The Distribution of Gains from Access to Stocks*

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Abstract

Recent market developments raise doubts regarding further spread of household stock market participation. We study, computationally and econometrically, net gains from access to stocks. A calibrated intertemporal model with income risk, participation costs, uncertain lifetime, and retirement uncovers often conflicting effects of demographic and market factors. Modern binary quantile regression techniques, applied to data from Surveys of Consumer Finances, show changing effects and investor profiles when moving from infra-marginal to marginal stockholders and to likely potential entrants. Findings indicate that economic downturns can have significant effects around the participation margin, through their influence on incomes, wealth, and employment. The role of education is found more limited than typically estimated, and confined to the low end of the gains distribution. Further expansion of the stockholder base is likely to pose challenges, in view of more limited finances and education, younger age, and significantly less willingness to assume financial risk by potential entrants.

JEL Classification: G11, E21.

Key Words: Portfolio choice, stock market participation, binary quantile regression.

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1 Introduction

Recent empirical studies have documented substantial increases in the proportion of households holding stocks, either directly or indirectly through mutual funds and retirement accounts.[1] This spread of 'equity culture' has been linked to investor euphoria in the 1990s and to supply-side developments such as privatization of public utilities, growth of the mutual fund industry with concomitant reductions in participation costs for investors,[2] as well as the demographic transition and consequent policies to promote individual retirement accounts. In the current decade, when about one in two US households already holds stocks and euphoria has been tempered by recession and stock market downturns, continued growth of the stockholder base cannot be taken for granted. Concerns are often voiced of a possible exodus by marginal stockholders who feel the pressure of the economic downturn. At the same time, there are continued efforts to attract new stockholders on the part of firms, brokers, and managers of mutual funds and other managed accounts. It thus becomes crucial to understand which factors gain or lose prominence in household stock market participation decisions and how the demographic composition of the most likely prospective entrants changes as stock market participation spreads. For example, products and strategies designed to attract highly educated, affluent households willing to undertake financial risk are likely to be much less effective when applied to households with fewer resources, limited ability to process financial information, and considerable skepticism regarding risky financial investments.

Stock market participation has received considerable attention in recent literature.[3] While it is typically regarded as based on expected gains from participation net of any participation costs, there has been hardly any systematic analysis of the distribution of net gains from access that could allow us to address the questions raised in the first paragraph. This paper first employs computational methods to shed light on the often conflicting roles of important determinants of such gains, in the context of a modern calibrated dynamic model of household portfolio choice with non-diversifiable income risk, finite horizon, uncertain length of life, and a retirement period. It then applies recently proposed quantile regression techniques for binary choice models to pooled US data from the 1995 and 1998 Surveys of Consumer Finances to estimate how the influence of determinants changes as the participation margin moves through the distribution of gains, and how the demographic characteristics of current marginal stockholders differ from those of the most likely future prospects for expansion of the stockholder base.

In the computational exercise, we focus on the role of education, financial resources, degree of risk aversion, age, and on two important features of the stock market environment, namely the size of the perceived equity premium and stock market volatility. In determining participation, households are assumed to set expected gains from having access to an additional asset against their perceived fixed cost of entry or participation in the market, which is unobservable and incorporates not only objective costs but also inertia, value of time, ignorance, misperceptions, etc. Existing literature has established that fixed costs are important for participation decisions.[4] In lieu of direct observation of actual or perceived fixed costs, existing literature estimates threshold cost levels sufficient to deter participation by optimizing households. Empirical estimates of such costs (Vissing-Jorgensen, 2002; Paiella, 2001), as well as estimates from infinite-horizon computational models (Haliassos and Michaelides, 2003) suggest that reasonably small costs could keep most households out of the stock market. Our analysis incorporates fixed costs of entry and participation in a finite-horizon model of portfolio choice with an explicit retirement period. We compute implied utility gains from stock market access over the life cycle that take participation costs into account, as well as their monetary equivalents that provide an upper bound to the amount of fixed entry costs that households would be willing to pay in order to gain access to the stock market. We then investigate how gains and implied costs are affected by the relevant factors, and we uncover some intriguing conflicting effects.

Existing econometric studies employ probit or logit estimation to show that richer households are not scaled-up versions of poorer households (Carroll, 2001) and that participation is influenced by education, risk aversion, and employment status, while the role of age, if any, is less clear and less consistent across countries.[5] Though useful, these techniques estimate the role of each factor on *mean* net gains, and they assume that it is the same for all households regardless of their position in the distribution of net gains. Our econometric findings in this paper, based on binary quantile regressions, suggest that there is considerable variation in the influence of each factor, depending on the position of the household in the distribution of net gains from access. When we use our estimates to assign households to different parts of the distribution of net gains based on their characteristics, we find that the most likely future entrants differ in important respects from those most likely to have been the marginal stockholders, most notably in their declared willingness to undertake financial risk. Such factors should not be ignored in designing financial products or marketing strategies for expanding the stockholder base.

In Section 2, we describe the model and the concept of gains, as well as the calibration of the model. Section 3 uses the calibrated model to derive the role of education, age, financial resources, and degree of risk aversion for the size of gains from stock market access. In Section 4, we describe the quantile regression approach that we follow in our econometric estimation. Section 5 describes the data and recent trends in stock market participation in the United States. Section 6 reports our empirical findings on coefficient estimates and on the implied demographics of households at different points in the distribution of gains from stock market access. Section 7 concludes.

2 Gains from Access to Stocks

2.1 Definition of Gains

We model finite-horizon households that choose savings and portfolio share of the risky asset to maximize lifetime expected utility, taking as known and given asset return processes, income process, and any borrowing constraints and entry of participation costs they face. We compare two situations: one in which the household has access to the riskless asset but no access to stocks; and another in which the household has access to stocks, as well, and can choose whether and how much to hold, after payment of any participation costs. Gains from access to stocks at a point in the life cycle are defined as the difference in value functions of the two problems at that point in time and for the values of the state variable(s) faced by the household. Note that this specification of gains from stock market access is consistent with households not holding stocks when they do not find it optimal to do so. Although net gains are unobservable (a 'latent variable' in econometric specifications), and no analytical expression can be derived for them in the presence of non-diversifiable income risk, their dependence on state variables and on household characteristics can be studied by use of modern computational methods.

