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Tullio Jappelli and Mario Padula

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University of Naples Federico II

University of Salerno

Bocconi University, Milan

CSEF - Centre for Studies in Economics and Finance
DEPARTMENT OF ECONOMICS – UNIVERSITY OF NAPLES
80126 NAPLES - ITALY
Tel. and fax +39 081 675372 – e-mail: csef@unisa.it

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Abstract

We present an intertemporal consumption model of consumer investment in financial literacy. Consumers benefit from such investment because their stock of financial literacy allows them to increase the returns on their wealth. Since literacy depreciates over time and has a cost in terms of current consumption, the model determines an optimal investment in literacy. The model shows that financial literacy and wealth are determined jointly, and are positively correlated over the life cycle. Empirically, the model leads to an instrumental variables approach, in which the initial stock of financial literacy (as measured by math performance in school) is used as an instrument for the current stock of literacy. Using microeconomic and aggregate data, we find a strong effect of financial literacy on wealth accumulation and national saving, and also show that ordinary least squares estimates underestate the impact of financial literacy on saving.

JEL Classification: E2, D8, G1, J24

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* University of Naples Federico II, CSEF and CEPR.

** University "Ca' Foscari" of Venice, CSEF and CEPR.

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1 Introduction

The standard model of intertemporal choice posits that people maximize expected utility, and choose consumption and saving at each point in time on the basis of expected lifetime resources and preference parameters. The model assumes that individuals are rational and fully informed, are able to project future income and interest rates and discount them appropriately. In reality, many studies have provided convincing evidence that a large proportion of the adult population knows little about finance and that many individuals are unfamiliar with basic economic concepts, such as risk diversification, inflation, and interest compounding. There is also considerable evidence that financial literacy affects saving and portfolio decisions. Van Rooij et al. (2007) find that financial sophistication is associated with greater wealth, a higher probability to invest in the stock market and a higher propensity to plan for retirement. In related papers, Christelis et al. (2010) and McArdle et al. (2009) find that the accuracy of responses to simple mathematical questions is a strong predictor of total wealth, financial wealth, stockholding and the fraction of wealth held in stocks. Ameriks et al. (2003) and Lusardi and Mitchell (2007) also provide evidence of a link between financial literacy and saving decisions.

In all these studies financial literacy is taken as an exogenous determinant of saving and portfolio decisions, with no recognition 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. Some studies tackle the endogeneity issue empirically, using an IV approach, see for instance van Rooij et al. (2009) and the recent study on Chile by Behrman et al. (2010). But none of them provides an explicit framework to integrate financial literacy in an intertemporal consumption model. In this paper we address the endogeneity of financial literacy and study the joint determination of financial literacy and wealth accumulation, both empirically and theoretically. 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 saving. Acquiring financial information, however, has some costs in terms of time, effort, and resources. Accordingly, our model features rational agents who choose how much to invest in financial information and how much to save.

Our model implies that, in a cross-section of households, financial literacy and saving are positively correlated (as estimated in many of the studies already mentioned), and that literacy

and wealth are correlated over the consumer's life-cycle. The relation between financial literacy and saving is not causal, however, because both variables depend on preference parameters, households' resources, and the costs of literacy. For instance, other things being equal, more patient consumers save more and end up with a larger stock of financial literacy. Higher levels of resources, higher returns to literacy and a larger initial endowment of literacy are also associated with higher levels of saving as well as a greater current stock of literacy. Also, introducing a social security system reduces the incentives to save and to invest in financial literacy.

The empirical implication of the model is that the coefficient of the stock of literacy in a saving or wealth regression is potentially biased, and that the direction of this bias is ambiguous. However, we can estimate the coefficient by identifying an exogenous source of variation in the stock of literacy that is not related directly to wealth accumulation. The model suggests that the literacy endowment before entering the labor market is a potentially valid instrument for the current level of literacy.

We apply these ideas and our instrumental variables strategy to microeconomic data derived by merging the Survey of Health, Ageing, Retirement in Europe (SHARE), a representative sample of individuals aged 50+ in Europe, with SHARELIFE, a retrospective survey of the same individuals. We show that the current level of financial skills is strongly correlated to the measure of mathematical skills at school age, available in SHARELIFE. This is a quite powerful instrument and explains about 30 percent of the variability in the indicator of financial literacy. We find that financial literacy is strongly associated with wealth in both the ordinary least squares (OLS) and instrumental variables (IV) regressions, and that the OLS estimates underestimate the effect of literacy.

We apply a similar approach to the aggregate data. We merge international data on saving and other macroeconomic variables with the IMD World Competitiveness Yearbook summary indicators of economic literacy and financial education. These indicators are computed based on a survey of senior business leaders, that asks about their level of financial literacy. Responses are aggregated for each country to provide an overall score for financial literacy. PISA score tests in math (at the age of 15) provide our main instrument for the average level of literacy in a country. First stage regressions indicate that PISA test scores are a strong predictor of economy-wide indicators of financial literacy. Our analysis suggests that countries that exhibit higher levels of financial literacy also have higher saving rates, and that OLS estimates tend to

underestimate the literacy coefficient.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature, with a particular focus on studies that consider the endogeneity of literacy with respect to saving decisions. Section 3 presents a simple, two-period model of financial literacy and wealth accumulation and its multi-period extension. Section 4 discusses the econometric issues that need to be addressed to estimate the relation between financial literacy and saving. Section 5 and 6 present the econometric estimates obtained respectively using the microeconomic and aggregate data. Section 7 concludes.

2 Financial literacy and asset accumulation

Several empirical studies find that poor financial literacy is associated with poor risk diversification, inefficient portfolio allocations and low levels of savings. Banks and Oldfield (2007) look at numerical ability and other dimensions of cognitive function in a sample of older adults in England (the English Longitudinal Study of Ageing) and find that numeracy levels are strongly correlated with measures of retirement savings and investment portfolios, understanding of pension arrangements, and perceived financial security. In subsequent work, Banks et al. (2010) look at the extent to which differences in numeracy and broader cognitive ability predict subsequent trajectories for key economic outcomes such as wealth, retirement income and retirement expectations.[1] 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.

Van Rooij et al. (2007) estimate the relation between financial sophistication and wealth, relying on specific measures of financial literacy available in 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

[1] In a related paper, McArdle et al. (2009) find that numeracy, measured by the accuracy of the responses to three simple mathematical questions, is a strong predictor of total wealth, financial wealth, and the fraction of wealth held in stocks.

is associated with higher wealth, higher probability to invest in the stock market and higher propensity to plan for retirement. Guiso and Jappelli (2008) use the 2007 Unicredit Customer Survey (UCS), which has detailed indicators of investors' portfolio choice and financial literacy, and find that literacy is strongly correlated to the degree of portfolio diversification, even controlling for other socioeconomic characteristics and proxies for risk aversion. 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. They find also that more biased households borrow more, save less, favor shorter maturities, and use and benefit more from financial advice.[2]

Some recent studies acknowledge the endogeneity of financial literacy with respect to saving decisions, and how incentives to invest in financial literacy may affect the relation between literacy and saving, see Delevande et al. (2008), Willis (2009) and Lusardi (2008). Since the true stock of financial literacy is not observed, empirical studies face similar measurement error problems in relation to literacy. In both cases, there are similarities with the literature that tries to estimate the returns to schooling: any attempt to estimate the structural relation between schooling and wages is faced with issues related to omitted variable bias, endogeneity of the schooling decision, and measurement error (see Card (2001) for a discussion of these in the schooling context).

