market participation can be clearly seen in columns 3 and 5 of Table 4. Referring to the narrow definition, the proportion of investors holding risky assets in 2000 is 3 times bigger than the one observed in 1991. It is twice as big when using the broad definition. The increase in the share of risky assets is even more sizeable. For the narrow definition, it passes from roughly 4% in 1991 to 20% in 2000, whereas, using the broad definition, it is 7% in 1991 and 21% in 2000. The impact of the stock market downturn of 2000 can be read through the 6 points drop in the percentage of individuals with non-zero financial wealth from 1998 to 2000. The Nasdaq crash in the early months of 2000 may have led some investors to switch back to real assets.

In their recent analysis of stockholding in Italy, Guiso and Jappelli (2002) identify different factors that originated these changes in household investing strategies. Surely, financial innovation and increasing competition among firms offering financial services made stock market participation more accessible and less costly for Italian households. At the same time, part of the observed shift towards a riskier portfolio was likely caused by the reduction of Italian Treasury bill returns, the privatization process of public companies and the major institutional reforms of the 90's. As showed in the previous sections, the Italian social security system reforms diminished both the expected amount and the variability of future pension benefits for several categories and cohorts of active workers. Lower expected pension wealth forces individuals to rely more heavily on their own savings for retirement. As a consequence, individuals may want to switch from long-term government bonds to equities, as those guarantee higher returns in the long run and higher liquidity. This process could be enhanced by an amelioration in background risk if the new granting rules imply a lower degree of pension uncertainty.

²¹Even though the event that one of the major OECD countries will default on its debt is extremely unlikely, it should be stressed that Italy accumulated a huge debt over the past decades. Public debt reached its peak of 135% of GDP in 1996 and decreased only up to 125% of GDP in 2000. Growing concerns about public debt sustainability may clearly compromise investors' confidence.

6 The Effect of Pension Uncertainty on Portfolio Choices

Having estimated expected pension benefits and pension uncertainty for each household in the sample and documented both the differential effects of the pension reforms on different groups' entitlements and the time evolution of risky asset holdings in Italy, I now turn to empirically assess the effect of pension risk on household portfolio decisions.

For this purpose, I relate, within the regression framework of the model (6)-(7), the household share of risky assets to the head's expected level of future pension benefits/wealth and degree of pension uncertainty. Keeping the distinction introduced in the previous section, I compute the dependent variable using both the narrow and broad definitions of risky assets.

As discussed in sections 2.2 and 2.3, the model (6)-(7) is estimated using the Smith and Blundell (1986) two-step procedure. The variables serving as instruments (Z_{it}) are a binary variable taking value 1 in the post-reform period and its interactions with group dummies. Thus, it is the differential variation in expected pension benefits and pension risk brought in by the legislative intervention across different categories and cohorts of workers that identifies the parameters of interest. I check the rank condition on the proposed estimator by regressing pension benefits (PB_{it}) and pension uncertainty (PU_{it}) on time dummies, group dummies, and Z_{it} , and testing the significance of the interaction terms in Z_{it} . I reject the null hypothesis that the interaction terms do not help explain the variation in PB_{it} and PU_{it} besides group and time dummies at any reasonable significance level. The F -statistics are $F(5, 13493) = 69$ and $F(5, 13493) = 144$ for the regressions using PB_{it} and PU_{it} as dependent variables, respectively.

Table 5 reports the Smith-Blundell estimation results for the narrow definition of risky assets. The same regression exercise is repeated in Table 6 using pension wealth in the place of annual pension benefits as a measure of expected resources at retirement. In both cases I experiment with different specifications, amending the baseline model of column (I), previously described in section 2.2, with additional controls. In particular, I add indicators for house ownership and mortgage payments - column (II) - an indicator for poor health status - column (III) - and a dummy taking value 1 if the household head holds a life insurance policy - column (IV). The marginal effects for the two richest specifications (III) and (IV) are shown in Tables 7 and 8. As the survey questions do not allow to distinguish among different types of life insurance and selection issues may be of great importance, I have a preference for specification (III) and I will mainly refer to it throughout this section. The set of regressions referring to the broad definition of risky assets is reported in Tables 9 and 10.

The results in Tables 5-8 are consistent with the implications of the model described in section 2.1 and, when a comparison is possible, with previous empirical studies. The estimated coefficients on pension entitlements and pension uncertainty are statistically significant and with the expected sign. The former is more precisely estimated when pension wealth replaces annual pension benefits as a measure of expected resources at retirement.²² Theoretical predictions suggest that household incentives to bear financial risks should increase with the expected level of future pension entitlements and decrease with the degree of pension uncertainty. The

²²Since $Var(x) = E(x^2) - E(x)^2$, it could be that the coefficient on pension uncertainty is spuriously significant because of a curvature effect in the expected value of pension benefits/wealth. However, the introduction of a quadratic term in the expected value of pension benefits/wealth among the explanatory variables does not affect the results. Moreover, the quadratic term is itself never significant.

Table 5: Smith-Blundell Regression, equations (6)-(7)
 Dependent variable: share of risky assets on financial wealth (narrow definition)

	(I)	(II)	(III)	(IV)
<i>Pension Benefits</i>	0.065* (0.033)	0.065* (0.033)	0.067** (0.033)	0.061* (0.033)
<i>Pension Uncertainty</i>	-0.134** (0.043)	-0.133** (0.043)	-0.134** (0.043)	-0.127** (0.043)
<i>Income</i>	0.013** (0.006)	0.012** (0.006)	0.012** (0.006)	0.012** (0.006)
<i>(Income)²</i>	-9.47e-05** (0.000)	-9.43e-05** (0.000)	-9.43e-05** (0.000)	-8.86e-05** (0.000)
<i>Net Real Wealth</i>	1.79e-04* (0.000)	1.71e-04* (0.000)	1.69e-04* (0.000)	1.43e-04 (0.000)
<i>(Net Real Wealth)²</i>	-7.86e-09 (0.000)	-7.44e-09 (0.000)	-7.36e-09 (0.000)	-5.57e-09 (0.000)
<i>Age</i>	0.037** (0.010)	0.037** (0.010)	0.037** (0.010)	0.032** (0.010)
<i>Age²</i>	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)
<i>North</i>	0.255** (0.075)	0.254** (0.075)	0.250** (0.074)	0.242** (0.073)
<i>South</i>	-0.036** (0.010)	-0.035** (0.010)	-0.035** (0.010)	-0.041** (0.010)
<i>High Education</i>	0.148** (0.026)	0.151** (0.025)	0.151** (0.025)	0.157** (0.025)
<i>Household Members</i>	-0.192** (0.036)	-0.191** (0.036)	-0.191** (0.036)	-0.185** (0.036)
<i>Working Spouse</i>	0.079 (0.080)	0.084 (0.080)	0.087 (0.080)	0.071 (0.078)
<i>Private Pension</i>	0.305** (0.025)	0.306** (0.025)	0.307** (0.025)	0.312** (0.025)
<i>House Ownership</i>		0.049 (0.034)	0.050 (0.034)	0.046 (0.033)
<i>Mortgage</i>		-0.065** (0.029)	-0.066** (0.029)	-0.072** (0.029)
<i>Poor Health</i>			-0.144** (0.066)	-0.154** (0.066)
<i>Life Insurance</i>				0.221** (0.021)
<i>Exogeneity Test (PB)</i>	-1.61	-1.64	-1.67	-1.56
<i>Exogeneity Test (PU)</i>	2.26	2.23	2.21	2.14
<i>Time Dummies</i>	Y	Y	Y	Y
<i>Group Dummies</i>	Y	Y	Y	Y
<i>Observations</i>	13507	13507	13507	13507
<i>Uncensored Observations</i>	2357	2357	2357	2357

Variables are in thousands of 2000 euros. Time dummies refer to the years 1991, 1998 and 2000. Group dummies include indicators for old and middle-aged public employees, old and middle-aged self-employed and middle-aged private employees. Instruments: indicator for the post-reform period and its interactions with groups dummies. Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance. Exogeneity test is the Smith-Blundell test for the exogeneity of pension benefits and pension uncertainty as described in section 2.3. The bootstrap (500 replications) *t* - statistic is reported.

estimated marginal effects in Table 7 indicate that the share of risky assets increases by roughly 1.2 percentage points for each 1000 euros of expected annual pension benefits, and by 2.4 percentage points if the standard deviation of annual entitlements decreases by 1000 euros. The estimated effect on pension wealth in Table 8 is sizeable, given the definition of this variable, and coherent with the coefficient on annual pension benefits in Table 7. Also, the coefficient on pension risk is essentially unchanged when the regression features expected pension wealth in the place of annual benefits. These numbers imply that, other things being equal, the Italian social security reforms of the 90's might have reduced the share of risky assets by 1.7 percentage points, through the reduction of pension provisions, and increased it by 4.0, through the cutback of pension risk. These are sizeable effects, as risky asset holdings account, on average, for less than 25% of household financial wealth. Not surprisingly, the sensitivity of the demand of risky assets to changes in pension expectations and pension risk is more pronounced for the sub-sample of active stock market participants, that is when marginal effects are conditioned on $\alpha > 0$.

The Smith-Blundell test rejects the exogeneity of pension uncertainty at any sensible level of significance. There is less conclusive evidence of the exogeneity of pension benefits, as the null is often rejected at 10% significance level, but not at 5%. In general, the test provides convincing evidence that ignoring the possible endogeneity of PB_{it} (or PW_{it}) and PU_{it} and estimating equation (6) by standard Tobit could seriously bias the parameters of interest.²³

The estimated age profile of the share of risky assets shows that risky investments increase with age at a decreasing rate. Such a pattern has been found in previous studies and supports the hypothesis that individual incentives to hold risky assets follow the acquisition of financial information and the learning process about more sophisticated financial products over the life cycle.²⁴ At the same time, it may point to the presence of more stringent liquidity constraints at relatively younger ages. Notice also that investors approaching retirement face less uncertainty about the amount of resources available through their pension and could therefore decide to become less conservative when taking financial decisions.²⁵

The observed differences in household stock holdings in the South and in the North of Italy, documented in section 5, are reflected in the estimated coefficients for the location dummies. The average northern household tends to hold a significantly larger share of its wealth in risky assets than the southern counterpart. This may occur because of different degrees of financial literacy in different geographic areas and different information role of social networks.

The coefficient on the education dummy is positive and always very significant. The estimates imply that a level of schooling above compulsory education increases the share of risky

²³A comparison between Smith-Blundell and Tobit estimates (the latter are provided in Appendix D) indicates that ignoring the possible endogeneity of PB_{it} and PU_{it} would imply the coefficient on expected pension benefits to be downward biased, and the one on pension uncertainty to be upward biased. This is consistent with the selection argument used in section 2.2. Suppose, for example, that a risk loving person selects into an occupation with relatively higher earnings variability and, therefore, pension uncertainty. The fact that this person is also likely to hold a relatively riskier portfolio, would lead the estimated effect of pension uncertainty on stock holdings to be upward biased.

²⁴King and Leape (1987) analyse the life-cycle pattern of asset holdings and some related issues.

²⁵The theoretical age profile in a model of consumption and portfolio allocation is typically decreasing. Unless labour income shocks and asset returns exhibit a large enough positive correlation, young workers can afford more aggressive investment strategies, given the possibility of smoothing out negative shocks throughout a longer working horizon and the greater labour supply flexibility. See for example Bodie, Merton and Samuelson (1992) and Viceira (2001).