2.2 Value Function for a Household with Access to Stocks

We first consider a household with finite horizon but uncertain lifetime, that maximizes expected intertemporal utility faced with a menu of a risky and a riskless asset. The value of the household's problem in the first period of life, $t = 0$, is given by

$$V_0^S(X_0, P_0) = MAX_{\{C_t,\alpha_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{T-1} \beta^t \left(\prod_{j=1}^{t} \widehat{s}_j \right) U(C_t), \tag{1}$$

subject to

$$C_t + S_t + F_t \leq X_t \tag{2}$$

$$X_{t+1} = S_t \left[R_f + \alpha_t \left(\widetilde{R}_{t+1} - R_f \right) \right] + Y_{t+1} \tag{3}$$

$$C_t \geq 0 \tag{4}$$

$$0 \leq_t \alpha \leq 1 \tag{5}$$

All variables are in real terms. S_t is the real amount of total saving between the beginning of period t and of period $t+1$, α_t is the portfolio share of the risky asset held between t and $t+1$, E_t denotes the mathematical expectation operator based on information available up to the beginning of period t, β is the discount factor that satisfies $0 < \beta < 1$, $\widehat{s}_j$ is the probability that the household is alive in period j, conditional on being alive in period $j-1$. $U(C_t)$ is the felicity derived from consumption in period t, X_t is cash on hand at the beginning of period t,defined as the sum of net wealth and labor income, $\widetilde{R}_{t+1}$ is the risky gross return on stocks held between period t and $t+1$, R_f is the gross riskless rate assumed time-invariant, Y_t is income received at the beginning of t, and P_t refers to the permanent component of income, defined below. The term "income" is used loosely to encompass all after-tax income from transfers and wages, including pension income. $F_t \geq 0$ is the exogenous, fixed per period real cost of participating in the stock market. The nature of stock market access costs is discussed in Section 2.4. Note that V_0^S is a function of participation costs, but this dependence is omitted for brevity. The size of cash on hand at the beginning of life, X_0, is given.

The budget constraint (2) will hold with equality in equilibrium, given non-satiation. We employ a felicity function of the constant relative risk aversion (CRRA) form

$$U(C_t) = \frac{C_t^{1-\rho} - 1}{1-\rho}, \quad \rho \neq 1, \quad \rho > 0 \tag{6}$$

Constraint (4) is never binding under CRRA utility, since $\lim_{C_t \to 0} U'(C_t) = \infty$.

Denote by $\widehat{\beta}$ the product of the discount factor with the conditional probability that the household will be alive next period, $\beta \widehat{s}_{t+1}$. First order conditions for control variable θ_t are given by:

$$U'(C_t) \frac{\partial C_t}{\partial \theta_t} + \widehat{\beta} E_t U'(C_{t+1}) \frac{\partial C_{t+1}}{\partial \theta_t} = 0 \tag{7}$$

where θ is either S or α. Now,

$$C_{t+1} = \left[R_{t+1} + (\widetilde{R}_{t+1} - R_{t+1}) \alpha_t \right] S_t + Y_{t+1} - S_{t+1} - F_{t+1} \tag{8}$$

Thus, the first order condition for saving, $\theta_t \equiv S_t$, is

$$U'(X_t - S_t - F_t) = \widehat{\beta}\ E_t \left\{ \left[R_{t+1} + (\widetilde{R}_{t+1} - R_{t+1}) \alpha_t \right] U'(C_{t+1}) \right\} \tag{9}$$

and for the portfolio share of stocks, $\theta_t \equiv \alpha_t$, is

$$S_t\ E_t \left\{ \left(\widetilde{R}_{t+1} - R_{t+1} \right) U'(C_{t+1}) \right\} = 0. \tag{10}$$

In the presence of constraint (5), which precludes borrowing at the riskless or the risky rate, this formulation generates ranges of cash on hand in which it is optimal to hold no stocks. Intuitively, in such ranges, households may like to transfer consumption from the future to the present borrowing at the riskless rate. Being precluded from doing so, they may be willing to borrow even at the risky rate through short sales of stock. When short sales are not allowed, they end up at a corner with zero stockholding and no other saving.[6]

The value function in period t is $V_t^S(X_t, P_t)$, a function of household age, t, of total cash on hand in period t, X_t, and of the permanent component of income, P_t:

$$V_t^S(X_t, P_t) = \underset{S_t,\ \alpha_t}{MAX} U(C_t) + \widehat{\beta}\ E_t V_{t+1}^S(X_{t+1}, P_{t+1}). \tag{11}$$

Income of household i, Y_{it}, is assumed to entail non-diversifiable risk because of moral hazard and adverse selection considerations. Observed income follows

$$Y_{it} = P_{it} U_{it}, \tag{12}$$

where U_{it} is a transitory shock. During working life, the permanent component, P_{it}, follows

$$P_{it} = G_t P_{it-1} N_{it} \tag{13}$$

and is thus subject to shocks, N_{it}. During retirement it follows the deterministic process

$$P_{it} = G_t P_{it-1} \tag{14}$$

so that retirement income is only subject to transitory shocks. We assume that $\ln U_{it}$ and $\ln N_{it}$ are each independent and identically (normally) distributed with means $\{-.5 * \sigma_u^2\ ,\ -.5 * \sigma_n^2\}$, and variances σ_u^2 and σ_n^2, respectively. The lognormality of U_{it} and the assumption about the mean of its logarithm imply that

$$EU_{it} = \exp(-.5 * \sigma_u^2 + .5 * \sigma_u^2) = 1 \tag{15}$$

and similarly for EN_{it}. Thus, the permanent component of income is the value observed when transitory shocks are at their expected value. The growth factor, G_t, is assumed to be a function of household characteristics and is calibrated using empirical estimates for different education categories, distinguishing between working life and retirement (see below).