Two studies explicitly address these important econometric issues. Christiansen et al. (2008) use a large register-based panel data set containing detailed information on Danish investors' education attainment, and financial and socioeconomic variables. The authors show that stockholding increases if individuals have completed an economics education program and if an economist becomes part of the household. To sort out the double causality between portfolio choice and the decision to become an economist, Christiansen et al. (2008) use better access to education due to the establishment of a new university, as an instrument for economics

[2]In the context of developing countries, Cole et al. (2009) analyze the relation between economic literacy and participation in formal financial markets. Using survey data on India and Indonesia, they show that financial literacy is a powerful predictor of demand for financial services. Hastings and Tejeda-Ashton (2008) use survey responses and the results of an experiment involving participants in Mexico's privatized social security system, and find that the way that information is presented to workers can have a substantial impact on the optimal fees that firms can charge in the marketplace.

education. The IV estimates suggest that causation runs from economics education to stock market participation. Behrman et al. (2010) use the Chilean Social Protection Survey and an IV approach to isolate the causal effects of financial literacy on wealth accumulation and wealth components. The study suggests that the OLS estimate of the effect of financial literacy is potentially biased due to measurement error and unobserved factors. The study proposes 11 instruments for financial literacy, and finds that the effect of literacy on wealth accumulation is stronger in the IV regressions than in their OLS counterparts.[3]

Despite the fact that some studies take account of the econometric problems associated with estimation of the structural relations between financial literacy and saving, they do not provide a theoretical framework to study the issues involved. We show that the simple model proposed in the next section provides an appropriate empirical strategy.

3 The theoretical model

We integrate investment in financial literacy in a standard model of intertemporal choice. The model highlights that accumulating financial information has both costs and benefits. On the benefits side, financial literacy allows consumers access to better investment opportunities, thereby raising the return on each euro saved. On the costs side, investing in financial literacy requires time and monetary resources. We illustrate this simple trade-off first in a two-period model with endogenous saving and investment in financial information. We then use a multiperiod model to study the age profile of wealth and financial literacy and how the introduction of a social security system modifies the incentives to invest in financial literacy and to accumulate assets.

[3]Four instruments are factors indicative of where the respondents attended primary school, their age in 1981 when a national voucher program was implemented, and the macroeconomic conditions obtaining when they entered (a) school and (b) the labor market. The other instruments are indicators of family background (paternal and maternal education attainment, economic background in childhood, whether the respondent worked before the age of 15), and personality traits (risk aversion, positive and negative self esteem). Although the statistical tests suggest that the 11 instruments predict financial literacy, only three or four coefficients are statistically different from zero in the first stage regression (mainly economic background and enrollment rates during childhood). In addition, the interpretation of the personality trait factors is questionable, since they could be related to other omitted factors affecting saving.

3.1 The two-period model

We assume that the life of consumers covers two-periods, and that they earn income y in period 0 and live in retirement in period 1. At the beginning of period 0 they have no assets but are endowed with a stock of financial literacy, Φ_0, which depreciates at a rate equal to δ. The initial stock of literacy is what people know about finance before entering the labor market; it is related, therefore, to schooling decisions and parental background, neither of which we model explicitly. The return to saving is the interest factor rate R, which is paid at the beginning of the second period, on wealth transferred from the first to the second period. Raising the stock of financial literacy allows consumers to access better investment opportunities and to save on transaction costs and fees. We posit, therefore, that the interest factor is a function of the stock of financial literacy at the beginning of period 1:

$$R(\Phi_1) = \Phi_1^{\alpha}$$

where $\alpha \in (0, 1)$ and Φ_1 is the stock of financial literacy at the beginning of period 1. The parameter α is the elasticity of the interest factor with respect to the stock of financial literacy, and we refer to it as the return on financial literacy. In line with the human capital literature, we assume that investment in literacy raises returns, though at a decreasing rate.

Consumers can increase the stock of financial literacy by buying financial literacy in period 0. The relative cost of literacy in terms of the consumption good is p, which includes the monetary and time costs incurred by consumers.[4] The stock of literacy therefore evolves according to:

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

where ϕ denotes investment in financial literacy. In the first period people choose saving and financial literacy investment maximizing the following log utility function:

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

subject to the dynamic budget constraints:

[4] Alternatively, we could assume that the utility function depends on consumption and leisure, and that consumers must use some of their time to increase financial literacy.

$$c_0 + s + p\phi = y \quad \text{and } c_1 = \Phi_1^{\alpha} s$$

where $0 < \beta < 1$ is the discount factor and s first period saving.

The first order conditions with respect to s and ϕ are:

$$s \;:\; \frac{c_1}{\beta c_0} = \Phi_1^{\alpha} \tag{2}$$

$$\phi \;:\; p = \frac{\alpha\beta c_0 s \Phi_1^{\alpha-1}}{c_1} \tag{3}$$

Equation (2) is the standard Euler equation for consumption, and states that the marginal rate of substitution equals the interest factor, which in turn depends on investment in literacy. Equation (3) states that in equilibrium the marginal cost of literacy (the left-hand side of (3)) should equal the marginal return. Using the Euler equation and the budget constraint one can rewrite the condition as:

$$p = \frac{\alpha\beta(y - p\phi)}{[(1-\delta)\Phi_0 + \phi](1+\beta)} \tag{4}$$

Equation (4) defines implicitly optimal investment in financial literacy. To see this, we plot in Figure 1 the two sides of equation (4) as a function of financial literacy investment. While the marginal cost of literacy is the constant p, the marginal return falls with financial literacy investment. Note also that the marginal return curve shifts up if income increases, suggesting that investment in literacy is more profitable when households have a higher volume of resources to invest. On the other hand, the curve shifts down if the cost of literacy increases.

The reduced form for optimal investment in financial literacy is:

$$\phi^* = \frac{1}{1+\beta+\alpha\beta}\left[\frac{\alpha\beta y}{p} - \Phi_0(1-\delta)(1+\beta)\right] \tag{5}$$

To solve for the optimal stock of financial literacy we substitute equation (5) in (1) and obtain:

$$\Phi_1^* = \frac{\alpha\beta}{1+\beta+\alpha\beta}\left[\Phi_0(1-\delta) + \frac{y}{p}\right]$$

The optimal stock increases with income, the discount factor, the return to literacy and the initial stock of literacy. On the other hand, a higher price of literacy or a higher depreciation

rate reduces the optimal stock. Finally, the optimal level of saving is:

$$s^* = \frac{\beta}{(1+\beta+\alpha\beta)}\left[y + p\Phi_0(1-\delta)\right]$$

The solution indicates that a higher discount rate, higher income and higher initial stock of literacy are associated with higher saving.[5] In our simple model, consumers allocate their income between first-period consumption, saving, and investment in financial literacy. Saving is inversely related to the return to literacy α and the depreciation rate δ because if these parameters increase, investment in financial literacy increases at the expense of first-period consumption and saving.

The solution means that optimal saving is a linear function of the stock of literacy, $s^* = \alpha^{-1}p\Phi_1^*$. This has three implications. First, the incentive to invest in financial literacy depends on the return to literacy as well as the amount saved in the first period. Second, in a cross-section of households reporting information on financial literacy and saving, we should find a positive association between the two variables. But clearly it cannot be concluded from this correlation that a higher stock of current literacy leads to higher saving, because both variables are endogenous. Third, in the model the initial stock of literacy, Φ_0, affects saving only through its effect on the current stock of literacy Φ_1^*. This implies that Φ_0 can be used as an instrument for Φ_1^* to estimate a saving regression, as we show in Section 4.

The simple case examined highlights that financial literacy is a choice variable, and that, empirically, a higher stock of literacy will be associated with a higher saving rate. With logarithmic utility literacy affects saving by raising the return to each dollar saved. However, a change in the interest rate does not affect the incentive to save, because income and substitution effects cancel one another out. We thus turn to a case in which the utility function is isoelastic, so that consumers maximize:

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

[5]Recall that a higher β means greater willingness to postpone consumption and therefore to increase first-period saving. Moreover log utility means saving is a linear function of income. Finally, a higher initial stock of financial literacy implies lower investment in financial literacy from equation (4), which frees up resources for saving.

where σ is the intertemporal elasticity of substitution (IES). The Euler equation is:

$$\frac{c_1}{(\beta\Phi_1^{\alpha})^{\sigma}} = c_0$$

while the analog of (4) is:

$$p = \frac{\alpha\beta^{\sigma}\Phi_1^{\alpha(\sigma-1)-1}}{1+\beta^{\sigma}\Phi_1^{\alpha(\sigma-1)}}(y - p\phi) \tag{6}$$

The left-hand side of (6) is again the marginal cost of financial literacy, while the right-hand-side is the marginal return. While the former is constant, the latter is a decreasing function of ϕ if $\alpha(\sigma-1) < 1$, that is, for sufficiently low levels of the intertemporal rate of substitution.

