Investment in Financial Literacy, Social Security and Portfolio Choice*

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Abstract

We present an intertemporal portfolio choice model where individuals invest in financial literacy, save, allocate their wealth between a safe and a risky asset, and receive a pension when they retire. Financial literacy affects the excess return and the cost of stock market participation. Since literacy depreciates over time and has a cost in terms of current consumption, investors choose simultaneosly how much to save, the portfolio allocation and the optimal investment in literacy. The latter depends on households' resources, preference parameters and on how financial literacy affects the risky asset returns and the stock market participation cost, as well as on the generosity of social security system. The model implies that in a cross-section of households one should observe a positive correlation between stock market participation (and the risky asset share, conditional on participation) and financial literacy and a negative correlation between the generosity of the social security system and financial literacy. The model also implies that the stock of financial literacy early in life is positively correlated with wealth and portfolio allocations later in life. Using microeconomic cross-country data, we find support for these predictions.

Keywords: Financial Literacy, Portfolio Choice, Saving.

JEL classification: E2, D8, G1, J24

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1 Introduction

The classical theory of portfolio choice rests on the assumptions that there are no transaction costs and that investors have full information about the risk and return of available assets. If all investors face the same distribution of returns and have the same information set, in equilibrium they also select the same menu of risky assets. Differences in attitudes to risk affect the allocation of wealth between safe and risky assets, but not the particular asset selected. And if the utility function has constant relative risk aversion, asset shares are independent of wealth. Under these assumptions, the rich man's portfolio is simply a scaled-up version of that of poor man's. However, recent empirical studies have shown that household portfolios exhibit too much heterogeneity to be consistent with the classical model. In particular, many individuals do not invest in stocks, a feature that has come to be known as the stockholding puzzle (Haliassos and Bertaut, 1995).

Fixed entry costs have been the main focus of the literature to resolve the puzzle. With entry costs, investors benefit from stockholding only if the expected excess return from participation exceeds the fixed cost. Since the gain increases with wealth, entry costs relate wealth to stockholding. In particular, models with entry costs suggest that investors with wealth below a certain threshold do not enter the stock market, and that only those above it do. Empirical evidence documents a strong positive correlation between stock market participation and financial wealth in many industrialized countries, supporting models with entry costs (Guiso, Haliassos and Jappelli, 2003; Vissing-Jorgensen, 2002). The exact nature of entry costs, however, is not well understood. Are these monetary costs or information costs? Do all investors face the same entry costs, or do they vary across investors? Are there ways by which investors are able to avoid or reduce such costs?

In this paper we focus on the lack of financial sophistication as a potential explanation for limited financial market participation. In the paper we posit that, like other forms of human capital, financial information can be accumulated, and that the decision to invest in financial literacy has costs and benefits. Accordingly, we study the joint determination of financial information, saving and portfolio decisions, both theoretically and empirically. In the theoretical model we posit that people are endowed with an initial stock of financial literacy, which they acquire before entering the labor market, and that investing in financial literacy gives access to better investment opportunities, raising the returns to risky assets or lowering entry costs. Acquiring financial information, however, entails also costs in terms of time, effort and resources. Our model delivers conditions for optimal saving, asset allocation and investment in financial literacy. In particular, the model implies that in a cross-section of households, financial literacy and stockholding are positively correlated. However, the relation between the two variables is not a causal relationship, because both variables depend on preference parameters, households' resources and the cost of acquiring literacy. We also find that introducing a social security system (or making the system more generous) reduces the incentive to save, to invest in financial literacy and to invest in risky assets, other things equal. Therefore the social security system impacts stockholding in two ways: directly, by reducing discretionary wealth, and indirectly by reducing the incentive to invest in financial literacy, thereby making stockholding less desirable.

In Section 2 we review the relevant literature, with particular focus on previous studies of the relation between financial sophistication and stockholding and studies that address the endogeneity of financial literacy with respect to stockholding. Section 3 presents our theoretical model, analyzing two distinct channels through which financial literacy affects asset allocation, i.e. by raising assets returns (Model I) and by lowering transaction costs (Model II). To convey the main insights in the simplest framework, we focus on a two-period model with isoelastic utility function. The model also features a social security system, showing that the replacement rate (as an indicator of the generosity of the system) affects saving, portfolio choice, and investment in financial literacy. The two models deliver several important testable implications: (1) in both models, the initial stock of financial literacy affects the trajectory of literacy later in life; (2) Model I predicts that the stockholding decision does not depend on financial literacy, while the share invested in risky assets increases with literacy; (3) Model II predicts a positive relation between literacy and participation, but no relation between literacy and the share of risky assets; (4) both models predict that social security affects portfolio choice, reducing stock market participation and investment in risky assets; (5) the effect of social security on the demand for risky assets depends on the initial stock of financial literacy.

In Section 4 we present our microeconomic data derived by merging the Survey of Health, Ageing, Retirement in Europe (SHARE), a representative sample of individuals aged 50+ in Europe, and SHARELIFE, a retrospective survey of the same individuals. We define an indicator of financial literacy based on a series of specific questions available in SHARE and measure initial literacy in SHARELIFE as mathematical skills at school age. Section 5 presents the regression results on the determinants of stockholding and of the share of risky assets. We find that the initial stock of financial literacy is strongly associated with stockholding, but not with the share of risky assets, lending support to models in which literacy lowers transaction costs (Model II). Section 6 summarizes our results.

2 Financial sophistication and portofolio perfomance

Many recent empirical studies using panel data on household portfolios find that low financial sophistication is associated with poor risk diversification, inefficient portfolio allocations and low wealth accumulation. Calvet *et al.* (2007) and (2009) uncover substantial heterogeneity in account performance in Swedish data, and find that part of the variability of returns across investors is explained by financial sophistication. In particular, they show that predictors of financial sophistication (such as wealth, income, occupation and education) are associated with higher Sharpe ratios, and that richer and more sophisticated households invest more efficiently. Hackethal *et al.* (2012) use data on German brokerage accounts and find that years of experience tend to contribute to higher returns. Feng and Seasholes (2005) find that investor sophistication and trading experience eliminate the reluctance to realize losses.[1] Campbell *et al.* (2012) study investment strategies and performance of individual investors in Indian equities over the period from 2002 to 2012.[2] They study learning by relating account age (the length of time since an account was opened) and past portfolio mistakes to the performance of each account and find that account performance improves significantly with account age.

Other studies relate household portoflio decisions to direct indicators of financial literacy as a measure of sophistication. Van Rooij *et al.* (2007) rely on a special module of the Dutch DNB Household Survey. The module contains questions on the ability to perform simple calculations and to understand compound interest, inflation, and money illusion, and more advanced questions on stock market functioning, characteristics of stocks, mutual funds and bonds, equity premiums, and the benefits of diversification. The authors find that financial sophistication is associated with the probability to invest in the stock market and higher propensity to plan for retirement.

[1] See also Grinblatt and Keloharju (2001), Zhu (2002), and Lusardi and Mitchell (2007)

[2] They find substantial heterogeneity in the time-series average returns, with the 10^{th} percentile account under-performing by 2.6 percent per month and the 90^{th} percentile account over-performing by 1.23 percent per month

Guiso and Jappelli (2008) use the 2007 Unicredit Customer Survey (UCS), and find that financial literacy is strongly correlated to the degree of portfolio diversification, even controlling for socioeconomic characteristics and risk aversion. Banks and Oldfield (2007) look at numerical ability and other dimensions of cognitive functions in a sample of older adults in the English Longitudinal Study of Ageing (ELSA) and find that numeracy levels are strongly correlated with indicators of retirement savings and investment portfolios, understanding of pension arrangements, and perceived financial security. Stango and Zinman (2009) analyze the pervasive tendency to linearize exponential functions. Using the 1977 and 1983 Surveys of Consumer Finances, they show that exponential growth bias can explain the tendency to underestimate an interest rate given other loan terms, and the tendency to underestimate a future value given other investment terms. Christelis *et al.* (2010) study the relation between cognitive abilities and stockholding using SHARE data, and find that the propensity to invest directly and indirectly in stocks (through mutual funds and retirement accounts) is strongly associated with mathematical ability, verbal fluency, and recall skills.

A problem of these studies is that the incentive to invest in financial information depends on household resources, because the benefit of stockholding (and therefore the cost of not investing in the stock market) depends on the amount invested, see Delevande *et al.* (2008) and Willis (2009) Furthermore, since the true stock of financial literacy is not observed by applied researchers, empirical studies face also a difficult measurement error problem. The endogeneity and measurement issues are similar to those arising in the literature that estimates the returns to schooling: any attempt to estimate the structural relation between schooling and wages must deal with the endogeneity of the schooling decision and the measurement error in the quantity and quality of education (Card, 2001).Some studies address these important econometric concerns using an instrumental variable approach, see Christiansen *et al.* (2008), Lusardi (2008), and Behrman *et al.* (2010). In the next section we build upon the insights of these paper and provide a theoretical framework to study the relation between financial literacy and portfolio choice, and in later sections we explore its empirical implications.

3 Theoretical background

We propose a model in which financial literacy, saving and asset allocation are jointly determined. The model builds on the idea that that investors can increase the payoff on their financial portfolios by acquiring information on the rate of return, an idea first proposed by Arrow (1987). We posit that people are endowed with an initial stock of financial literacy, which they acquire before entering the labor market and that investing in financial literacy gives access to better investment opportunities, raising the expected return to saving (Model I) or reducing the cost of participating in financial markets (Model II).[3] In each period, people can invest their wealth in a safe and in a risky asset and in financial literacy. Investment in literacy can directly raise the risk-free rate available to investors or the mean of the return of the risky asset (for instance, through lower fees), reduce the variance of the return of the risky asset through increased diversification, or affect the entry cost in the market for the risky asset. There are of course several special cases, such as one in which the risk free rate is constant, but the mean and variance of the risky asset are affected by financial literacy.

The stock of financial literacy depreciates over time, but people can acquire financial information, which entails costs in terms of time, effort, or resources. Accordingly, agents choose how much to invest in financial literacy, how much to save and how much to invest in the risky asset, given their initial level of literacy, the cost of literacy, the depreciation of the stock of literacy, and their preferences. As noted by Arrow (1987), the incentive to invest in literacy depends not only on the return to literacy (e.g. on the grounds that which raising literacy provides access to better investment opportunities and improved risk diversification) but also on the amount of wealth available for financial investment (the incentive is an increasing function of wealth).

Our theoretical analysis of Models I and II proceeds in two steps. In the first step, we derive optimal saving, investment in risky assets and investment in financial literacy in each of the two models . In the second step we study how the generosity of the social security system - as summarized by the replacement rate - affect these decisions. We find that in the presence of mandatory contributions people have fewer resources to invest in the market (the familiar Feldstein displacement effect), acquire less financial information and have fewer incentives to invest in stocks. In both models, the focus is to derive testable implications of the models in the simplest frameworks.[4]

[3]We build on the model with no uncertainty and a single asset of Jappelli and Padula (2011).

[4]For expositional simplicity we anlyze the two models separately. One could of course study a model in which finacial literacy affects the returns of risky assets (Model I) as well as participation costs (Model II). The nested model has the same qualitative insights as Models I and II, although different quantitave implications. For instance, in the nested model the level of Φ_0 that triggers stock market participation is lower compared to

3.1 Model I: Financial literacy and asset returns

We assume that consumers live two periods, and that they earn income y in period 0 and retire in period 1. At the beginning of period 0 they have no assets but are endowed with a stock of financial literacy, Φ_0. The initial stock of literacy is what people know about finance before entering the labor market. It depends therefore on schooling decisions and parental background, neither of which we model explicitly.

Consumers can increase their stock of financial literacy by investing in financial literacy in period 0. Literacy depreciates at the rate δ; the relative cost of literacy in terms of the consumption good is p, which includes monetary and time costs incurred by consumers. The stock of literacy therefore evolves according to:

$$\Phi_1 = (1-\delta)\Phi_0 + \phi \tag{1}$$

where ϕ denotes investment in financial literacy.

The portfolio return is paid at the beginning of period 1 on wealth transferred from period 0 to 1. Denoting by ω the share of wealth invested in the risky asset, the gross portfolio return is:

$$R(\Phi_1,\alpha,\zeta,\omega) = \begin{cases} \theta_1(\Phi_1,\alpha,\zeta,\omega) & \text{with probability} \quad \eta(\Phi_1) \\ \theta_2(\Phi_1,\alpha,\zeta,\omega) & \text{with probability} \quad 1-\eta(\Phi_1) \end{cases}$$

where $\theta_1(\Phi_1,\alpha,\zeta,\omega) = \Phi_1^\alpha(1+\omega\zeta)$ and $\theta_2(\Phi_1,\alpha,\zeta,\omega) = \Phi_1^\alpha(1-\omega\zeta)$, $\alpha \in (0,1)$, $\zeta > 0$ and $\eta'(\cdot) > 0$ and $\eta''(\cdot) < 0$. If $\omega = 0$, wealth is entirely invested in the riskless asset and the gross return is Φ_1^α. If $\omega = 1$, wealth is entirely invested in the riskless asset and the gross return is $\Phi_1^\alpha(1+\zeta)$ with probability $\eta(\Phi_1)$ and $\Phi_1^\alpha(1-\zeta)$ with probability $1-\eta(\Phi_1)$. Therefore, the mean return of the risky asset is $\{\zeta[2\eta(\Phi_1)-1]+1\}\Phi_1^\alpha$ and the first and second moment of the equity premium distribution are $[2\eta(\Phi_1)-1]\Phi_1^\alpha\zeta$ and $\Phi_1^{2\alpha}\zeta$, respectively. The Sharpe ratio is thus an increasing function of financial literacy since $\eta'(\cdot) > 0$, an assumption that is motivated by the empirical literature on portfolio performance and financial sophistication surveyed in Section 2. [5]

Model II. Since we do not calibrate and simulate the theoretical models, but use them to derive comparative static results, there is no real advantage in presenting the nested model.