To reduce the number of state variables by one, we normalize asset holdings and cash on hand by the permanent component of labor income, P_{it}. Lower case letters denote normalized variables. To simplify notation, we drop the subscript i. Recalling that marginal utility is homogeneous of degree $(-\rho)$ under CRRA preferences, we can rewrite the first-order conditions (9) and (10) as

$$U'(x_t - s_t - f_t) = \widehat{\beta}\ E_t \left\{ (G_{t+1} N_{t+1})^{-\rho} \left[R_{t+1} + (\widetilde{R}_{t+1} - R_{t+1})\alpha_t \right] U'(c_{t+1}(x_{t+1})) \right\} \tag{16}$$

and

$$s_t\ E_t \left\{ (G_{t+1} N_{t+1})^{-\rho} \left(\widetilde{R}_{t+1} - R_{t+1} \right) U'(c_{t+1}(x_{t+1})) \right\} = 0 \tag{17}$$

where $c_{t+1}(x_{t+1})$ denotes the policy function for normalized consumption in period $t+1$. The normalized state variable x evolves according to

$$x_{t+1} = \left[R_{t+1} + (\widetilde{R}_{t+1} - R_{t+1})\alpha_t \right]\ s_t\ \ (G_{t+1} N_{t+1})^{-1} + U_{it+1} \tag{18}$$

Recalling that the value function is homogeneous of degree $(1-\rho)$ when felicity exhibits constant relative risk aversion, we can rewrite the Bellman equation for the problem with access to stocks as

$$V_t^S(x_t) = \underset{s_t(x_t),\ \alpha_t(x_t)}{MAX} U(c_t(x_t)) + \widehat{\beta}\ E_t\{G_{t+1}N_{t+1}\}^{1-\rho}\ V_t^S(x_{t+1}) \tag{19}$$

2.3 Value Function for a Household without Access to Stocks

If the household has no access to stocks, it chooses only the real amount of bonds to hold. The value of the household's problem in the first period of life is given by

$$V_0^B(X_0, P_0) = MAX_{\{B_t,\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{T-1} \beta^t \left(\prod_{j=1}^{t} \widehat{s}_j \right) U(C_t), \tag{20}$$

subject to

$$C_t + B_t \leq X_t \tag{21}$$

$$X_{t+1} = B_t R_f + Y_{t+1} \tag{22}$$

$$C_t \geq 0 \tag{23}$$

$$B_t \ \geq 0 \tag{24}$$

where B_t denotes saving in the (single) riskless asset, and notation is otherwise as above. Constraint (24) prevents borrowing at the riskless rate. Off corners, analytical first order conditions for saving are:

$$U'(C_t) = \widehat{\beta}\ R_f\ E_t U'(C_{t+1}) \tag{25}$$

which become upon normalization

$$U'(x_t - b_t) = \widehat{\beta}\ R_f\ E_t \left\{ (G_{t+1}N_{t+1})^{-\rho} U'(c_{t+1}(x_{t+1})) \right\}. \tag{26}$$

At low levels of cash on hand, households who want to borrow against expected higher future resources are prevented from doing so, and they end up consuming their cash on hand and holding zero assets.

The value function of the problem in period t is denoted by $V_t^B(X_t, P_t)$, and the relevant Bellman equation is

$$V_t^B(X_t, P_t) = \underset{B_t}{MAX} U(C_t) + \widehat{\beta}\ E_t V_{t+1}^B(X_{t+1}, P_{t+1}). \tag{27}$$

Normalizing all variables by P_t, we rewrite the Bellman equation for the value function of the problem without access to stocks as

$$V_t^B(x_t) = \underset{b_t(x_t)}{MAX} U(c_t) + \widehat{\beta}\ E_t \left\{ (G_{t+1}N_{t+1})^{1-\rho}\ \ V_t^B(x_{t+1}) \right\} \tag{28}$$

2.4 Gains from Stock Market Access and Participation Costs

As analytical solutions are not available for this class of models, we solve numerically the constrained portfolio and saving problems. We compute solutions in Matlab, using portfolio algorithms recently developed by Haliassos and Mavridis to exploit some clever computational shortcuts proposed by Carroll (2002) (see Appendix). We generate value functions $V_t^S(x_t)$ and $V_t^B(x_t)$ for each period in life t. Subtracting one from the other, we derive gains from stock market access in each period

$$DV_t(x_t) = V_t^S(x_t) - V_t^B(x_t) \tag{29}$$

as a function of normalized cash on hand and for given household characteristics (e.g., education level, age, risk aversion, etc.). By varying one household characteristic at a time, keeping others constant, we derive in Section 3 model predictions for the nature of effects of this characteristic on gains from access.

The existing theoretical and empirical literature on the stockholding puzzle has found that entry or participation costs can help account for observed stock market participation patterns at a point in time, over time, and across countries. In principle, one can distinguish three potentially relevant types of such costs: a fixed entry cost, a per period participation cost, and a transactions cost that depends on the volume of transactions. Vissing-Jorgensen (2002) has found little role for the third type of costs in explaining observed participation rates, but found support for the first two types of costs.

Our calibrated model incorporates both fixed entry costs and per period participation costs. Fixed entry costs can be thought of as the costs that a previously uninformed household pays in order to familiarize itself with stocks and stock-related financial assets (e.g., mutual funds, retirement accounts, etc.), and with the process of using them to smooth consumption intertemporally. Once these costs are paid, the household perceives stock-related assets as part of its asset menu and solves the portfolio allocation problem over its remaining horizon. Processing information necessary to figure out optimal holdings in each future period (or assigning professionals to do this) is assumed to entail a per period normalized participation cost f_s for $s \geq t$, that we incorporate in computation of V_t^S.[7]

Gains in the presence of any fixed (normalized) entry costs, $k(x_t)$, over and above the current per period participation cost are given by

$$D\widetilde{V}_t(x_t, k(x_t)) = V_t^S(x_t - k(x_t)) - V_t^B(x_t) \tag{30}$$

Their computation is complicated by the fact that entry costs, as these are *perceived* by households making the participation choice, are essentially unobservable and could vary significantly among households without any previous stock market experience. Rather than imposing some arbitrary $k(x_t)$ and plotting (30) for that choice, we prefer to plot gains in the absence of fixed entry costs using (29), and to solve for the $\widehat{k}(x_t)$ that makes (30) equal to zero. This $\widehat{k}(x_t)$ represents the horizontal difference between the value functions with and without stock market access, and it has two useful interpretations. One is as the monetary sum that should be taken away from a household with access to stocks in order to eliminate its gains from such access. In this sense, it is a dollar measure of how much stock market access is worth to a household with a particular set of characteristics. Clearly, a household would not be willing to pay a fixed entry cost in excess of this amount in order to gain access to stocks. Hence, its second interpretation is as the (minimum) fixed entry cost (beyond the participation cost f_t paid at the time of entry) that would deter a household of given characteristics from obtaining access to the stock market.[8]

