Journal of Banking & Finance 37 (2013) 2779–2792

Contents lists available at SciVerse ScienceDirect

Journal of Banking & Finance

journal homepage: www.elsevier.com/locate/jbf

Investment in financial literacy and saving decisions

Tullio Jappelli [a], Mario Padula [b,*]

[a] University of Naples Federico II and CSEF, Italy
[b] University Ca' Foscari of Venice and CSEF, Italy

ARTICLE INFO

Article history:
Received 30 November 2012
Accepted 23 March 2013
Available online 18 April 2013

JEL classification:
E2
D8
G1
J24

Keywords:
Financial literacy
Human capital
Saving

ABSTRACT

We present an intertemporal consumption model of investment in financial literacy. Consumers benefit from such investment because financial literacy allows them to increase the returns on wealth. Since literacy depreciates over time and has a cost in terms of current consumption, the model delivers an optimal investment in literacy. Furthermore, literacy and wealth are determined jointly, and are positively correlated over the life-cycle. The model drives our empirical approach to the analysis of the effect of financial literacy on wealth and saving and indicates that the stock of financial literacy early in life is a valid instrument in the regression of wealth on financial literacy. Using microeconomic and aggregate data, we find strong support for the model's predictions.

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 to discount them appropriately. In reality, many studies provide 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. (2011b) 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. Some of these studies recognize the endogeneity of financial literacy, but do not provide a model to discuss the possible sources of endogeneity. For instance van Rooij et al. (2011a) and the recent study on Chile by Behrman et al. (2010) tackle the endogeneity issue empirically, using an IV approach, but do not provide an explicit framework to integrate financial literacy in an intertemporal consumption model.

In this paper we emphasize 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. To discuss these costs and benefits, building on the insight of Arrow (1987), we propose an intertemporal consumption model which assumes that investing in financial literacy increases the net returns to saving, but requires money, time and effort. We posit that people are endowed with an initial stock of financial literacy, which they acquire before entering the labor market. The model implies that the very same factors drive both the decision to invest in financial literacy and saving decisions.[1]

Our model implies that, in a cross-section of households, financial literacy and wealth are positively correlated (as estimated in some of the empirical studies mentioned), and that literacy and wealth are correlated over the consumer's life-cycle. The relation

[1] Three other papers relate portfolio returns to financial literacy. Calvet et al. (2009) show that the portfolios of more financial sophisticated households yield higher returns. Delavande et al. (2008) assume that the maximum expected return on assets depends on financial literacy, financial advice and risk, and estimate a human capital production function for financial knowledge using data from the US Cognitive Economic Survey. More recently, Lusardi et al. (2013) make a similar assumption and calibrate a life-cycle model multi-period model to study how financial knowledge affects wealth inequality.

* Corresponding author. Address: Sestriere Cannareggio, 873, 30121, Venezia, Italy. Tel.: +39 234 9181; fax: +39 234 9176.
E-mail addresses: tullio.jappelli@unina.it (T. Jappelli), mpadula@unive.it (M. Padula).

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http://dx.doi.org/10.1016/j.jbankfin.2013.03.019

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 returns to literacy and a larger initial endowment of literacy or of resources are also associated with higher levels of saving as well as a greater current stock of literacy. The model also implies that the correlation between financial literacy and wealth depends also on the generosity of the social security system. A system in which saving decisions are intermediated by the government provides little incentive to save and to accumulate financial literacy, while a less generous system in which people rely on private wealth raises the incentive to invest in financial literacy. In comparing literacy across countries it is important therefore to consider that different social security arrangements may lead to different levels of literacy and saving.

We investigate the empirical implication of our theoretical model using microeconomic and aggregate cross-country data. In both data we estimate two equations: the relation between current financial literacy and initial financial literacy (before entering the labor market), and the relation between wealth (or saving in the aggregate data) and financial literacy. Our empirical approach recognizes the endogeneity of financial literacy in the wealth and saving regressions, and that the OLS estimates of the wealth regression are biased. To address the endogeneity issue, we exploit a restriction that naturally arises from the model, i.e. that initial literacy affects wealth and saving only insofar as it affects current literacy. Using this restriction, we obtain the IV estimates of the wealth and saving regressions using initial literacy as an instrument for current literacy.

The microeconomic data are drawn from the Survey of Health, Ageing, Retirement in Europe (SHARE) for individuals aged 50+ and SHARELIFE, a retrospective survey of the same individuals. We define an indicator of current financial literacy based on a series of specific questions available in SHARE. We measure initial literacy in SHARELIFE as mathematical skills at school age. We find that our indicator of current financial literacy is strongly correlated with the indicator of initial literacy, which explains about 30% of the variability of current literacy. Comparison of OLS and IV estimates shows that current literacy is strongly associated with current wealth, and that OLS estimates are downward biased.

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 financial literacy. This indicator is computed based on a survey of senior business leaders, that asks about their level of financial literacy. We measure initial literacy with the PISA score test in math (at the age of 15) in each country. We find that PISA test scores are strongly positively correlated with economy-wide indicators of financial literacy, and that countries with more generous pension systems feature lower literacy, confirming one of the model's predictions. In addition, we relate national saving to financial literacy. As with the microdata, to address the endogeneity of financial literacy, we provide IV estimates of the saving regression using the PISA test scores as instrument for financial literacy. Also in this case we compare IV and OLS estimates, and find that OLS estimates tend to underestimate the coefficient of literacy in the saving regression.

Overall, the microeconomic and aggregate data highlight the effect of two important determinants of financial literacy: (i) mathematical skills early in life has a positive effect on financial literacy and wealth accumulation later on; (ii) raising the incentive to invest in financial literacy – for instance reducing the generosity of the social security system – leads also to higher financial literacy and saving.

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 develops a multi-period model of financial literacy and wealth accumulation. Sections 4 and 5 present the econometric estimates obtained, respectively, using the microeconomic and aggregate data. Section 6 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 wealth accumulation. 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 trajectories for key economic outcomes such as wealth, retirement income and retirement expectations.[2] 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. (2011b) 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 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.[3]

Since the true stock of financial literacy is not observed, empirical studies face also a measurement error problem. The endogeneity and the measurement issues are similar to those arising in the literature that tries to estimate the returns to schooling: any attempt to estimate the structural relation between schooling and wages has to deal with the omitted variable bias, the endogeneity

[2] 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. Gerardi et al. (2010) focus instead on the liability side, and show that numerical ability is a strong predictor of delinquency and default in the sub-prime market.

[3] In the context of developing countries, Cole et al. (2011) 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 the 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.

of the schooling decision, and with measurement error (see Card (2001) for a discussion of these in the schooling context).

Two studies explicitly address these important econometric concerns. Christiansen et al. (2008) use a large register-based panel data set containing detailed information on Danish investors' education attainment, financial and socioeconomic variables. They 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 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.[4] Other recent studies acknowledge the endogeneity of financial literacy with respect to saving decisions, and that incentives to invest in financial literacy may affect the relation between literacy and saving, see Willis (2009), and Lusardi and Mitchell (2008). On a related issue, Gustman et al. (2012) focus on the correlation between pension wealth and pension knowledge and argue that the causality can run from the former to the latter.

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. In the next section we provide such model, while in later sections we explore its empirical implications.

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, building on the insight of Arrow (1987), financial literacy allows consumers to 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.[5]

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 (or an increase in the generosity of the system) modifies the incentives to invest in financial literacy and to accumulate assets.