[5] Notice that depending on the shape of $\eta(\Phi_1)$ the equity premium can be negative if Φ_0 is sufficiently low. This makes it optimal not to participate in the stock market even in the absence of transaction costs. For instance, if $\eta(\Phi_1)$ is a normal cumulative distribution function with mean equal to μ, participating to the stock market is optimal only if Φ_0 is large enough to make the optimal $\Phi_1 > \mu$.

We assume that the utility function is isoelastic, so that consumers choose saving (s), investment in financial literacy (ϕ) and the risky asset share (ω) to maximize:

$$\left(1-\frac{1}{\sigma}\right)^{-1}\left(c_0^{1-\frac{1}{\sigma}}+\beta E_0 c_1^{1-\frac{1}{\sigma}}\right)$$

subject to $c_0 = y - p\phi - s$ and $c_1 = R(\Phi_1, \alpha, \zeta, \omega)s$, where $0 < \beta < 1$ is the discount factor and $E_0(\cdot)$ is the expected value of consumption in period 1. Appendix A.1 deals with the logarithmic case. The first order conditions with respect to s, ϕ and ω are:

$$\begin{aligned}
s^{\frac{1}{\sigma}} &= \beta c_0^{\frac{1}{\sigma}} E_0 R(\Phi_1,\alpha,\zeta,\omega)^{1-\frac{1}{\sigma}} && (2)\\
\frac{p}{s}-\frac{\alpha}{\Phi_1} &= \frac{\sigma\eta'(\Phi_1)\left[\theta_1(\Phi_1,\alpha,\zeta,\omega)^{1-\frac{1}{\sigma}}-\theta_2(\Phi_1,\alpha,\zeta,\omega)^{1-\frac{1}{\sigma}}\right]}{(\sigma-1)E_0R(\Phi_1,\alpha,\zeta,\omega)^{1-\frac{1}{\sigma}}} && (3)\\
\theta_1(\Phi_1,\alpha,\zeta,\omega) &= \left[\frac{\eta(\Phi_1)}{1-\eta(\Phi_1)}\right]^{\sigma}\theta_2(\Phi_1,\alpha,\zeta,\omega) && (4)
\end{aligned}$$

From (4), one obtains an expression for the share of wealth invested in the risky asset:

$$\omega = \frac{\eta(\Phi_1)^{\sigma}-[1-\eta(\Phi_1)]^{\sigma}}{\zeta\left\{\eta(\Phi_1)^{\sigma}+[1-\eta(\Phi_1)]^{\sigma}\right\}} \qquad (5)$$

Equation (5) has an important implication for empirical work. In a cross-section of households reporting information on financial literacy (Φ_1) and the risky asset share (ω), equation (5) implies a positive association between the two variables. But clearly it cannot be concluded from this correlation that a higher stock of literacy leads to a higher risky asset share, because both variables are endogenous. In our model, equation (5) is therefore an equilibrium condition between the optimal share and the optimal stock of literacy, not a reduced form equation. It therefore implies that any factor that leads to higher financial literacy will also raise investment in the risky asset.

Using the budget constraint, (2) and (5), one can show that:

$$s = \frac{\kappa(\Phi_1,\alpha,\beta,\sigma)}{1+\kappa(\Phi_1,\alpha,\beta,\sigma)}(y-p\phi) \qquad (6)$$

where $\kappa(\Phi_1,\alpha,\beta,\sigma) = (2\Phi_1^{\alpha})^{\sigma-1}\beta^{\sigma}\left\{\eta^{\sigma}(\Phi_1)+[1-\eta(\Phi_1)]^{\sigma}\right\}$. Notice that $\kappa(\Phi_1,\alpha,\beta,\sigma) = \beta$ if $\sigma = 1$.

From equations (3), (5) and (6) the optimal level of investment in literacy is implicitly defined by:

$$p = \frac{\kappa(\Phi_1,\alpha,\beta,\sigma)}{1+\kappa(\Phi_1,\alpha,\beta,\sigma)}\left[\frac{\alpha}{\Phi_1}+\lambda(\Phi_1,\sigma)\right](y-p\phi) \qquad (7)$$

where:

$$\lambda(\Phi_1, \sigma) = \frac{\sigma\eta'(\Phi_1)}{\sigma - 1}\left\{\frac{\eta(\Phi_1)^{\sigma-1} - [1-\eta(\Phi_1)]^{\sigma-1}}{\eta(\Phi_1)^{\sigma} + [1-\eta(\Phi_1)]^{\sigma}}\right\}$$

The right-hand side of equation (7) is the marginal return of financial literacy investment. The return has two components. The first component depends on $\frac{\alpha}{\Phi_1}$; this component is positive and captures the effect of literacy on the expected return to saving, and it is also present in the model without uncertainty (Jappelli and Padula, 2011). The second component depends on $\lambda(\Phi_1, \sigma)$, and is also positive, capturing the effect of literacy on the distribution of the risky asset return. The first component is an increasing function of α, while the second component is an increasing function of $\eta'(\Phi_1)$, i.e. of how much literacy raises the risky asset return.[6]

Straightforward application of the Dini theorem for implicit functions implies the following proposition.

Proposition 1 *If the right-hand side of (7) is a decreasing function of Φ_1, the optimal level of financial literacy is an increasing function of α (or β, Φ_0, y) and a decreasing functon of p (or δ), i.e.:*

$$\frac{\partial\Phi_1^*}{\partial\alpha} > 0, \frac{\partial\Phi_1^*}{\partial\beta} > 0, \frac{\partial\Phi_1^*}{\partial\Phi_0} > 0, \frac{\partial\Phi_1^*}{\partial y} > 0, \frac{\partial\Phi_1^*}{\partial p} < 0, \frac{\partial\Phi_1^*}{\partial\delta} < 0$$

In addition, Appendix B shows that $\lim_{\sigma\to\infty}\Phi_1^* > \lim_{\sigma\to 0}\Phi_1^*$ and provides sufficient conditions for the marginal return of financial literacy to be a decreasing function of literacy.

Figure 1 plots the left-hand side (dashed line) and the right-hand side (continuous line) of (7) as a function of Φ_1. The continuous curve shifts up if α increases which implies that the optimal level of financial literacy increases with α. Similar results (an upward shift of the curve) obtain if β, Φ_0, y increase. Instead, the line shifts down if p or δ falls.

One can solve equation (7) with respect to Φ_1 and find the optimal value of financial literacy, which in turn determines saving through (6) and the share of wealth invested in the risky assets through (5). Given our interest in deriving testable implications for portfolio choice, we find it useful to focus on the share of wealth invested in the risky asset. From equation (5) it is easy to verify that the share is positively associated with financial literacy, which leads to the following proposition.

[6] Note that the marginal return of financial literacy increases with α, β, Φ_0 and y and decreases with δ and p. In addition, if $\eta(\Phi_1) = (1+e^{-\Phi_1})^{-1}$, one can show that: (a) $\lambda(\Phi_1, \sigma)$ is a non-monotone function of Φ_1, increasing for small values for Φ_1 and decreasing for large values; (b) $\lim_{\Phi_1\to\infty}\lambda(\Phi_1, \sigma) = 0$; (c) $\lambda(\Phi_1, \sigma)$ is a non-monotone function of σ, increasing for small values of σ and decreasing for large values; (d) $\lim_{\sigma\to\infty}\lambda(\Phi_1, \sigma) = 1 - \eta(\Phi_1)$; (e) $\lambda(\Phi_1, 0) = 0$.

Proposition 2 *If the right-hand side of (7) is a decreasing function of* Φ_1*, the optimal share of risky assets is an increasing function of* α, β*,* Φ_0*, and* y *and a decreasing function of* p *and* δ*, i.e.:*

$$\frac{\partial \omega^*}{\partial \alpha} > 0, \frac{\partial \omega^*}{\partial \beta} > 0, \frac{\partial \omega^*}{\partial \Phi_0} > 0, \frac{\partial \omega^*}{\partial y} > 0, \frac{\partial \omega^*}{\partial p} < 0, \frac{\partial \omega^*}{\partial \delta} < 0$$

In addition, $\lim_{\sigma \to \infty} \omega^* = \frac{1}{\zeta} > \lim_{\sigma \to 0} \omega^* = 0$

Proposition (2) has three implications. First, any factor leading to high a share of wealth invested in risky assets also increases financial literacy. For instance, patient individuals (high β) feature a relative high risky assets share and at the same time a relatively high level of financial literacy.[7] For the same reason, any variable that affects literacy also affects the risky asset share; for instance, as we shall see below, the generosity of the social security system affects the risky asset share. Second, in the model the initial stock of literacy, Φ_0, affects the risky asset share only through its effect on the current stock of literacy Φ_1^*. Therefore in a regression framework Φ_0 can be used as an instrument for Φ_1^*. The third implication is that in standard models with constant relative risk aversion (CRRA) the risky asset share does not depend on wealth. Here we still have CRRA, but the share depends - through its effect on literacy - on household resources. Therefore, the model delivers a positive correlation between the risky asset share and wealth, contrary to the standard model.

3.1.1 Social security

We now introduce social security in the model and discuss its impact on financial literacy and portfolio allocations. In period 0 consumers earn income y, net of social seurity contributions, in period 1 they receive benefits equal to b.

The first order conditions with respect to s, Φ_1 and ω are:

$$s^{\frac{1}{\sigma}} = \beta c_0^{\frac{1}{\sigma}} E_0 \left\{ R(\Phi_1, \alpha, \zeta, \omega) \left[R(\Phi_1, \alpha, \zeta, \omega) + \frac{b}{s} \right]^{-\frac{1}{\sigma}} \right\} \tag{8}$$

$$\frac{p}{s} - \frac{\alpha}{\Phi_1} = \frac{\sigma \eta'(\Phi_1) \left\{ \left[\theta_1(\Phi_1, \alpha, \zeta, \omega) + \frac{b}{s\Phi_1^\alpha} \right]^{1-\frac{1}{\sigma}} - \left[\theta_2(\Phi_1, \alpha, \zeta, \omega) + \frac{b}{s\Phi_1^\alpha} \right]^{1-\frac{1}{\sigma}} \right\}}{(\sigma - 1) E_0 \left\{ R(\Phi_1, \alpha, \zeta, \omega) \left[R(\Phi_1, \alpha, \zeta, \omega) + \frac{b}{s} \right]^{-\frac{1}{\sigma}} \right\}} \tag{9}$$

$$\theta_1(\Phi_1, \alpha, \zeta, \omega) + \frac{b}{s\Phi_1^\alpha} = \left[\frac{\eta(\Phi_1)}{1 - \eta(\Phi_1)} \right]^\sigma \left[\theta_2(\Phi_1, \alpha, \zeta, \omega) + \frac{b}{s\Phi_1^\alpha} \right] \tag{10}$$

[7] As noted above, this does not imply any causal link between financial literacy and the risky asset share.

From (10), the share of wealth invested in the risky asset is:

$$\omega = \frac{\eta(\Phi_1)^\sigma - [1-\eta(\Phi_1)]^\sigma}{\zeta\left\{\eta(\Phi_1)^\sigma + [1-\eta(\Phi_1)]^\sigma\right\}}\left(1+\frac{b}{s\Phi_1^\alpha}\right) \tag{11}$$

Using the budget constraint, (11) and (8) one can show that:

$$s = \frac{\kappa(\Phi_1,\alpha,\beta,\sigma)}{1+\kappa(\Phi_1,\alpha,\beta,\sigma)}\left[y - p\phi - \frac{b}{\kappa(\Phi_1,\alpha,\beta,\sigma)\Phi_1^\alpha}\right] \tag{12}$$

The optimal level of financial literacy is implicitly defined by:

$$p = \frac{\kappa(\Phi_1,\alpha,\beta,\sigma)}{1+\kappa(\Phi_1,\alpha,\beta,\sigma)}\left[\frac{\alpha}{\Phi_1}+\lambda(\Phi_1,\sigma)\right]\left[y - p\phi - \frac{b}{\kappa(\Phi_1,\alpha,\beta,\sigma)\Phi_1^\alpha}\right] + \lambda(\Phi_1,\sigma)\frac{b}{\Phi_1^\alpha} \tag{13}$$

Equation (13) indicates that b has a positive and a negative effect on the marginal return to financial literacy. The negative effect causes the optimal level of financial literacy to decrease if b increases. The effect is also present in the model without uncertainty on asset returns (see Jappelli and Padula, 2011) and is due to the offset between social security and private wealth. If b increases, social security wealth increases, and therefore s and Φ_1 decrease. The positive effect is instead new to the model with uncertain asset returns and is due to b being not uncertain. The higher b, the more individuals invest in the risky asset, which induces the individuals to invest more in financial literacy. If α is large enough, the former effect prevails, and the optimal level of financial literacy is a decreasing function of b.[8] This results is summarized in the following.

Proposition 3 *If the right-hand side of (13) is a decreasing function of Φ_1, for large enough α the optimal level of financial literacy is a decreasing function of b, i.e.:*

$$\frac{\partial \Phi_1^*}{\partial b} < 0$$

Equation (13) implies that Φ_0 also affects the link between b and financial literacy. Depending on the model's parameters, a higher Φ_0 can attenuate the effect of b on Φ_1. Defining the right-hand side of (13) as $\Xi(\alpha,\beta,\delta,\Phi_0,\Phi_1,\sigma,y,p,b)$, it is immediate to verify the following proposition.