Since the right-hand-side of equation (6) is non-linear in ϕ, we solve it numerically, maintaining the assumption that $\alpha(\sigma-1) < 1$. In order to relate the model to the empirical evidence, we are particularly interested in studying the correlation between the two endogenous variables, that is, how saving and the stock of financial literacy change as a function of the parameters of the model. In our baseline scenario we set $\alpha = 0.3$, $\beta = 0.99$, $\delta = 0.3$, $p = 1$, $\sigma = 0.5$, $\Phi_0 = 1$, and $y = 10$.[6] We then vary one parameter at the time, reporting the numerical solution of investment in financial literacy (ϕ^*), stock of financial literacy (Φ_1^*) and saving (s^*). The top panel of Table 1 shows that a higher intertemporal elasticity of substitution is associated with greater financial literacy and higher saving levels. Therefore, in a cross-section of households in which there is heterogeneity in σ there will be a positive correlation between saving and financial literacy. But to conclude that a higher stock of literacy causes a higher saving rate would be incorrect: indeed, the driving force of the correlation is the positive effect of σ on both variables.

The important point, however, is that the two endogenous variables are not always positively correlated. The bottom panel of Table 1 reports the same calculations for different levels of the discount factor and points to a much weaker correlation between saving and financial literacy. On the contrary, Table 2 suggests that raising p (top panel) or α (bottom panel) reduces Φ_1^* but increases s^*, inducing a negative correlation between the two variables.[7]

The two-period model highlights some of the main factors inducing the correlation between

[6]The intertemporal rate of substitution, σ, is chosen to be broadly consistent with the evidence in Attanasio and Weber (1993) and (1995).

[7]Similar calculations are performed, but not reported for brevity, to investigate how income, the depreciation rate and the initial stock of literacy shape the relation between the saving and financial literacy.

financial literacy and saving. In particular, it clarifies that there is a positive relation between saving and financial literacy only to the extent that the driving forces of the model (initial stock of literacy, income, preference parameters, return to literacy and cost of literacy), affect saving and the current stock of literacy in the same direction. However, the simple structure of the two-period model does not capture a relevant dimension of heterogeneity, namely the accumulation and decumulation of the stocks of wealth and financial literacy that occur over the life-cycle. To capture this we move to a multiperiod model.

3.2 The multiperiod model

We now assume that consumers live for T periods (from 0 to $T-1$) and die at the end of period $T-1$, so that they consume their entire wealth and income in the final period $T-1$. Using the same notation and assumptions as in the two-period model with isolestic utility, the value function of the optimization problem is:

$$V_t(A_t, \Phi_t) = \max_{\{c_s, \Phi_{s+1}\}} \frac{1}{1-\frac{1}{\sigma}} \sum_{s=t}^{T-1} \beta^{s-t} c_s^{1-\frac{1}{\sigma}}$$

which can be written as the recursion:

$$V_t(A_t, \Phi_t) = \max_{\{c_t, \Phi_{t+1}\}} \left[\frac{1}{1-\frac{1}{\sigma}} c_t^{1-\frac{1}{\sigma}} + \beta V_{t+1}(A_{t+1}, \Phi_{t+1}) \right]$$

where:

$$A_{t+1} \quad = \quad \Phi_{t+1}^{\alpha} \left[A_t + y_t - c_t - p\Phi_{t+1} + p(1-\delta)\Phi_t \right]$$

The Appendix A shows that the Euler equation for the problem is:

$$\frac{c_{t+1}}{c_t} = (\beta \Phi_{t+1}^{\alpha})^{\sigma}$$

and that Φ_t evolves according the following recursion:

$$\left(p - \alpha \frac{s_{t-1}}{\Phi_t} \right) \Phi_t^{\alpha} - p\,(1-\delta) = 0 \quad \text{for} \quad t \leq T-2 \tag{7}$$

$$p - \alpha \frac{s_{t-1}}{\Phi_t} = 0 \quad \text{for} \quad t = T-1 \tag{8}$$

The Euler equation states that consumption growth is directly related to the interest rate, and therefore increases with the return to literacy α and the stock of financial literacy Φ_t. The sequence of optimal c_t and Φ_t can be found by solving the system given by the Euler equation, the budget constraint, and equations (7) and (8).

To illustrate the solution, we consider a consumer who lives for six periods, where each period should be interpreted as 10 years. In the first four periods income is positive, increasing at a rate of 20 percent per period (approximately 1.5 percent per year); in the fifth and sixth period the consumer retires, and earns only interest income.[8] The second case we examine is where during the working life the consumer contributes 20 percent of income to a social security system, and in the last two-period receives an actuarially fair and constant pension.

We illustrate the solution in Figure 2 where we plot the age-profile of wealth and the stock of financial literacy in the two scenarios (with or without a social security system). The top panel shows that wealth has the hump-shaped profile typical of life-cycle models. In the bottom panel the stock of literacy has a similar age-profile, increasing in the first portion of the life-cycle and decreasing after retirement, when net investment in literacy becomes negative, due to depreciation of the stock and the reduced incentive to invest in literacy. Notice that in the fifth period (immediately after retirement) consumers still purchase financial literacy and the stock of financial literacy increases. It is only in the final period that the elderly have no incentives to accumulate financial literacy, so that the dynamics of the stock of literacy is driven only by the depreciation rate.[9]

Figure 2 also shows that a social security system reduces not only the incentive to accumulate assets, but also investment in financial literacy. The reduction in wealth accumulation (top panel) is the familiar displacement effect induced by social security: given the presence of mandatory saving and pension benefits, people need to accumulate less wealth during their working life to finance retirement consumption. Since the incentive to invest in financial literacy depends on the amount saved, with social security consumers also accumulate a lower stock of financial literacy (lower panel). Although we do not model the composition of household

[8]The other parameters are the following: $\alpha = 0.30$, $\beta = 0.99$, $\delta = 0.3$, $p = 1$, $\Phi_0 = 1$, $\sigma = 0.5$ and first-period income is 10.

[9]In a different context, Mazzonna and Peracchi (2009) investigate the effect of aging on cognitive abilities. In their human capital model cognitive abilities are valued because they increase people's earnings before retirement (rather than the interest rate as in our model). Thus, when people cease to work they have no incentives to invest in cognitive abilities.

portfolios, this might explain why in countries with more generous social security systems households participate less in financial markets and have relatively simpler portfolios.[10]

To summarize, the multiperiod model shows that literacy and wealth are strongly correlated over the life-cycle: both profiles increase during the working life, wealth peaks at retirement, literacy peaks one period after retirement, and both decrease at the end of the life-cycle. The figure also suggests that in a cross-section of individuals of different ages one should observe a positive correlation between financial literacy and saving. The correlation depends also on the generosity of the social security system. A system in which saving decisions are intermediated by government provides little incentive to save and to accumulate financial literacy. In comparing literacy across countries it is important therefore to consider different social security arrangements, and to condition on the generosity of social security. On other aspects, the multiperiod model confirms what we found in the two-period case. More impatient consumers invest less in financial literacy and accumulate less wealth. A higher intertemporal elasticity of substitution raises the slope of the consumption profile, investment in literacy, and wealth accumulation. A higher cost of literacy reduces the incentive to invest in literacy, but increases wealth accumulation. In the next section we show how the predictions of the theoretical model guide the empirical analysis.