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.[6] 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 rate factor, paid at the beginning of period 1 on wealth transferred from period 0 to period 1. 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 $\alpha$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 asset 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.[7] 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:

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

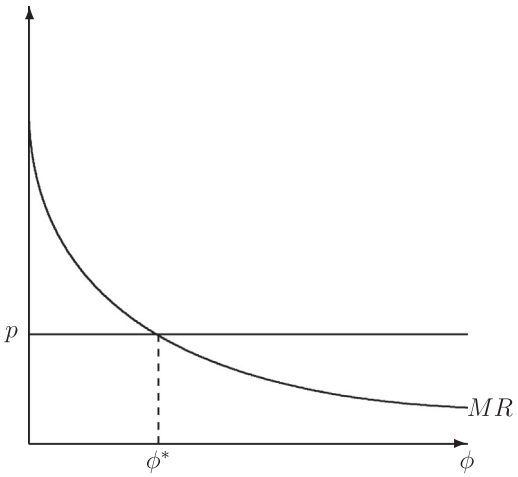
where $0 < \beta < 1$ is the discount factor and s first period saving.

[4] 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.

[5] Financial literacy can affect wealth through many different channels. It could affect expectations (by making them more precise, more accurate, and/or less biased). It could affect preferences, by helping people understand risk and reducing "direct risk aversion". It could affect price perceptions, by making people less prone to underestimate compounding effects, and/or by helping people avoid shrouded fees. It could affect whether and how people optimize, whether and how well someone shops for a good deal on a mutual fund or a loan and whether and how well someone diversifies. In principle, these various channels can operate at the same time, which makes it hard attempting at sorting them out. However, whatever is the most relevant channel, all point towards financial literacy being positively correlated with wealth. Therefore, in this paper we focus only on one of them, and we argue that even a simplistic model where financial literacy affects only returns can deliver a strong correlation between wealth and financial education, which cannot not to be given a causal interpretation.

[6] The literature provides little guidance on how to set δ. Speculating that financial literacy evolves at rate similar to that of cognitive abilities does not simplify matters. The age decline of cognitive abilities is subject of intense debate. Salthouse (2010) discusses some of the available evidence and highlights that definite answers are not yet possible since the age at which cognitive abilities start declining varies between different abilities and also depending on the data used. Cross-sectional studies indicate that cognitive abilities start declining at the age between 20 and 30, while longitudinal studies locate the peak much later in life, see Schaie (2005). Salthouse (2009) shows that the discrepancies between longitudinal and cross-section results are much reduced, when retest effects are taken into account. Notice, however, that setting δ to zero does not alter the model's predictions.

[7] 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.



Note. The graph measures investment in financial literacy investment on the horizontal axis and, on the vertical axis, the marginal return of literacy (MR) and the marginal cost of literacy (p); ϕ^* is the optimal level of investment, for which the marginal return equals the marginal cost.

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

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

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

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

Eq. (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. Eq. (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:

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

Eq. (4) defines implicitly optimal investment in financial literacy. To see this, we plot in Fig. 1 the two sides of Eq. (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 Eq. (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 reduce the optimal stock. Finally, the optimal level of saving is:

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

The solution indicates that a higher discount factor, higher income and higher initial stock of literacy are associated with higher saving.[8] 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 δbecause if these parameters increase, investment in financial literacy increases at the expense of first-period consumption and saving.

The solution implies 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 on 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^*. Therefore in a saving regression Φ_0 can be used as an instrument for Φ_1^*.

The simple case examined highlights that financial literacy is a choice variable, and that, empirically, literacy and saving are positively correlated. However, in the model with logarithmic utility the intertemporal elasticity of substitution is equal to one. To explore how the incentive to invest in financial literacy is affected by the strength of intertemporal substitution, we turn to a case in which the utility function is isoelastic, so that consumers maximize:

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

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

$$\frac{c_1}{(\beta\Phi_1^{\alpha})^{\sigma}} = c_0 \tag{6}$$

[8] 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 Eq. (4), which frees up resources for saving.

while the analog of (4) is:

$$p = \frac{\alpha\beta^{\sigma}\Phi_1^{\alpha(\sigma-1)-1}}{1+\beta^{\sigma}\Phi_1^{\alpha(\sigma-1)}}(y-p\phi) \tag{7}$$

The left-hand side of (7) 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 $\alpha(\sigma-1)<1$. This condition is always satisfied when $\sigma \leqslant 1$ (consistent with microeconomic evidence) but holds also if $\sigma > 1$for relatively low levels of α.[9]

Saving is proportional to financial literacy also in the model with isoelastic utility. It is immediate to verify that $s^* = \alpha^{-1}p\Phi_1^*$. Furthermore, from the budget constraint and (6) $s^* = \frac{\beta^{\sigma}(y-p\phi)}{\beta^{\sigma}+\Phi_1^{\alpha(\sigma-1)}}$; from (7) $\Phi_1^* = \frac{\alpha}{p}\frac{\beta^{\sigma}(y-p\phi)}{\beta^{\sigma}+\Phi_1^{\alpha(\sigma-1)}}$.

In the isoelastic utility case the derivatives of saving and financial literacy with respect to the model's parameters have the same sign as in the log utility case if $\sigma < 1$. In particular, the derivative of literacy and saving with respect to β, δ, σ, y and Φ_0 have the same sign. This implies that in a cross-section of households in which there is heterogeneity in β (or any of these parameters) there will be a positive correlation between saving and 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 β on both variables. Note, however, that heterogeneity in other parameters may induce a negative correlation between literacy and saving. Indeed, the derivatives of literacy and saving with respect to p and α have opposite signs.

The two-period model highlights some of the main factors inducing the correlation between 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 source of the model heterogeneity affects saving and literacy in the same direction. As we shall see, this insight is useful to evaluate current research, and the source of bias of the coefficient of current literacy in a saving or wealth regression.

In our simple model we do not consider uncertainty. However, in related work Jappelli and Padula (2013) explore the role of financial information in a multi-period portfolio model with uncertain asset returns. The work shows that financial literacy may raise the equity premium, reduce the volatility of returns or the fixed cost to access the stock market, and that an increase in Φ_0 leads not only to higher saving and financial literacy in later periods, but also to higher stock market participation and a larger share of risky assets in total wealth. This is consistent also with the empirical findings of Christelis et al. (2010) and van Rooij et al. (2012), who show that financial literacy is correlated with stockholding.

The simple structure of the two-period model describes the main forces behind the decision to invest in financial literacy. However, it does not capture the accumulation and decumulation of the stocks of wealth and financial literacy that occur over the life-cycle. To study these dynamics 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 isoelastic 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

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

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+1} evolves according to the following recursion:

$$\left(p - \alpha\frac{s_t}{\Phi_{t+1}}\right)\Phi_{t+1}^{\alpha} - p(1-\delta) = 0 \quad \text{for } t \leqslant T-3 \tag{8}$$

$$p - \alpha\frac{s_t}{\Phi_{t+1}} = 0 \quad \text{for } t = T-2 \tag{9}$$

where $s_t = [A_t + y_t - c_t - p\Phi_{t+1} + p(1-\delta)\Phi_t]$. 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+1}. The sequence of optimal c_t and Φ_{t+1} can be found by solving the system given by the Euler equation, the budget constraint, and Eqs. (8) and (9).[10]

To illustrate the solution, we consider a consumer who lives for sixty periods. In the first forty periods income is constant (simulations with positive income growth are qualitatively similar); in the last twenty periods the consumer retires, and earns only interest income.[11] The second case we examine is one in which during the working life the consumer contributes 20% of income to a social security system, and in the last twenty periods receives an actuarially fair and constant pension.