[8]The condition is $\alpha > \Phi_1\kappa(\Phi_1,\alpha,\beta,\sigma)\lambda(\Phi_1,\sigma)$ and therefore the value of α that makes the optimal Φ_1 to be a decreasing function of b depends on the values of the remaining model's parameters. For instance, the condition is satisfied if $\beta = 0.99$, $\delta = 0.3$, $\Phi_0 = 1$, $\sigma = 0.5$, $y = 0.9$, $p = 0.1$, and $\alpha > 0.23$. More in general, the higher σ, the higher the value of α, which makes the optimal Φ_1 a decreasing function of b.

Proposition 4 *A higher Φ_0 attenuates the effect of b on the optimal level of financial literacy if:*

$$\frac{\partial \Xi \left(\alpha, \beta, \delta, \Phi_0, \Phi_1, \sigma, y, p, b\right)}{\partial \Phi_1 \partial b} < 0$$

Proposition 4 implies that the sign of $\frac{\partial \Phi_1^*}{\partial \Phi_0 \partial b}$ is the same as the sign of $\frac{\partial \Xi(\alpha,\beta,\delta,\Phi_0,\Phi_1,\sigma,y,p,b)}{\partial \Phi_1 \partial b}$. Figure 2 shows that the optimal level of financial literacy is a decreasing function of b. The figure displays two lines, one for low and one for high values of Φ_0 and shows that a higher Φ_0 attenuates the effect of the generosity of the social security systems on financial literacy, an implication of the model that we will confront with the empirical evidence.

3.2 Model II: Financial literacy and transaction costs

We now assume that acquiring financial literacy reduces the transaction cost of entering the stock market, rather than assuming that it raises the asset return (as in Model I). In particular, we assume that:

$$R = \begin{cases} 1 + \omega\zeta & \text{with probability} \quad \eta \\ 1 - \omega\zeta & \text{with probability} \quad 1 - \eta \end{cases}$$

where $\eta > \frac{1}{2}$. Moreover, we assume that if $\omega > 0$, the consumer incurs a transaction cost equal to $\frac{\Phi_1^{-\gamma}}{\gamma}$, with $\gamma > 0$.

Under these assumptions the intertemporal budget constraint is

$$c_0 + \frac{c_1}{R} - p\Phi_1 + p(1-\delta)\Phi_0 - \frac{\Phi_1^{-\gamma}}{\gamma} \mathbb{1}\left\{\omega > 0\right\} = y$$

where as before c_0 and c_1 denote consumption in period 0 and 1, Φ_0 and Φ_1 the stock of financial literacy in period 0 and 1, δ the depreciation rate of the stock of literacy, p and y the price of financial literacy investment and first-period income and $\mathbb{1}\left\{\cdot\right\}$ is an indicator function. As in Model I, $\phi = \Phi_1 - (1-\delta)\Phi_0$.

We again assume that the utility function is isoelastic. To compute the indirect utility from investing in the risky asset, let's assume also that $\omega > 0$. The first order conditions with respect to s, ϕ and ω are:

$$\begin{aligned} s^{\frac{1}{\sigma}} &= \beta c_0^{\frac{1}{\sigma}} E_0 R^{1-\frac{1}{\sigma}} \\ p &= \Phi_1^{-(1+\gamma)} \\ 1 + \omega\zeta &= \left(\frac{\eta}{1-\eta}\right)^{\sigma} (1 - \omega\zeta) \end{aligned}$$

which reduce to the logarithmic case if $\sigma = 1$ (see Appendix A.2). The first order condition with respect to s delivers the standard Euler equation for consumption. The first order condition with respect to ϕ implies that:

$$\Phi_1 = \left(\frac{1}{p}\right)^{\frac{1}{1+\gamma}} \tag{14}$$

Notice that equation (14) is not a reduced form, because it is obtained assuming that $\omega > 0$, a condition that holds only if the utility from investing in the risky asset is greater than that of not investing. From the first order condition with respect to ω, the share of wealth invested in the risky asset is:

$$\omega = \frac{\eta^\sigma - (1-\eta)^\sigma}{\zeta[\eta^\sigma + (1-\eta)^\sigma]} \tag{15}$$

Equation (15) implies that the conditional risky assets share does not depend on financial literacy. Using the Euler equation for consumption, (14), (15) and the budget constraint, one gets:

$$c_0^I = \frac{\widetilde{y}}{1+\widetilde{\beta}} \tag{16}$$

and:

$$c_1^I = (2\beta)^\sigma c_0^I \times \begin{cases} \eta^\sigma & \text{with probability} \quad \eta \\ (1-\eta)^\sigma & \text{with probability} \quad 1-\eta \end{cases} \tag{17}$$

where $\widetilde{\beta} \equiv 2^{\sigma-1}\beta^\sigma \left[\eta^\sigma + (1-\eta)^\sigma\right]$ and $\widetilde{y} \equiv y - p^{\frac{\gamma}{1+\gamma}}\left(1+\frac{1}{\gamma}\right) + p\Phi_0(1-\delta)$.

The indirect utility of investing in the risky asset (V^I) is computed using (16) and (17) and can be written as:

$$V^I = \left(1 - \frac{1}{\sigma}\right)^{-1}\left[\left(1+\widetilde{\beta}\right)^{\frac{1}{\sigma}} \widetilde{y}^{1-\frac{1}{\sigma}} - (1+\beta)\right]$$

If the consumer does not invest in the risky asset, $c_0^{NI} = \frac{y}{1+\beta^\sigma}$ and $c_1^{NI} = \beta^\sigma c_0^{NI}$. Therefore, the indirect utility of not investing in the risky asset is:

$$V^{NI} = \left(1 - \frac{1}{\sigma}\right)^{-1}\left[(1+\beta^\sigma)^{\frac{1}{\sigma}} y^{1-\frac{1}{\sigma}} - (1+\beta)\right] \tag{18}$$

The utility gain from stockholding is a monotonically increasing function of Φ_0 since the utility of investing in the risky asset is an increasing function of Φ_0, while the utility of not investing in risky assets is not affected. Therefore, it is immediate to verify the following proposition.

Proposition 5 *The utility gain from investing in the risky asset, $V^I - V^{NI}$, is an increasing function of Φ_0.*

Proposition 5 implies that (in a random utility setting) the probability of stock market participation increases with Φ_0, an important difference between Model II and Model I. From proposition 5 one can further show that the optimal level of financial literacy is an increasing function of Φ_0. The argument proceeds as follows. Note that if $\Phi_0 = 0$, the utility of investing in the risky asset is negative, i.e. $V^I < V^{NI}$ when the following condition holds:

$$p > \left[\frac{\gamma}{1+\gamma} y \left(1 - \widetilde{\Psi}\right)\right]^{\frac{1+\gamma}{\gamma}}. \tag{19}$$

where $\widetilde{\Psi} \equiv \left(\frac{1+\beta^{\sigma}}{1+\widetilde{\beta}}\right)^{\frac{1}{\sigma-1}}$. [9] Condition (19) implies that if the price of financial literacy is large enough, it is not optimal to invest in the risky asset if $\Phi_0 = 0$. Moreover, $\lim_{\Phi_0 \to +\infty} V^I - V^{NI} = +\infty$, which, together with condition (19), implies that one can find a value for Φ_0, say $\overline{\Phi}_0$, such that $\omega > 0$ if $\Phi_0 > \overline{\Phi}_0$. Since it is optimal to invest in financial literacy only if $\omega > 0$, this implies that Φ_0 has to be high enough to trigger investment in financial literacy. The argument is summarized in the following proposition.

Proposition 6 *If condition (19) is satisfied, there exists a value for Φ_0, $\overline{\Phi}_0$, such that $V^I = V^{NI}$, i.e.:*

$$\overline{\Phi}_0 = \frac{1}{p(1-\delta)}\left[\left(\frac{1+\gamma}{\gamma\widetilde{\Psi}}\right) p^{\frac{\gamma}{1+\gamma}} + \frac{y}{\widetilde{\Psi}}\left(\widetilde{\Psi} - 1\right)\right]$$

Moreover, if $\Phi_0 \geq \overline{\Phi}_0$, then $\omega > 0$ and $\phi^* > 0$.

The empirical implication of proposition 6 is that if the initial level of financial literacy differs across individuals, Φ_1 and Φ_0 are positively correlated.

3.2.1 Social security

As in Section 3.1.1, we assume that income net of social security contributions is earned in period 0 and social security benefits b are paid in period 1. The budget constraint is:

$$c_0 + \frac{c_1}{R} - p\Phi_1 + p(1-\delta)\Phi_0 - \frac{\Phi_1^{-\gamma}}{\gamma}\mathbb{1}\{\omega > 0\} = y + \frac{b}{R}$$

and the first order conditions with respect to s, ϕ and ω are unaffected.

The indirect utility of investing in the risky asset is:

$$V^I = \left(1 - \frac{1}{\sigma}\right)^{-1}\left[\left(1+\widetilde{\beta}\right)^{\frac{1}{\sigma}}\left(\widetilde{y} - t + \frac{b}{R}\right)^{1-\frac{1}{\sigma}} - (1+\beta)\right]$$

[9] Notice that if γ goes to zero, the right-hand-side of (19) goes to zero as well, which implies that it is not optimal to invest in the risky asset market if $p > 0$.

and that of not investing:

$$V^{NI} = \left(1 - \frac{1}{\sigma}\right)^{-1} \left[(1+\beta^{\sigma})^{\frac{1}{\sigma}} \left(y + \frac{b}{R}\right)^{1-\frac{1}{\sigma}} - (1+\beta) \right]$$

By comparing V^I and V^{NI} one can show that the analog of condition (19) is:

$$p > \left[\frac{\gamma}{1+\gamma} \left(y + \frac{b}{R}\right) \left(1 - \widetilde{\Psi}\right) \right]^{\frac{1+\gamma}{\gamma}}. \tag{20}$$

If condition (20) holds, one can show that for Φ_0 equal to zero, $V^{NI} > V^I$, leading to the following proposition.

Proposition 7 *If condition (20) is satisfied, there exists a value for Φ_0, $\overline{\Phi}_0$, such that $V^I = V^{NI}$, i.e.:*

$$\overline{\Phi}_0 = \frac{1}{p(1-\delta)} \left[\left(\frac{1+\gamma}{\gamma \widetilde{\Psi}}\right) p^{\frac{\gamma}{1+\gamma}} + \left(\frac{y + \frac{b}{R}}{\widetilde{\Psi}}\right) \left(\widetilde{\Psi} - 1\right) \right]$$

Moreover, if $\Phi_0 \geq \overline{\Phi}_0$, then $\omega > 0$ and $\phi^* > 0$.

There are two implications of proposition 7. First, if p is large enough, the utility gain from investing in the risky assets becomes positive for sufficiently high values of Φ_0, as in proposition 6. Second, $\overline{\Phi}_0$ is an increasing function of b. This implies that the higher b, the higher the initial level of financial literacy that triggers stock-market participation and investment in financial literacy.

To appreciate the effect of the generosity of the social security system on stockholding, notice that both V^I and V^{NI} are increasing functions of b. From proposition 6, if $\Phi_0 > \overline{\Phi}_0$ and $b = 0$, $V^I > V^{NI}$. Furthermore, as b increases, V^I approaches V^{NI} from below. If $\sigma \geq 1$, V^I and V^{NI} diverge, but V^I does it at a slower rate than V^{NI}. If $\sigma < 1$, $\lim_{b \to \infty} V^I - V^{NI} = 0^-$. This leads to the following proposition.

Proposition 8 *There exists a value for b, say $\overline{b}$, such that $V^I = V^{NI}$. Moreover, if $b \geq \overline{b}$, then $\omega = 0$ and $\phi^* = 0$.*

Proposition 8 states that the generosity of the social security system is negatively correlated with stock market participation and investment in financial literacy.

3.3 Empirical implications

Section 3 shows two channels through which financial literacy can affect portfolio choice. Model I focuses on the effect of literacy on the distribution of asset returns, and posits that higher (and safer) returns are associated with higher financial literacy. By assuming that higher financial literacy reduces the cost of stock market participation, Model II also implies a positive link between financial literacy and portfolio returns. Both models predict a positive effect of literacy earlier in life (Φ_0) on the trajectory of financial literacy (Φ_1), but differ along important dimensions. Model I implies that in an heterogeneous population, where people are identical except for their initial stock of literacy, (a) everyone participates to the stock market, and (b) the risky asset share is positively related to financial literacy. Instead, Model II implies that (a) participation depends on literacy, but (b) the asset share, conditional on participation, does not. Therefore, to compare the validity of the two models one should study the correlation between asset shares, participation and financial literacy. A positive correlation between literacy and asset shares, and absence of correlation between literacy and participation, would support Model I. On the other, finding a positive correlation between literacy and stockholding and no correlation between literacy and the risky asset share supports Model II.

In our empirical study we verify also other important implications of the model. In particular, we focus on the role of social security in affecting the incentives to accumulate financial literacy, exploiting cross-country variation in the replacement rate. In particular, we test if propositions 3 and 4 for Model I and 7 and 8 for Model II are borne out by the data introducing in our regressions the replacement rate and its interaction with Φ_0.

We summarize the relations between the variables of the model estimating the linear projections of financial literacy, asset shares, and stock market participation on the initial level of literacy and the social security replacement rate; the projections can be seen as the linear approximation of the model's reduced form equations. To account for the role of other potential effects on stockholding and on the risky asset share, we control for a number of additional variables, which are held constant in the theoretical model. Indexing households by i, countries by c and survey years by t, this leads us to the following specification:

$$y_{i,c,t} = d_c + \xi_1 \Phi_{i,0} + \xi_2 \Phi_{i,0} \times \rho_c + \xi_3 x_{i,t} + \varepsilon_{i,t} \tag{21}$$

where d_c is a country dummy, ρ_c is the country-level replacement rate, $x_{i,t}$ is the vector of additional variables affecting portfolio choice, $\varepsilon_{i,t}$ an error term and $y_{i,c,t}$ is either the current stock of financial literacy ($\Phi_{i,t}$), stock market participation or the share of wealth invested in risky assets ($\omega_{i,t}$). Suppose first that $y_{i,c,t}$ is financial literacy. Propositions 1 of Model I and 5 of Model II imply a positive correlation between $\Phi_{i,t}$and $\Phi_{i,0}$, that is $\xi_1 > 0$. Furthermore, both Model I and II indicate that a higher replacement rate reduces the effect of $\Phi_{i,0}$ on $\Phi_{i,t}$, implying $\xi_2 < 0$ (see proposition 4 of Model I and proposition 7 of Model II).