4 The empirical model

The standard approach to estimate the impact of financial literacy on saving (or wealth accumulation) is to run a regression of the form:

$$\frac{s}{y} = \pi_0 + \pi_1 \Phi_1 + x'\pi_2 + u \tag{9}$$

where $\frac{s}{y}$ is the saving rate (or the wealth-income ratio), Φ_1 is a measure of the current stock of financial literacy (e.g., an indicator constructed from responses to questions about finance), x is a set of demographic and economic variables, and u is an error term. In the regression above, π_1 is often interpreted as the causal impact of literacy on saving. Our discussion in Section 3, however, suggests that Φ_1 is itself a choice variable and therefore OLS estimation

[10] On the relation between retirement decisions and limited participation in financial markets see Angelini et al. (2009).

of the saving regression does not deliver consistent estimates of π_1. To show this, note that according to equation (1) the stock of financial literacy equals the initial stock plus any subsequent investment in literacy. We approximate equation (1) with the linear projection of Φ_1 on Φ_0 and x:

$$\Phi_1 = \psi_0 + \psi_1 \Phi_0 + x'\psi_2 + v$$

where v is orthogonal to Φ_0 and x, and therefore reflects variation in ϕ not accounted for by Φ_0 or x. Section 3 offers various reasons for why u and v may be correlated. For instance, a higher intertemporal elasticity of substitution increases Φ_1 as well as the saving rate; instead, a higher price of literacy increases Φ_1 but reduces saving. It is easy to show that if u and v are correlated OLS is asymptotically biased. In fact, assuming for simplicity that $\pi_2 = \psi_2 = 0$, the relation between the OLS estimate and π_1 is:

$$\operatorname*{plim}_{n\to\infty} \hat{\pi}_1 = \pi_1 + \frac{Cov(u,v)}{Var(\Phi_1)}$$

where n is the sample size, $\hat{\pi}_1$ is the OLS estimator of π_1 and $Cov(u,v)$ may be positive or negative. For instance, suppose that the correlation between current literacy and saving is due to heterogeneity in the intertemporal rate of substitution. Projecting u and v on σ we obtain:

$$\begin{aligned} u &= \lambda_0 + \lambda_1 \sigma + \varepsilon \\ v &= \zeta_0 + \zeta_1 \sigma + \xi \end{aligned}$$

where ε and ξ are orthogonal to σ, $Cov(\varepsilon, \xi) = 0$ and λ_1 and ζ_1 are positive, as shown in Table 1, implying $Cov(u,v) > 0$.

In more general settings, the sign of the asymptotic bias depends also on how other latent factors, such as the discount factor, the return to literacy, and the price of literacy, affect the correlation between saving and the current stock of literacy. To exemplify, assume that there is unobserved heterogeneity in both the intertemporal elasticity of substitution and the price of literacy:

$$\begin{aligned} u &= \lambda_0 + \lambda_1 \sigma + \lambda_2 p + \varepsilon \\ v &= \zeta_0 + \zeta_1 \sigma + \zeta_2 p + \xi \end{aligned}$$

where, as before, ε and ξ are orthogonal to β and p, and $Cov(\varepsilon, \xi) = 0$. Our model implies that λ_1, λ_2 and ζ_1 are positive, while ζ_2 is negative, as shown in Tables 1 and 2. Assuming that σ and p are independent traits, the bias depends on the sign of:

$$Cov(u, v) = \lambda_1 \zeta_1 Var(\sigma) + \lambda_2 \zeta_2 Var(p)$$

While the first term of the covariance is positive, the second is negative because $\zeta_2 < 0$. Thus, the sign of the bias is theoretically ambiguous.

Another reason why OLS estimates might be biased is measurement error. It is well known that in the presence of measurement error OLS estimation does not produce consistent estimates. In particular, if financial literacy is imperfectly observed, measurement error affects u and v in opposite directions, $Cov(u, v)$ will be negative, and OLS will underestimate π_1.

To summarize, the discussion shows that in general $\hat{\pi}_1$ is biased and that OLS estimation of the effect of literacy is inadequate. The simple theoretical model presented in Section 3 suggests that the endogeneity of literacy (and possibly measurement error for literacy) is at the root of this bias. The size and direction of the bias in general are ambiguous. They will be positive ($\operatorname{plim}_{n\to\infty} \hat{\pi}_1 > \pi_1$) if the error terms of the saving and literacy equations are positively correlated, and negative if the errors are negatively correlated or if the stock of literacy is measured with error. The model suggests, however, that π_1 can be consistently estimated if a suitable measure of Φ_0 is available. This measure should be correlated with Φ_1, satisfying the rank condition for the validity of an instrument. The additional, important assumption is that Φ_0 is not correlated with the error term of the saving equation u. To the extent that this assumption holds, IV estimation of the saving equation using Φ_0 as instrument for Φ_1, provides a consistent estimate of π_1. In the remainder of this paper we present estimates of saving and wealth regressions that use microeconomic and aggregate data, propose suitable proxies for Φ_0 and Φ_1, and compare the OLS and IV estimates.

5 Microeconomic data

In order to address the econometric issue described in Section 4 we use a unique microeconomic dataset with information on wealth, measures of current and past stocks of financial literacy, and many other demographic and economic variables. The data are drawn from Waves 1, 2 and

3 of SHARE, covering a representative panel of the population aged 50+ in several European countries, including all the largest ones.[11] The survey covers many aspects of the well-being of elderly populations, ranging from socio-economic to physical and mental health conditions. 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. 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.

In Waves 1 and 2 respondents are presented with four financial and numerical questions, on the basis of which we can construct a measure of financial literacy. The first question is to understand whether consumers 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 interest rate compounding in a savings account, and is commonly regarded as a very good proxy for financial literacy, see Lusardi and Mitchell (2008) and Lusardi et al. (2010).[12] Following Dewey and Prince (2005) the answers to these questions are combined into a summary indicator which we interpret as a measure of the current stock of financial literacy Φ_t. Details of the actual questions, and the construction of this indicator are given in Appendix B and further discussed in Christelis et al. (2010).[13]

Selected statistics for the variables used in the estimation are reported in Table 3. Since SHARE does not have a good measure of consumption, our key dependent variable is the logarithm of wealth, defined as the sum of real and financial assets. Details on wealth definition and the imputation of missing values are reported in Appendix B. With the exception of income,

[11] 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).

[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.

which is gross of taxes in 2003 but net of taxes in 2006, the variables have the same definitions in the 2003 and 2006 surveys. Therefore, we report separate estimates of the wealth regressions in the two samples.[14]

To test the main predictions of the model, in Table 4 we start by reporting OLS estimates of wealth equation in the Wave 1 sample. The regression includes a full set of country dummies whose coefficients are omitted from 4. The age coefficient is close to zero and rather imprecisely estimated. Note however that in our cross-sectional data we do not control for cohort effects, so an alternative and equally plausible interpretation of the coefficient is that age and cohort offset each other. We also find that wealth is 68 percent lower for single households; higher education, good health and income are associated with higher wealth, in line with many previous studies and international evidence on the subject.

The most important coefficient, from the point of view of the present study, is the coefficient of financial literacy, which is positive and highly significant, suggesting that a one-point increase in financial literacy is associated with a 9 percent increase in wealth. As we stress in Sections 3 and 4, the coefficient might be biased, due to the endogeneity of literacy (poorer households have lower incentives to invest in financial information), omitted variables (such as preference parameters), or measurement errors.

We then move to the IV estimations. Our discussion in Section 3 suggests that the ideal candidate for an instrument is pre-labor market entry literacy endowment (Φ_0). Wave 3 of SHARE (i.e. SHARELIFE retrospective data) provides such instrument. Respondents 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?"[15]

The correlation between our proposed instrument and the current stock of literacy is quite strong. About 30 percent of the variability in financial literacy in adult age is accounted for by mathematical skills at age 10. Also, the evidence in Herd and Holden (2010) corroborates our choice: in a different context and using different data, they show that early-life cognition and schooling have a strong relation to late-life financial literacy. The first stage regression,

[14]Wave 1 includes 31,115 households, and Wave 2 includes 33,281 households. Of these, 18,741 were interviewed in both surveys. 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.

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

reported in the second column of Table 4, delivers a coefficient of mathematical skills of 0.21. The coefficient is also precisely estimated (the standard error is 0.009). The other variables conform to intuition and predictions of the model. The age effect is negative, and can be rationalized within our model which shows that households decumulate wealth after retirement and therefore have less incentive to invest in literacy (we also experiment with a quadratic term for age, which is not statistically different from zero). Women have lower financial literacy, in line with the evidence of many studies that find that women are less financially skilled; our model would also predict a negative effect since women generally have less wealth than men and less incentive therefore to invest in financial literacy. Human capital variables (schooling and health status) are correlated with household resources and are strong predictors of financial literacy.