Table 6: Smith-Blundell Regression, equations (6)-(7)
 Dependent variable: share of risky assets on financial wealth (narrow definition)

	(I)	(II)	(III)	(IV)
<i>Pension Wealth</i>	0.003** (0.001)	0.003** (0.001)	0.003** (0.001)	0.003** (0.001)
<i>Pension Uncertainty</i>	-0.125** (0.039)	-0.124** (0.039)	-0.125** (0.039)	-0.119** (0.039)
<i>Income</i>	0.016** (0.004)	0.015** (0.004)	0.015** (0.004)	0.015** (0.004)
<i>(Income)²</i>	-9.06e-05** (0.000)	-8.99e-05** (0.000)	-8.99e-05** (0.000)	-8.45e-05** (0.000)
<i>Net Real Wealth</i>	1.82e-04* (0.000)	1.74e-04* (0.000)	1.72e-04* (0.000)	1.45e-04 (0.000)
<i>(Net Real Wealth)²</i>	-7.98e-09 (0.000)	-7.51e-09 (0.000)	-7.43e-09 (0.000)	-5.64e-09 (0.000)
<i>Age</i>	0.029** (0.010)	0.029** (0.010)	0.029** (0.010)	0.024** (0.010)
<i>Age²</i>	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)
<i>North</i>	0.310** (0.051)	0.309** (0.051)	0.306** (0.051)	0.296** (0.050)
<i>South</i>	-0.030** (0.011)	-0.030** (0.011)	-0.030** (0.011)	-0.036** (0.011)
<i>High Education</i>	0.133** (0.027)	0.136** (0.026)	0.136** (0.026)	0.144** (0.026)
<i>Household Members</i>	-0.170** (0.035)	-0.169** (0.035)	-0.169** (0.035)	-0.165** (0.034)
<i>Working Spouse</i>	0.040 (0.049)	0.044 (0.049)	0.047 (0.049)	0.031 (0.048)
<i>Private Pension</i>	0.307** (0.024)	0.309** (0.024)	0.310** (0.024)	0.315** (0.024)
<i>House Ownership</i>		0.037 (0.030)	0.038 (0.030)	0.035 (0.029)
<i>Mortgage</i>		-0.067** (0.029)	-0.068** (0.029)	-0.073** (0.029)
<i>Poor Health</i>			-0.168** (0.067)	-0.175** (0.067)
<i>Life Insurance</i>				0.221** (0.021)
<i>Exogeneity Test (PW)</i>	-2.01	-2.02	-2.01	-1.99
<i>Exogeneity Test (PU)</i>	2.49	2.43	2.49	2.36
<i>Time Dummies</i>	Y	Y	Y	Y
<i>Group Dummies</i>	Y	Y	Y	Y
<i>Observations</i>	13507	13507	13507	13507
<i>Uncensored Observations</i>	2357	2357	2357	2357

Variables are in thousands of 2000 euros. Time dummies refer to the years 1991, 1998 and 2000. Group dummies include indicators for old and middle-aged public employees, old and middle-aged self-employed and middle-aged private employees. Instruments: indicator for the post-reform period and its interactions with groups dummies. Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance. Exogeneity test is the Smith-Blundell test for the exogeneity of pension benefits and pension uncertainty as described in section 2.3. The bootstrap (500 replications) t - statistic is reported.

Table 7: Smith-Blundell Regression, Marginal Effects

Dependent variable: share of risky assets on financial wealth (narrow definition)

	Specification III		Specification IV	
	$\frac{\partial E[\alpha \bar{x}]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}, \alpha > 0]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}, \alpha > 0]}{\partial \bar{x}_j}$
<i>Pension Benefits</i>	0.011** (0.005)	0.013** (0.006)	0.010* (0.006)	0.012* (0.007)
<i>Pension Uncertainty</i>	-0.022** (0.008)	-0.026** (0.009)	-0.021** (0.008)	-0.025** (0.009)
<i>Income</i>	0.002* (0.001)	0.002* (0.001)	0.002* (0.001)	0.002* (0.001)
<i>Real Wealth</i>	0.3e-04 (0.2e-04)	0.3e-04 (0.2e-04)	0.2e-04 (0.2e-04)	0.3e-04 (0.2e-04)
<i>North</i>	0.025** (0.005)	0.029** (0.005)	0.026** (0.004)	0.030** (0.005)
<i>South</i>	-0.031** (0.007)	-0.037** (0.007)	-0.030** (0.007)	-0.036** (0.007)
<i>High Education</i>	0.041** (0.013)	0.048** (0.015)	0.039** (0.013)	0.047** (0.015)
<i>Household Members</i>	-0.006** (0.002)	-0.007** (0.002)	-0.007** (0.002)	-0.008** (0.002)
<i>Private Pension</i>	0.050** (0.005)	0.059** (0.005)	0.051** (0.005)	0.060** (0.005)
<i>Mortgage</i>	-0.011** (0.005)	-0.013** (0.006)	-0.012** (0.005)	-0.014** (0.006)
<i>Poor Health</i>	-0.023* (0.012)	-0.028** (0.013)	-0.025** (0.012)	-0.029** (0.013)
<i>Life Insurance</i>			0.036** (0.004)	0.043** (0.004)

Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance.

assets on financial wealth by 4-5 percentage points. The number of household members is negatively correlated to equity holdings. An additional person (typically a child) requires current and future extra resources and is likely to make the household less willing to bear financial risks. The presence of a working spouse does not seem to have an effect on household investment decisions. This may appear surprising, as a working spouse represents a further source of income both during work and after retirement through his/her own pension provision. One would therefore expect his/her presence within the household to act as an insurance against income risk and influence portfolio choices towards more risk taking. Such an effect is likely captured by the measure of household disposable income, which includes spouse's earnings. Thus, the fact that the coefficient on the working spouse indicator is not statistically different from zero indicates that, besides a pure wealth effect, the presence of a working spouse does not impact household portfolio choices.

Household disposable income has a positive and significant effect on the demand for risky assets. The estimated relationship appears to be concave. This is consistent with a utility function exhibiting decreasing absolute prudence, and, consequently, with the notion of standard risk aversion of Kimball (1993). Individuals with such preferences should reduce their

Table 8: Smith-Blundell Regression, Marginal Effects

Dependent variable: share of risky assets on financial wealth (narrow definition)

	Specification III		Specification IV	
	$\frac{\partial E[\alpha \bar{x}]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}, \alpha > 0]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}, \alpha > 0]}{\partial \bar{x}_j}$
<i>Pension Wealth</i>	0.0005** (0.0002)	0.0006** (0.0002)	0.0004** (0.0002)	0.0005** (0.0002)
<i>Pension Uncertainty</i>	-0.020** (0.007)	-0.024** (0.008)	-0.019** (0.007)	-0.023** (0.008)
<i>Income</i>	0.002** (0.001)	0.003** (0.001)	0.002** (0.001)	0.003** (0.001)
<i>Real Wealth</i>	0.3e-04 (0.2e-04)	0.3e-04 (0.2e-04)	0.2e-04 (0.2e-04)	0.3e-04 (0.2e-04)
<i>North</i>	0.022** (0.005)	0.026** (0.005)	0.023** (0.005)	0.028** (0.005)
<i>South</i>	-0.028** (0.006)	-0.033** (0.007)	-0.027** (0.006)	-0.032** (0.007)
<i>High Education</i>	0.050** (0.009)	0.059** (0.010)	0.048** (0.009)	0.057** (0.010)
<i>Household Members</i>	-0.005** (0.002)	-0.006** (0.002)	-0.006** (0.002)	-0.007** (0.002)
<i>Private Pension</i>	0.051** (0.004)	0.060** (0.005)	0.051** (0.004)	0.061** (0.005)
<i>Mortgage</i>	-0.011** (0.005)	-0.013** (0.006)	-0.012** (0.005)	-0.014** (0.006)
<i>Poor Health</i>	-0.027** (0.012)	-0.032** (0.014)	-0.028** (0.012)	-0.034** (0.014)
<i>Life Insurance</i>			0.036** (0.004)	0.043** (0.004)

Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance.

exposure to endogenously controlled risks (e.g. financial investments) when confronted with a deterioration in background risk (e.g. a higher degree of pension uncertainty). At the same time, a positive coefficient on household disposable income may indicate that richer households overcome more easily transaction and information costs related to the acquisition of more sophisticated financial products. The marginal effects suggest that 1000 more euros of household annual income increase the share of risky assets by 0.2-0.3 percentage points. Net real wealth and house ownership do not have a significant effect on household investment decisions. On the other hand, mortgage payments are an important deterrent for risk taking. Homeowners making mortgage payments keep safer portfolios cutting their share of risky assets by 1.3 percentage points on average.

Future medical expenses are a primary source of background risk, particularly for workers approaching retirement. If prudent individuals cannot fully insure against health risk, they should be less willing to take up financial risks when allocating their wealth to different asset categories. Unfortunately, the SHIW does not provide direct information about medical care utilization, medical expenditure or health status, making it difficult to investigate this issue in great detail. However, in order to control for the potential effect of health uncertainty, I add

to the set of regressors a proxy for poor health status based on the number of days off sick in a year (the indicator takes value 1 if the household head was off sick at least 50 days in a year). The idea is that individuals with such a poor health status face higher risk of unexpected medical expenditures. The estimated marginal effects on this variable are always negative and statistically significant. A poor health status implies reductions in the share of risky assets between 2.5 and 3 percentage points. It should be noticed that, unlike in the US, the public health system in Italy offers a wide coverage to the entire resident population, irrespective of income or contributions, employment or pre-existing health conditions. The system, however, is plagued by crippling bureaucracy, mismanagement and unsustainable deficits. As a consequence, long waiting lists and inadequate treatment make low-cost public health care virtually unaccessible for many patients and often force them to rely on private and more expensive health care providers.

Table 9: Smith-Blundell Regression, Marginal Effects
Dependent variable: share of risky assets on financial wealth (broad definition)

	Specification III		Specification IV	
	$\frac{\partial E[\alpha \bar{x}]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}, \alpha > 0]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}, \alpha > 0]}{\partial \bar{x}_j}$
<i>Pension Benefits</i>	0.010* (0.006)	0.010* (0.006)	0.008 (0.006)	0.009 (0.006)
<i>Pension Uncertainty</i>	-0.024** (0.009)	-0.026** (0.009)	-0.023** (0.008)	-0.024** (0.009)
<i>Income</i>	0.003** (0.001)	0.003** (0.001)	0.003** (0.001)	0.003** (0.001)
<i>Real Wealth</i>	0.3e-04 (0.2e-04)	0.3e-04 (0.2e-04)	0.3e-04 (0.2e-04)	0.3e-04 (0.2e-04)
<i>North</i>	0.040** (0.005)	0.043** (0.005)	0.041** (0.005)	0.044** (0.005)
<i>South</i>	-0.042** (0.007)	-0.045** (0.007)	-0.040** (0.007)	-0.043** (0.007)
<i>High Education</i>	0.059** (0.015)	0.063** (0.015)	0.058** (0.014)	0.061** (0.014)
<i>Household Members</i>	-0.009** (0.002)	-0.009** (0.002)	-0.010** (0.002)	-0.010** (0.002)
<i>Private Pension</i>	0.060** (0.005)	0.063** (0.005)	0.060** (0.005)	0.064** (0.005)
<i>Mortgage</i>	-0.020** (0.006)	-0.021** (0.006)	-0.021** (0.006)	-0.022** (0.006)
<i>Poor Health</i>	-0.038** (0.013)	-0.041** (0.014)	-0.040** (0.014)	-0.042** (0.014)
<i>Life Insurance</i>			0.042** (0.004)	0.045** (0.004)

Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance.

Individuals participating in a private pension fund can count on additional resources at retirement, even though they typically face a relatively higher degree of pension uncertainty through the funded scheme. The empirical evidence points to the presence of a strong wealth effect. The marginal effects on the private pension indicator are, in fact, positive, significant

and quite sizeable (further issues on this point are postponed to the next sub-section). Also, households where the head holds a life insurance policy take riskier positions in their financial portfolio. Their share of risky assets is estimated to be roughly 4 percentage points higher. Given the available data, however, it is not possible to distinguish between protection and investment policies and to disentangle bequest from other precautionary saving motives. Both issues are undoubtedly important to assess the actual effect of such insurance contracts on household portfolio decisions.