We illustrate the solution in Fig. 2 where we plot the age-profiles 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 even during retirement consumers still purchase financial literacy ($\phi_t > 0$), but the stock of financial literacy (Φ_t) falls because the effect of depreciation dominates. 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.[12]

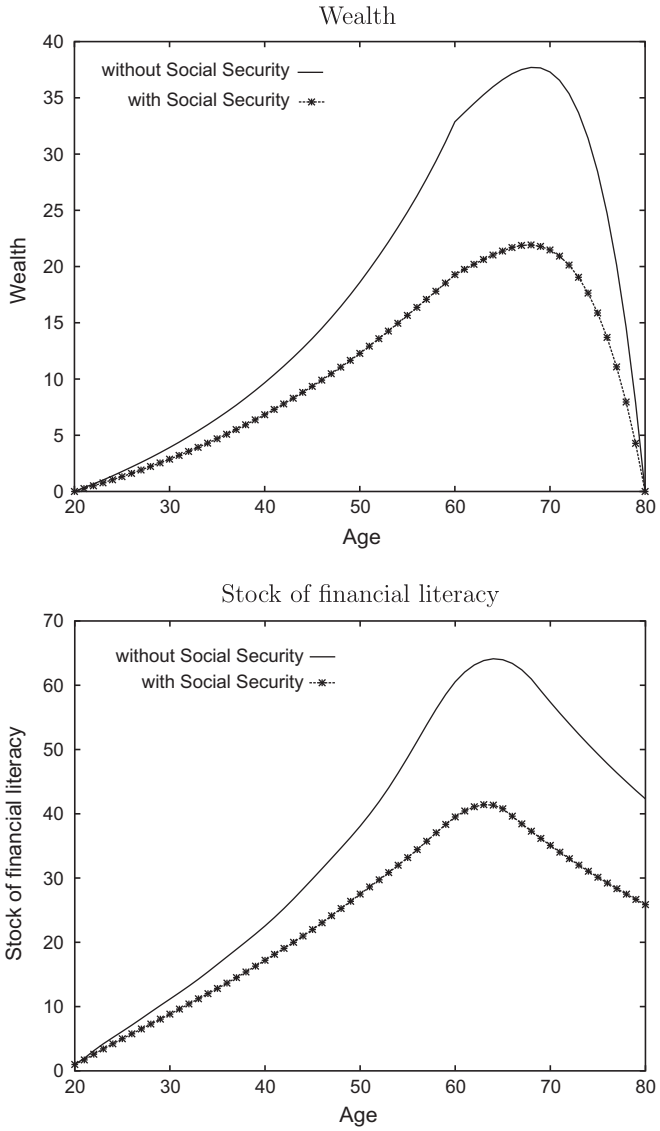
Fig. 2 shows that a social security system reduces not only the incentive to accumulate assets, but also investment in financial literacy. The reduction in wealth accumulation (top panel) is the familiar displacement effect induced by social security: given the presence of mandatory saving and pension 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

[9] See Attanasio and Weber (1993, 1995) for evidence on the intertemporal rate of substitution.

[10] Note that also in the multiperiod model saving is proportional to financial literacy if δ is equal to 1.

[11] The other parameters are the following: $\alpha = 0.03$, $\beta = 0.99$, $\delta = 0.03$, $p = 0.1$, $\Phi_0 = 1$, $\sigma = 0.5$ and first-period income equals 1.

[12] In a different context, Mazzonna and Peracchi (2012) 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.



Note. To draw the figure, we use the following parameters: $T = 60$, $\alpha = 0.03$, $\beta = 0.99$, $\delta = 0.03$, $p = 0.1$, $\sigma = 0.5$, $\Phi_0 = 1$, and $y_0 = 1$. Furthermore, we assume that consumers retire after 40 periods, that income is constant and that the social security contribution rate is 20%.

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

panel). Although we do not model explicitly the composition of household portfolios, this might explain why in countries with more generous social security systems households participate less in financial markets and have relatively simpler portfolios.[13]

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 and literacy peak at retirement, and both decrease in old age. 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 the government provides little incentive to save and to accumulate financial literacy. In comparing literacy across countries it is important therefore to consider that different social security arrangements may lead to different levels of literacy and saving. 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. Finally, a higher cost of literacy reduces the incentive to invest in literacy, but increases wealth accumulation.

To make the model operational, we consider the linear projections of financial literacy and wealth on, respectively, initial literacy Φ_0 and current literacy Φ_t, and on other exogenous variables that control for differences in preferences and economic resources:

$$\begin{aligned} \Phi_t &= \gamma_0 + \gamma_1 \Phi_0 + x_t' \gamma_2 + \varepsilon_t^{\Phi} \\ a_t &= \pi_0 + \pi_1 \Phi_t + x_t' \pi_2 + \varepsilon_t^{a} \end{aligned} \tag{10}$$

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

where a_t is the logarithm of wealth at time t, x_t is a set of demographic and economic variables, and ε_t^{Φ} and ε_t^{a} are error terms. To estimate the wealth equation, one must take into account the fact that a_t and Φ_t are both endogenous variables. However, our model implies that Φ_0 is a valid instrument for Φ_t in the wealth regression, because Φ_0 affects wealth only through its effect on Φ_t, see Eqs. (8) and (9). In Appendix B we show that the OLS coefficient of Φ_t in the wealth regression is biased. The direction of the bias depends on the covariance between the error terms and the presence of measurement error, and is a priori ambiguous. In Sections 4 and 5 we present our empirical estimates based on, respectively, microeconomic and aggregate data.

4. Microeconomic data

To estimate the model 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, a representative sample of the population aged 50+ in several European countries, including all the largest ones.[14] 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.[15] Wave 3 (which excludes Ireland) is known as SHARELIFE, and records individual life-histories for Waves 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 obtained merging Wave 1 with SHARELIFE includes 14,631 observations (18,332 merging Wave 2 with SHARELIFE).

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% 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).[16] Following Dewey and Prince (2005) the answers to these questions are combined into a summary indicator. The latter is our 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 C and further discussed in Christelis et al. (2010).[17]

In the model of Section 3 Φ_0 is the financial literacy endowment before entering the labor market. Wave 3 of SHARE (i.e. SHARELIFE retrospective data) provides 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?"[18]

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, while in Wave 2 it is net of taxes. Wave 1 refers to 2003 and Wave 2 to 2006.

Selected statistics for the variables used in the estimation 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 indicator of current financial literacy (Φ_t) ranges from 1 to 5, and has a sample mean of 3.43 in Wave 1 and 3.48 in Wave 2. In both years it exhibits considerable sample variability, with a coefficient of variation of 0.32. Our measure of initial literacy (Φ_0) also ranges from 1 to 5, with similar means and coefficients of variation. Our second dependent variable is the logarithm of wealth, defined as the sum of real and financial assets.[19] Details on wealth definition and the imputation of missing values are reported in Appendix C. The other variables in Table 1 (age, gender, dummy for singles, family size, high school and college dummies, health status, and log income) will be used as further controls in the literacy and wealth regressions – the x_t variables in Eq. (10). Sample statistics for each of these variables are quite stable across waves, except for income (reflecting different definitions).