If $y_{i,c,t}$ denotes the share of risky assets, in Model I $\xi_1 > 0$ and $\xi_2 < 0$, since the share of risky assets is an increasing function of financial literacy, while in Model II $\xi_1 = \xi_2 = 0$, because conditional on stock market participation, the share of wealth invested in the risky asset does not depend on financial literacy. When $y_{i,c,t}$ is the indirect utility of stockholding, the reverse implications apply to stock market participation. Model I predicts that everyone should invest in stocks ($\xi_1 = 0$ if the equity premium is positive). In Model II the utility of participating is an increasing function of Φ_0 ($\xi_1 > 0$) while b attenuates the effect of Φ_0 on the stockholding decision ($\xi_2 < 0$), see propositions 7 and 8, respectively).

The list of x variables is potentially large, but three variables are prominent in our exercise. First, the incentive to accumulate wealth and to invest in financial literacy depends on age, because younger individuals hold less wealth and have therefore lower incentive to invest in financial literacy, see Jappelli and Padula (2011). A second important element is that financial literacy is likely to be correlated with schooling attainment. Third, households' resources (real estate, financial wealth and household disposable income) affect the incentives to acquire financial literacy, but also stock market participation and possibly asset shares. As we explain in the next section, to estimate the model we use cross-country microeconomic data with information on portfolio composition, current financial literacy and financial literacy early in the life-cycle.

4 Data

We test the theoretical predictions of Models I and II using the Survey of Health, Ageing, Retirement in Europe (SHARE), a representative sample of 50+ in 11 European countries. There are several advantages of using this dataset. First, SHARE has good proxies for financial sophistication, based on specific questions that allow us to construct an indicator of financial literacy. Second, the survey has data on mathematical and language skills before entering the labor market (at school age), providing a valuable instrument to address the joint determination of literacy, stockholding and the asset share. Third, SHARE has consistent and comparable information on household portfolios (transaction accounts, bonds, stocks, mutual funds, and retirement accounts) allowing us to measure direct stockholding, indirect stockholding through mutual funds, and the respective asset shares. Finally, the cross-country dimension of SHARE allows us to study portfolio decisions and their interactions with financial literacy in countries with relatively generous public pension systems (e.g. France and Italy) and to contrast them with data from countries in which occupational pension scheme (e.g. Netherlands) play a prominent role.

SHARE data refer to 2003 and 2006 and cover many aspects of the well-being of elderly populations, ranging from socio-economic to physical and mental health conditions.[10] Wave 1 refers to 2003 and covers 11 European countries (Austria, Belgium, Denmark, France, Greece, Germany, Italy, Netherlands, Spain, Sweden, Switzerland). Waves 2 refers to 2006 and includes also the Czech Republic, Poland, and Ireland.[11] Wave 3 (which excludes Ireland) is known as SHARELIFE, and records individual life-histories for Wave 1 and 2 respondents, based on the so-called life-history calendar method of questioning, which is designed to help respondents recall past events more accurately. The sample includes 14,631 observations obtained merging Wave 1 and SHARELIFE, and 18,332 observations merging Wave 2 and SHARELIFE. Selected sample statistics are reported in Table 1, separately for Waves 1 and 2. The variables have the same definitions in 2003 and 2006, except for income which is gross of taxes in 2003 and net of taxes in 2006. Therefore, we report separate estimates for the two samples.

The average age of the household head is 64 years in both waves, while the fraction of females is just above 50 percent. Singles account for 24 percent of the sample in both waves. The fraction of high-school and college graduates is also stable in the two waves, with high school graduates accounting for 30 percent of the sample, and college graduates for another 20 percent.

[10]We use data from SHARELIFE release 1, dated November 24th 2010 and SHARE release 2.3.1, dated July 29th 2010. SHARE data collection is funded primarily by the European Commission through the 5th Framework Programme (Project QLK6-CT-2001- 00360 in the thematic Quality of Life), the 6th Framework Programme (Projects SHARE-I3, RII-CT- 2006-062193, COMPARE, CIT5-CT-2005-028857, and SHARELIFE, CIT4-CT-2006-028812) and the 7th Framework Programme (SHARE-PREP, 211909 and SHARE-LEAP, 227822), with additional funding from the U.S. National Institute on Aging (U01 AG09740-13S2, P01 AG005842, P01 AG08291, P30 AG12815, Y1-AG-4553-01 and OGHA 04-064, IAG BSR06-11, R21 AG025169), and various national sources (see www.share-project.org/t3/share/index.php for a full list of funding institutions). For information on sampling and data collection see Klevmarken (2005).

[11]In Wave 2 a refresher sample is drawn for all countries except Austria and the Flemish part of Belgium. The refresher sample includes only one age-eligible (50+) person per household.

These figures hide considerable cross-country heterogeneity. Nordic countries feature a much higher share of college graduates than Italy, Spain and Greece. The fraction of couples ranges from 53 percent in Austria to 67 percent in Belgium. Household financial wealth also varies considerably, with Switzerland clearly above the rest, followed by Sweden, while households in Italy, Spain and Greece report lower gross financial assets. The ranking between Scandinavian and Mediterranean countries is reversed if one looks at real assets, with median values of around 157,000 euro in Belgium, 139,000 euro in Italy and 65,000 euro in Sweden.

4.1 Financial literacy

The questionnaire of Waves 1 and 2 of SHARE contains four questions about simple financial decisions, on the basis of which we construct a measure of financial literacy. The first question aims at understanding if respondents know how to compute a percentage. The second and third questions ask consumers to compute the price of a good if there is a 50 percent discount, and the price of a second hand car that sells at two-thirds of its cost when new. The fourth question is about understanding interest rate compounding in a saving account, and is commonly considered a very good proxy for financial literacy, see Lusardi and Mitchell (2008), Lusardi *et al.* (2010) and Hastings *et al.* (2012).[12] Following Dewey and Prince (2005) we combine the answers to the three questions into a summary indicator as a measure of the current stock of literacy Φ_{it}. Details on the wording of the questions and the construction of the indicator are given in Appendix C and discussed further in Christelis *et al.* (2010).[13]

In the model of Section 3 Φ_{i0} is the financial literacy endowment before entering the labor market. SHARE retrospective data (SHARELIFE) provide a plausible measure of such endowment. Survey participants report their mathematical ability at age 10 in response to the question: "How did you perform in Maths compared to other children in your class? Did you perform much better, better, about the same, worse or much worse than the average?"[14]

The indicator of current financial literacy (Φ_{it}) ranges from 1 to 5, and has a sample mean of 3.43 in Wave 1 and 3.48 in Wave 2, as shown in Table 1. In both years the indicator exhibits

[12]The interest rate question is one of three financial literacy questions in the Health and Retirement Study (HRS) and is used in several other international surveys.

[13]While Dewey and Prince (2005) term the indicator "Numeracy" we prefer the term financial literacy, which is more aligned to the focus of the paper.

[14]The survey also asks about relative performance in language, and we use this variable in our robustness checks.

considerable sample variability, with a coefficient of variation of 0.32. Our measure of initial literacy (Φ_{i0}) also ranges from 1 to 5, with similar means and coefficients of variation.

4.2 Stockholding and risky asset share

SHARE has detailed information on both financial and real assets. Financial assets include bank and other transaction accounts, government and corporate bonds, stocks, mutual funds, individual retirement accounts, contractual savings for housing, and life insurance policies. The questions on real assets refer to the value of the house of residence, other real estate, business wealth and vehicles (see Christelis *et al.*, 2010).

We adopt two definitions of stockholding: direct stockholding and total stockholding, defined as stocks held directly plus stocks held through mutual funds and investment accounts (assuming that whoever holds mutual funds and retirement accounts has some stocks in them). Figure 3 reports participation in direct and total stockholding in the 11 countries of our sample. The prevalence of direct stockholding ranges from less than 6 percent in Greece and Italy to 49 percent in Sweden. Total stockholding goes from about 10 percent in Austria, Spain and Italy to 75 percent in Sweden. Broadly speaking, stockholding increases from Southern to Northern Europe, with a group of intermediate countries (France, Germany, Belgium, Netherlands and Switzerland). Sweden and Denmark have by the far the highest prevalence of both direct and total stockholding, while Austria, Spain, Greece and Italy are at the other end of the spectrum. The histogram suggests that country effects are potentially quite important in explaining stockholding decisions of European investors. Our regression framework therefore introduces country fixed effects in each of the specifications.

On the contrary, as shown in Figure 4, cross-country differences in the conditional asset shares (excluding households with zero stockholding) are much less pronounced. The share of wealth directly held in stocks ranges from 20 percent in Denmark and Sweden to 35 percent in Austria and Italy. The suggests that the relatively small number of stockholders in Italy and Greece invest in stocks more than the average European household. Northern countries feature intermediate values for the share of risky assets, with the notable exception of Sweden where riskty assets represent almost 40 percent of financial wealth.

5 Empirical estimates

5.1 Financial literacy

In Table 2 we report OLS regressions for financial literacy, separately for Waves 1 and 2. Each regression includes also a full set of country dummies whose coefficients are not reported for brevity. In the baseline specification of column 1 we find that Φ_{i0} is a strong predictor of Φ_{it}. The coefficient of Φ_{i0} is large (0.30) and quite precisely estimated (the standard error is 0.025). This finding is consistent not only with our model's prediction, but also with other evidence on the long-term impact of early-life conditions (see, for instance, Herd and Holden, 2012). The age coefficient is negative (-0.017), and shows that in this sample of old individuals, the stock of literacy falls by about 0.5 percent per year, suggesting that households incentives to invest in financial literacy decline with age, when wealth also tends to fall.

The coefficient of the female dummy is also negative. That women have lower financial literacy than men is a result found in other studies (see Lusardi and Mitchell, 2008). Our model would also predict a negative effect because women generally have less wealth than men and therefore less incentives to invest in financial literacy. Education is strongly correlated with literacy (a coefficient of 0.40 for high-school and 0.59 for college graduates). The positive correlation is also consistent with our model, because higher human capital and lifetime income are associated with a higher stock of financial literacy. The negative signs of the coefficient of the dummy for singles and of family size is likely to depend on the fact that these variables are negatively correlated with wealth. The coefficient of the interaction term between the replacement rate and Φ_{i0} is negative, indicating that more generous social security systems attenuate the effect of Φ_{i0} on later financial literacy, as predicted by Models I and II.[15] The regression implies that a 1 percent increase in the replacement rate reduces the effect of Φ_{i0} on Φ_{it} by about 0.16 percent. Figure 6 shows how the effect of Φ_{i0} on Φ_{it}varies across countries, depending on replacement rate. The effect is relatively large for countries like the Netherlands (a one standard deviation increase in Φ_0 leads to an increase of Φ_{it} of 0.23) and Switzerland (0.22), and is relatively low in Italy (0.17) and Spain (0.14), which feature relatively high replacement rates.

In column 2 of Table 2 we add health status and log disposable income to rule out that

[15]The replacement rate is drawn from Disney (2004).

the effect of Φ_{i0} on Φ_{it} is simply due to the correlation between Φ_{i0} and these variables. The coefficients of health status and log income are positive and statistically different from zero, while the other coefficients (and that of Φ_{i0} in particular) are not affected. In the next regression (column 3) we check the stability of the coefficients replacing the age variable with a full set of age dummies. The pattern of the estimated coefficients of the age dummies (not reported for brevity) indicates that the stock of financial literacy falls during retirement, while the coefficients of the other variables are unaffected. Of course, in with cross-sectional data we cannot distinguish age from cohort effects, and therefore an interpretation of the age dummies in terms of cohort effects (literacy improves for younger generations) would be equally possible.

The other three regressions of Table 2 repeat the estimation using data from Wave 2. The size and significance of the coefficients is very similar to Wave 1. In particular, the coefficient of Φ_{i0} ranges between 0.27 to 0.29 and is precisely estimated, while that on the interaction between Φ_{i0} and ρ_c is negative, confirming the model's prediction that a more generous social security system attenuates the effect of Φ_{i0}.[16]

5.2 Stockholding

Next, in order to discriminate between our two alternative models of how financial literacy affects portfolio choice (through the returns or the transaction cost channel), we investigate the determinants of the decision to invest in stocks (or other risky assets). In order to single out the determinants of financial market participation, we study separately direct and total stockholding, which also includes stocks owned through managed investment accounts and mutual funds. We use the same specification as for financial literacy, relating stock market participation to demographic variables, education, indicators of household resources and, most importantly for the present study, the initial stock of literacy Φ_{i0}.

The results for direct and total stockholding are reported in Tables 3 and 4, respectively. In each table columns 1 to 3 refer to Wave 1, and columns 4 to 6 to Wave 2. The results show that both direct and total stockholding fall with age, a finding that we share with many other studies (see, for instance, Ameriks and Zeldes, 2004). The results are similar for direct and total stockholding and in the two waves of SHARE, and imply that one year is associated with

[16]Φ_0 is not the only early childhood variables that can affect later financial literacy. In a related paper, Jappelli and Padula (2011) add to the financial literacy regression a number of other controls proxing for early life resources in the house, family cultural background and health conditions. These augmented regression confirm a positive and sizable effect of Φ_0 on later financial literacy.

a reduction of stockholding between 0.1 and 0.2 percent.[17] Introducing age as a linear variable does not affect any of our results, as shown by columns 3 and 6 of Tables 3 and 4, which replace the linear age term with a set of age dummies. The coefficient of the female dummy is negative but imprecisely estimated, possibly because financial literacy captures part of the gender gap in stockholding, as argued in a recent paper by Alemberg and Dreber (2011).