Tables 9 and 10 refer to the regressions using the broad share of risky assets on financial wealth as dependent variable.²⁶ The sign of the two main parameters of interest - the ones on pension benefits/wealth and pension uncertainty - is in line with the theoretical predictions of the model in section 2.1. However, when comparing these results with the ones presented above, it can be noticed that the coefficients on expected pension benefits and pension wealth are smaller in magnitude and less precisely estimated. The marginal effects on pension uncertainty are instead significant and very similar, although, once conditioning on stock market participation, the effect of pension uncertainty on household portfolio decisions seems somehow less pronounced. It could be argued that, since risky assets include now some illiquid assets like long-term bonds, their demand is likely to be relatively less responsive to changes in pension expectations and pension risk. All the other estimates do not change significantly.

6.1 Robustness checks

6.1.1 Private pension

As previously mentioned, the vast majority of Italian workers, over the period considered in this paper, is exclusively covered by the public pension scheme. It is precisely because of this reason that I have focused so far on public pension only to study the effect of retirement income uncertainty on household portfolio choices.

Having reduced the generosity of the public, compulsory pay-as-you-go system, the reforms of the 90's formally regulated the market for private pension funds. Individuals have the possibility of contributing to a "closed" pension fund, which is typically implemented by single (often big) companies, employers' associations and trade unions, or to an "open" pension fund, administered by banks, insurance and savings management companies. Closed pension funds, created after 1995, predominantly offer one single investment strategy for all their members, ignoring factors such as age or risk profiles. Therefore, asset allocation has traditionally been based on balanced portfolios with a heavy weight in bonds and cash. Open pension funds are less regulated. Thus, multiple diversification strategies have been used and investment in equities has been much more common.

Following the legislative intervention, participation in private pension funds has been increasing steadily in the last decade. In the pre-reform period, 1989-1991, only 7% of active workers was contributing to a private fund, whereas more than 15% was in the post-reform period, 1998-2000. Clearly, participation in a closed or an open fund has different implications both for lifetime savings allocation and pension uncertainty. In the first case, in fact, the in-

²⁶For brevity I only report here the marginal effects. The full set of IVTobit/Smith-Blundell regressions can be found in Appendix D

Table 10: Smith-Blundell Regression, Marginal Effects
 Dependent variable: share of risky assets on financial wealth (broad definition)

	Specification III		Specification IV	
	$\frac{\partial E[\alpha \bar{x}]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}, \alpha > 0]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}]}{\partial \bar{x}_j}$	$\frac{\partial E[\alpha \bar{x}, \alpha > 0]}{\partial \bar{x}_j}$
<i>Pension Wealth</i>	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)
<i>Pension Uncertainty</i>	-0.022** (0.008)	-0.024** (0.008)	-0.021** (0.008)	-0.022** (0.008)
<i>Income</i>	0.003** (0.001)	0.004** (0.001)	0.003** (0.001)	0.004** (0.001)
<i>Real Wealth</i>	0.3e-04 (0.2e-04)	0.3e-04 (0.2e-04)	0.3e-04 (0.2e-04)	0.3e-04 (0.2e-04)
<i>North</i>	0.039** (0.005)	0.041** (0.005)	0.041** (0.005)	0.043** (0.005)
<i>South</i>	-0.039** (0.007)	-0.041** (0.007)	-0.038** (0.007)	-0.039** (0.007)
<i>High Education</i>	0.070** (0.010)	0.074** (0.010)	0.068** (0.009)	0.072** (0.010)
<i>Household Members</i>	-0.008** (0.002)	-0.009** (0.002)	-0.009** (0.002)	-0.010** (0.002)
<i>Private Pension</i>	0.061** (0.005)	0.064** (0.005)	0.061** (0.005)	0.065** (0.005)
<i>Mortgage</i>	-0.019** (0.006)	-0.021** (0.006)	-0.020** (0.006)	-0.02** (0.006)
<i>Poor Health</i>	-0.041** (0.014)	-0.044** (0.014)	-0.043** (0.014)	-0.045** (0.014)
<i>Life Insurance</i>			0.043** (0.004)	0.045** (0.004)

Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance.

dividual holds a safer asset, whose returns at retirement are less volatile. On the other hand, open funds appear to be a more flexible mean to manage risk over the life cycle.

Unfortunately, it is not possible from the survey question to differentiate between these two types of investment and somehow approximate the degree of private pension uncertainty. In the previous section, I have simply added to the set of regressors an indicator for pension fund contribution so to take into account other sources of retirement income besides social security provisions. The results indicate the presence of a robust positive effect: the ratio of risky assets to financial wealth is roughly 6 percentage points higher for pension fund participants. This may be interpreted as a mere wealth effect, but it could also stem from a better knowledge of financial products by fund contributors. However, given the scarce diffusion of private pension plans, selection issues may play a crucial role and drive some of the results presented above. The main concern is that some individuals may have reported as risky assets part of their pension account balance. As a robustness check I therefore repeat the same regression exercise as above excluding from the sample all the individuals contributing to private pension funds. The corresponding estimated marginal effects are shown in Table 11. For brevity I only report the results referring to the preferred specification (III) and to the regressions using the narrow

share of risky assets as dependent variable.

Table 11: Smith-Blundell Regression, Marginal Effects
 Dependent variable: share of risky assets on financial wealth (narrow definition)
 Excluding individuals contributing to private pension funds

	Specification III pension entitlements: annual benefits		Specification III pension entitlements: pension wealth	
	$\frac{\partial E[\alpha x]}{\partial x_j}$	$\frac{\partial E[\alpha x, \alpha > 0]}{\partial x_j}$	$\frac{\partial E[\alpha x]}{\partial x_j}$	$\frac{\partial E[\alpha x, \alpha > 0]}{\partial x_j}$
<i>Pension Benefits</i>	0.010* (0.006)	0.013* (0.007)		
<i>Pension Wealth</i>			0.0005** (0.0002)	0.0007** (0.0003)
<i>Pension Uncertainty</i>	-0.022** (0.008)	-0.029** (0.009)	-0.021** (0.007)	-0.029** (0.009)
<i>Income</i>	0.002* (0.001)	0.003** (0.001)	0.002** (0.001)	0.003** (0.001)
<i>Real Wealth</i>	0.2e-04 (0.2e-04)	0.2e-04 (0.2e-04)	0.2e-04 (0.2e-04)	0.2e-04 (0.2e-04)
<i>North</i>	0.017** (0.005)	0.022** (0.006)	0.013** (0.005)	0.018** (0.007)
<i>South</i>	-0.030** (0.006)	-0.041** (0.007)	-0.027** (0.006)	-0.037** (0.007)
<i>High Education</i>	0.036** (0.014)	0.048** (0.017)	0.042** (0.009)	0.056** (0.011)
<i>Household Members</i>	-0.006** (0.002)	-0.008** (0.002)	-0.005** (0.002)	-0.006** (0.002)
<i>Mortgage</i>	-0.011** (0.005)	-0.014** (0.007)	-0.012** (0.005)	-0.016** (0.006)
<i>Poor Health</i>	-0.024** (0.012)	-0.033** (0.015)	-0.029** (0.012)	-0.039** (0.015)

Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance. Corresponding Smith-Blundell regression results are reported in Appendix D.

The unconditional marginal effects for pension expectations and risk do not change significantly. Conditioning on stock market participation, instead, the coefficient on pension uncertainty increases by 4 percentage points, from roughly 2.5 to 2.9. It should be stressed that in this case the sample does not feature individuals with both public DB and private fully funded pension. These individuals respond to different sources of pension uncertainty and can, in most cases, reallocate their private contributions to different asset categories so to modify the risk profile of their overall wealth and keep the desired exposure to risk. For example, other things being equal, they may want to increase the share of risky assets in their pension fund if public pension risk decreased because of exogenous changes in the pension award formula. Thus, their exclusion from the regression sample could explain a higher responsiveness of the demand for risky assets to variation in the degree of public pension uncertainty. All the other coefficients do not vary significantly with respect to the ones in Tables 7 and 8. It is worth mentioning the exception of the indicator for residence in the north, whose coefficient decreases appreciably. This is because almost 70% of the households participating in private pension plans, and

therefore dropped from the empirical analysis in Table 11, live in the north.

6.1.2 Expected retirement age

In order to compute public pension entitlements and a measure of pension risk for each household in the sample, I use individual expectations about retirement age elicited by the SHIW. Clearly, planned retirement age is endogenously determined according to preferences, attitude towards risk, and economic incentives. The use of such a variable to estimate pension benefits and the degree of pension uncertainty should, in turn, warn about the potential endogeneity of PB_{it} and PU_{it} in equation (4). As stressed throughout the paper the source of exogenous variation that identifies the effect of pension expectation and risk on household portfolio decisions is the differential variation in PB_{it} and PU_{it} introduced by the Italian social security system reforms across different groups workers.

Table 12: Planned retirement age: revision after the reforms (group averages)

	Pre-reform regime 1989-1991	Post-reform regime 1998-2000
Public Employees		
<i>Old</i>	60.2	60.3
<i>Middle-Aged</i>	60.1	61.8
Private Employees		
<i>Old</i>	59.8	59.7
<i>Middle-Aged</i>	60.0	61.9
Self-Employed		
<i>Old</i>	62.5	62.9
<i>Middle-Aged</i>	62.4	64.0

It should be pointed out that the reforms of the 90's also attempted to delay the exit from the labour market of the average Italian worker through a gradual increase of the legal retirement age and minimum years of contribution for eligibility. However, it was the youngest cohort of workers - those who started working after 1995 - who was affected by the major changes. Old and middle-aged workers, the two cohorts used in this study, were only marginally affected. More precisely, in the private sector legal retirement age was gradually increased from 60 to 65 for men and from 55 to 60 for women, whereas for public employees and self-employed individuals it was left at 65 for men and 60 for women as in the pre-reform regime. The minimum number of years of contribution for pension eligibility and seniority pension was progressively risen from 15 to 20 and from 35 to 40 respectively, for both cohorts independently of the sector. The table above shows the effect of the legislative intervention on individual expectations about retirement age. There appears to be no revision for the old cohort. On the other hand, planned retirement age increases by roughly 1.5 years for middle-aged workers.

In order to check that the results presented above are not driven by the use of self-reported retirement age to estimate pension benefits and pension risk and/or by the partial revision in planned retirement age that followed the reforms, I experiment with two alternative scenarios. In the first one I assume the absence of any adjustment and fix individual retirement age at a

given level, independently of the reform.²⁷ In the second one I imagine full adjustment and use the legal retirement age as legislated in the pre- and in the post-reform regimes. The estimated marginal effects on pension entitlements and pension uncertainty are shown in Table 13 below (the full set of estimation results is available on request).