2.5 Calibration

2.5.1 Income Processes

Income is defined as after-tax, non-asset income. It includes not only labor income, but also government transfers, bequests, and lump-sum windfalls. We distinguish between three education categories, based on the educational attainment of the household head: less than high-school education, high-school graduates, and college graduates (or more). Income processes consist of (deterministic) age-income profiles and of stochastic shocks. Income during working life is assumed to follow equation (12), and its permanent component is modeled as

$$P_{it} = G(t, Z_{it})\ P_{it-1} N_{it}, \tag{31}$$

where $G(t, Z_{it})$ denotes the growth factor of the permanent component of income derived from regressions of the logarithm of non-asset, after-tax income on age variables, separately on the number of head and spouse, number of dependent adults, and number of children, on cohort dummies (based on year of birth and split into five-year cohorts), and on the unemployment rate in the household's state of residence (as a proxy for time effects). The permanent component of income during retirement is assumed to take the form

$$P_{it} = G^R(t, Z_{it})\ P_{it-1}, \tag{32}$$

i.e. retirement income is assumed to be subject only to transitory shocks. Regressions for log income during working life allow for a third-order polynomial in age, while those for retirement assume a linear age term. Coefficient estimates are based on data from PSID 1983-1990 and are taken from Laibson et al. (2000, Tables 3 and 4). The retirement age for high-school dropouts is set to 61, for high-school graduates to 63, and for college graduates to 65, based on mean ages observed in the data. Estimated age income profiles are hump-shaped during working age for all education categories, but with different peaks prior to retirement.

Education groups also face differences in the process followed by income shocks. We employ the estimates of Carroll and Samwick (1997) regarding variances of transitory and permanent shocks, (σ_u^2, σ_n^2), for different education categories during working life.[9] For high-school dropouts, we use the Carroll-Samwick estimates for those who had completed between 9 and 12 grades: $(0.0658, 0.0214)$; for high-school graduates, we use $(0.0431, 0.0277)$; and for college graduates $(0.0385, 0.0146)$. These and other estimates in the literature suggest a decreasing pattern of risk associated with temporary earnings shocks as education increases. There is a less clear pattern with respect to the variance of permanent income shocks.

We follow Laibson et al. (2000) in modeling (logarithms of) shocks to retirement income as the sum of a household fixed effect and of a purely transitory shock:

$$u_{it}^R = \vartheta_i + \nu_{it}^R \tag{33}$$

They estimate the variance of ν^R using residuals from the income regressions during retirement years. Estimates of $\sigma^2_{\nu^R}$ for high-school dropouts, high-school graduates, and college graduates are, respectively, 0.077, 0.051, 0.042. In simulations, household fixed effects are set to zero.

2.5.2 Parameters

Conditional probabilities of survival are calculated from the 1998 United States Life Tables (National Vital Statistics Report, 2001). We set the rate of time preference, $\delta \equiv \beta^{-1} - 1$, equal to

0.05. The expected rate of return on equity, μ_r, is set to 0.06 in the benchmark runs, and the constant real interest rate, r, to 0.01. Understating the historical equity premium is an often used shortcut to introducing unaccounted for proportional costs, but we also consider higher values. The assumed standard deviation of the equity premium is set at its historical value of 18 percent in the benchmark, and raised to twice this level in sensitivity analysis. The benchmark value for risk aversion is $\rho = 2$, but we also consider values up to $\rho = 8$.

Perceived participation costs are unobservable. Vissing Jorgensen (2002) has estimated that per period costs of about 260 dollars (in 2000 prices) can account for the behavior of 75 percent of non-participants in the stock market. Paiella's (2001) estimates were not far from those. We use a real amount of 250 dollars, normalized by permanent income derived from the age income profile for each education category. Assuming the same real cost of participation across education categories is a useful benchmark, consistent with the notion that less educated households face bigger participation costs relative to permanent income. Still, it is conservative in the sense that low-education households may indeed face higher real costs than their more educated counterparts, leading to lower gains, both because they find it more costly to acquire and process such specialized financial information, and because they do not typically have access to the lower fees available to bigger investors.

3 Determinants of Gains from Stock Market Access

In this section, we study model predictions regarding the influence of household-specific variables as well as of stock market factors, namely the equity premium and its volatility, on gains from stock market access. We vary one factor at a time, holding all others constant, in order to isolate effects, and we differentiate between working life and retirement. We find that even these fairly stylized models uncover a rich pattern of often conflicting and sometimes surprising effects.

3.1 Effects of Education

A standard result in existing empirical literature based on probit or logit estimation is that education increases gains from stock market participation and hence the probability of participation. Usually, these findings are justified by reference to higher fixed entry and participation *costs* relative to, say, permanent income that are faced by less educated households. Higher costs can be attributed to greater difficulty in processing complicated financial information, reduced or costlier access to sources of information such as the internet, and more limited access to financial products and advisors because of the more limited scale of potential investments. The conflicting effect of higher opportunity cost of time for the more educated households is normally controlled for by allowing explicitly for household income.