Singles are 10 percent less likely to invest in stocks than couples (the omitted category). But, being single is correlated with household resources. In fact, controlling for income and wealth reduces the effect by roughly a factor of 3. High-school and college graduates are, respectively 4.6 and 15 percent more likely than high school drop-outs to hold stocks directly. The coefficient of initial literacy (Φ_{i0}) is positive and statistically different from zero. In columns 1 and 4 of Table 3 an increase of one standard deviation of Φ_{i0} is associated with an increase in stockholding of 7 percentage points, and the result is quite stable across specifications. Results for total stockholding (Table 4) are similar, with a somewhat smaller effect on Φ_{i0} (about 5.5 points). These results are consistent with the prediction of Model II, where financial literacy triggers participation by reducing the entry costs.

Finally, we interact Φ_{i0} with the replacement rate (ρ_c) to check if the generosity of the social security system affects the incentive to acquire financial information. Notice that the replacement rate varies only across countries and therefore the direct effect of ρ_c is absorbed by the country dummies, which are included in all regressions. The coefficient of the interaction term is negative ($\xi_2 < 0$), meaning that a higher replacement rate attenuates the effect of Φ_{i0} on stockholding, consistent again with Model II. The effect is similar across specifications and definitions of stockholding (direct or total), meaning that a 1 percent increase in the replacement rate reduces the effect of Φ_{i0} on stock-ownership by about 0.06 percentage points.

Figure 5 shows how the effect of Φ_{i0} on direct stockownership varies with the replacement rate. The effect is a decreasing function of replacement rate, that is countries with relatively low replacement rates feature stronger effects. For instance, in the Netherlands and in Switzerland a one standard deviation increase of Φ_{i0} raises participation by 4 percentage points, while in Italy the increase is only 1.6 points.

[17] Note again that in our context we cannot distinguish between a genuine age effect and a cohort effect, by which younger cohorts are more likely to invest in stocks.

5.3 Risky asset share

In the final set of results we present regressons for the asset share invested in stocks. Also in this case we use two definitions of stockholding (direct and total). Model I shows that financial literacy might affect not only stock market participation but also the share of risky assets, allowing people to invest in assets with higher returns. As a result, people with higher financial literacy might also invest more in risky assets. We estimate a Tobit model for the financial asset share invested in stocks, and find no effect of financial literacy on the risky asset share (at conventional significance level), regardless of the definition of the share (direct stockholding, as in Table 5, or total stockholding, as in Table 6). In conjunction with the evidence on stock market participation, the results lend support to models (such as Model II) in which literacy affects the decision to own stocks but not the asset share invested.

Note that, compared to stock market participation, asset shares are more volatile and more difficult to predict. Most of the estimated coefficients, while reasonably signed, are not precisely estimated, with the notable exception of the high-school and college dummies, which suggest a positive relation between education and the share of risky assets.

According to standard portfolio theory, the main determinant of the share of risky assets is the coefficient of relative risk aversion (the lower risk aversion, the higher the share). In the special case of constant relative risk aversion the share is independent from wealth. Our results reveal a positive relation between households resources and asset shares, suggesting that exposure to stock market risk tends to be higher for the wealthy. The dummy for singles has a negative and statistically significant coefficient, somewhat reduced when we control for household resources (income and wealth). Better health status is also positively associated with a higher share of risky assets, consistent with the argument that people exposed to background risks (such as health) tend to limit exposure to risks that they can avoid.

The regressions in Tables 5 and 6 also indicate that the effect of Φ_{i0} is positive, but rather small and not precisely estimated. We therefore use Φ_{i0} as identifying variable in a selectivity-model of the asset share, assuming that Φ_{i0} affects the participation decision but not the asset share. The main advantage of a selectivity model is that we can focus on the conditional asset share, i.e. restrict attention to the sample of those who actually hold stocks. The model also allows us to distinguish between extensive and intensive margins (the decision to invest in stocks and the amount invested, respectively). The results are reported in Tables 7 and 8 for direct and indirect stockholding, respectively.

The selectivity model confirms many of the results of the Tobit regressions, in particular that household resources affect also conditional asset shares, not just the participation decision. The age effect is positive and statistically different from zero. Aging by 1 year is associated with a 0.3-0.5 percentage points increase of the share of wealth invested in directly held stocks (0.6 percent for total stockholding). However, the pattern of age dummies (estimated in columns 3 and 6 and not reported) rejects the hypothesis that the age effect is linear, in favor of a hump shaped profile. The coefficients of the other variables are less precisely estimated than in the Tobit model. The selectivity model is also consistent with non-random selection, as the coefficient of the Mills ratio is statistically different from zero in most specifications for both direct and total stockholding.

6 Conclusions

Identifying the channels through which financial literacy affects household saving behavior is a challenge for empirical research. Previous findings of a positive correlation between measures of financial literacy and portfolio outcomes does not necessarily mean that financial literacy improves portfolio diversification, or that it causes higher stockholding and higher saving. Therefore the evidence does not provide sufficient grounds for policies aimed at raising the level of financial literacy of the general population, or of some targeted groups. To understand the causal nexus between financial literacy and portfolio choice one must be explicit about the channel through which literacy affects portfolio decisions, and address explicitly the endogeneity of literacy with respect to portfolio choice. In this paper we focus on the lack of financial sophistication as a potential explanation for limited financial market participation. In the paper we posit that, like other forms of human capital, financial information can be accumulated, and that the decision to invest in financial literacy has costs and benefits. Accordingly, we study the joint determination of financial information, saving and portfolio decisions, both theoretically and empirically. We assume that financial literacy is costly to acquire but allows individuals to access better financial investment opportunities. In particular, we posit two channels through which financial literacy can affect saving behavior, by raising the returns on risky assets and by reducing the transaction costs to enter the stock market.

We test some of the implications of the model using household data drawn from the Survey of Health, Ageing, Retirement in Europe (SHARE). We find that the link between financial literacy and portfolio choice is likely to be duer to the fact that financial sophistication reduces participation costs. The empirical results also show that the level of financial sophistication before individuals enter the labor market affects financial literacy in life. Therefore policies aimed at improving the level of financial education early in the life-cycle are likely to have long-run consequences on portfolio allocations.

We also exploit the cross-country dimension of our data to test an important implication of our model, namely the role of social security in shaping the decision to accumulate financial literacy. The results indicate that more generous social security systems reduce the incentives to accumulate wealth and invest in stocks, attenuating the effect of initial literacy on the stockholding decision, consistent with the model's prediction.

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7 Tables and Figures

Table 1. Summary statistics, SHARE Waves 1 and 2

Variable	**Mean**	**Std. Dev.**	**N**
Wave 1			
Log wealth	12.141	1.726	14,631
Age	63.577	9.272	14,631
Female	0.545	0.498	14,631
Single	0.242	0.428	14,631
Family size	2.204	0.985	14,631
Log income	10.571	1.384	14,555
High school	0.298	0.457	14,631
College	0.202	0.402	14,631
Health status	3.159	1.015	14,631
Financial literacy	3.426	1.087	14,631
Math skills at the age of 10	3.296	0.895	14,631
Wave 2			
Log wealth	12.423	1.705	18,332
Age	64.335	9.513	18,332
Female	0.542	0.498	18,332
Single	0.235	0.424	18,332
Family size	2.182	0.953	18,332
Log income	10.474	1.406	18,141
High school	0.318	0.466	18,332
College	0.212	0.409	18,332
Health status	3.06	1.054	18,332
Financial literacy	3.481	1.107	18,332
Math skills at the age of 10	3.297	0.898	18,332

Note. The table reports sample statistics for selected variables in SHARE Wave 1 (top panel) and Wave 2 (bottom panel). In Wave 1 income is gross of taxes, in Wave 2 it is net of taxes.

TABLE 2. Financial literacy

	Wave 1			*Wave 2*		
Age	−0.017***	−0.015***		−0.019***	−0.017***	
	(0.001)	(0.001)		(0.001)	(0.001)	
Female	−0.313***	−0.302***	−0.300***	−0.292***	−0.281***	−0.277***
	(0.014)	(0.014)	(0.014)	(0.013)	(0.013)	(0.013)
Single	−0.064***	−0.031	−0.010	−0.091***	−0.070***	−0.045**
	(0.020)	(0.020)	(0.020)	(0.018)	(0.018)	(0.019)
Family size	−0.030***	−0.037***	−0.027***	−0.037***	−0.041***	−0.031***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)
High school	0.400***	0.361***	0.360***	0.352***	0.318***	0.318***
	(0.018)	(0.018)	(0.018)	(0.016)	(0.016)	(0.016)
College	0.586***	0.509***	0.509***	0.530***	0.464***	0.465***
	(0.020)	(0.021)	(0.021)	(0.018)	(0.019)	(0.019)
Φ_0	0.300***	0.293***	0.293***	0.289***	0.271***	0.272***
	(0.025)	(0.025)	(0.025)	(0.022)	(0.022)	(0.022)
$\Phi_0 \times \rho_c$	−0.163***	−0.162***	−0.162***	−0.131***	−0.116***	−0.117***
	(0.033)	(0.033)	(0.033)	(0.029)	(0.029)	(0.029)
Health status		0.102***	0.101***		0.117***	0.117***
		(0.007)	(0.008)		(0.007)	(0.007)
Log income		0.061***	0.062***		0.040***	0.041***
		(0.008)	(0.008)		(0.007)	(0.007)
N	14,631	14,555	14,508	18,332	18,141	18,055
Full set of age dummies	*No*	*No*	*Yes*	*No*	*No*	*Yes*

Note. All regressions include a full set of country dummies. One star means 5% significantly different from zero, two stars 1%, three stars 0.1%.

TABLE 3. Participation in risky assets - direct stockholding

	Wave 1			*Wave 2*		
Age	-0.002^{***}	-0.001^{**}		-0.001^{***}	-0.001^{**}	
	(0.000)	(0.000)		(0.000)	(0.000)	
Female	-0.007	-0.004	-0.004	-0.004	-0.005	-0.003
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Single	-0.095^{***}	-0.030^{***}	-0.065^{***}	-0.095^{***}	-0.032^{***}	-0.026^{***}
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Family size	-0.006	-0.011^{***}	-0.009^{**}	-0.012^{***}	-0.016^{***}	-0.013^{***}
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
High school	0.046^{***}	0.015^{*}	0.029^{***}	0.061^{***}	0.031^{***}	0.031^{***}
	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
College	0.150^{***}	0.085^{***}	0.112^{***}	0.138^{***}	0.077^{***}	0.076^{***}
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Φ_0	0.069^{***}	0.056^{***}	0.068^{***}	0.067^{***}	0.052^{***}	0.052^{***}
	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)
$\Phi_0 \times \rho_c$	-0.066^{***}	-0.056^{***}	-0.069^{***}	-0.065^{***}	-0.055^{***}	-0.055^{***}
	(0.014)	(0.014)	(0.014)	(0.013)	(0.013)	(0.013)
Health status		0.012^{***}	0.019^{***}		0.006^{**}	0.006^{**}
		(0.003)	(0.003)		(0.003)	(0.003)
Log income		0.041^{***}	0.057^{***}		0.028^{***}	0.028^{***}
		(0.004)	(0.004)		(0.003)	(0.003)
Log wealth		0.053^{***}			0.060^{***}	0.060^{***}
		(0.002)			(0.002)	(0.002)
N	$14,631$	$14,555$	$14,508$	$18,332$	$18,141$	$18,055$
Full set of age dummies	*No*	*No*	*Yes*	*No*	*No*	*Yes*

Note. All regressions include a full set of country dummies. One star means 5% significantly different from zero, two stars 1%, three stars 0.1%.

Table 4. Participation in risky assets - direct and indirect stockholding

	Wave 1			*Wave 2*		
Age	-0.002^{***}	-0.001^{**}		-0.002^{***}	-0.001^{***}	
	(0.000)	(0.000)		(0.000)	(0.000)	
Female	-0.008	-0.005	-0.006	-0.001	-0.002	-0.001
	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Single	-0.118^{***}	-0.037^{***}	-0.035^{***}	-0.107^{***}	-0.029^{***}	-0.022^{**}
	(0.009)	(0.009)	(0.010)	(0.008)	(0.008)	(0.009)
Family size	-0.013^{***}	-0.020^{***}	-0.018^{***}	-0.016^{***}	-0.021^{***}	-0.017^{***}
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
High school	0.068^{***}	0.029^{***}	0.028^{***}	0.077^{***}	0.038^{***}	0.038^{***}
	(0.009)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)
College	0.202^{***}	0.121^{***}	0.119^{***}	0.165^{***}	0.088^{***}	0.087^{***}
	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)	(0.009)
Φ_0	0.071^{***}	0.055^{***}	0.055^{***}	0.073^{***}	0.054^{***}	0.054^{***}
	(0.012)	(0.012)	(0.012)	(0.010)	(0.010)	(0.010)
$\Phi_0 \times \rho_c$	-0.069^{***}	-0.058^{***}	-0.058^{***}	-0.070^{***}	-0.058^{***}	-0.058^{***}
	(0.016)	(0.015)	(0.015)	(0.014)	(0.013)	(0.013)
Health status		0.013^{***}	0.013^{***}		0.013^{***}	0.013^{***}
		(0.003)	(0.004)		(0.003)	(0.003)
Log income		0.055^{***}	0.055^{***}		0.037^{***}	0.037^{***}
		(0.004)	(0.004)		(0.003)	(0.003)
Log wealth		0.065^{***}	0.065^{***}		0.073^{***}	0.072^{***}
		(0.002)	(0.002)		(0.002)	(0.002)
N	$14,631$	$14,555$	$14,508$	$18,332$	$18,141$	$18,055$
Full set of age dummies	*No*	*No*	*Yes*	*No*	*No*	*Yes*

Note. All regressions include a full set of country dummies. One star means 5% significantly different from zero, two stars 1%, three stars 0.1%.