Table 13: Smith-Blundell Regression, Marginal Effects
 Dependent variable: share of risky assets on financial wealth (narrow definition)
 Fixed and legislated retirement age

	Specification III		Specification III	
	pension entitlements: annual benefits		pension entitlements: pension wealth	
	$\frac{\partial E[\alpha x]}{\partial x_j}$	$\frac{\partial E[\alpha x, \alpha>0]}{\partial x_j}$	$\frac{\partial E[\alpha x]}{\partial x_j}$	$\frac{\partial E[\alpha x, \alpha>0]}{\partial x_j}$
Fixed Retirement Age				
<i>Pension Benefits</i>	0.010* (0.006)	0.012* (0.007)		
<i>Pension Wealth</i>			0.0004* (0.0002)	0.0005** (0.0002)
<i>Pension Uncertainty</i>	-0.017** (0.008)	-0.020** (0.009)	-0.012** (0.005)	-0.014** (0.006)
Legislated Retirement Age				
<i>Pension Benefits</i>	0.009* (0.005)	0.011* (0.006)		
<i>Pension Wealth</i>			0.0006* (0.0003)	0.0007** (0.0003)
<i>Pension Uncertainty</i>	-0.010* (0.006)	-0.012* (0.007)	-0.009 (0.006)	-0.011 (0.007)

Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance. Fixed retirement age is as follows. Public employees: 61 for men, 60 for women. Private employees: 60 for men, 59 for women. Self-employed: 63 for men, 61 for women. These numbers are the sample average of the self-reported expected retirement age by job sector and sex. Legislated retirement age is as follows. Public employees and self-employed: 65 for men, 60 for women in the pre- and in the post-reform regimes. Private employees: 60 for men, 55 for women in the pre-reform regime; 65 for men, 60 for women in the post-reform regime.

The sign of the coefficients is in line with theoretical predictions. Overall, the results confirm the positive effect of expected pension provision on the willingness to take up financial risks on one hand, and the negative effect of pension uncertainty on the other. Starting from the scenario where retirement age is fixed at a given level, the size of the coefficient on pension uncertainty is only slightly smaller than before when pension entitlements are measured by annual pension benefits. It drops notably when pension wealth replaces pension benefits in the regression equation. It is likely that the measure of expected pension wealth is more affected by the choice of imposing a certain retirement age to everybody. Such a choice, in fact, may imply significant changes in the number of years during which individuals expect to receive their retirement income stream. A further, and perhaps more relevant, consequence of this strategy

²⁷In this case I assign to each individual the sample average retirement age in his/her job sector (public or private sector and self-employment). I also experimented with individual retirement age fixed at 60, 61 and 62 obtaining similar results.

is that it shuts down cross-section variability in a crucial variable like planned retirement age. However, given the data at my disposal, it is hard to think of alternative options. Ideally, this exercise would require a panel data set so to fix planned retirement age at the value that each individual reported in the pre-reform period. The results somewhat worsen in the scenario where individuals are forced to retire at the legal retirement age. Besides the same considerations as above, the issue here is that the legislated retirement age forces workers to exit the labour market much later than they actually intend to.

7 Conclusions

Recent papers have concentrated on the determinants of household stock market participation and asset holdings. Heterogeneity and idiosyncratic risks are crucial aspects to account for when analysing such questions. Empirical studies seem to support the theory of "temperant" portfolio choices: individuals facing undesirable and uninsurable background risks are observed to hold more conservative portfolios, so to reduce their exposure to endogenously controlled financial risks.

In this paper I have focused on the background risk represented by uncertain public pension benefits and its effect on household portfolio decisions. Typical defined benefit formulae in public schemes average earnings over a short period of final years. In this case, earnings variability is greatly reflected into benefit variability. As contributions to the social security system are mandatory and unexpected labour income variations largely uninsurable and non-diversifiable, pension uncertainty can be thought of as a background risk. If there exists substitutability between exogenous and endogenous risks, one should observe individuals with higher pension variability reducing their exposure to the stock market.

I have empirically tested this proposition using cross-sections of Italian workers observed before and after two important pension reforms. In the mid 90's Italy underwent a series of social security reforms aiming to gradually replace the traditional defined benefit scheme with a notional defined contribution one. By averaging earnings realizations over a longer career span, the post-reform pension formula exogenously changed the level of pension benefits and the degree of pension uncertainty faced by active workers before retirement. More importantly for the purposes of this study, different categories and cohorts of individuals were differently affected by these changes. I have exploited this differential variation in expected entitlements and pension risk across well-defined groups of Italian workers to identify the effect of pension uncertainty on household portfolio choices.

The results indicate that higher uncertainty about pension entitlements is associated with safer portfolios. After controlling for expected pension benefits, an amelioration in background risk equivalent to a 1000 euros decrease in the standard deviation of annual pension entitlements, increase the share of risky assets by 2.4 percentage points. This is a sizeable effect given that, on average, risky asset holdings amount to less than 25% of household financial wealth.

The findings of this paper can help to shed light on household investment behaviour over the life cycle and to better understand the role that pension expectations can have for household stock market participation and asset holdings. They also provide some insight on the relevance of pension legislation and features of the social security system for private wealth allocation

strategies. Studying the impact on household portfolio of the ongoing shift from DB to DC schemes in both the US and Europe represents an interesting area for future investigation.

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Appendix

A Portfolio Choice with a Non-Tradable Risky Asset: Approximate Solution

A.1 The model

Consider the same model set-up of section 2.1. Suppose, for simplicity, that the only choice variable is the share of risky assets, α_t . The agent's problem writes:

$$MAX_{\alpha_t} E_t \left[\beta \frac{W_{t+1}^{1-\gamma}}{1-\gamma} \right] \quad (\text{A-1})$$

subject to

$$W_{t+1} = R_{t+1}W_t + B_{t+1}, \quad (\text{A-2})$$

and the next-period gross return on financial wealth

$$R_{t+1} = \alpha_t R_{1,t+1} + (1 - \alpha_t)R_0. \quad (\text{A-3})$$

The first order condition is:

$$E_t \left[\delta W_{t+1}^{-\gamma} R_{1,t+1} \right] = E_t \left[\delta W_{t+1}^{-\gamma} R_0 \right]. \quad (\text{A-4})$$

Following Campbell and Viceira (2002), I work out an analytical approximate solution for the optimal investment policy α_t , by using log-linear approximations of equations (A-2)-(A-4). I then study how the exposure to financial risks should change with the expected value and volatility of the non-tradable asset.

A.2 Log-Linearizations

- **Budget constraint**

Divide both sides of (A-2) by B_{t+1} and take logs to obtain

$$w_{t+1} - b_{t+1} = \log(\exp(w_t - b_{t+1} + r_{t+1}) + 1), \quad (\text{A-5})$$

where lowercase letters indicate variables in logs. Taking a first-order Taylor expansion of the right-hand side around $E(w_t - b_{t+1}) \equiv w - b$ and $E(r_{t+1}) \equiv r$, gives

$$w_{t+1} - b_{t+1} \approx \log(1 + e^{w-b+r}) + \frac{e^{w-b+r}}{1 + e^{w-b+r}}(w_t - b_{t+1} - w + b) + \frac{e^{w-b+r}}{1 + e^{w-b+r}}(r_{t+1} - r),$$

leading to

$$w_{t+1} \approx k + \rho(w_t + r_{t+1}) + (1 - \rho)b_{t+1}, \quad (\text{A-6})$$

with constants ρ and k defined by

$$\rho \equiv \frac{e^{w-b+r}}{1 + e^{w-b+r}} \quad (\text{A-7})$$

$$k \equiv \log(1 + e^{w-b+r}) + \rho(b - w - r). \quad (\text{A-8})$$

- **Return on financial wealth**

Taking logs of equation (A-3):

$$r_{t+1} - r_0 = \log(\alpha_t [\exp(r_{1,t+1}) - r_0] + (1 - \alpha_t)). \quad (\text{A-9})$$

Approximating the right-hand side with a first-order Taylor expansion around $(r_{1,t+1} - r_0) = 0$ yields

$$r_{t+1} \approx \alpha_t r_{1,t+1} + (1 - \alpha_t) r_0. \quad (\text{A-10})$$

- **Euler equation** The Euler equation (A-4) can be written as follows:

$$E_t [\exp(\log \delta - \gamma w_{t+1} + r_{1,t+1})] = E_t [\exp(\log \delta - \gamma w_{t+1} + r_0)], \quad (\text{A-11})$$

Using a second order Taylor expansion around $E_t w_{t+1}$ and $E_t r_{1,t+1}$ yields:

$$\begin{aligned} E_t r_{1,t+1} + \frac{1}{2} \text{Var}_t(-\gamma w_{t+1} + r_{1,t+1}) &= r_0 + \frac{1}{2} \text{Var}_t(-\gamma w_{t+1}) \\ \implies E_t (r_{1,t+1} - r_0) + \frac{1}{2} \sigma_\nu^2 &= \gamma \text{Cov}_t(w_{t+1}, r_{1,t+1}) \end{aligned} \quad (\text{A-12})$$

A.3 Approximate optimal investment rule

Replacing w_{t+1} in equation (A-12) with the right hand side of equation (A-6) and exploiting the assumption of zero correlation between the returns on the tradable and non-tradable risky assets, one has:

$$E_t (r_{1,t+1} - r_0) + \frac{1}{2} \sigma_\nu^2 = \gamma \text{Cov}_t(\rho r_{t+1}, r_{1,t+1}) = \gamma \text{Cov}_t(\rho(\alpha_t r_{1,t+1} + (1 - \alpha_t) r_0), r_{1,t+1}) = \gamma \rho \alpha_t \sigma_\nu^2,$$

where the second equality substitutes the log return on tradable wealth with the right hand side of equation (A-10).²⁸ Solving the last equation for α_t gives the approximate optimal investment rule:

$$\alpha_t = \frac{1}{\rho} \left(\frac{\nu + \frac{1}{2} \sigma_\nu^2}{\gamma \sigma_\nu^2} \right). \quad (\text{A-13})$$

A.4 Sign of $\partial \alpha_t / \partial B$ and $\partial \alpha_t / \partial \sigma_b^2$

The lognormality of the return on the non-tradable risky asset implies

$$E_t(B_{t+1}) \equiv B = \exp(b + \frac{1}{2} \sigma_b^2) \implies b = \log(B) - \frac{1}{2} \sigma_b^2, \quad (\text{A-14})$$

$$\text{Var}_t(B_{t+1}) = [\exp(\sigma_b^2) - 1] \exp(2b + \sigma_b^2). \quad (\text{A-15})$$

Given the monotonic positive relationship between $\text{Var}_t(B_{t+1})$ and σ_b^2 established by equation (A-15), (A-14) suggests that b increases with the expected value of the return on the non-tradable risky asset and decreases with its variability. Using this result, it is possible to study how variations in $E_t(B_{t+1})$ and $\text{Var}_t(B_{t+1})$ affect ρ via b , and ultimately the optimal share of tradable risky asset α_t , by determining the sign of the partial derivatives $\partial \alpha_t / \partial B$ and $\partial \alpha_t / \partial \sigma_b^2$. Starting from (A-13) and noting that ρ is itself a function of α_t through the log-return on financial wealth r , the chain rule of differentiation gives

$$\frac{\partial \alpha_t}{\partial B} = \frac{\partial \alpha_t}{\partial \rho} \left(\frac{\partial \rho}{\partial b} \frac{\partial b}{\partial B} + \frac{\partial \rho}{\partial r} \frac{\partial r}{\partial \alpha_t} \frac{\partial \alpha_t}{\partial B} \right), \quad (\text{A-16})$$

²⁸In the case of non zero correlation between the returns on the risky tradable and non-tradable asset, there would be an additional term in equation (A-13) accounting for the agent's hedging behaviour. If $\text{Cov}(r_{1,t+1}, b_{t+1}) < 0$, the non-tradable asset represents an insurance against unfavourable realizations of tradable asset returns. Consequently, the agent is more willing to hold risky tradable assets in her portfolio. In contrast, if $\text{Cov}(r_{1,t+1}, b_{t+1}) > 0$, the non-tradable asset does not offer any shield against low liquidation values of the tradable portfolio and the agent, all things being equal, would reduce her exposure to financial risks by lowering α_t .

$$\frac{\partial \alpha_t}{\partial \sigma_b^2} = \frac{\partial \alpha_t}{\partial \rho} \left(\frac{\partial \rho}{\partial b} \frac{\partial b}{\partial \sigma_b^2} + \frac{\partial \rho}{\partial r} \frac{\partial r}{\partial \alpha_t} \frac{\partial \alpha_t}{\partial \sigma_b^2} \right). \quad (\text{A-17})$$