In Table 2 we report OLS regressions for financial literacy, separately for Waves 1 and 2. Each regression includes also a set of country dummies whose coefficients are not reported for brevity. Given the recursive nature of the system of Eq. (10), the regressions in Table 2 represent our first-stage regressions. In the baseline specification of column 1 we find that Φ_0 is a strong predictor of Φ_t. The coefficient of Φ_0 is large (0.22) and quite precisely estimated (the standard error is 0.009). This finding is consistent not only with our model's prediction, but also with other evidence

[14] 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).

[15] 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.

[16] 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.

[17] 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.

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

[19] SHARE has detailed wealth and income data, but only limited information on consumption. We therefore use wealth as our dependent variable rather than saving.

Table 2
Regressions for financial literacy.

	Wave 1		Wave 2	
Age	−0.019***	−0.016***	−0.021***	−0.019***
	(0.001)	(0.001)	(0.001)	(0.001)
Female	−0.341***	−0.328***	−0.324***	−0.312***
	(0.016)	(0.016)	(0.014)	(0.014)
Single	−0.071***	−0.035	−0.103***	−0.079***
	(0.021)	(0.022)	(0.020)	(0.020)
Family size	−0.034***	−0.041***	−0.041***	−0.046***
	(0.010)	(0.010)	(0.009)	(0.009)
High school	0.430***	0.388***	0.385***	0.348***
	(0.019)	(0.019)	(0.018)	(0.018)
College	0.635***	0.552***	0.584***	0.512***
	(0.022)	(0.023)	(0.020)	(0.021)
Φ_0	0.217***	0.210***	0.239***	0.231***
	(0.009)	(0.009)	(0.008)	(0.008)
Health status		0.110***		0.123***
		(0.008)		(0.007)
Log income		0.065***		0.043***
		(0.009)		(0.008)
N	14,631	14,555	18,332	18,141

Note: All regressions include a full set of country dummies. Wave 1 refers to 2003 and Wave 2 to 2006.
* 5% Significantly different from zero.
** 1% Significantly different from zero.
*** 0.1% Significantly different from zero.

on the long-term impact of early-life conditions. For instance, Herd et al. (2012), in a different context and using different data, find that early-life cognition and schooling are strongly correlated with late-life financial literacy.

The age coefficient is negative (−0.019), and shows that in this sample of relatively old individuals, the stock of literacy falls by 0.5% per year. This effect can be rationalized within our model where that households decumulate wealth after retirement and therefore have less incentives to invest in literacy.[20] Women have lower financial literacy than men, in line with the evidence of many studies that find that women are less financially skilled (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 financial literacy (a coefficient of 0.43 for high-school and 0.63 for college degree). This positive correlation is also consistent with our model, because higher human capital and lifetime income are associated with a higher stock of financial literacy.

In column 2 of Table 2 we add health status and log disposable income to rule out that the effect of Φ_0 on Φ_t is simply due to the correlation between Φ_0 and these variables. The coefficients of health status and log income are positive and statistically different from zero, but the other coefficients (and that of Φ_0 in particular) are not affected.[21] 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_0 is 0.24 and again precisely estimated.

We further check the stability of the regression for financial literacy introducing other family background variables: language skill at age 10, number of rooms in the accommodation at age 10, number of people living in that accommodation, number of books in the house, and parents' occupation. The results, not reported for brevity, suggest that language, number of books and number of rooms are positively associated with literacy. However, the coefficient of Φ_0 is essentially unchanged (0.19 and 0.21 in Wave 1 and 2, respectively).

In Table 3 we report the wealth regressions for Wave 1 (top panel) and Wave 2 (bottom panel). For each specification we report OLS and IV estimates, using Φ_0 as an instrument for Φ_t.[22] In the top panel, the age coefficient is negative, consistent with wealth decumulation at old ages. However, the interpretation of this coefficient is questionable, as with the regressions for literacy in Table 2, because in the cross-section we cannot distinguish age from cohort effects. We also find that wealth is substantially lower for single households and that high school and college education are associated with higher wealth, in line with many previous studies.

The most important coefficient for the present study is that of financial literacy. The IV estimate in column 2 is positive and statistically significant (0.395), as predicted by the model. The coefficient implies that a one-point increase in Φ_0 (approximately an increase in one standard deviation) is associated with 8.6% increase in wealth. The comparison of the IV estimates with the corresponding OLS estimate (column 1) indicates that the OLS coefficient of financial literacy is downward biased. The remaining columns of Table 3 focus on the extended specification, adding health status and income to the baseline controls. The results are qualitatively similar, but the coefficient of literacy is smaller.[23]

The evidence from Wave 2 is similar, except for a slightly larger coefficient of Φ_t. As with the regressions of Table 2, the results are not affected if we introduce 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, and parents' occupation all have a positive effect on wealth, but the coefficient of Φ_t is unaffected (the IV coefficients in this extended specification are 0.27 and 0.37 in Wave 1 and 2, respectively).[24]

While our model naturally delivers an instrument for financial literacy, relying on a single instrument does not allow one to test for the over-identifying restrictions. Therefore, to check the quality of our instrument, we run the IV regressions using as additional instruments language skills at age 10 and a variable obtained imputing for each individual the years of compulsory schooling of her birth-cohort. The Sargan statistics for the specification controlling also for family background variables are 4.35 in Wave 1 and 1.64 in Wave 2, and do not reject the over-identifying restrictions at the 1% level.[25] Furthermore, the coefficient of the wealth regressions are very similar to those reported in Table 3. The coefficient of financial literacy is 0.30 in Wave 1 and 0.36 in Wave 2 and the OLS bias is essentially unchanged with this expanded set of instruments.

5. Cross-country data

In this section we provide further evidence of the main predictions of the model using macroeconomic data. As with

[20] With cross-sectional data we cannot control simultaneously for age and cohort effects, so an alternative and plausible interpretation of the declining age profile is that older generations have lower stock of financial literacy than younger ones.

[21] We check the stability of the regression replacing the age variable with a full set of age dummies. The results are quite similar to the estimates of Table 2 and not reported for brevity. The pattern of the estimated age coefficients indicates that the stock of financial literacy decreases throughout retirement.

[22] In principle, one could use other variables that are correlated with literacy as an additional instruments, such as lagged values of wealth. That, however, would require exploiting the panel dimension of SHARE, and, setting aside the issue of how income is defined in the Waves 1 and 2, would imply loosing the possibility to use initial literacy as an instrument, a time-invariant variables, which would be absorbed into the fixed effect.

[23] The results are also similar if we replace the linear age term with a set of age dummies.

[24] Combining the OLS and IV estimates one obtains the reduced form coefficient of Φ_0 in the wealth regression. For the specification including income and health status, they are 0.062 (standard error of 0.014) for Wave 1, and 0.094 (standard error of 0.012) for Wave 2.

[25] The *F*-test on excluded instruments is 135.43 in Wave 1 (401.12 the Anderson canononical correlation LR statistic) and 230.75 (679.19) in Wave 2.

Table 3
Wealth regressions.