Less attention is paid to the size of potential *gains* from access to stocks, often presumed to be lower for less educated households. Our results in this Section suggest that this latter presumption is not justified. This is because more educated households typically face lower variance of transitory shocks both in working life and in retirement, lower variances of permanent shocks, later retirement, and better prospects for income growth over their working lives. Age-income profiles by education are shown in Figure 1, and variances of income shocks were presented in Section 2.5.[10]

Figure 2 plots in the top panel predicted gains from stock market access net of participation costs (29) against normalized cash on hand for different education categories. The left column refers to working households at the age of 45, while the right refers to retirees aged 70. The four lower panels show policy functions from the portfolio model: the portfolio share of stocks, the real amounts of stocks, of the riskless asset, and of consumption, all plotted against normalized cash on hand. Controlling for normalized cash on hand and for other characteristics at age 45, high-school dropouts are found to gain most by having permanent access to stocks over their remaining lifetimes, while college graduates stand to gain the least. The ranking is reversed, however, among retirees aged 70 (shown on the right). Given more limited prospects for future income growth, working high-school dropouts have stronger incentives to save for the future. Because of higher income risk, they also have greater incentive to accumulate precautionary wealth. Indeed, the bottom row of Figure 2 confirms that optimal consumption is lower and optimal saving is higher for high-school dropouts that can afford to save than for college graduates, controlling for current cash on hand. By retirement age 70, however, participation costs are so large relative to planned stockholding for high-school dropouts with limited cash on hand, that it would not be optimal for them to gain access to the stock market (negative net gains).[11]

Note that these findings are produced by a model consistent with the basic intuition that low-education households should limit their exposure to stocks *relative* to the riskless asset. The second row of Figure 2 shows that portfolio shares of stocks should be lower during working life for the low-education households than for college graduates, as long as the borrowing constraint is not binding. The third and fourth rows show that the lower education categories should start to hold the riskless asset at lower levels of normalized cash on hand than college graduates, and put smaller amounts in stocks than college graduates if they have large amounts of cash on hand. Differences in policy functions are less pronounced over the retirement period than over the working period of life.

Figure 3 (top row) plots normalized monetary equivalents of gains from stock market access for the three education categories against normalized cash on hand. We find that high-school dropouts stand to gain more from access in proportion to their permanent income (between 1 and 1.5 times their permanent income component), compared to more educated counterparts.[12] Rankings are reversed by age 70, when the value of access is close to zero for the two more educated categories, and negative for the third, in view of participation costs. Figure 4 plots the same monetary equivalents but in a model with zero participation costs. We see that even small per period participation costs of 250 constant dollars are sufficient to essentially halve monetary equivalents at age 45, and to turn them negative for some retired 70-year olds, implying that they would not benefit from gaining stock market access at such a late stage in their lives.

All in all, results in this Section show that there are two conflicting effects of education on gains from stock market access: a negative one arising from the more limited need of more educated groups to save for the future; and a positive one resulting from lower participation costs relative to permanent income associated with higher educational attainment. The standard empirical finding in probit or logit regressions of a positive education effect on participation is, thus, consistent with the view that low-education households face significantly higher entry and participation costs than their more educated counterparts, sufficient to overturn the effects of income processes. We will see, however, that quantile regression questions the range of applicability of this standard result and limits it to households at the bottom of the distribution of gains from access.

3.2 Effects of Risk Aversion

Figure 5 plots predicted gains for college graduates under different degrees of risk aversion, ρ, of the felicity function, $U(C_t)$. The second row of Figures 3 and 4 presents monetary equivalents of gains, with and without participation costs, respectively. We find that, at working age 45 (left column), higher values of ρ are associated with larger gains from stock market access. At retirement age 70 (right column), differences are eliminated in all but the lowest range of cash on hand, where the ranking is actually reversed. Implied differences in monetary equivalents are small (of the order of 5,000 dollars), again about half of what they would be without participation costs.

Risk aversion affects gains through two conflicting channels. On the one hand, higher risk aversion discourages stockholding, *ceteris paribus*. Optimal (unconstrained) portfolio shares of stocks are lower at any level of normalized cash on hand (Fig. 5, second panel); it is optimal to start accumulating riskless assets at lower levels of normalized cash on hand; and to accumulate more at higher levels (fourth panel). On the other hand, greater risk aversion generates greater wealth holding. This is because it implies higher prudence (precautionary motive) and thus larger precautionary wealth accumulation under HARA utility functions, provided that $U''' > 0$. This is reflected at the bottom panel, where distances of the consumption policy function from the 45-degree line, representing wealth holding, widen as risk aversion increases.

As shown by the stockholding policy function (Fig. 5, row 3), aversion to the riskiness of stocks dominates at high levels of normalized cash on hand (above 2 or 2.5 times the permanent income component), and in most of the range where stockholding is positive during retirement. However, there is a wide range of cash on hand, where the precautionary saving effect dominates the risk effect during working years, and where it is optimal for higher risk aversion households to hold more stocks. This ranking is found even for the group of college graduates shown here, who tend to face smaller income risks and thus have more limited precautionary motives than the other two groups. It is also interesting that payment commitments in the form of per-period participation costs are not sufficient to reverse the dominance of the precautionary effect over the risk aversion effect. By the age of 70, precautionary motives are significantly reduced as a result of reduced future income risk (panel 5). Thus, not only portfolio shares but also amounts of stocks drop with risk aversion among savers. This produces the different rankings of gains during retirement compared to working life, as well as the result that highly risk averse retirees with low cash on hand should not obtain permanent access to the stock market (negative net gains).[13]

An important empirical implication of these findings is that higher risk aversion of the felicity function, ρ, is not necessarily associated with lower gains from stock market access nor with lower demand for stocks and more limited willingness to undertake stockholding risk in the presence of background income risk. Willingness to hold stocks is determined by risk aversion of the value function, which is not only a function of ρ but also of the other elements of the household's problem. Indeed, survey data usually elicit direct responses regarding willingness to undertake financial risk, and while they are often interpreted as referring to ρ, they may well be capturing risk aversion of the value function. Indeed, a systematically positive empirical relationship between survey responses and probability of stockholding would seem to support this latter interpretation.

3.3 Age Effects

Age effects on gains from access result from two main factors. First, as the household ages, fewer periods are left in which to benefit from making use of stocks and in which to pay the participation cost. Shifts in the stockholding policy function with age determine whether remaining years are high- or low-stockholding years compared to those that preceded them.[14] Second, since age effects are computed at given normalized cash on hand over time, gains computed at older ages incorporate revised expectations regarding future resources. The slope of future stockholding policy functions determines by how much expected future stockholding is revised as a result of this updating.