The IV regression in the third column of Table 4 confirms most but not all the OLS results. We still find that income, schooling and health status are strong predictors of wealth accumulation. The age coefficient is slightly positive, while the coefficients of schooling and health are lower than in the OLS estimation. The coefficient of financial literacy (0.29) is larger than in the OLS estimation. As explained in Section 4, this suggests the presence of measurement error or of a negative correlation between the error terms of the saving and financial literacy equations. Finally, the F-statistic on the excluded instrument is large and statistically different from zero at a the conventional levels.

Notice that since we use only one instrument, our baseline specification does not allow us to test the identifying restrictions. For this reason, we run a number of robustness checks. First, we include in the instruments the initial level of language skills. The correlation between this variable and the current level of financial literacy is much weaker than in the case of mathematical skills. The Cragg-Donald Wald F-statistics is still high (235.254) and the Sargan test does not reject the overidentifying restrictions (the Sargan statistics is 2.876 with a 9 percent rejection probability).

Second, we do not want to rule out mathematical skills at age 10 having an independent effect on wealth accumulation due to their correlation with other early-life events (including health events) and family background. We therefore increase the number of variables in the wealth regression by including several family background variables: number of rooms in the accommodation at age 10, number of people living in that accommodation, number of books in

the house, occupation of the main bread-winner, xexistence of an inside toilet. The results, not reported for reasons of space, suggest that expanding the set of regressors does not affect the coefficient of numeracy. In some specifications we find that family background affects current wealth, notably number of rooms in the home (an extra room in the home is associated with 4.6 percent greater wealth). In other specifications we find that the breadwinner's occupation is associated with greater wealth (in particular, managers and senior officers have 12 percent greater wealth).

In Table 5 we repeat the estimation for the Wave 2 sample. In the OLS regression the financial literacy coefficient is 0.11, quite close to 2003 estimates. The other coefficients have similar signs, sizes, and significance. The first stage regression in column 2 suggests again that current financial literacy is strongly correlated to school-age mathematical skills (a highly significant coefficient of 0.23). The F-test on the excluded instrument shows that mathematical skills are a very strong predictors of financial literacy later in life. Finally, in the IV regression, again the coefficient of literacy is higher than in the OLS estimates (0.409).

6 Cross-country data

In this section we provide further evidence of the main predictions of the model using macroeconomic data. As with SHARE, we exploit an IV approach that links a country's current level of financial literacy to its initial level. For the current level of financial literacy we rely on an indicator from the IMD World Competitiveness Yearbook (WCY), for the years 1995 to 2008. The indicator is computed from a survey of senior business leaders who represent a cross-section of the business community in the countries examined.[16] One of the survey questions asks business leaders to rank, on a 0-10 scale, the sentence: "Economic literacy among the population is generally high." The indicator is collected in 47 countries, and when more than one year is available, it is averaged across 1995 to 2008 (or the maximum number of years available). The sample includes a total of 14 countries in Asia, 7 in Latin America, 15 in the EU, 12 former socialist countries, and 7 other countries (South Africa, U.S., New Zealand, Norway, Canada,

[16]The sample distribution of business leaders reflects a breakdown of industry by sectors (manufacturing, services, and primary). The sample size is proportional to each country's GDP. The survey questions are aimed at top and middle managers, nationals or expatriates, located in local and foreign enterprises in the country in question, who generally have international experience and a global perspective. The surveys are administered in January for completion and return by March of the same year. In each year the overall size of the survey is about 4,000 business leaders in a maximum of 55 countries.

Switzerland, Australia). Jappelli (2010) relies on the same indicator of financial literacy to demonstrate the substantial heterogeneity of financial competence across countries, and that human capital variables (PISA test scores and college attendance) are strongly and positively correlated with financial literacy. His study also reports that inhabitants of countries with more generous social security systems are less financially literate, which is in line with one of the implications of the model in Section 3 that the incentives to acquire financial literacy depend on to the amount of resources available for private accumulation.

To assess the reliability of the WCY indicator, Figure 3 compares it with the SHARE indicator of financial literacy used in Section 5. The figure shows that the two variables are strongly positively correlated (the correlation coefficient is 0.79). In both surveys, Italy and Spain score lowest, and Sweden, Switzerland, and Denmark score highest. Despite the very different design of these surveys, the countries are well aligned, which makes us fairly confident that the WCY literacy indicator is a reasonable proxy for financial literacy. The comparison is useful because the scale of the WCY indicator is not directly interpretable. Figure 3 implies that a two-point change in the WCY indicator (the distance between Italy and Belgium, or between France and Sweden) is associated with a one-point change in the SHARE indicator. It would be rather arbitrary, however, to interpret the WCY indicator as a function of the number of correctly asked questions in each country, as in SHARE. Therefore, in the regression analysis we standardize the WCY indicator and the independent variables to a mean zero and a standard deviation of 1.

Figure 4 shows that national saving is positively associated with the WCY financial literacy indicator, and that the literacy effect is potentially large. Indeed, in countries where the WCY indicator is less than 4, national saving is less than 20 percent of GDP; in countries with literacy scores above 6, national saving is close to 30 percent.

Since the positive relation between literacy and national saving might be driven by other variables, we next perform regression analysis. The reason for using national saving as the dependent variable is that national saving is measured as national income less total (private plus public) consumption, a measure that is independent of inflation, whereas conventional definitions of private saving require a measure of private sector income, which is affected by the loss incurred from the depreciation of nominal assets due to inflation. Furthermore, private saving definitions are largely arbitrary and depend, among other things, on the way mandatory

contributions and pension withdrawals are treated. All variables are averaged over the 1995-2008 period. Data sources and variables definitions are reported in the Appendix B.

Table 6 reports the regression results. The OLS regression relies on a cross-section of 47 countries for which we have complete records of national saving and financial literacy. In the first specification we include the GDP growth rate, government saving and financial literacy. The coefficient of financial literacy is positive and statistically different from zero at the 5 percent level. In terms of economic significance, an increase of one standard deviation in literacy is associated with an increase in national saving of 2 percentage points. Furthermore, a one-point increase in public saving is associated with an almost equal increase in national saving. This stands in sharp contrast to the Ricardian equivalence proposition that public and private saving are perfect substitutes, so that an increase in government saving should not affect national saving. To check the robustness of the results, we add to the baseline specification the dependency ratio (defined as the ratio of those aged less than 15 or more than 65 years in the total population) and the generosity of the social security system (measured by the social security contribution rate). The coefficient of literacy is hardly affected in the extended specification.

We next apply our IV approach to the cross-country dataset. Recall that the theoretical model suggests that the initial level of financial literacy is an ideal instrument for the current level of literacy. In the international comparison, the most informative and reliable indicator of the level of literacy before entry to the labor market is provided by the PISA scores (see Hanushek and Woessman (2008), and Jappelli (2010)). The scores are available for 1995, 2000, 2003, and 2006 for a maximum of 44 countries.[17]

In keeping with the analysis in Section 5, our preferred measure of the initial stock of literacy (our instrument) is the country's average PISA test score for mathematics. Figure 5 shows that there is a strong positive association between financial literacy and mathematical abilities across countries. In countries where the PISA score is less than 400, the WCY indicator of financial literacy does not exceed 4, while in virtually all countries with math scores above 500 the indicator of financial literacy is higher than 6. The first stage regression in Table 6 confirms this correlation, suggesting that the PISA score is the most important determinant of international differences in financial literacy. The coefficient of the PISA score is positive

[17]PISA are available for 27 countries in 1998, 28 in 2000, 33 in 2003 and 44 in 2006. For each country, we take the average value if more than one observation is available.

and large, and in terms of economic significance it implies that an increase of one standard deviation in math score (equivalent to moving from Greece to Germany or from Ireland to Korea) is associated with an increase in literacy of 0.66 standard deviations.

In the IV estimates financial literacy again is an important determinant of national saving. In fact, the estimates indicate that increasing literacy by one standard deviation from the sample mean increases national saving rate by 3.6 percentage points. Although the IV estimates are based on only 39 observations, the international comparison confirms our previous finding that OLS estimates tend to underestimate the effect of literacy on national saving. As robustness checks, we include in the saving regression additional variables that might potentially affect saving: the real interest rate (measured as the difference between the nominal interest rate on government bills and the actual inflation rate), log of per capita income, the Gini coefficient of income inequality, and continental dummies. The coefficient of financial literacy in these extended specifications is hardly affected.