TABLE 5. Asset shares - direct stockholding

	Wave 1			*Wave 2*		
Age	-0.002^{***}	-0.000		-0.001	0.001^{*}	
	(0.001)	(0.001)		(0.001)	(0.001)	
Female	-0.015	-0.009	-0.010	-0.012	-0.011	-0.009
	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)
Single	-0.161^{***}	-0.048^{***}	-0.047^{***}	-0.142^{***}	-0.016	-0.003
	(0.016)	(0.016)	(0.017)	(0.015)	(0.015)	(0.016)
Family size	-0.008	-0.018^{**}	-0.017^{**}	-0.021^{***}	-0.026^{***}	-0.021^{***}
	(0.007)	(0.007)	(0.008)	(0.008)	(0.007)	(0.008)
High school	0.069^{***}	0.020	0.020	0.108^{***}	0.057^{***}	0.056^{***}
	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
College	0.186^{***}	0.081^{***}	0.081^{***}	0.208^{***}	0.101^{***}	0.099^{***}
	(0.014)	(0.015)	(0.015)	(0.014)	(0.014)	(0.014)
Φ_0	0.050^{**}	0.028	0.026	0.041^{*}	0.022	0.022
	(0.021)	(0.020)	(0.020)	(0.021)	(0.021)	(0.020)
$\Phi_0 \times \rho_c$	-0.033	-0.016	-0.014	-0.017	-0.008	-0.010
	(0.029)	(0.028)	(0.028)	(0.031)	(0.030)	(0.030)
Health status		0.013^{**}	0.012^{**}		0.007	0.007
		(0.006)	(0.006)		(0.005)	(0.005)
Log income		0.069^{***}	0.068^{***}		0.049^{***}	0.051^{***}
		(0.007)	(0.007)		(0.006)	(0.006)
Log wealth		0.106^{***}	0.106^{***}		0.122^{***}	0.121^{***}
		(0.005)	(0.005)		(0.005)	(0.005)
N	13,014	12,994	12,953	16,579	16,515	16,440
Full set of age dummies	*No*	*No*	*Yes*	*No*	*No*	*Yes*

Note. All regressions include a full set of country dummies. One star means 5% significantly different from zero, two stars 1%, three stars 0.1%.

Table 6. Asset shares - direct and indirect stockholding

	Wave 1			*Wave 2*		
Age	−0.001	0.001**		−0.000	0.002***	
	(0.001)	(0.001)		(0.001)	(0.001)	
Female	−0.011	−0.005	−0.005	−0.003	−0.001	0.000
	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)
Single	−0.160***	−0.035**	−0.027*	−0.138***	0.003	0.018
	(0.016)	(0.016)	(0.017)	(0.015)	(0.015)	(0.015)
Family size	−0.016**	−0.027***	−0.024***	−0.028***	−0.034***	−0.027***
	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
High school	0.092***	0.038***	0.038***	0.121***	0.063***	0.062***
	(0.014)	(0.013)	(0.013)	(0.013)	(0.012)	(0.012)
College	0.245***	0.130***	0.128***	0.230***	0.109***	0.107***
	(0.015)	(0.015)	(0.015)	(0.014)	(0.014)	(0.014)
Φ_0	0.030	0.005	0.005	0.027	0.004	0.004
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
$\Phi_0 \times \rho_c$	−0.004	0.016	0.017	0.004	0.016	0.015
	(0.030)	(0.029)	(0.029)	(0.031)	(0.030)	(0.030)
Health status		0.017***	0.016***		0.016***	0.016***
		(0.006)	(0.006)		(0.005)	(0.005)
Log income		0.077***	0.078***		0.061***	0.062***
		(0.007)	(0.007)		(0.006)	(0.006)
Log wealth		0.109***	0.109***		0.129***	0.127***
		(0.005)	(0.005)		(0.004)	(0.004)
N	13,014	12,994	12,953	16,579	16,515	16,440
Full set of age dummies	*No*	*No*	*Yes*	*No*	*No*	*Yes*

Note. All regressions include a full set of country dummies. One star means 5% significantly different from zero, two stars 1%, three stars 0.1%.

Table 7. Conditional asset shares - direct and indirect stockholding

	Wave 1			*Wave 2*		
Age	0.003***	0.003***		0.005***	0.005***	
	(0.001)	(0.001)		(0.001)	(0.001)	
Female	0.005	0.002	0.001	0.006	0.002	0.005
	(0.010)	(0.011)	(0.011)	(0.009)	(0.010)	(0.010)
Single	−0.026	−0.010	−0.008	0.019	0.022	0.036**
	(0.027)	(0.019)	(0.020)	(0.024)	(0.017)	(0.016)
Family size	0.004	−0.005	−0.005	−0.000	−0.010	−0.007
	(0.007)	(0.009)	(0.009)	(0.007)	(0.009)	(0.008)
High school	0.015	0.008	0.009	0.014	0.029*	0.027*
	(0.016)	(0.014)	(0.015)	(0.018)	(0.015)	(0.015)
College	0.056*	0.056***	0.056***	0.041	0.065***	0.060***
	(0.030)	(0.022)	(0.022)	(0.029)	(0.021)	(0.020)
Health status		0.010	0.011*		0.001	0.001
		(0.006)	(0.006)		(0.005)	(0.005)
Log income		0.044***	0.047***		0.025**	0.024**
		(0.014)	(0.013)		(0.010)	(0.010)
Log wealth		0.062***	0.064***		0.062***	0.058***
		(0.019)	(0.019)		(0.020)	(0.019)
λ	0.176**	0.343***	0.353***	0.094	0.292***	0.276***
	(0.071)	(0.085)	(0.085)	(0.068)	(0.082)	(0.080)
N	13,014	12,994	12,953	16,579	16,515	16,440
Full set of age dummies	*No*	*No*	*Yes*	*No*	*No*	*Yes*

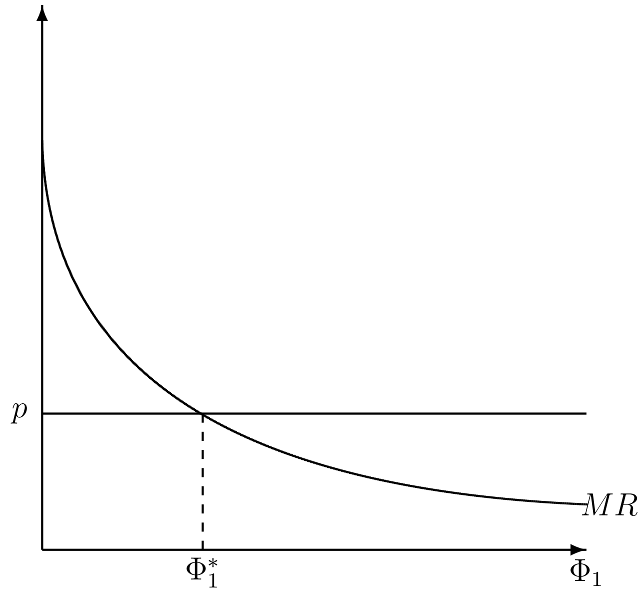
Note. All regressions include a full set of country dummies. One star means 5% significantly different from zero, two stars 1%, three stars 0.1%. λ is the Mills ratio.

TABLE 8. Conditional asset shares - total stockholding

	Wave 1			*Wave 2*		
Age	0.006***	0.006***		0.006***	0.006***	
	(0.001)	(0.001)		(0.001)	(0.001)	
Female	0.020**	0.018**	0.017*	0.012	0.011	0.012
	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Single	0.060***	0.037***	0.044***	0.035*	0.045***	0.055***
	(0.022)	(0.014)	(0.014)	(0.020)	(0.013)	(0.013)
Family size	0.006	0.003	0.005	−0.007	−0.014*	−0.010
	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
High school	−0.011	0.001	0.002	0.006	0.011	0.009
	(0.014)	(0.011)	(0.011)	(0.015)	(0.012)	(0.012)
College	−0.002	0.031**	0.032**	0.028	0.035**	0.034**
	(0.027)	(0.015)	(0.015)	(0.025)	(0.015)	(0.014)
Health status		0.008*	0.009*		0.004	0.004
		(0.005)	(0.005)		(0.004)	(0.004)
Log income		−0.000	0.002		0.022***	0.022***
		(0.009)	(0.009)		(0.008)	(0.007)
Log wealth		0.004	0.006		0.038***	0.036***
		(0.010)	(0.010)		(0.012)	(0.012)
λ	−0.025	0.076	0.087*	0.046	0.166***	0.164***
	(0.061)	(0.051)	(0.051)	(0.062)	(0.056)	(0.055)
N	13,014	12,994	12,953	16,579	16,515	16,440
Full set of age dummies	*No*	*No*	*Yes*	*No*	*No*	*Yes*

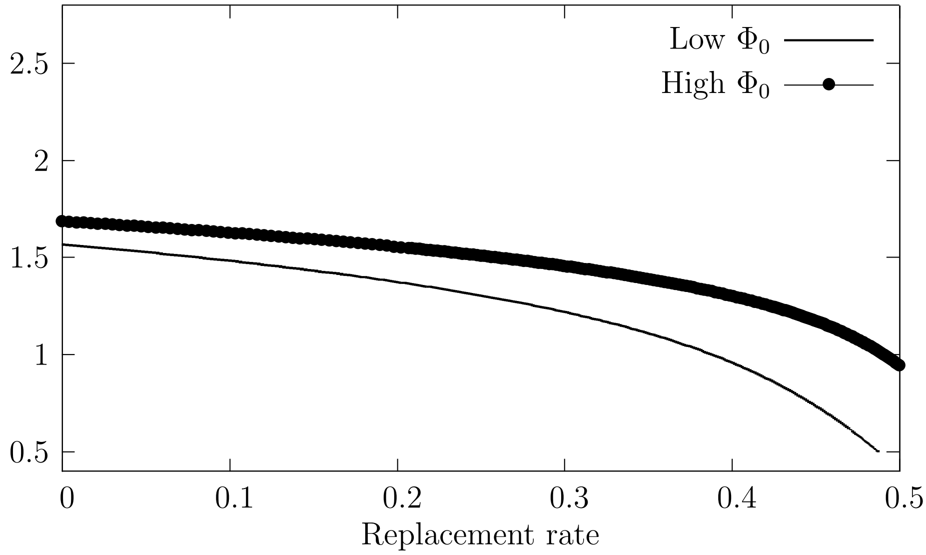
Note. All regressions include a full set of country dummies. One star means 5% significantly different from zero, two stars 1%, three stars 0.1%. λ is the Mills ratio.

FIGURE 1. Marginal return and cost of investing in financial literacy



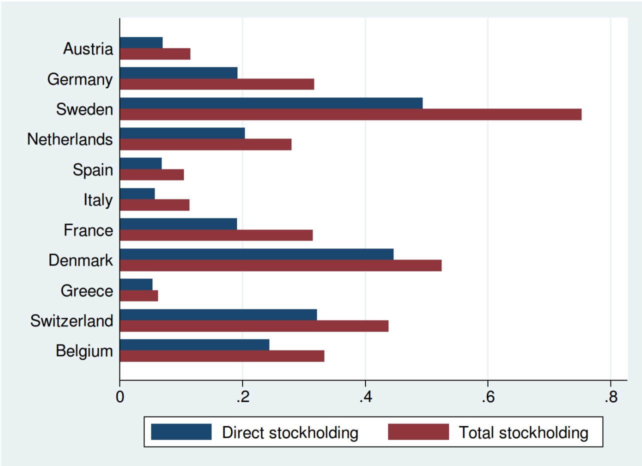
Note. The stock of financial literacy is on the horizontal, marginal return (MR) and cost (p) are on the vertical axis; Φ_1^* is the optimal level of financial literacy investment at which the marginal return equals the marginal cost.

FIGURE 2. Optimal stock of financial literacy and replacement rate



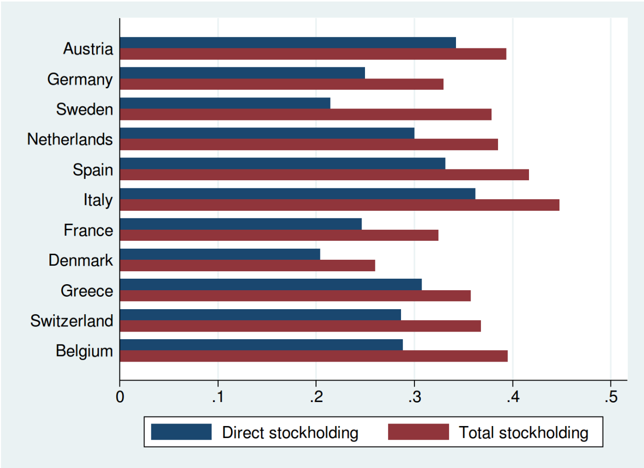
Note. Replacement rate is on the horizontal, the optimal level of financial literacy on the vertical axis. The model's parameters are set as follows: $\alpha = 0.3$, $\beta = 0.99$, $\delta = 0.3$, $\sigma = 0.5$, $y = 0.7$, $p = 0.1$. The continuous line is obtained setting Φ_0 to 1, the bulleted to 2.