Figure 6 shows predicted age effects on gains for a household with less than high school education. The left column refers to working life, and the right one to retirement. Age effects are predicted to be generally negative and non-linear over the life cycle, for given levels of cash on hand and other characteristics.[15] Downward shifts of the gains schedule are bigger after the middle of working life (e.g., between 45 and 55), and much smaller during retirement. In the econometric part below, we will allow for a non-linear (quadratic) age effect. Figure 3 (third panel) shows additionally that monetary equivalents of gains from access to stocks can be quite sizeable early on in working life and they drop at an uneven pace during working life. Implied costs of postponing stock market access are estimated to be of the order of 2,000 dollars per year of delay between ages 25 and 35, but rise to 4,000 dollars between 35 and 55. Without per period participation costs, monetary equivalents would be about double (Fig. 4, third panel).[16]

Age effects on gains from access are small at the beginning of working life because stockholding tends to be limited early on and there are still many future periods of life left, over which to enjoy benefits from access to stocks. As working life continues, progressively more years of high stockholding lie behind and fewer ahead. Moreover, a given level of cash on hand implies progressively worse future prospects, and thus lower stockholding, as the household ages. Age effects are more substantial in the latter part of working life, for both reasons.

What underlies these effects can be seen in Fig. 6. The second row shows that unconstrained portfolio shares are predicted to fall with age,[17] though binding borrowing constraints preclude such drops over some range of normalized cash on hand.[18] The bottom panel shows increases in assets with age (downward shifts in consumption) for working savers. The net age effect on stockholding (third row) is positive in the range where borrowing constraints are binding, but clearly negative where they are not binding. During retirement, precautionary and other motives for saving weaken, and this generates downward shifts in stockholding. Thus, passage of time removes a significant portion of remaining lifetime over which the household is to enjoy benefits from stock market access. Moreover, since the household is only subject to transitory shocks with small variance during retirement, its future expectations of cash on hand tend to cluster around current levels, and future stockholding is expected to follow closely the drops of the stockholding schedule. Taken together with the per-period participation costs implied by continued access to the stock market, these factors generate negative gains from gaining access in retirement.

3.4 Equity Premium and Volatility

In this section, we derive effects on gains generated by different levels of the equity premium or its volatility, as perceived by the household. These results can help us understand year effects (1995 versus 1998) in latent net gains from stock market access found in the econometric section, albeit to an extent limited by our understanding of the stock market environment in those years. In comparing 1995 and 1998, perhaps the two most relevant features are the continuing increase in stockholding participation and the decline in participation costs throughout the 1990s (see Section 5). While the latter feature clearly increases net gains from stock market access, it has not been established empirically that the equity premium increased, despite the surge in stock market indices. The limited theoretical, general equilibrium literature on effects of stock market participation seems to imply negligible or negative but small effects on the equity premium.[19] There seems to be more empirical support for the idea that volatility increased, at least over the longer haul.[20] However, general equilibrium literature is still inconclusive regarding effects of increased participation on stock market volatility[21].

Not surprisingly, a reduction in the (perceived) equity premium exerts a negative effect on gains for a household contemplating entry. This is shown in Figure 7 that plots gains for expected equity returns of 6 and 12 percent for college graduates. Faced with a lower equity premium, the household tilts its portfolio away from stocks and towards the riskless asset (second to fourth panels), but it also increases consumption and reduces the amount of assets held (bottom panel) in view of the worse investment prospects. Qualitatively similar effects are observed for working life and retirement, though effects on gains are much smaller during retirement. Figure 3 (fourth panel) shows that a doubling of the equity premium increases considerably both the level and the slope of the monetary equivalent of gains plotted against cash on hand, but more so at working age 45. Figure 4 (fourth panel) presents the higher monetary equivalents for zero participation costs.

Effects of changes in (perceived) volatility are shown in Figure 8, where the benchmark standard deviation of the equity premium (18 percent) is doubled. Households value stock market access less, with the monetary equivalent of gains dropping by about 10,000 dollars at working age 45 (Fig. 3, fifth row). While the consumption rule remains largely unaffected (bottom panel of Figure 8), increased volatility causes a portfolio switch away from stocks and towards the riskless asset (second row). Households start holding the riskless asset at lower levels of normalized cash on hand, and they hold smaller stock amounts, except for low normalized cash on hand where they either do not save or they save little in stocks. Effects are qualitatively similar across working and retirement periods.

Results in this Section can also be put to a different use, namely to show effects that could arise from heterogeneous perceptions regarding the equity premium and its volatility among households. Indeed, Kezdi and Willis (2003) provide interesting preliminary evidence that heterogeneous expectations, in terms both of levels and of degree of precision, help predict stockholding participation.[22] We turn next to a description of the estimation approach we follow.

4 Econometric Approach

A study of the distribution of utility gains from stock market access is made possible by recent binary quantile regression techniques not previously applied to analysis of stock market participation. Existing analyses of stock market participation have relied on standard discrete choice models of the following general structure:

$$y^* = x'\beta + u \tag{34}$$

$$y = I\left(y^* \geq 0\right) \tag{35}$$

where y^* is a latent response variable (in this case, the utility gain from access to stocks net of entry or participation costs), y is a binary dependent variable observable by the researcher (participation or non-participation in the stock market), and x is a vector of covariates (typically household demographic characteristics, financial variables, and reported attitudes).

The usual maximum likelihood methods, probit and logit, allow estimation of the mean of the distribution of the latent variable y^* and of covariate effects on this mean alone. Thus, probit or logit estimation uncovers effects only on the average utility gain from access to stocks in the population, and it does not allow for differences of covariate effects among households at different points in the distribution, e.g. for marginal investors, for those most likely to be the next entrants, and those that stand to gain a lot or very little from stocks. Moreover, although parametric distributional assumptions on the error term u usually allow estimation of β by maximum likelihood methods, excessive use of such assumptions entails the risk of inconsistent estimation in case they are violated.

By contrast, quantile regression originally proposed by Koenker and Basset (1978, 1982) allows estimation, in principle, of all the percentiles of the distribution of the dependent variable, while its semiparametric nature greatly reduces the risk of inconsistent estimation. In particular, quantile regression can provide valid statistical inference in the presence of heterogeneity of unknown form. As a result, the quantile regression methodology offers a considerably enhanced picture of the effects of the conditioning variables x across the entire spectrum of net utility gains from access to stocks.