	OLS	IV	OLS	IV
Wave 1				
Age	−0.004*	0.001	0.001	0.004*
	(0.001)	(0.002)	(0.001)	(0.002)
Female	0.015	0.112**	0.019	0.091**
	(0.025)	(0.034)	(0.025)	(0.034)
Single	−0.833***	−0.814***	−0.682***	−0.676***
	(0.033)	(0.034)	(0.033)	(0.034)
Family size	0.035*	0.043**	0.003	0.011
	(0.015)	(0.016)	(0.015)	(0.016)
High school	0.334***	0.202***	0.242***	0.151***
	(0.031)	(0.044)	(0.030)	(0.042)
College	0.691***	0.486***	0.490***	0.352***
	(0.035)	(0.061)	(0.035)	(0.056)
Φ_t	0.128***	0.395***	0.090***	0.294***
	(0.013)	(0.065)	(0.013)	(0.066)
Health status			0.132***	0.108***
			(0.012)	(0.015)
Log income			0.307***	0.292***
			(0.014)	(0.015)
Anderson canon. corr. LR statistic		581.215		548.810
N	14,631	14,631	14,555	14,555
Wave 2				
Age	−0.005***	0.002	−0.002	0.003*
	(0.001)	(0.002)	(0.001)	(0.002)
Female	0.045*	0.164***	0.047*	0.148***
	(0.021)	(0.028)	(0.021)	(0.027)
Single	−0.801***	−0.767***	−0.694***	−0.673***
	(0.029)	(0.030)	(0.029)	(0.030)
Family size	0.034*	0.048***	0.020	0.034*
	(0.014)	(0.014)	(0.013)	(0.014)
High school	0.349***	0.198***	0.280***	0.159***
	(0.026)	(0.035)	(0.026)	(0.033)
College	0.715***	0.472***	0.564***	0.374***
	(0.029)	(0.047)	(0.030)	(0.044)
Φ_t	0.145***	0.478***	0.112***	0.409***
	(0.010)	(0.050)	(0.010)	(0.051)
Health status			0.135***	0.096***
			(0.010)	(0.012)
Log income			0.219***	0.203***
			(0.011)	(0.011)
Anderson canon. corr. LR statistic		841.281		791.315
N	18,332	18,332	18,141	18,141

Note: All regressions include a full set of country dummies. Wave 1 refers to 2003 and Wave 2 to 2006.
* 5% Significantly different from zero.
** 1%, Significantly different from zero.
*** 0.1% Significantly different from zero.

the microeconomic data, we estimate two equations. The first equation links a measure financial literacy of the country's labor force (Φ_t) with an indicator of the level of literacy at school age (Φ_0). The second equation relates the country's national saving rate to Φ_t.[26]

To measure Φ_t we use an indicator available in the IMD World Competitiveness Yearbook (WCY) for the years 1995–2008. The indicator is computed from a survey of senior business leaders who represent a cross-section of the business community in several countries.[27] 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 1 year is available, it is averaged across 1995–2008 (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, US, New Zealand, Norway, Canada, Switzerland, Australia). Jappelli (2010) relies on the same indicator of financial literacy to document the substantial heterogeneity of financial literacy across countries, and that human capital variables (PISA test scores and college attendance) are strongly and positively correlated with financial literacy. The 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.

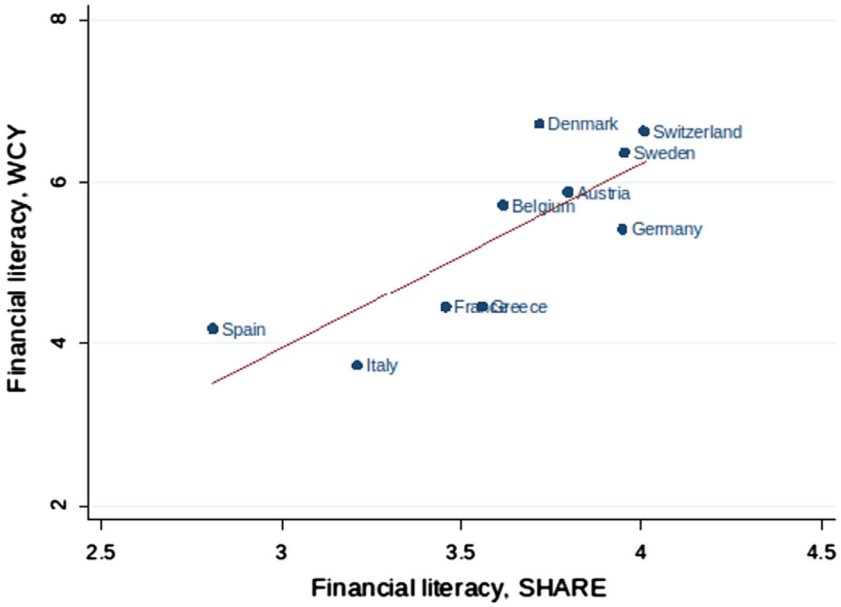
To assess the reliability of the WCY indicator, Fig. 3 compares it with the SHARE indicator of financial literacy used in Section 4. The figure shows that the two variables are strongly positively correlated (the correlation coefficient is 0.79). In both surveys, Italy and Spain score lowest, and Sweden, 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. Fig. 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 to have mean zero and a standard deviation of 1.

In the international comparison, the most informative and reliable indicators of the level of literacy before the entry to the labor market are the PISA scores on 15-years old students, which are described, among others, by Hanushek and Woessmann (2008). The test scores are available for 1995, 2000, 2003, and 2006 for a maximum of 44 countries. In keeping with the analysis in Section 4, our measure of Φ_0 is the country's average PISA test score for mathematics.[28] Fig. 4 shows that there is a strong positive association between Φ_t (as measured by the WCY indicator) and Φ_0 (the PISA score in mathematical abilities). 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. Fig. 5 shows that national saving is positively associated with PISA test scores, and that the effect is potentially large. Indeed, in most countries where PISA scores are less than 400, national saving is less than 20% of GDP, while in most countries with PISA scores above 500 national saving exceeds 25 and even 30%.

[26] In the cross-country analysis we use national saving as our dependent variable because wealth data are hard to compare across countries. The reason for using national saving as the dependent variable (as opposed to private saving) is that national saving is measured as national income less total (private plus public) consumption, and 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.

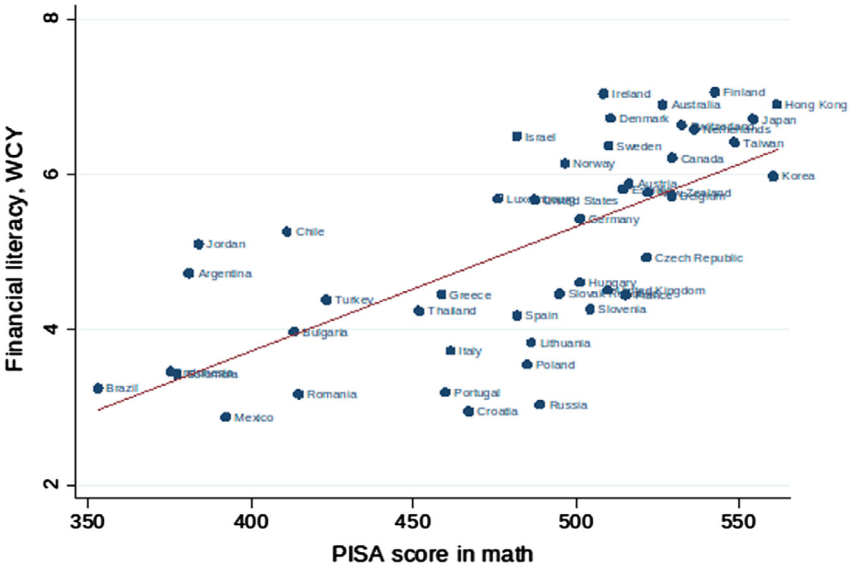
[27] The sample distribution of business leaders reflects a breakdown of industry by sectors (manufacturing, services, and primary). The sample size is proportional to each country's GDP. The survey questions are aimed at top and middle managers, nationals or expatriates, located in local and foreign 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 4000 business leaders in a maximum of 55 countries.