7 Conclusions

Many papers suggest that a large proportion of the adult population knows little about finance and that many individuals are unfamiliar with basic economics concepts, such as risk diversification, inflation, and interest compounding. There is also considerable evidence that financial literacy is correlated with wealth accumulation and portfolio decisions. None of these papers, however, recognizes that financial literacy is a choice, and that in choosing how much to invest to acquire financial literacy, consumers trade-off the costs and benefits. In this paper we considered financial literacy as a particular form of human capital accumulation and recognized the potential role of mathematical ability early in life. We posited that the initial stock of financial literacy is strongly related to mathematical skills acquired at the onset of the life-cycle. These skills determine the stock of financial literacy: the stock depreciates over time at a rate that potentially differs among individuals, and initial disparities might either attenuate or compound depending on individual investment in acquiring financial literacy.

We proposed a simple intertemporal model to discuss the costs and benefits of financial literacy investment. The model assumes that investing in financial literacy increases the net returns from intertemporal trade, but requires money, time and effort. We show that the deci-

sion to acquire financial literacy depends on the same factors affecting the saving decisions over the life-cycle. The model clarifies that financial literacy and saving are endogenous variables. Simple simulations show that these two variables are positively correlated over the life-cycle. The model guided our estimation strategy, suggesting that measures of the stock of peoples' mathematical skills before entering the labor market can be used as an instrument for the stock of financial literacy. We validated the model with microeconomic and aggregate cross-country data.

We merged the Survey of Health, Ageing, Retirement in Europe (SHARE) for individuals aged 50+ with SHARELIFE, a retrospective survey of the same individuals. We show that the current level of financial skills is strongly correlated with a measure of mathematical skills at school age available in SHARELIFE. We found that financial literacy is strongly associated with wealth in both the OLS and IV regressions, but that the OLS estimates underestimate the effect of literacy. We treated the aggregate data in a similar way and found that PISA scores in mathematics are strongly correlated with country-wide indicators of financial literacy supplied by business leaders. Our analysis suggests that countries that exhibit higher financial literacy also have higher saving rates. Again, OLS estimates tend to underestimate the literacy coefficient. Overall, our evidence suggests that there is a strong link between financial literacy and wealth accumulation, which has two implications for policy. The results from the analysis using microeconomic and aggregate data suggest that improving mathematical skills could increase a country' financial literacy and wealth accumulation. The international comparison suggests that financial market reforms associated with financial market deepening (e.g., the creation of private pension funds), by raising the incentive to invest in financial literacy, could lead also to improvements in financial literacy and saving.

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8 Tables and Figures

TABLE 1. The effect of the discount factor and the intertemporal rate of substitution on financial literacy and saving.

σ	ϕ^*	Φ_1^*	s^*
0.20	0.65	1.35	4.50
0.40	0.66	1.36	4.53
0.60	0.67	1.37	4.56
0.80	0.68	1.38	4.60
1.00	0.69	1.39	4.63
1.20	0.70	1.40	4.67
1.40	0.71	1.41	4.71
1.60	0.72	1.42	4.75
1.80	0.74	1.44	4.79
2.00	0.75	1.45	4.84

β	ϕ^*	Φ_1^*	s^*
0.90	0.64	1.34	4.46
0.91	0.64	1.34	4.47
0.92	0.64	1.34	4.48
0.93	0.65	1.35	4.49
0.94	0.65	1.35	4.50
0.95	0.65	1.35	4.51
0.96	0.66	1.36	4.52
0.97	0.66	1.36	4.53
0.98	0.66	1.36	4.54
0.99	0.66	1.36	4.55

Note. σ is the intertemporal elasticity of substitution, β the discount factor, ϕ^*, Φ_1^* and s^* the optimal investment in financial literacy, the optimal stock of financial literacy, the optimal level of saving. In the top panel β is set to 0.99, in the bottom panel σ is set to 0.5. The other parameters are: $\alpha = 0.3$, $\delta = 0.3$, $p = 1$, $\Phi_0 = 1$, $y = 10$.

TABLE 2. The effect of the cost of literacy and the return to literacy on financial literacy and saving.

α	ϕ^*	Φ_1^*	s^*
0.20	0.27	0.97	4.86
0.22	0.36	1.06	4.80
0.24	0.44	1.14	4.73
0.26	0.51	1.21	4.67
0.28	0.59	1.29	4.61
0.30	0.66	1.36	4.55
0.32	0.74	1.44	4.49
0.34	0.80	1.50	4.43
0.36	0.87	1.57	4.37
0.38	0.94	1.64	4.31

p	ϕ^*	Φ_1^*	s^*
0.75	1.06	1.76	4.17
0.80	0.96	1.66	4.24
0.85	0.87	1.57	4.31
0.90	0.80	1.50	4.37
0.95	0.73	1.43	4.43
1.00	0.66	1.36	4.48
1.05	0.61	1.31	4.53
1.10	0.56	1.26	4.58
1.15	0.51	1.21	4.62
1.20	0.46	1.16	4.66

Note. α is the return to literacy, p the price, ϕ^*, Φ_1^* and s^* the optimal investment in financial literacy, the optimal stock of financial literacy, the optimal level of saving. In the top panel p is set to 1, in the bottom panel α is set to 0.3. The other parameters are: $\beta = 0.99$, $\delta = 0.3$, $p = 1$, $\sigma = 0.5$, $\Phi_0 = 1$, $y = 10$.

TABLE 3. Summary statistics, SHARE Waves 1 and 2

Variable	Mean	Std. Dev.	N
	Wave 1		
Log wealth	12.141	1.726	14631
Age	63.577	9.272	14631
Female	0.545	0.498	14631
Single	0.242	0.428	14631
Family size	2.204	0.985	14631
Log income	10.571	1.384	14555
High school	0.298	0.457	14631
College	0.202	0.402	14631
Health status	3.159	1.015	14631
Financial literacy	3.426	1.087	14631
Math skills at the age of 10	3.296	0.895	14631
	Wave 2		
Log wealth	12.423	1.705	18332
Age	64.335	9.513	18332
Female	0.542	0.498	18332
Single	0.235	0.424	18332
Family size	2.182	0.953	18332
Log income	10.474	1.406	18141
High school	0.318	0.466	18332
College	0.212	0.409	18332
Health status	3.06	1.054	18332
Financial literacy	3.481	1.107	18332
Math skills at the age of 10	3.297	0.898	18332

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 4. Wealth regressions with Share Wave 1

	OLS	*First stage*	*IV*
Age	0.001	−0.016***	0.004*
	(0.001)	(0.001)	(0.002)
Female	0.019	−0.328***	0.091**
	(0.025)	(0.016)	(0.034)
Single	−0.682***	−0.035	−0.676***
	(0.033)	(0.022)	(0.034)
Family size	0.003	−0.041***	0.011
	(0.015)	(0.010)	(0.016)
Log income	0.307***	0.065***	0.292***
	(0.014)	(0.009)	(0.015)
High school	0.242***	0.388***	0.151***
	(0.030)	(0.019)	(0.042)
College	0.490***	0.552***	0.352***
	(0.035)	(0.023)	(0.056)
Health status	0.132***	0.110***	0.108***
	(0.012)	(0.008)	(0.015)
Financial literacy	0.090***		0.294***
	(0.013)		(0.066)
Math skills at the age of 10		0.210***	
		(0.009)	
Cragg-Donald Wald F statistic			558.520
N	14555	14555	14555

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. Wealth regressions with SHARE Wave 2

	OLS	*First stage*	*IV*
Age	−0.002	−0.019***	0.003*
	(0.001)	(0.001)	(0.002)
Female	0.047*	−0.312***	0.148***
	(0.021)	(0.014)	(0.027)
Single	−0.694***	−0.079***	−0.673***
	(0.029)	(0.020)	(0.030)
Family size	0.020	−0.046***	0.034*
	(0.013)	(0.009)	(0.014)
Log income	0.219***	0.043***	0.203***
	(0.011)	(0.008)	(0.011)
High school	0.280***	0.348***	0.159***
	(0.026)	(0.018)	(0.033)
College	0.564***	0.512***	0.374***
	(0.030)	(0.021)	(0.044)
Health status	0.135***	0.123***	0.096***
	(0.010)	(0.007)	(0.012)
Financial literacy	0.112***		0.409***
	(0.010)		(0.051)
Math skills at the age of 10		0.231***	
		(0.008)	
Cragg-Donald Wald F statistic			807.936
N	18141	18141	18141