Formally, consider a particular percentile, $0 < \tau < 1$, of the distribution of the utility gains from access to stocks, y^*, and assume the following linear model for the conditional quantile function $Q_{y^*}(\tau|x)$:

$$Q_{y^*}(\tau|x) \equiv F_{y^*}^{-1}(\tau|x) = x'\beta(\tau) \tag{36}$$

The model for the τth percentile of the latent variable y^* can yield a model for the τth percentile of the binary observable variable y using the *equivariance* property of quantile functions to monotonic transformations: for any monotone function $h(\cdot)$, it holds that

$$Pr(Y < y|x) = Pr(h(Y) < h(y)|x). \tag{37}$$

Then it is easily shown that

$$Q_y(\tau|x) \equiv Q_{I(y^* \geq 0)}(\tau|x) = I\left(Q_{y^*}(\tau|x) \geq 0\right) \tag{38}$$

Thus

$$Q_y(\tau|x) = I\left(x'\beta(\tau) \geq 0\right) \tag{39}$$

is our proposed model for the τth percentile of the observable binary variable of stock market participation y.

Following the formulation of Koenker and Basset (1978), the Binary Quantile Regression (BQR) program is to find the estimate $b^*(\tau)$ for each chosen $0 < \tau < 1$ that solves

$$\min_{\{b:||b||=1\}} n^{-1} \sum_{i=1}^{n} \rho_\tau \left[y_i - I\left(x_i'b \geq 0\right)\right] \tag{40}$$

where $\rho_\tau(\nu) = [\tau - I(\nu < 0)]\,\nu$ is the *check function* of Koenker and Basset (1978). The estimator is normalized to have Euclidean norm equal to unity for purposes of identification. This problem and estimator were first studied by Manski (1975, 1985) under the name *maximum score estimator*. Manski proposed to find the estimate $b^*(\tau)$ that solves

$$\max_{\{b:||b||=1\}} n^{-1} \sum_{i=1}^{n} [y_i - (1-\tau)] I\left(x_i'b \geq 0\right). \tag{41}$$

Manski's estimator does not specify the form of relation between x and u; it only requires that the τth quantile of u conditional on x is zero. Based on this assumption, the model can be identified up to scale. A similar identification problem arises in the case of parametrically specified probit and logit. The fact that the error distribution in BQR is left unspecified forces us to place the identification restriction on the beta coefficients by normalizing their euclidean norm $\|b\| = 1$ (Manski, 1985).[23]

Manski (1985) has shown that his maximum score estimator of β is consistent under the identifying assumption $Q_u(\tau|x) = 0$. However, the estimator is not $n^{1/2}$-consistent and, asymptotic normality and subsequent statistical inference cannot be realized. Horowitz (1992) proposed a modification to the maximum score estimator by smoothing the objective function (called 'score function' in this literature). Horowitz (1992), utilizing ideas from nonparametric density and regression estimation, essentially replaces the indicator $I(x'b \geq 0)$ in the objective function by an integral of kernels. As a result, Horowitz's *smoothed maximum score estimator* solves a sufficiently smoothed objective function whose difference from Manski's objective function tends to 0 almost surely as $n \to \infty$.

Formally, the smoothed maximum score estimator $b^*(\tau)$ solves the program

$$\max_{\{b:||b||=1\}} n^{-1} \sum_{i=1}^{n} [y_i - (1-\tau)] K\left(x_i' b / \sigma_n\right), \tag{42}$$

where $\{\sigma_n\}$ is a sequence of positive real numbers (bandwidths) that converges to zero as $n \to \infty$. $K(\cdot)$ is a continuous bounded function that bears the properties of a cumulative distribution function; that is, *(i)* $|K(v)| < M$ for some finite M and all v in $(-\infty, \infty)$ and, *(ii)* $\lim_{v \to -\infty} K(v) = 0$, $\lim_{v \to \infty} K(v) = 1$.

The smoothed maximum score estimator was shown by Horowitz (1992) to be consistent and, after centering and suitable normalization, to be asymptotically normal. Its convergence rate is at least $n^{-2/5}$ and can become arbitrarily close to $n^{-1/2}$. Asymptotic normality allows statistical inference to be carried out in the usual way. However, the finite sample properties can be very different from the behavior claimed by asymptotic theory. In this paper we derive confidence intervals by use of bootstrap methodology. Experience with Monte Carlo experiments indicated that bootstrap can reduce substantially the difference between exact and nominal coverage levels. Equally important is the indication that bootstrap-based inference is not very sensitive to the selection of bandwidth parameter.[24]

Although the theoretical literature (Manski, 1975; Horowitz, 1992) usually concentrates on the median case, $\tau = 0.50$, extension to other quantiles is extremely useful when complete characterization of the distribution of the response variable is needed, as in our case, and essential for theoretical reasons as well (e.g. identification, efficiency, testing of various hypotheses). Kordas (2001) provides a useful treatment of these issues and calls this estimator *Smoothed Binary Quantile Regression* (SBQR).

Unlike probit and logit, binary quantile regression does not estimate probabilities directly. However, using the estimated coefficients for each quantile, we can characterize the probability of participation in the stock market for a given composition of covariates.

Since the assumed model for gains y^* is $Q_{y^*}(\tau|x) = x'\beta(\tau)$, we can use the basic definition of a quantile to write

$$\Pr(y^* \leq x'\beta(\tau)) = \tau \tag{43}$$

In view of (43), the following statements hold, conditional on the value of quantile index $x'\beta(\tau)$:

$$\left.\begin{array}{l} \Pr(y=1|x'\beta(\tau)>0) > (1-\tau) \\ \Pr(y=1|x'\beta(\tau)=0) = (1-\tau) \\ \Pr(y=1|x'\beta(\tau)<0) < (1-\tau) \end{array}\right\} \tag{44}$$

For given $\beta(\tau)$, the probability statements (44) show that the τth quantile model for y^* implies some relationships between observed data (y, x). Indeed, this was used by Manski (1985) for the identification of parameters $\beta(\tau)$.

We can use (44) to describe the characteristics of household groups belonging to each percentile of the distribution of gains y^*. For instance, it is of great interest to know the characteristics of the group of households estimated to be slightly above the threshold of stock market participation and how they compare to households slightly below the threshold. These two groups are most likely to be the marginal stockholders and future entrants in the stock market, respectively.