Thus

$$\frac{\partial \alpha_t}{\partial B} = \frac{(\partial \alpha_t / \partial \rho)(\partial \rho / \partial b)(\partial b / \partial B)}{1 - [(\partial \alpha_t / \partial \rho)(\partial \rho / \partial r)(\partial r / \partial \alpha_t)]} = \frac{(1/B)(\partial \alpha_t / \partial \rho)(\partial \rho / \partial b)}{1 - [(\partial \alpha_t / \partial \rho)(\partial \rho / \partial r)(\partial r / \partial \alpha_t)]}, \quad (\text{A-18})$$

$$\frac{\partial \alpha_t}{\partial \sigma_b^2} = \frac{(\partial \alpha_t / \partial \rho)(\partial \rho / \partial b)(\partial b / \partial \sigma_b^2)}{1 - [(\partial \alpha_t / \partial \rho)(\partial \rho / \partial r)(\partial r / \partial \alpha_t)]} = \frac{(-1/2)(\partial \alpha_t / \partial \rho)(\partial \rho / \partial b)}{1 - [(\partial \alpha_t / \partial \rho)(\partial \rho / \partial r)(\partial r / \partial \alpha_t)]}, \quad (\text{A-19})$$

where $\partial b / \partial B = 1/B$ and $\partial b / \partial \sigma_b^2 = -1/2$ follow from equation (A-14). Using equation (A-13) and the definition of ρ in (A-7), one obtains

$$\frac{\partial \alpha_t}{\partial \rho} = -\rho^{-1} \alpha_t < 0; \quad \frac{\partial \rho}{\partial b} = -\rho(1 + \rho) < 0; \quad \frac{\partial \rho}{\partial r} = \rho(1 + \rho) > 0.$$

It follows that the numerator of (A-18) is positive, whereas the numerator of (A-19) is negative. The sign of these two partial derivatives is then determined by the sign of their common denominator, which in turn depends on the sign of $\partial r / \partial \alpha_t$. Taking the conditional expectation of equation (A-10), yields

$$E_t r_{t+1} \equiv r = \alpha_t E_t (r_{1,t+1} - r_0) + r_0 = \alpha_t \nu + r_0,$$

implying $\frac{\partial r}{\partial \alpha_t} = \nu > 0$. It follows that $\frac{\partial \alpha_t}{\partial B} > 0$ and $\frac{\partial \alpha_t}{\partial \sigma_b^2} < 0$.

B Data Appendix

The empirical analysis in this paper is carried out in two steps. First, I estimate a model for earnings determination in order to assess the degree of labour income variability for workers in different sectors and education groups. The estimation strategy in this case relies on the longitudinal dimension of the survey and uses all the available waves (Sample 1). I then construct measures of expected pension benefits and pension risk at the individual level and I relate them to individual portfolio choices. In this second step I select a cross-section of active workers observed before and after the Italian pension reforms enacted in the mid 90's (Sample 2). The following data appendix provides a description of the variables and the selection criteria used in each step of the study.

• Estimation of σ_ξ^2 : Sample 1

There are currently 10 available waves for the Survey of Household Income and Wealth (SHIW), corresponding to the years 1987, 1989, 1991, 1993, 1995, 1998, 2000, 2002, 2004 and 2006. Around 8000 households are interviewed in each wave, out of whom 3500 were also interviewed in previous surveys. At the individual level, there are on average 22000 observations per year, out of whom about 14000 refer to income earners. Overall, there are 137192 observations referring to income earners in the survey. After dropping job pensioners, recipients of disability, survivor's and social pension, well off individuals, individuals with zero or negative earnings, labour income recipients under legal age or above 70 years of age, I am left with 80461 observations, corresponding to 56336 active workers. Of these individuals 7421 are interviewed in two successive periods, 3584 in three successive periods, 2411 in four successive periods and about 2500 in five or more successive periods.

I group these active workers in three major categories: public employees, private employees and self-employed individuals. Public employees are all the individuals who report

themselves to be employee and to work in general government, defense, education, health and other public services. I also assign to these category individuals working in extraterritorial organizations and entities. All the other employees are defined as private employees. This group mainly consists of white-collar and blue-collar employees. I consider as self-employed individuals labour income recipients who report themselves as members of arts and professions, sole proprietors, free lances, owners or members of family businesses and active shareholders.

Roughly 28% of the sampled individuals are public employees, 50% are private employees and 22% are self-employed. Within each working category, I distinguish individuals according to their education achievement. I form two broad educational groups. The first group includes people with at most compulsory education, the second one people with more than compulsory education. I therefore have six groups defined by the interaction of job sectors and education categories: public employees with compulsory education, public employees with more than compulsory education, private employees with compulsory education, private employees with more than compulsory education, self-employed with compulsory education and self-employed with more than compulsory education.

I separately estimate the variance of the shock to the permanent component of earnings for each of these six sub-samples. To minimize sample selection issues, I run the OLS regressions of equation (17) only considering active workers aged 22-61 and whose labour income is above 4999 euros per year and below 50000 euros per year. I also drop from the estimation sample labour income recipients who are not the head of the households, his/her spouse or partner. The resulting estimation sample is made of 68905 observations, referring to 44953 working individuals.

Table B-1 below reports the estimated age coefficients (standard errors in parentheses) from the OLS regressions of equation (17) for each of the six job-education groups. Those are the group-specific age coefficients $\hat{\delta}_1$ and $\hat{\delta}_2$ used in equations (23) and (24) to simulate individual earnings profiles.

Table B-1: Estimated Age Coefficients

	Public Employees		Private Employees		Self-Employed	
	Low Educ.	High Educ.	Low Educ.	High Educ.	Low Educ.	High Educ.
<i>Age</i>	.0182972 (0.0046)	.0253822 (0.0031)	.0256919 (0.0024)	.0302682 (0.0033)	.0353679 (0.0065)	.0532979 (0.0079)
<i>Age</i> ²	-.0001940 (0.0001)	-.0001808 (0.0000)	-.0003240 (0.0000)	-.0003004 (0.0000)	-.000448 (0.0001)	-.0006264 (0.0001)
<i>N</i>	5828	14888	18979	14803	7653	6754

- **Regression analysis: Sample 2**

Starting from Sample 1, several steps are taken to select the sample for the regression analysis studying the effect of pension uncertainty on household portfolio choices. The identification of the parameters of interest exploits the differential variation in pension expectations and risk introduced by the Italian pension reforms of 1992 and 1995 across sectors and cohorts of workers. I define as the pre-reform period the pooled 1989-1991 sample and as the post-reform period the pooled 1998-2000 sample. I regard the years 1993 and 1995 as transitional with respect to the social security reforming process and I drop the corresponding surveys from the final empirical analysis.

As asset allocation information is collected at the household level, I only select active workers who report themselves to be head of the household. All pension measures used in this exercise refer to the head of the household and are assumed to be representative of the corresponding household quantities.

I fix the retirement age for each worker at the planned retirement age elicited by the SHIW. The number of years of contribution is computed as *Planned Retirement Age - Current Age + Current Years of Contribution*. In the 1998-2000 surveys, workers are directly asked to report their current years of contribution. This information is missing in the 1989 and 1991 waves and is approximated by the difference between current age and age began work (self-reported). For these computations, I assume that there are no unemployment spells throughout a worker's career.

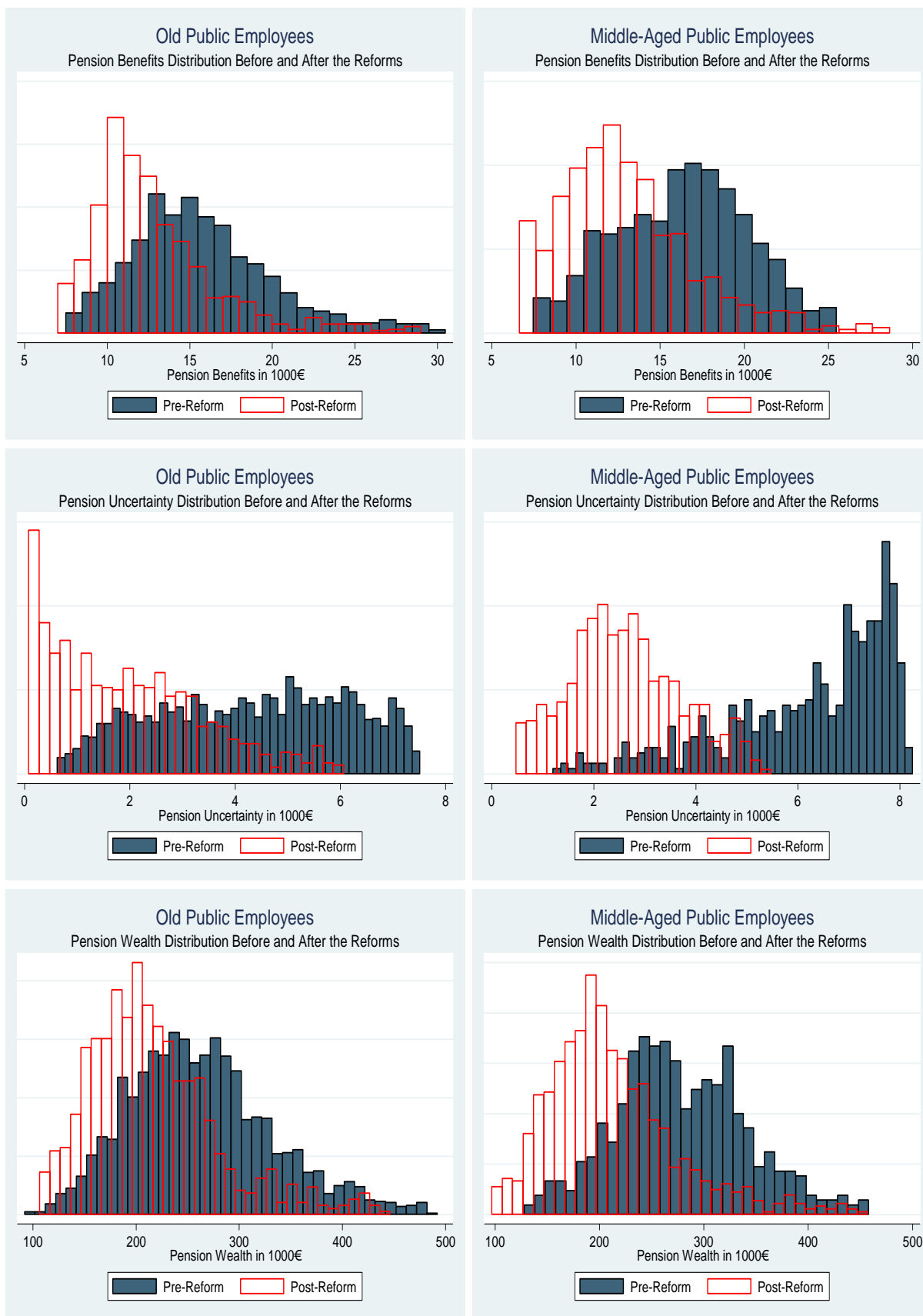
In order to maximize the differential variation in the expected value and riskiness of future benefits brought about by the new legislation, I form groups following the selection criteria of the reforms. While keeping the distinction introduced in Sample 1 between public employees, private employees and self-employed, I assign workers to two cohorts depending on the years of contribution in 1995. The first cohort consists of "old workers" with at least 18 years of contribution in 1995, the second of "middle-aged workers" with less than 18 years of contribution in 1995. The system also identifies a further cohort made of individuals who started working after 1995. As it can only be observed under the post-reform social security regime, I drop this young cohort from the sample.