[28] PISA surveys are available for 27 countries in 1995, 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.



Note. Sources and variables' definitions are reported in Appendix C.

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

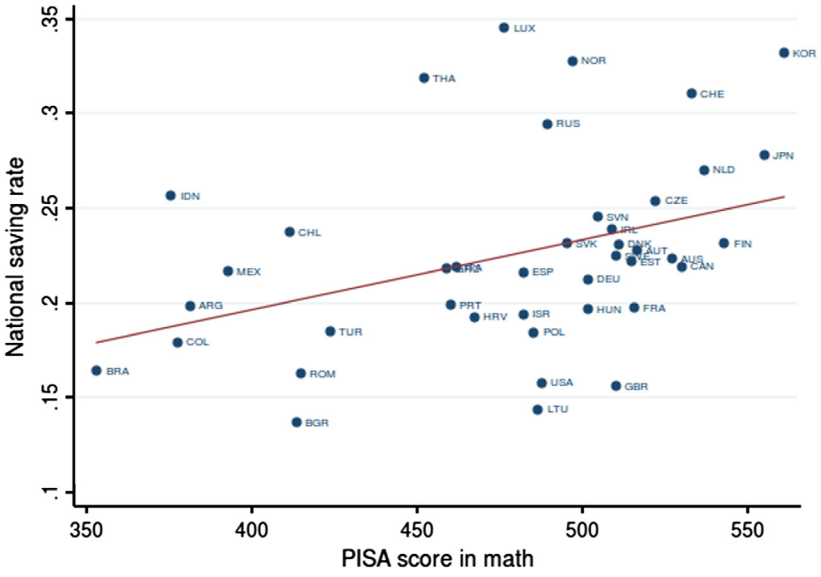


Note. Sources and variables' definitions are reported in Appendix C.

Fig. 4. PISA score in mathematics and financial literacy.

Since the correlations in Figs. 4 and 5 are driven also by other variables, in Table 4 we perform regression analysis, controlling also for other determinants of financial literacy and saving. The sample is a cross-section of 38 countries for which we have complete records of national saving and financial literacy. All variables are averaged over the 1994–2008 period. To ease interpretation of the coefficients, variables are standardized to have mean zero and standard deviation equal to one. Data sources and variables definitions are reported in Appendix C.

In column (1) of Table 4 we present *OLS* estimates of a regression of financial literacy (Φ_t) on the growth rate of GDP, the public sector saving rate, the old-age dependency ratio (defined as the ratio of those aged less than 15 or more than 65 years in the total population), an indicator of the generosity of the social security system (measured by the social security contribution rate) and the PISA math score (Φ_0). The regression shows that the PISA score is a very important determinant of international differences in financial literacy. The coefficient is positive, large and precisely estimated. 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 0.65 standard deviations. The negative coefficient of social security contributions implies that an increase in one standard deviation of contributions is associated with a reduction of 0.37



Note. Sources and variables' definitions are reported in Appendix C.

Fig. 5. National saving and financial literacy across countries.

Table 4
Regressions for financial literacy and national saving (cross-country data).

	Financial literacy		National saving rate	
	OLS	Robust	OLS	IV
Growth rate of GDP	0.053	0.057	−0.223	−0.234
	(0.133)	(0.144)	(0.154)	(0.147)
Public saving rate	−0.136	−0.126	0.580***	0.546***
	(0.123)	(0.134)	(0.145)	(0.138)
Dependency ratio	0.231	0.250	0.001	−0.074
	(0.122)	(0.132)	(0.141)	(0.136)
Total social security contributions	−0.373**	−0.371**	0.054	0.178
	(0.116)	(0.125)	(0.134)	(0.142)
Φ_0	0.653***	0.665***		
	(0.107)	(0.116)		
Φ_t			0.295*	0.592***
			(0.134)	(0.178)
Andreson canon. corr. LR statistic				29.311
N	38	38	42	38

Note: Robust regressions are obtained using an M-estimator with Huber weighting.
* 5% Significantly different from zero.
** 1% Significantly different from zero.
*** 0.1% Significantly different from zero.

standard deviations of literacy. Both findings agree with the predictions of our theoretical model. Since in a small sample the correlation between $\Phi_t$and Φ_0 might be affected by influential observations, we check the robustness of our results by using an M-estimator with Huber weighting. The results are shown in column (2), and confirm the evidence of column (1).[29]

The other columns of Table 4 report OLS and IV estimates of the saving regression. The coefficient of Φ_t is positive and substantially higher in the IV regression (0.59). This shows that the OLS coefficient (0.29) is downward biased, as was found in the microdata. The IV regression implies that an increase of one standard deviation in PISA scores is associated with an increase in 0.39 standard deviations of national saving (equivalent to just below 2% points). Furthermore, an increase of one standard deviation of government saving is associated with an increase of 0.55 standard deviations of 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. The coefficient of social security contributions is negative as expected, but not statistically different from zero.

To check the robustness of the results, we include in the regressions additional variables that might potentially affect national saving: the real interest rate (measured as the difference between the nominal interest rate on government bills and the actual inflation rate), log income per-capita, the Gini coefficient of income inequality and continental dummies. In these extended regressions, the coefficients of the financial literacy and national saving regressions for are hardly affected.

[29] We also check the residuals of the regression to single out potential outliers. Three observations (Estonia, Ireland and Russia) have relatively high values of the Cook's Distance (0.16, 0.13 and 0.30, respectively). Dropping these three observations does not affect the results.

6. 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 costs and benefits. In this paper we consider financial literacy as a particular form of human capital accumulation and recognize the potential role of mathematical ability early in life in determining future trajectories of financial literacy. We posit 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 propose an 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 decision to acquire financial literacy depends on the same factors affecting the saving decisions over the life-cycle. The model clarifies that financial literacy and wealth are endogenous variables, and that the two variables are positively correlated over the life-cycle. The model guides our estimation strategy, which relates measures of the stock of peoples' mathematical skills before entering the labor market to financial literacy and wealth later in life. Our approach differs from the one taken by the literature, which focuses on the contemporaneous relation between literacy and wealth.

We validate our theoretical model with microeconomic and aggregate cross-country data. We merge 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 and wealth are strongly correlated with a measure of mathematical skills at school age available in SHARELIFE. We also find that OLS underestimates the effect of current financial literacy on wealth, and propose an IV approach to address the endogeneity bias. We treat the aggregate data in a similar way and find that PISA scores in mathematics are strongly correlated with country-wide indicators of financial literacy supplied by business leaders as well as national saving. Furthermore, countries with more generous social security systems feature lower levels of financial literacy. As in the microdata, OLS estimates tend to underestimate the correlation between national saving and literacy.

Overall, our evidence singles out two important determinants of financial literacy. The microeconomic and aggregate data evidence show that improving mathematical skills early in life will eventually raise households' financial literacy and wealth accumulation. The international comparison suggests that reforms associated with financial market deepening (for instance the creation of private pension funds), by raising the incentive to invest in financial literacy, might lead also to higher financial literacy and saving.