FIGURE 3. Stock-ownership, by country



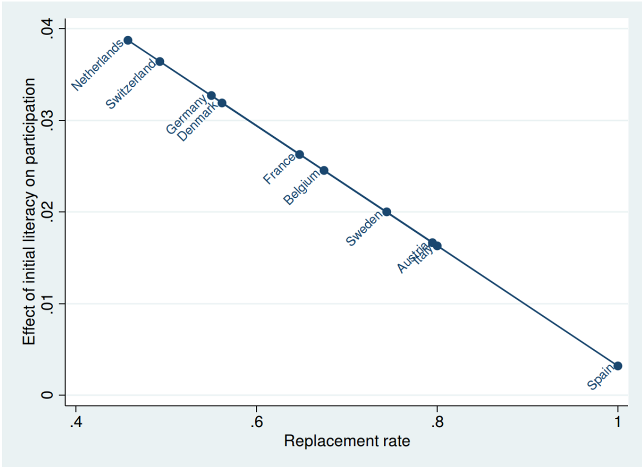
Note. The country means are computed on our working sample, obtained by merging SHARE Wave 1 and Wave 2 with SHARE life. Total stockholding is defined as direct ownership of stocks and ownership through mutual funds.

FIGURE 4. Asset shares, by country



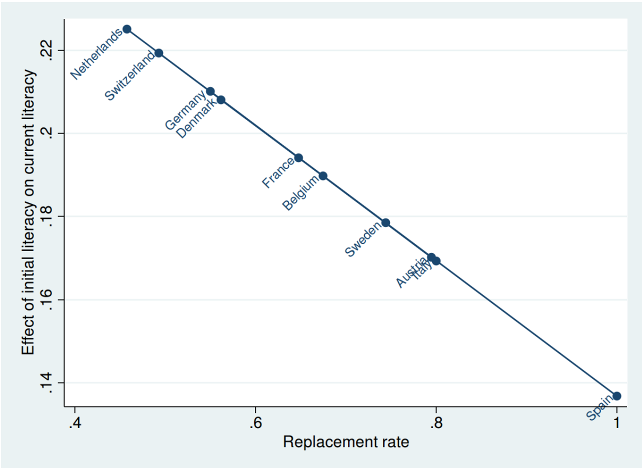
Note. The country means are computed on our working sample, obtained by merging SHARE Wave 1 and Wave 2 with SHARE life. Total stockholding is defined as direct ownership of stocks and ownership through mutual funds.

FIGURE 5. Marginal effect of Φ_0 on direct participation as function of the replacement rate



Note. The figure shows how the marginal effect of initial literacy on direct participation varies with the replacement rate. The marginal effect is constructed using the estimates reported in the first column of Table 3.

FIGURE 6. Marginal effect of Φ_0 on Φ_t as function of the replacement rate



Note. The figure shows how the marginal effect of initial on current financial literacy varies with the replacement rate. The marginal effect is constructed using the estimates reported in the first column of Table 2.

Appendix A Logarithmic Utility

Appendix A.1 Model I: : Financial literacy and asset returns

In this appendix we assume that consumers choose saving (s), investment in financial literacy (ϕ) and ω to maximize:

$$\ln c_0 + \beta E_0 \ln c_1$$

subject to $c_0 = y - p\phi - s$ and $c_1 = R(\Phi_1, \alpha, \zeta, \omega)s$, where $0 < \beta < 1$ is the discount factor and $E_0(\cdot)$ is the expected value of consumption in period 1. The first order conditions with respect to s, ϕ and ω are, respectively:

$$s = \beta c_0 \tag{22}$$

$$\frac{p}{s} = \frac{\alpha}{\Phi_1} + \eta'(\Phi_1) \ln\left(\frac{1+\omega\zeta}{1-\omega\zeta}\right) \tag{23}$$

$$1 + \omega\zeta = \left[\frac{\eta(\Phi_1)}{1-\eta(\Phi_1)}\right](1-\omega\zeta) \tag{24}$$

From (24), the share of wealth invested in the risky asset is:

$$\omega = \frac{\eta(\Phi_1) - [1-\eta(\Phi_1)]}{\zeta\left\{\eta(\Phi_1) + [1-\eta(\Phi_1)]\right\}} = \frac{2\eta(\Phi_1) - 1}{\zeta} \tag{25}$$

To give further insights on the solution, note that Equation (25) can also be written as the risk-free return multiplied by the ratio of the first to the second moments of the excess return distribution:

$$\omega = \Phi_1^{\alpha} \frac{[2\eta(\Phi_1) - 1]\Phi_1^{\alpha}\zeta}{\zeta^2 \Phi_1^{2\alpha}} \tag{26}$$

When the risk-free rate is constant and the distribution of the excess return does not depend on financial literacy, equation (26) reduces to the standard portfolio rule, which states that the optimal share of risky assets is proportional to the risk-adjusted excess return.

Using the first-period budget constraint and (22), one can show that:

$$s = \frac{\beta}{1+\beta}(y - p\phi) \tag{27}$$

Equation (27) is not a reduced form, but an equilibrium condition, implying that investment in financial literacy and first-period saving are negatively correlated.

Equations (23) and (27) can be used to show that the optimal level of financial literacy investment is implicitly defined by:

$$p = \frac{\beta}{1+\beta}\left\{\frac{\alpha}{\Phi_1} + \eta'(\Phi_1)\ln\left[\frac{\eta(\Phi_1)}{1-\eta(\Phi_1)}\right]\right\}(y - p\phi) \tag{28}$$

The left-hand side of (28) does not depend on Φ_1. Instead, Φ_1 affects the right-hand side of (28) in three ways. If Φ_1 increases the ratio $\frac{\alpha}{\Phi_1}$ decreases, $\eta'(\Phi_1)$ decreases due to the concavity of $\eta(\Phi_1)$, while the odds-ratio, i.e. the ratio between $\eta(\Phi_1)$ and $1-\eta(\Phi_1)$ increases. The overall effect of an increase of Φ_1 on the right-hand side of (28) is therefore negative if the following condition applies:

$$-\frac{\alpha}{\Phi_1^2} + \eta''(\Phi_1)\ln\left[\frac{\eta(\Phi_1)}{1-\eta(\Phi_1)}\right] + \frac{[\eta'(\Phi_1)]^2}{\eta(\Phi_1)[1-\eta(\Phi_1)]} \leq 0 \tag{29}$$

Equation (29) is satisfied for large enough values of α if $\eta(\Phi_1) = (1+e^{-\Phi_1})^{-1}$ (see Appendix B for details).

Using the Dini theorem for implicit functions, one can show that the optimal stock of financial literacy, Φ_1^*, is an increasing function of α (or β, y, Φ_0) and a decreasing function of p (or δ) if equation (29) is satisfied. This result is summarized in the following proposition.

Proposition 9 *If condition (29) holds, the optimal level of financial literacy is an increasing function of α (or β, y, Φ_0) and a decreasing function of p (or δ), i.e.:*

$$\frac{\partial\Phi_1^*}{\partial\alpha} > 0, \frac{\partial\Phi_1^*}{\partial\beta} > 0, \frac{\partial\Phi_1^*}{\partial y} > 0, \frac{\partial\Phi_1^*}{\partial\Phi_0} > 0, \frac{\partial\Phi_1^*}{\partial p} < 0, \frac{\partial\Phi_1^*}{\partial\delta} < 0$$

Equation (28) can be solved with respect to Φ_1 to find the optimal value of financial literacy, which in turn determines saving through (27) and the share of wealth invested in the risky assets through (26). Given our attempt to derive empirical implications for asset allocation, we focus here on the share of wealth invested in risky assets. From equation (25) it is easy to verify that the risky asset share share is positively associated with financial literacy, which leads to the following proposition.

Proposition 10 *If condition (29) holds, the optimal share of wealth invested in the risky asset is an increasing function of α, β, Φ_0, and y and a decreasing function of p and δ, i.e.:*

$$\frac{\partial\omega^*}{\partial\alpha} > 0, \frac{\partial\omega^*}{\partial\beta} > 0, \frac{\partial\omega^*}{\partial\Phi_0} > 0, \frac{\partial\omega^*}{\partial y} > 0, \frac{\partial\omega^*}{\partial p} < 0, \frac{\partial\omega^*}{\partial\delta} < 0$$

Proposition 10 leads to the same set of empirical implications as proposition 2.

Appendix A.2 Model II: Financial literacy and transaction costs

We compute the indirect utility when $\omega > 0$ and compare it with the indirect utility when $\omega = 0$. If $\omega > 0$, the first order conditions with respect to s, ϕ and ω are:

$$\begin{aligned} s &= \beta c_0 \\ p &= \Phi_1^{-(1+\gamma)} \\ 1+\omega\zeta &= \left[\frac{\eta}{1-\eta}\right](1-\omega\zeta) \end{aligned}$$

The first order condition with respect to ω implies that the share of assets is:

$$\omega = \frac{2\eta - 1}{\zeta} \tag{30}$$

Equation (30) implies that the risky asset share does not depend on financial literacy. The first order condition with respect to ϕ implies that:

$$\Phi_1 = \left(\frac{1}{p}\right)^{\frac{1}{1+\gamma}} \tag{31}$$

From the budget constraint and the first order conditions with respect to s and ϕ, one obtains consumption at time 0:

$$c_0^I = \frac{\widetilde{y}}{1+\beta} \tag{32}$$

where $\widetilde{y} \equiv y - p^{\frac{\gamma}{1+\gamma}}\left(1+\frac{1}{\gamma}\right) + p\Phi_0(1-\delta)$. Equation (32) defines the optimal level of consumption at time 0 if $\omega > 0$. To compute the indirect utility of investing in the risky assets, we compute optimal consumption in period 1 using the first order condition with respect to s and ω:

$$c_1^I = \frac{2\beta}{\theta+1} c_0^I \times \begin{cases} \theta & \text{with probability} \quad \eta \\ 1 & \text{with probability} \quad 1-\eta \end{cases} \tag{33}$$

Plugging (32) and (33) in the utility function, we obtain the indirect utility function of investing in the risky asset:

$$V^I = (1+\beta)\ln\tfrac{\widetilde{y}}{1+\beta} + \beta\ln\beta + \beta\left[\ln 2 + \eta\ln\eta + (1-\eta)\ln(1-\eta)\right] \tag{34}$$

Notice that if $\eta > \frac{1}{2}$ the term in square bracket is positive.

If the consumer does not invest in the risky asset, the return on saving is 1, and it is easy to verify that $c_0 = \frac{y}{1+\beta}$ and $c_1^{NI} = \beta c_0^{NI}$. The indirect utility of not investing in the risky asset is thus:

$$V^{NI} = (1+\beta)\ln\frac{y}{1+\beta} + \beta\ln\beta \tag{35}$$

The model implies that those who do not participate in the stock market have no incentives to invest in financial literacy. If $V^I < V^{NI}$, it is not optimal to participate in the stock market. This happens if Φ_0 is equal to zero and the following condition on the price of financial literacy holds:

$$p > \left[\frac{\gamma}{1+\gamma}y\left(1-\widetilde{\Psi}\right)\right]^{\frac{1+\gamma}{\gamma}} \tag{36}$$

where $\widetilde{\Psi} \equiv e^{-\frac{\beta}{1+\beta}[\ln 2+\eta\ln\eta+(1-\eta)\ln(1-\eta)]}$.[18] The indirect utility of investing in the risky asset increases with Φ_0, while that of not investing is not affected. Therefore, propositions 5 and 6 also hold in the logarithmic utility case.

Appendix B Comparative statics

Appendix B.1 The RHS of (28) is a decreasing function of Φ_1

We show here under what conditions the right-hand side of the equation:

$$p = \frac{\beta}{1+\beta}\left\{\frac{\alpha}{\Phi_1} + \eta'(\Phi_1)\ln\left[\frac{\eta(\Phi_1)}{1-\eta(\Phi_1)}\right]\right\}(y - p\phi) \tag{37}$$

is a decreasing function of financial literacy.

Assuming that $\eta(\Phi_1) = (1+e^{-\Phi_1})^{-1}$ and differentiating the right hand side of (37) with

[18] $\widetilde{\Psi} < 1$ since $\eta > 1/2$.

respect to Φ_1 gives:

$$-\frac{\beta}{1+\beta}\left\{\left[\frac{\alpha}{\Phi_1^2}+\frac{e^{-\Phi_1}}{(1+e^{-\Phi_1})^2}\left(\frac{1-e^{-\Phi_1}}{1+e^{-\Phi_1}}\Phi_1-1\right)\right](y-p\phi)+p\left[\frac{\alpha}{\Phi_1}+\frac{e^{-\Phi_1}}{(1+e^{-\Phi_1})^2}\Phi_1\right]\right\} \quad (38)$$

Since the second term in square brackets is positive for $\Phi_1 > 0$, a sufficient condition for (38) to be negative is that:

$$\left[\frac{\alpha}{\Phi_1^2}+\frac{e^{-\Phi_1}}{(1+e^{-\Phi_1})^2}\left(\frac{1-e^{-\Phi_1}}{1+e^{-\Phi_1}}\Phi_1-1\right)\right] \quad (39)$$

is also positive.

Figure A-1 plots the locus where (39) is equal to zero in the (Φ_1, α) plane.[19] Above the locus, the function (39) takes positive values, below negative. The figure shows that the locus has a maximum at about $\Phi_1 = 0.996$, where α is 0.1058. Therefore, $\alpha > 0.1058$ is a sufficient condition for (39) being positive and (38) a decreasing function of Φ_1.

Appendix B.2 The RHS of (7) is a decreasing function of Φ_1

We now turn to the isoelastic case and show under which conditions the right hand side of the equation:

$$p = \frac{\kappa(\Phi_1,\alpha,\beta,\sigma)}{1+\kappa(\Phi_1,\alpha,\beta,\sigma)}\left[\frac{\alpha}{\Phi_1}+\lambda(\Phi_1,\sigma)\right](y-p\phi) \quad (40)$$

is a decreasing function of Φ_1.