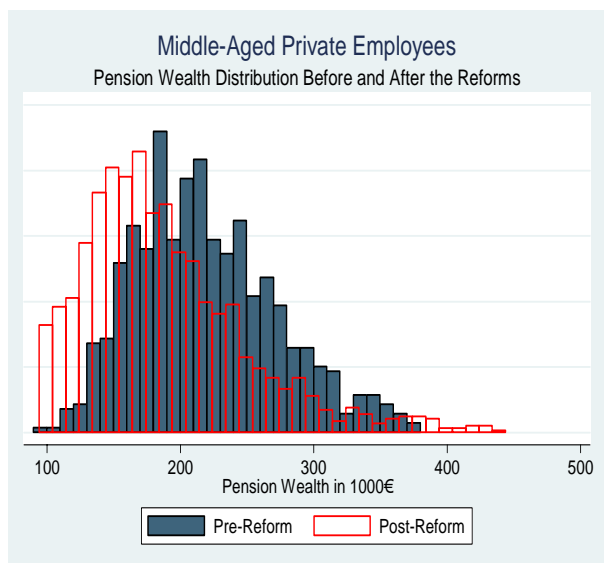
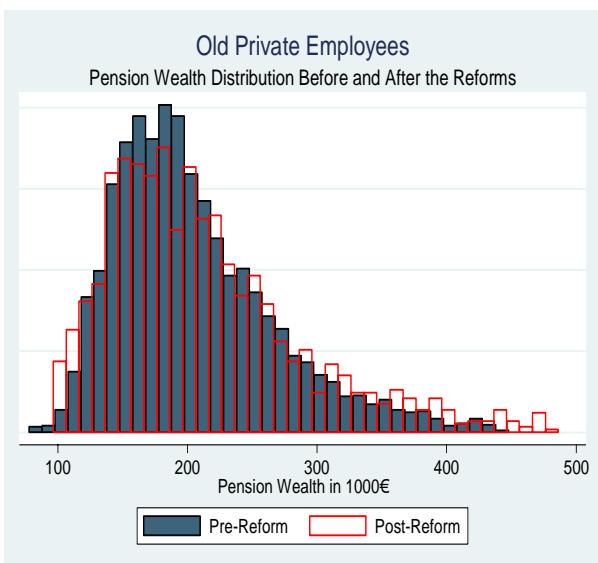
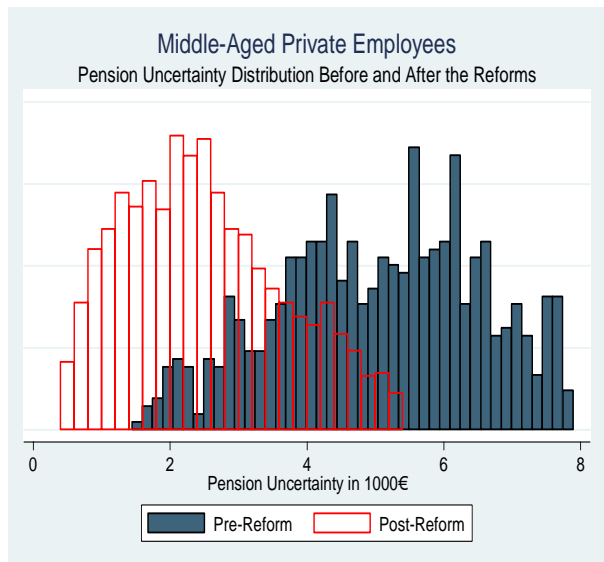
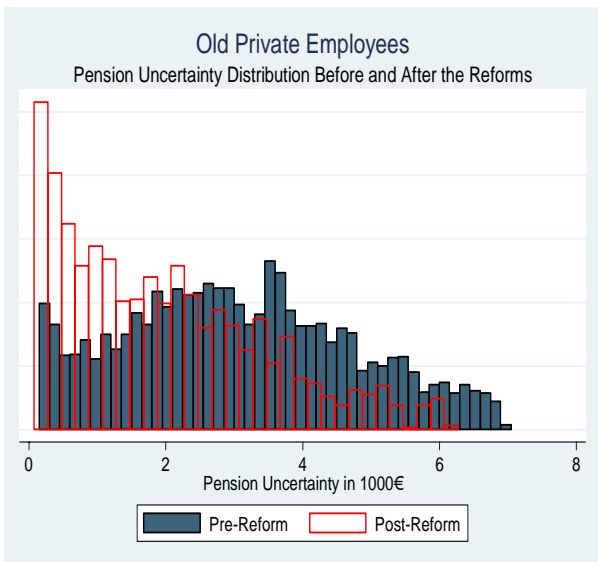
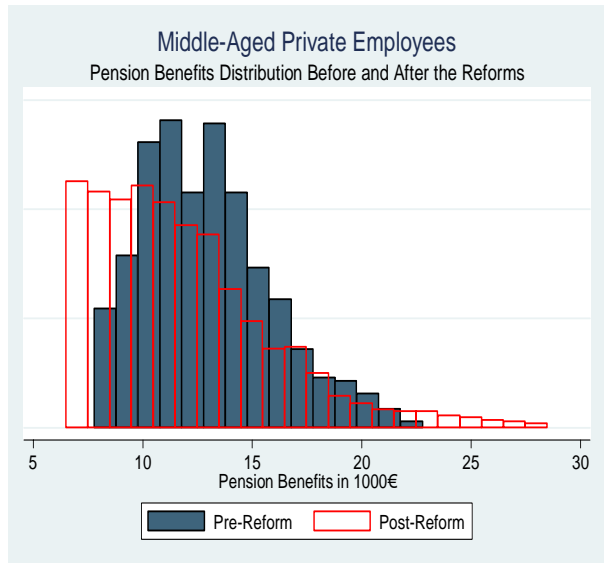
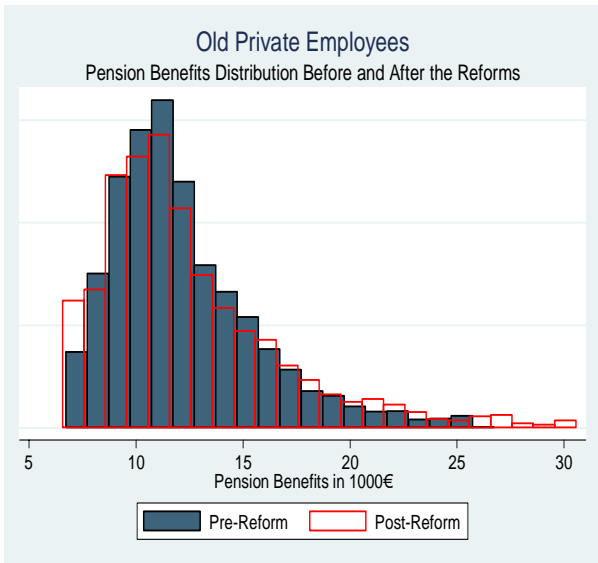
The final sample consists of 16171 observations, 9742 in the pre-reform 1989-1991 period and 6429 in the post-reform 1998-2000 period (a more detailed breakdown is provided in Table B-2 below). This selected sample is used in section 3 to assess the effect of the pension reforms on pension benefit expectations and pension risk, and for the regression analysis. Because of the panel dimension of the survey, a small fraction of the observations in the pre-reform and in the post-reform periods refer to the same household. I take this into account by appropriately correct the standard errors in the regression analysis.

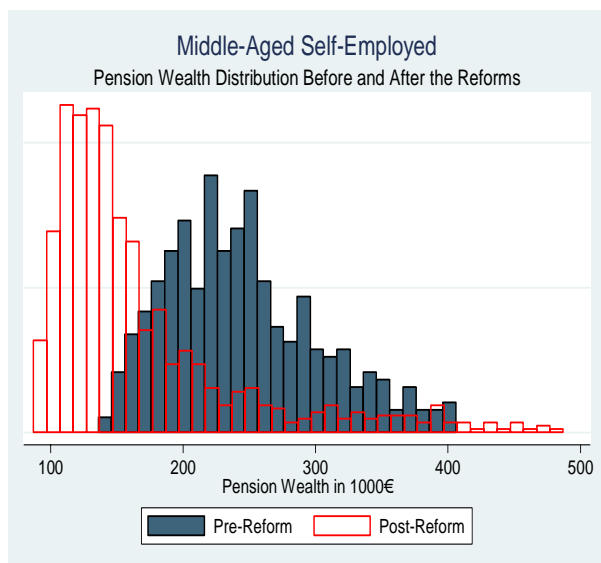
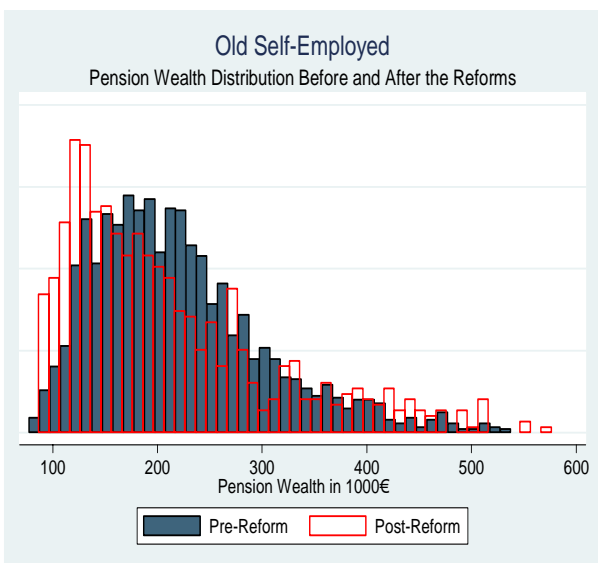
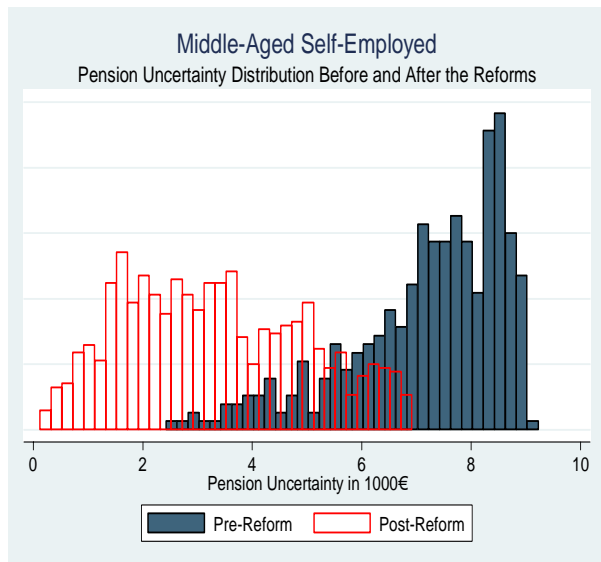
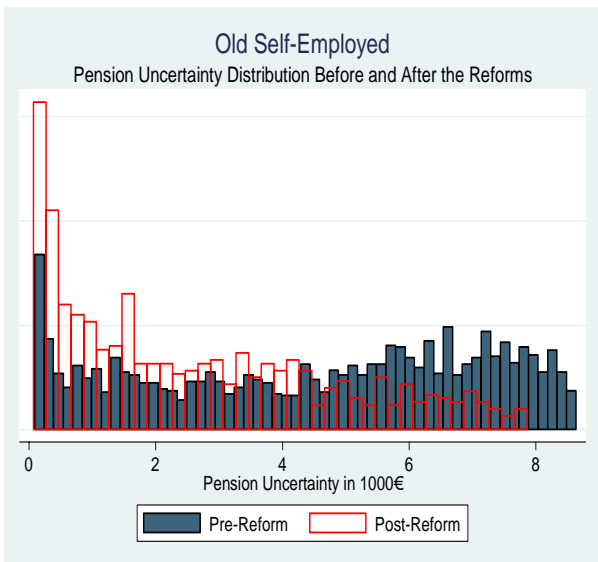
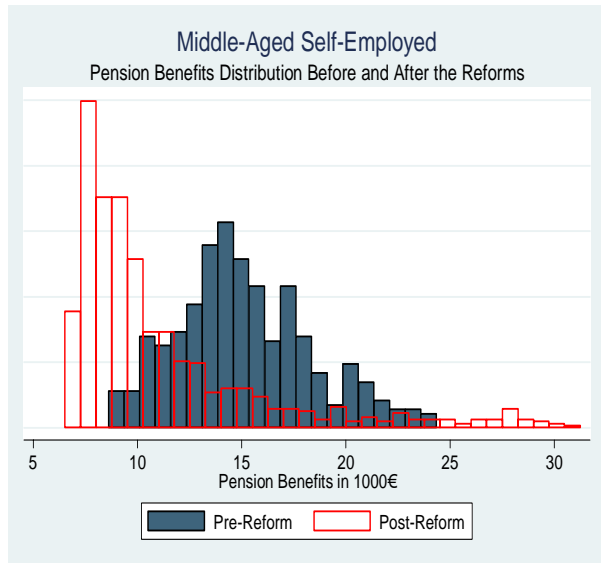
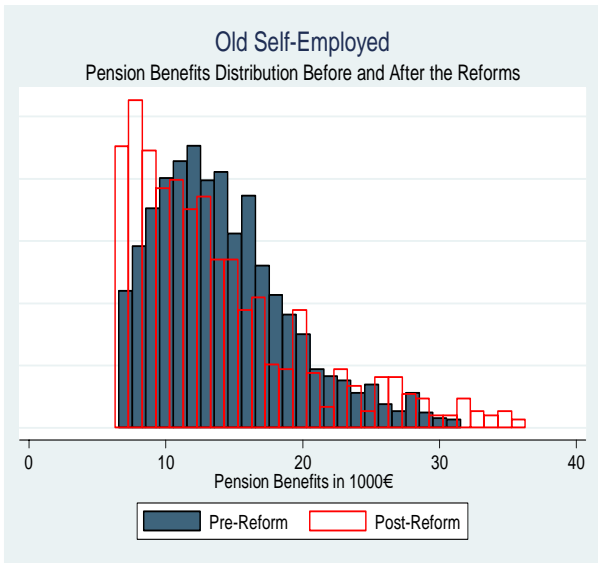
Table B-2: Sample 2: breakdown by groups