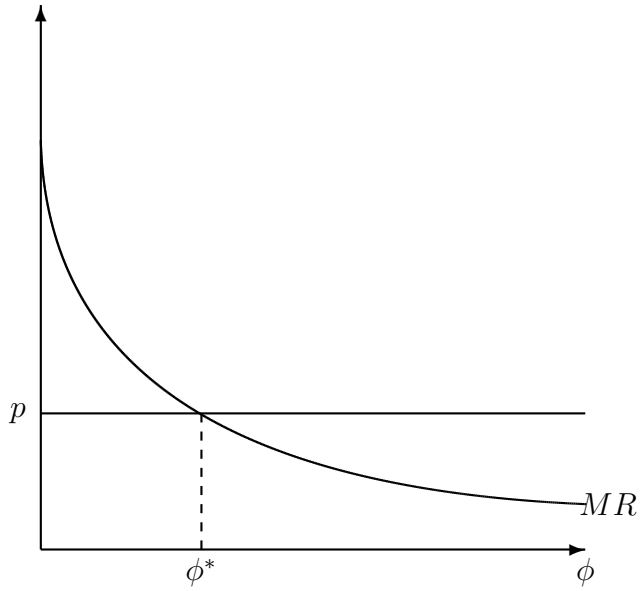
Note. All regressions include a full-set of country dummies. One star means 5% significantly different from zero, two stars 1%, three stars 0.1%.

TABLE 6. Regressions for national saving

	OLS		*First stage*		*IV*	
Growth rate of GDP	−0.006	−0.009	−0.105	0.034	−0.006	−0.010
	(0.006)	(0.006)	(0.086)	(0.085)	(0.005)	(0.006)
Public saving rate	1.189***	1.145***	3.036	−4.143	0.877***	1.079***
	(0.230)	(0.287)	(3.721)	(3.773)	(0.229)	(0.273)
Financial literacy	0.020**	0.019*			0.036**	0.038***
	(0.007)	(0.009)			(0.011)	(0.012)
Dependency ratio		0.001		2.580		−0.053
		(0.102)		(1.360)		(0.098)
Total social security contributions		0.000		−0.023**		0.001
		(0.001)		(0.007)		(0.001)
PISA score, math			0.666***	0.653***		
			(0.122)	(0.107)		
Cragg-Donald Wald F statistic					29.694	37.205
N	47	42	39	38	39	38

Note. One star means 5% significantly different from zero, two stars 1%, three stars 0.1%.

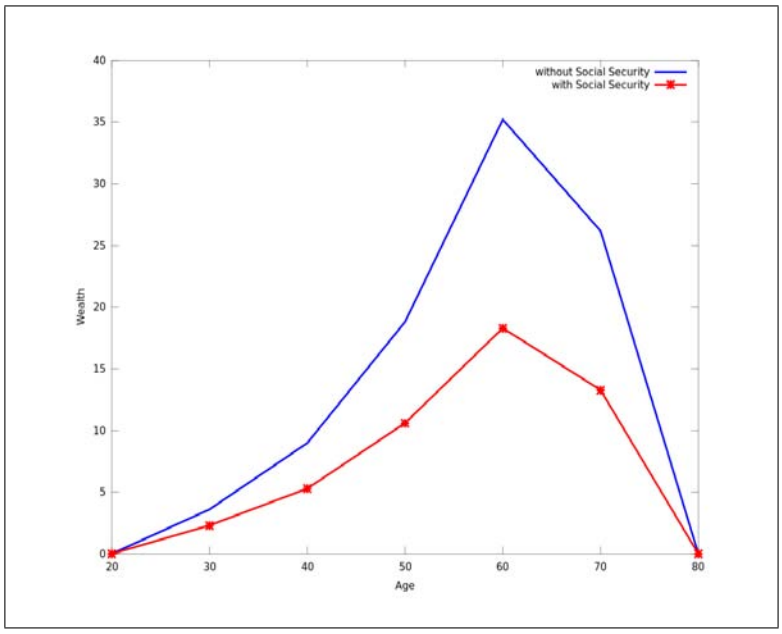
FIGURE 1. The optimal investment in financial literacy in the two-period model



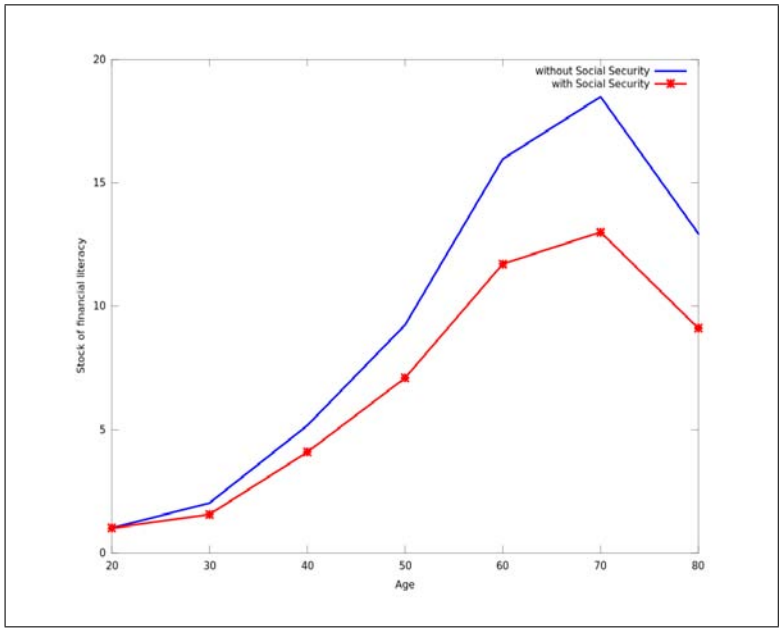
Note. Financial literacy investment is on the horizontal axis, marginal return (MR) and cost (p) are on the vertical axis; ϕ^* is the optimal level of financial literacy investment at which the marginal return equals the marginal cost.

FIGURE 2. The age-profile of wealth (A_t) and of the stock of financial literacy (Φ_t) in the multiperiod model