The last term, $y - p\phi$, decreases if Φ_1 increases, and the first term, $\frac{\kappa(\Phi_1,\alpha,\beta,\sigma)}{1+\kappa(\Phi_1,\alpha,\beta,\sigma)}$ decreases if Φ_1 increases provided that $\eta(\Phi_1) = (1+e^{-\Phi_1})^{-1}$ and $\sigma < 1$. Therefore, if the second term:

$$\frac{\alpha}{\Phi_1}+\lambda(\Phi_1,\sigma) \quad (41)$$

is decreasing, the right hand side of (7) is also decreasing function of Φ_1.

Assuming that $\eta(\Phi_1) = (1+e^{-\Phi_1})^{-1}$ and differentiating (41) with respect to Φ_1 gives:

$$-\left\{\frac{\alpha}{\Phi_1^2}+\frac{e^{-\Phi_1}}{(1+e^{-\Phi_1})^2}\left[\frac{\sigma^2 e^{-(\sigma-1)\Phi_1}(1+e^{-\Phi_1})^2}{(1-\sigma)(1+e^{-\sigma\Phi_1})^2}-\frac{\sigma}{1-\sigma}\right]\right\} \quad (42)$$

[19] Since (39) diverges to $+\infty$ for Φ_1 going to zero and converges to 0^+ for Φ_1 going to infinity, the figure focuses strictly larger than zero but small values for Φ_1.

Therefore if:

$$\frac{\alpha}{\Phi_1^2} + \frac{e^{-\Phi_1}}{(1+e^{-\Phi_1})^2}\left[\frac{\sigma^2 e^{-(\sigma-1)\Phi_1}(1+e^{-\Phi_1})^2}{(1-\sigma)\,(1+e^{-\sigma\Phi_1})^2} - \frac{\sigma}{1-\sigma}\right] \tag{43}$$

is positive, (41) is a decreasing function of Φ_1.

It is immediate to verify that:

$$\lim_{\sigma\to 0}\left[\frac{\sigma^2 e^{-(\sigma-1)\Phi_1}(1+e^{-\Phi_1})^2}{(1-\sigma)\,(1+e^{-\sigma\Phi_1})^2} - \frac{\sigma}{1-\sigma}\right] = 0$$

Therefore, for small σ (43) converges to $\frac{\alpha}{\Phi_1^2}$ and (7) is a decreasing fucntion of Φ_1. For larger σ, (43) can be positive or negative.

Figure A-2 plots the locuses where (43) is equal to zero in the (Φ_1, α) plane, for various values of σ. Above each the curves, the function (43) takes positive values, below it takes negative values. The figure shows that the maximum in curve for $\sigma = 1$ lies above the maxima for the other curves (and in fact for any other value of σ smaller than 1). Therefore, $\alpha > 0.1058$ is also a sufficient condition for (43) being positive and (41) a decreasing function of Φ_1.

Appendix B.3 $\lim_{\sigma\to\infty} \Phi_1^* > \lim_{\sigma\to 0} \Phi_1^*$

This section provides the conditions under which the optimal level of financial literacy obtained as σ goes to infinity is larger than the the optimal level of financial literacy obtained as σ goes to zero.

Recall that the optimal level of financial literacy is implicitly defined by:

$$p = \frac{\kappa(\Phi_1, \alpha, \beta, \sigma)}{1+\kappa(\Phi_1, \alpha, \beta, \sigma)}\left[\frac{\alpha}{\Phi_1} + \lambda(\Phi_1, \sigma)\right](y - p\phi) \tag{44}$$

Assume that $\eta(\Phi_1) = (1+e^{-\Phi_1})^{-1}$. For σ equal to zero, the right-hand side of (44) reduces to:

$$\frac{\alpha\Phi_1^{-\alpha}}{\Phi_1 + \Phi_1^{1-\alpha}}\,(y - p\phi) \tag{45}$$

To evaluate the limit of the right-hand side of (44) for σ going to infinity, notice that:

$$\lim_{\sigma\to\infty} \lambda(\Phi_1, \sigma) = 1 - \eta(\Phi_1)$$

Moreover:

$$\lim_{\sigma\to\infty} \frac{\kappa(\Phi_1,\alpha,\beta,\sigma)}{1+\kappa(\Phi_1,\alpha,\beta,\sigma)} = \begin{cases} 0 & \text{if} \quad \lim_{\sigma\to\infty}\kappa(\Phi_1,\alpha,\beta,\sigma)=0 \\ 1 & \text{if} \quad \lim_{\sigma\to\infty}\kappa(\Phi_1,\alpha,\beta,\sigma)=\infty \end{cases}$$

For Φ_1 to be implicitly defined by (44), it must happen that $\kappa(\Phi_1,\alpha,\beta,\sigma)$ diverges if σ goes to infinity. The limit of $\kappa(\Phi_1,\alpha,\beta,\sigma)$ for σ going to infinity is:

$$\lim_{\sigma\to\infty}\kappa(\Phi_1,\alpha,\beta,\sigma) = (2\Phi_1^{\alpha})^{-1}\lim_{\sigma\to\infty}(2\beta\Phi_1^{\alpha})^{\sigma}\left\{\eta(\Phi_1)^{\sigma}+[1-\eta(\Phi_1)]^{\sigma}\right\}$$

$$\geq (2\Phi_1^{\alpha})^{-1}\lim_{\sigma\to\infty}(2\beta\Phi_1^{\alpha})^{\sigma}[0.5^{\sigma}+0.5^{\sigma}] = (\Phi_1^{\alpha})^{-1}\lim_{\sigma\to\infty}(\beta\Phi_1^{\alpha})^{\sigma}=\infty$$

if $\beta[\Phi_0(1-\delta)]^{\alpha}>1$. Therefore:

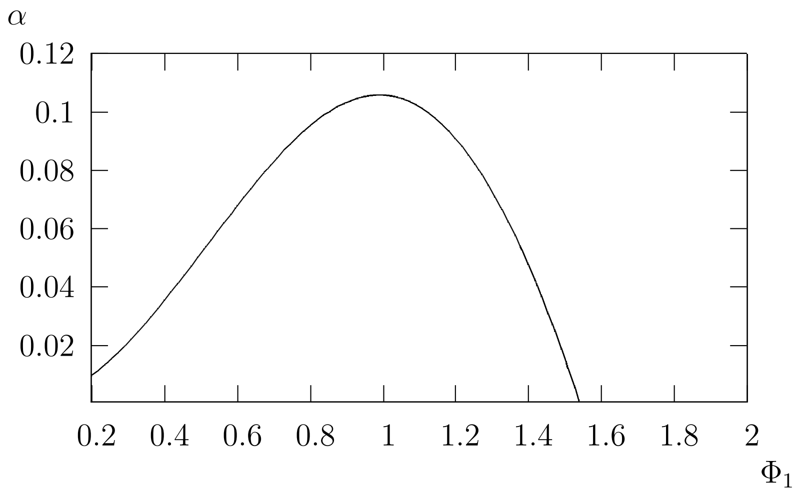
$$\lim_{\sigma\to\infty}\frac{\kappa(\Phi_1,\alpha,\beta,\sigma)}{1+\kappa(\Phi_1,\alpha,\beta,\sigma)}\left[\frac{\alpha}{\Phi_1}+\lambda(\Phi_1,\sigma)\right](y-p\phi) = \left[\frac{\alpha}{\Phi_1}+1-\eta(\Phi_1)\right](y-p\phi) \qquad (46)$$

This shows that if $\beta[\Phi_0(1-\delta)]^{\alpha}>1$, (46) lies above (45) since:

$$\left[\frac{\alpha}{\Phi_1}+1-\eta(\Phi_1)\right] > \frac{\alpha\Phi_1^{-\alpha}}{\Phi_1+\Phi_1^{1-\alpha}}$$

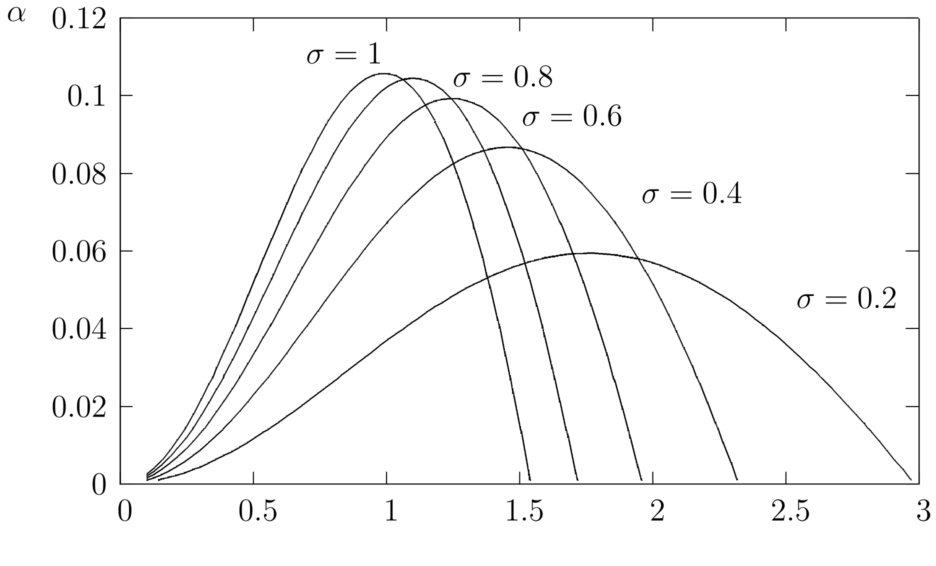
and the optimal level of financial literacy is larger when σ goes to infinity than when σ is equal to zero.

FIGURE A-1. $\left[\frac{\alpha}{\Phi_1^2}+\frac{e^{-\Phi_1}}{\left(1+e^{-\Phi_1}\right)^2}\left(\frac{1-e^{-\Phi_1}}{1+e^{-\Phi_1}}\Phi_1-1\right)\right]=0$



Note. The curve is the locus of all points in the plane (Φ_1,α) where (39) is equal to zero. For the points below the curve, (39) is negative, for the points above (39) is positive.

FIGURE A-2. $\frac{\alpha}{\Phi_1^2} + \frac{e^{-\Phi_1}}{\left(1+e^{-\Phi_1}\right)^2}\left[\frac{\sigma^2 e^{-(\sigma-1)\Phi_1}(1+e^{-\Phi_1})^2}{(1-\sigma)\left(1+e^{-\sigma\Phi_1}\right)^2} - \frac{\sigma}{1-\sigma}\right] = 0$



Note. The curve is the locus of all points in the plane (Φ_1, α) where (43) is equal to zero, for various values of σ. For the points below the curves, (43) is negative, for the points above (43) is positive.

Appendix C Data

Appendix C.1 Wealth data in SHARE

Wealth is the sum of real and financial assets and is imputed in case one or more items are missing. The questions on financial assets are about whether the respondent owns the asset and, if yes, in what amount. If the respondent declines to answer about the amount or claims not to know, she is referred to an unfolding brackets sequence that includes three threshold values which differ by country and asset item. The respondent is randomly assigned to one of the three thresholds and is asked whether she owns more or less than that threshold. Depending on the answer, the next question refers to the next higher or lower threshold, and so on. The thresholds impose barriers on the range of acceptable values for each asset, which are taken into account during the imputation process.

The imputation procedure involves the construction of a system of equations that include economic and demographic variables, and where each variable is imputed sequentially through many iterations, conditional on the values of the other variables in the system from the same or previous iterations (for a fuller description of the process see Christelis, 2008). This chained imputation procedure is analogous to the one implemented in the US Survey of Consumer

Finances, see Kennickel (1991).[20] All values are adjusted for differences in the purchasing power of money across countries using OECD purchasing power parity data.

Appendix C.2 Financial literacy in SHARE

The questions used to construct the financial literacy indicator are set out below. Possible answers are shown on cards displayed by the interviewer who is instructed not to read them out to respondents:

1. If the chance of getting a disease is 10 per cent, how many people out of 1,000 can be expected to get the disease? The possible answers are 100, 10, 90, 900 and another answer.

2. In a sale, a shop is selling all items at half price. Before the sale a sofa costs 300 euro. How much will it cost in the sale? The possible answers are 150, 600 and another answer.

3. A second hand car dealer is selling a car for 6,000 euro. This is two-thirds of what it costs new. How much did the car cost new? The possible answers are 9,000, 4,000, 8,000, 12,000, 18,000 and another answer.

4. Let's say you have 2,000 euro in a savings account. The account earns 10 per cent interest each year. How much would you have in the account at the end of the second year? The possible answers are 2,420, 2,020, 2,040, 2,100, 2,200, 2,400.

If a person answers (1) correctly she is then asked (3) and if she answers correctly again she is asked (4). Answering (1) correctly results in a score of 3, answering (3) correctly but not (4) results in a score of 4 while answering (4) correctly results in a score of 5. On the other hand if she answers (1) incorrectly she is directed to (2). If she answers (2) correctly she gets a score of 2 while if she answers (2) incorrectly she gets a score of 1.

Appendix C.3 Mathematical ability in SHARELIFE

SHARELIFE has a module on childhood that asks about living conditions, accommodation, and family structure. Additionally, the module asks questions about mathematical ability at

[20]The variables are imputed by regressing them on the full set of demographic and economic variables that are part of the SHARE imputation process, and generate five alternative imputed values for each missing observation, in order to match the five implicate datasets in SHARE.

10 years of age. The exact wording of the question is: “Now I would like you to think back to your time in school when you were 10 years old. How did you perform in Maths compared to other children in your class? Did you perform much better, better, about the same, worse or much worse than the average? ”

The module asks a similar question about language skills: “And how did you perform in [country’s Language] compared to other children in your class? Did you perform much better, better, about the same, worse or much worse than the average?