Acknowledgments

We thank seminar participants at the 2011 NBER Summer Institute Workshop on Aggregate Implications of Microeoconomic Behavior (Cambridge, 16–21 July 2011), Third Danish Microeconometric Network Meeting (Copenhagen, 22–24 June 2011), NBER Household Finance Workshop (Cambridge, 22 July 2011), University of Padua, University of Konstanz and 7th CSEF-IGIER Symposium on Economics and Institutions (Capri, 27 June–1 July 2011), University of Birmingham, University of St. Gallen, and University of Frankfurt for helpful comments. We also thank Chris Carroll, Stephan Meier, Franco Peracchi, Luigi Pistaferri, Nick Souleles, Guglielmo Weber and Steve Zeldes for valuable suggestions. Errors are our own

Appendix A. The multiperiod model

This appendix provides the first order conditions for 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:

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

where

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

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

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

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

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

$$V_t^1(A_t, \Phi_t) = \beta \Phi_{t+1}^{\alpha} V_{t+1}^1(A_{t+1}, \Phi_{t+1}) \tag{A.3}$$

and:

$$V_t^2(A_t, \Phi_t) = \alpha\beta\Phi_{t+1}^{\alpha-1}(1-\delta)s_t V_{t+1}^1(A_{t+1}, \Phi_{t+1}) + \beta(1 - \delta)V_{t+1}^2(A_{t+1}, \Phi_{t+1}) \tag{A.4}$$

Solving Eq. (A.2) with respect to $V_{t+1}^2(A_{t+1}, \Phi_{t+1})$, using Eq. (A.3) and substituting in Eq. (A.4) one obtains:

$$V_t^2(A_t, \Phi_t) = p(1-\delta)V_t^1(A_t, \Phi_t) \tag{A.5}$$

Using Eq. (A.5) to rewrite Eq. (A.2) one obtains:

$$\left(\alpha \frac{s_t}{\Phi_{t+1}} - p \right) \Phi_{t+1}^{\alpha} + p(1-\delta) = 0 \tag{A.6}$$

Appendix B. Endogeneity bias and measurement error

This Appendix shows that the OLS coefficients of the wealth regression are biased. To evaluate the bias, consider that our model relates wealth to the level of literacy before individuals enter the labor market, while the empirical literature focuses on the relation between indicators of *current* financial literacy and wealth. The most common approach taken by the literature is to estimate the following equation:

$$a_t = \pi_0 + \pi_1 \Phi_t + x_t' \pi_2 + \widetilde{\varepsilon}_t^a \tag{B.1}$$

where a_t is wealth (or saving), Φ_t is the current stock of financial literacy, x_t a set of demographic and economic variables, and $\widetilde{\varepsilon}_t^a$ is an error term. In the regression above, π_1 is often interpreted as the

causal impact of literacy on wealth. To assess the validity of this statement, recall from Section 3, that Φ_t is itself a choice variable, and that it depends on Φ_0 according to:

$$\Phi_t = \gamma_0 + \gamma_1 \Phi_0 + x_t' \gamma_2 + \varepsilon_t^{\Phi} \tag{B.2}$$

where ε_t^{Φ} is orthogonal to Φ_0 and x_t, and therefore reflects variation in financial literacy investment not accounted by Φ_0 or x_t. It is immediate to verify that if $\tilde{\varepsilon}_t^a$ and ε_t^{Φ} are correlated, OLS estimation of Eq. (B.1) does not deliver consistent estimates of π_1. In fact, assuming for simplicity that $\pi_2 = \gamma_2 = 0$, the relation between the OLS estimate and π_1 is:

$$\operatorname*{plim}_{n\to\infty} \hat{\pi}_1 = \pi_1 + \frac{Cov(\tilde{\varepsilon}_t^a, \varepsilon_t^{\Phi})}{Var(\Phi_t)}$$

where n is the sample size, $\hat{\pi}_1$ is the OLS estimator of π_1 and $Cov(\tilde{\varepsilon}_t^a, \varepsilon_t^{\Phi})$ may be positive or negative.

Section 3 offers various reasons for why $\tilde{\varepsilon}_t^a$ and ε_t^{Φ} might be correlated. There we show that a higher intertemporal elasticity of substitution, discount factor or income increase Φ_t as well as a_t; instead, a higher price or a lower return of literacy decrease Φ_t but increase a_t. To illustrate the source of the potential bias, suppose that the correlation between Φ_t and a_t is due only to heterogeneity in the intertemporal rate of substitution (σ). Projecting $\tilde{\varepsilon}_t^a$ and ε_t^{Φ} on σ we obtain:

$$\tilde{\varepsilon}_t^a = \theta_0 + \theta_1 \sigma + u$$
$$\varepsilon_t^{\Phi} = \lambda_0 + \lambda_1 \sigma + v$$

where u and v are orthogonal to σ, $Cov(u, v) = 0$ and θ_1 and λ_1 are positive, as discussed in Section 3, implying $Cov(\tilde{\varepsilon}_t^a, \varepsilon_t^{\Phi}) > 0$. But in slightly more general contexts the sign of the covariance (and therefore the asymptotic bias) is ambiguous. For instance, assume that there is unobserved heterogeneity in both σ and the price of literacy (p):

$$\tilde{\varepsilon}_t^a = \theta_0 + \theta_1 \sigma + \theta_2 p + u$$
$$\varepsilon_t^{\Phi} = \lambda_0 + \lambda_1 \sigma + \lambda_2 p + v$$

where, as before, u and v are orthogonal to σ and p, and $Cov(u, v) = 0$. The comparative statics analysis in Section 3 shows that θ_1, θ_2 and λ_1 are positive, while λ_2 is negative. Assuming that $Cov(\sigma, p) = 0$, the bias depends on the sign of:

$$Cov(\tilde{\varepsilon}_t^a, \varepsilon_t^{\Phi}) = \theta_1 \lambda_1 Var(\sigma) + \theta_2 \lambda_2 Var(p)$$

While the first term is positive, the second is negative because $\lambda_2 < 0$. Thus, according to our model the sign of the bias is theoretically ambiguous.

Another reason of concern is measurement error, because in the presence of measurement error OLS estimation does not produce consistent estimates. In particular, if Φ_t is imperfectly observed, measurement error affects $\tilde{\varepsilon}_t^a$ and ε_t^{Φ} in opposite directions, $Cov(\tilde{\varepsilon}_t^a, \varepsilon_t^{\Phi}) < 0$, and OLS underestimates π_1.

To summarize, in general OLS estimation of the effect of Φ_t on wealth is inadequate ($\hat{\pi}_1$ is biased). Theoretically, the bias is negative ($\operatorname{plim}_{n\to\infty} \hat{\pi}_1 < \pi_1$) if the errors are negatively correlated or if Φ_t is measured with error, and positive otherwise. We quantify the bias empirically with microeconomic and cross-country data. We know that even if Φ_t in Eq. (B.1) is endogenous, π_1 can be consistently estimated using Φ_0 as instrument for Φ_t . In fact, Φ_0 is correlated with Φ_t, satisfying the rank condition for the validity of an instrument. Our additional, important assumption is that Φ_0 is not correlated with the error term of the wealth equation $\tilde{\varepsilon}_t^a$.

Appendix C. Data

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 Kennickell (1991).[30] All values are adjusted for differences in the purchasing power of money across countries using OECD purchasing power parity data.

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%, how many people out of 1000 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 6000 euro. This is two-thirds of what it costs new. How much did the car cost new? The possible answers are 9000, 4000, 8000, 12,000, 18,000 and another answer.
4. Let's say you have 2000 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 2420, 2020, 2040, 2100, 2200, 2400.

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.

C.3. Mathematical ability in SHARELIFE

SHARELIFE has a module on childhood that asks about living conditions, accommodation, and family structure. Additionally,

[30] 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.

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?

C.4. Financial literacy in the World Competitiveness Yearbook

The IMD WCY is a comprehensive annual report on the competitiveness of nations, available for 1995–2008. The WCY includes 329 variables on economic performance, government efficiency, 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 3960 responses from 57 countries.