Wealth

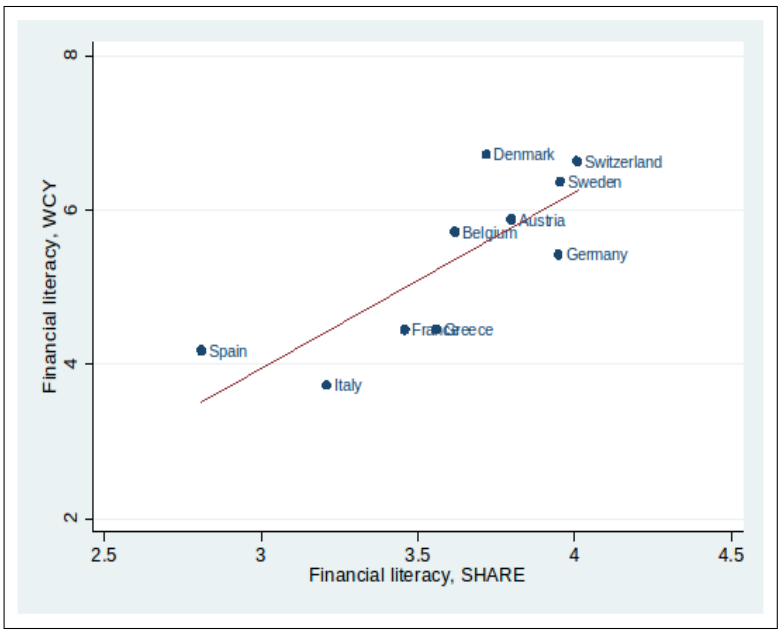


Stock of financial literacy



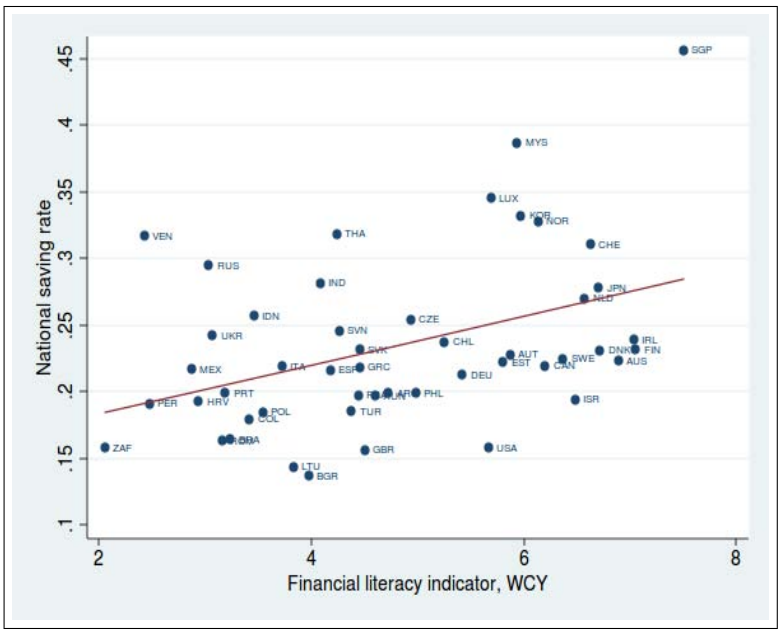
Note. To draw the figure, we use the following parameters: $T = 6$, $\alpha = 0.3$, $\beta = 0.99$, $\delta = 0.3$, $p = 1$, $\sigma = 0.5$, $\Phi_0 = 1$, and $y_0 = 10$. Furthermore, we assume that consumers retire after 4 periods, that income increase at a per-period rate equal to 0.2 and that the social security contribution rate is 20%.

FIGURE 3. A comparison between the WCY and SHARE indicators of financial literacy



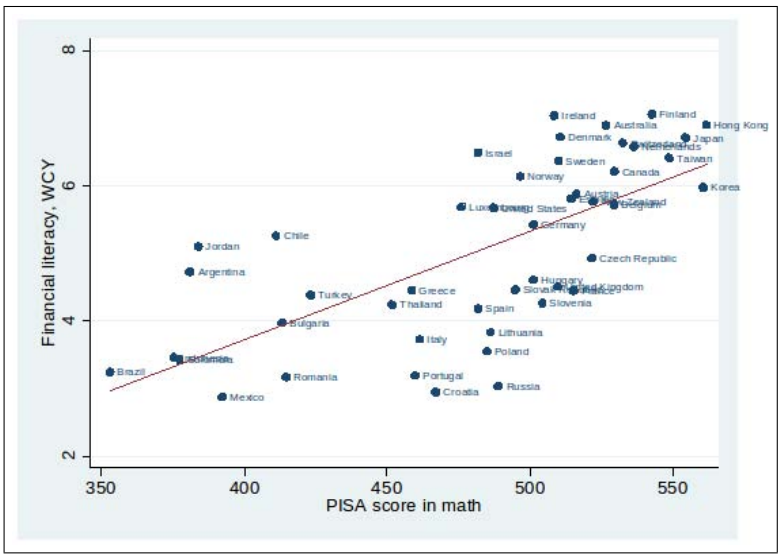
Note. Sources and variables' definitions are reported in the Data Appendix.

FIGURE 4. National saving and financial literacy across countries



Note. Sources and variables' definitions are reported in the Data Appendix.

FIGURE 5. PISA score in mathematics and financial literacy



Note. Sources and variables' definitions are reported in the Data Appendix.

Appendix A The multiperiod model

Consumers are born in period 0 and die at the end of period $T-1$. In period $T-1$ they consume their wealth and income, $A_{T-1}+Y_{T-1}$. The value function is:

$$V_t(A_t,\Phi_t)=\max_{\{c_s,\Phi_{s+1}\}}\frac{1}{1-\frac{1}{\sigma}}\sum_{s=t}^{T-1}\beta^{s-t}c_s^{1-\frac{1}{\sigma}}$$

and satisfies:

$$V_t(A_t,\Phi_t)=\max_{\{c_t,\Phi_{t+1}\}}\left[\frac{1}{1-\frac{1}{\sigma}}c_t^{1-\frac{1}{\sigma}}+\beta V_{t+1}(A_{t+1},\Phi_{t+1})\right] \tag{10}$$

where:

$$A_{t+1} \;=\; \Phi_{t+1}^{\alpha}\left[A_t+y_t-c_t-p\Phi_{t+1}+p(1-\delta)\Phi_t\right]$$

The first order conditions with respect to c_t and Φ_{t+1} are, respectively:

$$c_t^{-\frac{1}{\sigma}}-\beta\Phi_{t+1}^{\alpha}V_{t+1}^{1}(A_{t+1},\Phi_{t+1})=0$$

$$\left(\alpha\frac{s_t}{\Phi_{t+1}}-p\right)\Phi_{t+1}^{\alpha}V_{t+1}^{1}(A_{t+1},\Phi_{t+1})+V_{t+1}^{2}(A_{t+1},\Phi_{t+1})=0 \tag{11}$$

where $s_t=[A_t+y_t-c_t-p\Phi_{t+1}+p(1-\delta)\Phi_t]$. Differentiating equation (10) with respect to A_t and Φ_t one obtains, respectively:

$$V_t^{1}(A_t,\Phi_t)=\beta\Phi_{t+1}^{\alpha}V_{t+1}^{1}(A_{t+1},\Phi_{t+1}) \tag{12}$$

and:

$$V_t^{2}(A_t,\Phi_t)=\alpha\beta\Phi_{t+1}^{\alpha-1}(1-\delta)s_tV_{t+1}^{1}(A_{t+1},\Phi_{t+1})+\beta(1-\delta)V_{t+1}^{2}(A_{t+1},\Phi_{t+1}) \tag{13}$$

Solving equation (11) with respect to $V_{t+1}^{2}(A_{t+1},\Phi_{t+1})$, using equation (12) and substituting in equation (13) one obtains:

$$V_t^{2}(A_t,\Phi_t)=p\left(1-\delta\right)V_t^{1}(A_t,\Phi_t) \tag{14}$$

Using equation (14) to rewrite equation (11) one obtains:

$$\left(\alpha\frac{s_t}{\Phi_{t+1}}-p\right)\Phi_{t+1}^{\alpha}+p\left(1-\delta\right)=0 \tag{15}$$

Appendix B Data appendix

Appendix B.1 Data construction

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 which 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).[18]

All values are adjusted for differences in the purchasing power of money across countries using OECD purchasing power parity data.

Appendix B.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.

[18]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.

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 B.3 Mathematical ability at the age of 10 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 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?

Appendix B.4 The financial literacy indicator in the World Competitiveness Yearbook

The IMD WCY is a comprehensive annual report on the competitiveness of nations, available for 1995 to 2008. The WCY includes 329 variables on economic performance, government ef-

ficiency, business efficiency, infrastructure. Some of the WCY variables are drawn from the annual Executive Opinion Survey, which was designed to quantify issues that are not easily measured, for example, management practices, labor relations, corruption, environmental concerns, and quality of life. The Executive Opinion Survey is sent to executives in top and middle management in all of the economies covered by the WCY. The sample of respondents covers a cross-section of the business community in each economic sector: primary, manufacturing, and services, based on their contribution to their economy's GDP. The survey respondents are nationals or expatriates, located in local and foreign enterprises in a country and who have an international perspective. The surveys are sent out annually in January for return in April of that year. In the last Opinion Survey, WCY indicators were based on 3,960 responses from 57 countries.

Appendix B.5 Mathematical literacy in the OECD-PISA Survey

The OECD Programme for International Student Assessment (PISA - www.pisa.oecd.org) is a regular survey of 15-year olds which assesses aspects of their preparedness for adult life. Mathematical Literacy is defined as the capacity to identify, to understand, and to engage in mathematics and make well-founded judgments about the role of mathematics, needed in current and future private life, occupational life, social life with peers and relatives, and life as a constructive, concerned, and reflective citizen. Scientific Literacy is defined as the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and contribute to decisions about the natural world and the changes wrought on it by human activity