	Pre-reform regime 1989-1991	Post-reform regime 1998-2000
Private Employees		
Old	1839	988
Middle-aged	930	915
Private Employees		
Old	2933	1451
Middle-aged	1402	1467
Self-employed		
Old	1716	761
Middle-aged	922	847

C Pension Distributions







D Additional Regression Results

Table D-1: Tobit Regression, equation (6)

Dependent variable: share of risky assets on financial wealth (narrow definition)

	(I)	(II)	(III)	(IV)
<i>Pension Benefits</i>	0.012** (0.003)	0.012** (0.003)	0.012** (0.003)	0.011** (0.003)
<i>Pension Uncertainty</i>	-0.040** (0.008)	-0.040** (0.009)	-0.040** (0.009)	-0.038** (0.008)
<i>Income</i>	0.020** (0.002)	0.020** (0.002)	0.020** (0.002)	0.018** (0.002)
<i>(Income)²</i>	-9.69e-05** (0.000)	-9.64e-05** (0.000)	-9.64e-05** (0.000)	-9.05e-05** (0.000)
<i>Net Real Wealth</i>	1.76e-04** (0.000)	1.67e-04** (0.000)	1.66e-04** (0.000)	1.39e-04** (0.000)
<i>(Net Real Wealth)²</i>	-7.78e-09** (0.000)	-7.34e-09** (0.000)	-7.26e-09** (0.000)	-5.44e-09* (0.000)
<i>Age</i>	0.032** (0.010)	0.032** (0.010)	0.032** (0.010)	0.027** (0.010)
<i>Age²</i>	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)
<i>North</i>	0.170** (0.023)	0.172** (0.023)	0.172** (0.023)	0.177** (0.023)
<i>South</i>	-0.187** (0.029)	-0.186** (0.029)	-0.186** (0.029)	-0.181** (0.029)
<i>High Education</i>	0.295** (0.022)	0.296** (0.022)	0.294** (0.022)	0.278** (0.022)
<i>Household Members</i>	-0.042** (0.009)	-0.042** (0.009)	-0.042** (0.009)	-0.047** (0.009)
<i>Working Spouse</i>	-0.011 (0.022)	-0.008 (0.022)	-0.008 (0.022)	-0.013 (0.022)
<i>Private Pension</i>	0.313** (0.024)	0.315** (0.024)	0.316** (0.024)	0.320** (0.024)
<i>House Ownership</i>		0.019 (0.022)	0.019 (0.022)	0.019 (0.022)
<i>Mortgage</i>		-0.045* (0.025)	-0.045* (0.025)	-0.053** (0.025)
<i>Poor Health</i>			-0.132** (0.062)	-0.142** (0.062)
<i>Life Insurance</i>				0.225** (0.019)
<i>Time Dummies</i>	Y	Y	Y	Y
<i>Group Dummies</i>	Y	Y	Y	Y
<i>Observations</i>	13507	13507	13507	13507
<i>Uncensored Observations</i>	2357	2357	2357	2357

Risky assets include corporate bonds, investment fund units and equities. Variables are in thousands of 2000 euros. Time dummies refer to the years 1991, 1998 and 2000. Group dummies include indicators for old and middle-aged public employees, old and middle-aged self-employed and middle-aged private employees. Robust standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance.

Table D-2: Tobit Regression, equation (6)

Dependent variable: share of risky assets on financial wealth (narrow definition)

	(I)	(II)	(III)	(IV)
<i>Pension Wealth</i>	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)
<i>Pension Uncertainty</i>	-0.029** (0.007)	-0.029** (0.007)	-0.029** (0.007)	-0.028** (0.007)
<i>Income</i>	0.019** (0.002)	0.019** (0.002)	0.019** (0.002)	0.018** (0.002)
<i>(Income)²</i>	-9.29e-05** (0.000)	-9.22e-05** (0.000)	-9.22e-05** (0.000)	-8.67e-05** (0.000)
<i>Net Real Wealth</i>	1.77e-04** (0.000)	1.68e-04** (0.000)	1.67e-04** (0.000)	1.40e-04** (0.000)
<i>(Net Real Wealth)²</i>	-7.85e-09** (0.000)	-7.36e-09** (0.000)	-7.28e-09** (0.000)	-5.47e-09* (0.000)
<i>Age</i>	0.029** (0.010)	0.029** (0.010)	0.029** (0.010)	0.024** (0.010)
<i>Age²</i>	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)
<i>North</i>	0.167** (0.023)	0.168** (0.023)	0.169** (0.023)	0.173** (0.023)
<i>South</i>	-0.184** (0.029)	-0.184** (0.029)	-0.184** (0.029)	-0.179** (0.029)
<i>High Education</i>	0.293** (0.022)	0.294** (0.022)	0.292** (0.022)	0.276** (0.022)
<i>Household Members</i>	-0.040** (0.009)	-0.040** (0.009)	-0.040** (0.009)	-0.045** (0.009)
<i>Working Spouse</i>	-0.003 (0.022)	-0.001 (0.022)	-0.001 (0.022)	-0.006 (0.022)
<i>Private Pension</i>	0.312** (0.024)	0.314** (0.024)	0.315** (0.024)	0.319** (0.024)
<i>House Ownership</i>		0.021 (0.022)	0.021 (0.022)	0.021 (0.022)
<i>Mortgage</i>		-0.045* (0.025)	-0.045* (0.025)	-0.053** (0.025)
<i>Poor Health</i>			-0.135** (0.062)	-0.144** (0.062)
<i>Life Insurance</i>				0.225** (0.019)
<i>Time Dummies</i>	Y	Y	Y	Y
<i>Group Dummies</i>	Y	Y	Y	Y
<i>Observations</i>	13507	13507	13507	13507
<i>Uncensored Observations</i>	2357	2357	2357	2357

Risky assets include corporate bonds, investment fund units and equities. Variables are in thousands of 2000 euros. Time dummies refer to the years 1991, 1998 and 2000. Group dummies include indicators for old and middle-aged public employees, old and middle-aged self-employed and middle-aged private employees. Robust standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance.

Table D-3: Tobit Regression, equation (6)
 Dependent variable: share of risky assets on financial wealth (broad definition)

	(I)	(II)	(III)	(IV)
<i>Pension Benefits</i>	0.011** (0.003)	0.011** (0.003)	0.012** (0.003)	0.011** (0.003)
<i>Pension Uncertainty</i>	-0.032** (0.008)	-0.033** (0.008)	-0.033** (0.008)	-0.031** (0.008)
<i>Income</i>	0.017** (0.001)	0.017** (0.001)	0.017** (0.001)	0.016** (0.001)
<i>(Income)²</i>	-7.59e-05** (0.000)	-7.51e-05** (0.000)	-7.52e-05** (0.000)	-7.17e-05** (0.000)
<i>Net Real Wealth</i>	1.62e-04** (0.000)	1.45e-04** (0.000)	1.44e-04** (0.000)	1.20e-04** (0.000)
<i>(Net Real Wealth)²</i>	-7.46e-09** (0.000)	-6.53e-09** (0.000)	-6.44e-09** (0.000)	-4.82e-09* (0.000)
<i>Age</i>	0.036** (0.009)	0.036** (0.009)	0.037** (0.009)	0.032** (0.009)
<i>Age²</i>	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)
<i>North</i>	0.207** (0.021)	0.210** (0.021)	0.210** (0.021)	0.215** (0.021)
<i>South</i>	-0.204** (0.026)	-0.203** (0.026)	-0.203** (0.026)	-0.196** (0.026)
<i>High Education</i>	0.292** (0.020)	0.294** (0.020)	0.292** (0.020)	0.278** (0.019)
<i>Household Members</i>	-0.047** (0.008)	-0.047** (0.008)	-0.047** (0.008)	-0.051** (0.008)
<i>Working Spouse</i>	-0.014 (0.020)	-0.010 (0.020)	-0.010 (0.020)	-0.015 (0.020)
<i>Private Pension</i>	0.287** (0.022)	0.291** (0.022)	0.292** (0.022)	0.294** (0.022)
<i>House Ownership</i>		0.036* (0.020)	0.036* (0.020)	0.035* (0.020)
<i>Mortgage</i>		-0.082** (0.023)	-0.082** (0.023)	-0.089** (0.023)
<i>Poor Health</i>			-0.171** (0.058)	-0.179** (0.057)
<i>Life Insurance</i>				0.205** (0.018)
<i>Time Dummies</i>	Y	Y	Y	Y
<i>Group Dummies</i>	Y	Y	Y	Y
<i>Observations</i>	13507	13507	13507	13507
<i>Uncensored Observations</i>	2357	2357	2357	2357

Risky assets include corporate bonds, investment fund units, equities and long-term government bonds. Variables are in thousands of 2000 euros. Time dummies refer to the years 1991, 1998 and 2000. Group dummies include indicators for old and middle-aged public employees, old and middle-aged self-employed and middle-aged private employees. Robust standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance.