C.5. Mathematical literacy in PISA

The OECD Programme for International Student Assessment (PISA – www.pisa.oecd.org) is a regular survey of 15-year old 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.

References

Ameriks, J., Caplin, A., Leahy, J., 2003. Wealth accumulation and the propensity to plan. The Quarterly Journal of Economics 118 (3), 1007–1047.

Angelini, V., Brugiavini, A., Weber, G., 2009. Ageing and unused capacity in Europe: Is there an early retirement trap? Economic Policy 24, 463–508.

Arrow, K.J., 1987. The demand for information and the distribution of income. Probability in the Engineering and Informational Sciences 1, 3–13.

Attanasio, O., Weber, G., 1993. Consumption growth, the interest rate and aggregation. Review of Economic Studies 60, 631–649.

Attanasio, O., Weber, G., 1995. Is consumption growth consistent with intertemporal optimization? Evidence from the consumer expenditure survey. Journal of Political Economy 103, 1121–1157.

Banks, J., O'Dea, C., Oldfield, Z., 2010. Cognitive function, numeracy and retirement saving trajectories. The Economic Journal 120 (548), F381–F410.

Banks, J., Oldfield, Z., 2007. Understanding pensions: cognitive function, numerical ability and retirement saving. Fiscal Studies 28 (2), 143–170.

Behrman, J.R., Mitchell, O.S., Soo, C., Bravo, D., 2010. Financial Literacy, Schooling, and Wealth Accumulation. NBER Working Papers 16452, National Bureau of Economic Research, Inc.

Calvet, L.E., Campbell, J.Y., Sodini, P., 2009. Measuring the financial sophistication of households. American Economic Review 99 (2), 393–398.

Card, D., 2001. Estimating the return to schooling: progress on some persistent econometric problems. Econometrica 69 (5), 1127–1160.

Christelis, D., 2008. Item Non-response in Share Wave 2. First Results from the Survey on Health, Aging and Retirement in Europe (2004–2007): Starting the Longitudinal Dimension.

Christelis, D., Jappelli, T., Padula, M., 2010. Cognitive abilities and portfolio choice. European Economic Review 54 (1), 18–38.

Christiansen, C., Joensen, J.S., Rangvid, J., 2008. Are economists more likely to hold stocks? Review of Finance 12 (3), 465–496.

Cole, S., Sampson, T., Zia, B., 2011. Prices or knowledge? What drives demand for financial services in emerging markets? The Journal of Finance 66 (6), 1933–1967.

Delavande, A., Rohwedder, S., Willis, R., 2008. Preparation for Retirement, Financial Literacy and Cognitive Resources. Working Papers wp190, University of Michigan, Michigan Retirement Research Center.

Dewey, M.E., Prince, M.J., 2005. Cognitive function. In: Börsch-Supan, A., Brugiavini, A., Jürges, H., Mackenbach, J., Siegrist, J., Weber, G., (Eds.), Health, Aging and Retirement in Europe: First Results from the Survey of Health, Aging and Retirement in Europe. Mannheim: Mannheim Research Institute for the Economics of Aging (MEA), pp. 118–125.

Gerardi, K., Goette, L., Meier, S., 2010. Financial Literacy and Subprime Mortgage Delinquency: Evidence from A Survey Matched to Administrative Data. Working Paper 2010-10, Federal Reserve Bank of Atlanta.

Guiso, L., Jappelli, T., 2008. Financial Literacy and Portfolio Diversification. Tech. Rep., CSEF Working Paper 212.

Gustman, A.L., Steinmeier, T.L., Tabatabai, N., 2012. Financial knowledge and financial literacy at the household level. American Economic Review Papers and Proceedings 102, 309–313.

Hanushek, E.A., Woessmann, L., 2008. The role of cognitive skills in economic development. Journal of Economic Literature 46 (3), 607–668.

Hastings, J.S., Tejeda-Ashton, L., 2008. Financial Literacy, Information, and Demand Elasticity: Survey and Experimental Evidence from Mexico. NBER Working Paper 14538, National Bureau of Economic Research, Inc.

Herd, P., Holden, K., Su, Y.T., 2012. The links between early-life cognition and schooling and late-life financial knowledge. Journal of Consumer Affairs 46 (3), 411–435.

Jappelli, T., 2010. Economic literacy: an international comparison. The Economic Journal 120 (548), F429–F451.

Jappelli, T., Padula, M., 2013. Investment in Financial Literacy and Portfolio Choice, Mimeo, Center for Studies in Economics and Finance.

Kennickell, A.B., 1991. Imputation of the 1989 survey of consumer finances: stochastic relaxation and multiple imputation. In: ASA 1991 Proceedings of the Section on Survey Research Methods, pp. 1–10.

Klevmarken, A., 2005. Sample design. In: Börsch-Supan, A., Brugiavini, A., Jürges, H., Mackenbach, J., Siegrist, J., Weber, G., (Eds.), Health, Ageing and Retirement in Europe: First Results from the Survey of Health, Ageing and Retirement in Europe. Mannheim: Mannheim Research Institute for the Economics of Aging (MEA), p. 352.

Lusardi, A., Michaud, P.-C., Mitchell, O.S., 2013. Optimal Financial Knowledge and Wealth Inequality. NBER Working Paper 18669, National Bureau of Economic Research, Inc.

Lusardi, A., Mitchell, O.S., 2007. Baby boomer retirement security: the roles of planning, financial literacy, and housing wealth. Journal of Monetary Economics 54 (1), 205–224.

Lusardi, A., Mitchell, O.S., 2008. Planning and financial literacy: how do women fare? American Economic Review 98 (2), 413–417.

Lusardi, A., Mitchell, O.S., Curto, V., 2010. Financial literacy among the young. Journal of Consumer Affairs 44 (2), 358–380.

Mazzonna, F., Peracchi, F., 2012. Aging, cognitive abilities and retirement in Europe. European Economic Review 56 (152), 691–710.

McArdle, J.J., Smith, J.P., Willis, R., 2009. Cognition and Economic Outcomes in the Health and Retirement Survey. NBER Working Papers 15266, National Bureau of Economic Research, Inc.

Salthouse, T.A., 2009. When does age-related cognitive decline begin? Neurobiol Aging 30, 507–514.

Salthouse, T.A., 2010. Selective review of cognitive aging. Journal of the International Neuropsychological Society 16 (05), 754–760.

Schaie, K.W., 2005. Developmental Influences on Adult Intelligence: The Seattle Longitudinal Study. Oxford University Press, New York.

Stango, V., Zinman, J., 2009. Exponential growth bias and household finance. Journal of Finance 64 (6), 2807–2849.

van Rooij, M., Lusardi, A., Alessie, R., 2011a. Financial Literacy and Retirement Planning in the Netherlands. NBER Working Papers 17109, National Bureau of Economic Research, Inc.

van Rooij, M., Lusardi, A., Alessie, R., 2011b. Financial literacy and stock market participation. Journal of Financial Economics 101 (2), 449–472.

van Rooij, M., Lusardi, A., Alessie, R., 2012. Financial literacy, retirement planning, and household wealth. The Economic Journal 122 (560), 449–478.

Willis, R.J., 2009. Disentangling cognitive function and financial literacy: implications for financial retirement security research. Presented at the Conference on Financial Literacy in Times of Turmoiland Retirement Insecurity, Brookings Institution, Washington, DC, March 20, 2009.