Table D-4: Tobit Regression, equation (6)

Dependent variable: share of risky assets on financial wealth (broad definition)

	(I)	(II)	(III)	(IV)
<i>Pension Wealth</i>	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)
<i>Pension Uncertainty</i>	-0.022** (0.006)	-0.022** (0.006)	-0.022** (0.006)	-0.021** (0.006)
<i>Income</i>	0.017** (0.001)	0.017** (0.001)	0.017** (0.001)	0.016** (0.001)
<i>(Income)²</i>	-7.37e-05** (0.000)	-7.28e-05** (0.000)	-7.28e-05** (0.000)	-6.96e-05** (0.000)
<i>Net Real Wealth</i>	1.65e-04** (0.000)	1.48e-04** (0.000)	1.46e-04** (0.000)	1.22e-04** (0.000)
<i>(Net Real Wealth)²</i>	-7.58e-09** (0.000)	-6.62e-09** (0.000)	-6.53e-09** (0.000)	-4.90e-09* (0.000)
<i>Age</i>	0.034** (0.009)	0.034** (0.009)	0.034** (0.009)	0.030** (0.009)
<i>Age²</i>	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)	-0.000** (0.000)
<i>North</i>	0.204** (0.021)	0.206** (0.021)	0.207** (0.021)	0.212** (0.021)
<i>South</i>	-0.202** (0.026)	-0.201** (0.026)	-0.201** (0.026)	-0.194** (0.026)
<i>High Education</i>	0.290** (0.020)	0.291** (0.020)	0.290** (0.020)	0.276** (0.019)
<i>Household Members</i>	-0.045** (0.008)	-0.045** (0.008)	-0.045** (0.008)	-0.049** (0.008)
<i>Working Spouse</i>	-0.008 (0.020)	-0.004 (0.020)	-0.004 (0.020)	-0.009 (0.020)
<i>Private Pension</i>	0.286** (0.022)	0.289** (0.022)	0.290** (0.022)	0.292** (0.022)
<i>House Ownership</i>		0.037* (0.020)	0.037* (0.020)	0.036* (0.020)
<i>Mortgage</i>		-0.082** (0.023)	-0.083** (0.023)	-0.090** (0.023)
<i>Poor Health</i>			-0.174** (0.058)	-0.182** (0.057)
<i>Life Insurance</i>				0.204** (0.018)
<i>Time Dummies</i>	Y	Y	Y	Y
<i>Group Dummies</i>	Y	Y	Y	Y
<i>Observations</i>	13507	13507	13507	13507
<i>Uncensored Observations</i>	2357	2357	2357	2357

Risky assets include corporate bonds, investment fund units, equities and long-term government bonds. Variables are in thousands of 2000 euros. Time dummies refer to the years 1991, 1998 and 2000. Group dummies include indicators for old and middle-aged public employees, old and middle-aged self-employed and middle-aged private employees. Robust standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance.

Table D-5: Smith-Blundell Regression, equations (6)-(7)
 Dependent variable: share of risky assets on financial wealth (broad definition)

	(I)	(II)	(III)	(IV)
<i>Pension Benefits</i>	0.044 (0.028)	0.045 (0.028)	0.047* (0.028)	0.041 (0.028)
<i>Pension Uncertainty</i>	-0.117** (0.037)	-0.115** (0.038)	-0.117** (0.038)	-0.111** (0.037)
<i>Income</i>	0.014** (0.005)	0.013** (0.006)	0.013** (0.006)	0.013** (0.005)
<i>(Income)²</i>	-7.45e-05** (0.000)	-7.39e-05** (0.000)	-7.39e-05** (0.000)	-7.05e-05** (0.000)
<i>Net Real Wealth</i>	1.66e-04* (0.000)	1.50e-04 (0.000)	1.48e-04 (0.000)	1.24e-04 (0.000)
<i>(Net Real Wealth)²</i>	-7.54e-09 (0.000)	-6.66e-09 (0.000)	-6.57e-09 (0.000)	-4.95e-09 (0.000)
<i>Age</i>	0.040** (0.009)	0.040** (0.009)	0.040** (0.009)	0.036** (0.009)
<i>Age²</i>	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)
<i>North</i>	0.290** (0.065)	0.289** (0.064)	0.284** (0.064)	0.278** (0.063)
<i>South</i>	-0.043** (0.009)	-0.043** (0.009)	-0.043** (0.009)	-0.047** (0.009)
<i>High Education</i>	0.190** (0.023)	0.194** (0.023)	0.194** (0.023)	0.200** (0.023)
<i>Household Members</i>	-0.203** (0.032)	-0.202** (0.032)	-0.203** (0.032)	-0.195** (0.032)
<i>Working Spouse</i>	0.030 (0.069)	0.037 (0.069)	0.040 (0.069)	0.025 (0.067)
<i>Private Pension</i>	0.285** (0.023)	0.287** (0.023)	0.288** (0.023)	0.291** (0.023)
<i>House Ownership</i>		0.052* (0.031)	0.053* (0.031)	0.049 (0.030)
<i>Mortgage</i>		-0.096** (0.027)	-0.097** (0.027)	-0.102** (0.027)
<i>Poor Health</i>			-0.184** (0.059)	-0.193** (0.059)
<i>Life Insurance</i>				0.204** (0.019)
<i>Exogeneity Test (PB)</i>	-1.21	-1.21	-1.28	-1.15
<i>Exogeneity Test (PU)</i>	2.35	2.27	2.30	2.19
<i>Time Dummies</i>	Y	Y	Y	Y
<i>Group Dummies</i>	Y	Y	Y	Y
<i>Observations</i>	13507	13507	13507	13507
<i>Uncensored Observations</i>	2357	2357	2357	2357

Risky assets include corporate bonds, investment fund units, equities and long-term government bonds. Variables are in thousands of 2000 euros. Time dummies refer to the years 1991, 1998 and 2000. Group dummies include indicators for old and middle-aged public employees, old and middle-aged self-employed and middle-aged private employees. Instruments: indicator for the post-reform period and its interactions with groups dummies. Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance. Exogeneity test is the Smith-Blundell test for the exogeneity of pension benefits and pension uncertainty as described in section 2.3. The bootstrap (500 replications) *t* - statistic is reported.

Table D-6: Smith-Blundell Regression, equations (6)-(7)
 Dependent variable: share of risky assets on financial wealth (broad definition)

	(I)	(II)	(III)	(IV)
<i>Pension Wealth</i>	0.001 (0.001)	0.001 (0.001)	0.002 (0.001)	0.001 (0.001)
<i>Pension Uncertainty</i>	-0.108** (0.035)	-0.105** (0.035)	-0.107** (0.035)	-0.101** (0.035)
<i>Income</i>	0.017** (0.004)	0.017** (0.004)	0.017** (0.004)	0.017** (0.004)
<i>(Income)²</i>	-7.22e-05** (0.000)	-7.14e-05** (0.000)	-7.14e-05** (0.000)	-6.83e-05** (0.000)
<i>Net Real Wealth</i>	1.70e-04* (0.000)	1.53e-04 (0.000)	1.51e-04 (0.000)	1.27e-04 (0.000)
<i>(Net Real Wealth)²</i>	-7.67e-09 (0.000)	-6.75e-09 (0.000)	-6.67e-09 (0.000)	-5.04e-09 (0.000)
<i>Age</i>	0.035** (0.009)	0.035** (0.009)	0.036** (0.009)	0.032** (0.009)
<i>Age²</i>	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)	-0.000** (0.000)
<i>North</i>	0.342** (0.044)	0.341** (0.044)	0.338** (0.044)	0.328** (0.044)
<i>South</i>	-0.042** (0.010)	-0.041** (0.010)	-0.041** (0.010)	-0.047** (0.010)
<i>High Education</i>	0.185** (0.024)	0.189** (0.024)	0.188** (0.024)	0.196** (0.024)
<i>Household Members</i>	-0.189** (0.031)	-0.188** (0.031)	-0.188** (0.031)	-0.181** (0.030)
<i>Working Spouse</i>	-0.016 (0.044)	-0.011 (0.044)	-0.007 (0.044)	-0.022 (0.043)
<i>Private Pension</i>	0.289** (0.022)	0.292** (0.022)	0.293** (0.022)	0.296** (0.022)
<i>House Ownership</i>		0.038 (0.027)	0.039 (0.027)	0.035 (0.027)
<i>Mortgage</i>		-0.093** (0.027)	-0.094** (0.027)	-0.098** (0.027)
<i>Poor Health</i>			-0.199** (0.060)	-0.205** (0.060)
<i>Life Insurance</i>				0.206** (0.019)
<i>Exogeneity Test (PB)</i>	-1.00	-1.01	-1.00	-0.98
<i>Exogeneity Test (PU)</i>	2.48	2.43	2.46	2.34
<i>Time Dummies</i>	Y	Y	Y	Y
<i>Group Dummies</i>	Y	Y	Y	Y
<i>Observations</i>	13507	13507	13507	13507
<i>Uncensored Observations</i>	2357	2357	2357	2357

Risky assets include corporate bonds, investment fund units, equities and long-term government bonds. Variables are in thousands of 2000 euros. Time dummies refer to the years 1991, 1998 and 2000. Group dummies include indicators for old and middle-aged public employees, old and middle-aged self-employed and middle-aged private employees. Instruments: indicator for the post-reform period and its interactions with groups dummies. Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance. Exogeneity test is the Smith-Blundell test for the exogeneity of pension benefits and pension uncertainty as described in section 2.3. The bootstrap (500 replications) t -statistic is reported.

Table D-7: Smith-Blundell Regression, equations (6)-(7)
 Dependent variable: share of risky assets on financial wealth (narrow definition)
 Excluding individuals contributing to private pension funds

	Specification (III)	Specification (III)
	pension entitlements: pension benefits	pension entitlements: pension wealth
<i>Pension Benefits</i>	0.074* (0.043)	
<i>Pension Wealth</i>		0.004** (0.001)
<i>Pension Uncertainty</i>	-0.168** (0.053)	-0.163** (0.046)
<i>Income</i>	0.016** (0.008)	0.018** (0.005)
<i>(Income)²</i>	-1.12e-04** (0.000)	-1.07e-04** (0.000)
<i>Net Real Wealth</i>	1.30e-04 (0.000)	1.35e-04 (0.000)
<i>(Net Real Wealth)²</i>	-5.50e-09 (0.000)	-5.65e-09 (0.000)
<i>Age</i>	0.045** (0.012)	0.035** (0.012)
<i>Age²</i>	-0.001** (0.000)	-0.001** (0.000)
<i>North</i>	0.273** (0.092)	0.321** (0.059)
<i>South</i>	-0.045** (0.013)	-0.036** (0.013)
<i>High Education</i>	0.128** (0.033)	0.101** (0.035)
<i>Household Members</i>	-0.232** (0.040)	-0.209** (0.039)
<i>Working Spouse</i>	0.076 (0.099)	0.055 (0.059)
<i>House Ownership</i>	0.059 (0.042)	0.054 (0.036)
<i>Mortgage</i>	-0.082** (0.036)	-0.092** (0.035)
<i>Poor Health</i>	-0.188** (0.081)	-0.220** (0.083)
<i>Exogeneity Test (PB)</i>	-1.66	
<i>Exogeneity Test (PW)</i>		-2.53
<i>Exogeneity Test (PU)</i>	2.34	2.74
<i>Time Dummies</i>	Y	Y
<i>Group Dummies</i>	Y	Y
<i>Observations</i>	11890	11890
<i>Uncensored Observations</i>	1697	1697

Risky assets include corporate bonds, investment fund units and equities. Variables are in thousands of 2000 euros. Time dummies refer to the years 1991, 1998 and 2000. Group dummies include indicators for old and middle-aged public employees, old and middle-aged self-employed and middle-aged private employees. Instruments: indicator for the post-reform period and its interactions with groups dummies. Bootstrap (500 replications) standard errors are in parentheses. ** indicates 5% significance, * indicates 10% significance. Exogeneity test is the Smith-Blundell test for the exogeneity of pension benefits/wealth and pension uncertainty as described in section 2.3. The bootstrap (500 replications) *t* - statistic is reported.