Our approach is as follows. Consider a particular household with value of the regressor vector x_0. In principle, we can compute predicted gains $x_0'\beta(\tau)$ for all $0 < \tau < 1$. If we find that for, say, $\tau = \tau_0$ $x_0'\beta(\tau_0) = 0$, then it follows from (44) that the household's probability of participating in the stock market is $(1 - \tau_0)$. By repeating this for all households in the sample, we can rank them in terms of participation probabilities that ultimately reflect their ranking in terms of net gains from access to stocks. In practice, estimates are not computed for all τ, but only for a subset of percentiles to limit computational costs. We obtain estimates for 19 equally spaced percentiles, from $\tau = 0.05$ to $\tau = 0.95$, at increments of 0.05. For each x, we find the τ that makes the predicted gains closest to 0 from below. Having thus assigned households to each of the τ for which we have coefficient estimates, we group them further into quartiles of the gains distribution. We derive the demographic characteristics of these quartiles, using population weights. We then compare them to those derived by ranking households according to their probabilities of participation implied by probit or logit estimates.

5 Portfolio Data and Participation Trends

We use pooled data from the most detailed sources on household portfolios, the United States Surveys of Consumer Finances (SCF) for 1995 and 1998. The SCF provides information on whether households hold stocks directly, on whether they hold stocks indirectly (e.g., through mutual funds or defined contribution pension funds), and on a range of demographic characteristics as well as on attitudes towards risk taking, borrowing, saving, etc. Although participation in direct stockholding by households can also be observed in some European countries, the US SCF allows a much more precise estimate of participation in indirect stockholding, since it also asks respondents whether their mutual funds invest in stocks.

Bertaut and Starr-McCluer (2001) provide a comprehensive account of stockholding trends. They report an overall (direct and indirect) stockholding participation rate among households of 48.9 percent in 1998, compared to 40.4 in 1995 and to only 31.6 in 1989. This big spread of equity culture cannot be traced to an increase in direct participation in stocks. Indeed, by 1998, direct participation in stockholding was at 19.2 percent, roughly where it was in 1983, bouncing back from 15.2 percent in 1995. By contrast, participation in indirect stockholding rose dramatically. Mutual fund ownership rose from 4.5 percent in 1983 to 12.3 percent in 1995, to 16.5 percent in 1998. The demographic transition to an aging population and the concomitant policy measures induced a move away from defined-benefit pension plans and towards defined-contribution plans. The share of households having a tax-deferred retirement account –either IRA or 401(k)-type– rose from about 31 percent in 1983 to about 48 percent in 1998.

These increases in participation were occurring at a time when stock returns were rising and costs of stock market participation were falling. The S&P 500 stock price index rose from 165 in 1983 to 600 in 1995 and to 1,100 in 1998. At the same time, the number of mutual funds rose from 564 in 1980 to 6,778 in 1998 (Investment Company Institute, 1998). Rea and Reid (1998) report figures for "total shareholder cost", that includes fund operating expenses plus distribution costs, expressed as a percentage of the amount invested in the fund. The sales-weighted average of such cost ratios for different equity funds was 2.25 in 1980, 2.17 in 1988, and only 1.49 by 1997.[25]

6 Econometric Results

We consider the choice to participate in the stock market either directly or indirectly, through mutual funds or retirement accounts. The latent variable in the econometric specification represents gains net of any entry or participation costs perceived by the household. We control for a number of household characteristics and for year effects, using the discussion of determinants of gains in Section 3 to interpret relevant findings. In presenting our results, we compare smoothed binary quantile regression estimates to those obtained from traditional probit and logit estimation.

6.1 Regressors

Household resources (cash on hand) are measured by the logarithms of financial assets and of total household income. We control for the education level of the household head by including a dummy variable for high-school dropouts and one for heads with college education or more. The omitted dummy is for high-school graduates. In Section 3, we found conflicting effects of education on gains from access net of participation costs.

We allow for a possibly non-linear effect of age on the latent variable by including a linear and a quadratic term in the age of the household head. Age was shown in subsection 3 to have sizeable effects on gains from stock market access. On the other hand, existing empirical evidence on the importance of age for participation has been mixed.[26]

Measuring risk aversion in Survey data is difficult.[27] The Survey of Consumer Finances tries to elicit information on willingness to undertake financial risk (such as stockholding risk) by asking households to put themselves in one of four categories, ranging from "not willing to take any financial risk" to "willing to take above average risk for above average expected return". Although such responses are typically interpreted as reflecting the underlying degree of risk aversion, ρ, in the felicity function $U(C)$, our results in Section 3 reinforce the view that it is more natural to interpret them as reflecting the willingness of households to undertake financial risk given their preferences, constraints, and stochastic processes faced by them, i.e. the risk aversion of the value function. We introduce a dummy variable identifying households that declare lack of willingness to undertake any financial risk.

We also control for whether the household head is non-white or Hispanic, is not working, and is self-employed. Table 1 presents some descriptive statistics for the included regressors and for some additional variables in our data set, distinguishing between the 1995 and 1998 samples.[28]

6.2 Standard Approaches: Probit and Logit

The standard approach to estimation of participation equations, namely probit or logit regression, provides a useful benchmark. Results from these two approaches (Table 2) are quite similar and consistent with the empirical literature cited in the Introduction.

Education is estimated to have positive and statistically significant effects on mean gains from access net of entry and participation costs, and hence on participation, as is typical in existing literature. Age is estimated to have a nonlinear, hump-shaped, effect on participation. Thus, controlling for other factors, probit and logit regressions imply that participation is most likely in the middle range of ages, somewhat less likely for the very young and considerably less likely for older households. Hump-shaped patterns of participation also appear in simple graphs of participation data in the US, though Guiso et al. (2003) have pointed out that this robustness of the hump-shaped age-participation pattern to econometric controls is not necessarily observed across European countries.

The dummy variable declaring lack of willingness to undertake financial risk exhibits statistically significant negative effects on participation in any kind of stockholding, controlling for other factors. Being more affluent, in terms of current income or financial assets, makes a household more likely to participate in stocks, consistent with intuition and with the computational model. Self employment actually reduces the probability of participation. It is possible that this is due to the small probabilities of income disasters that face the self-employed but are less likely to influence salaried employees. Similarly, not working reduces the likelihood that the household will decide to put money in the stock market. The race variable is typically negative and statistically significant in participation probits, controlling for incomes and wealth. It is hard to know what causes this effect that appears also in many other studies, but it may be due to the practice of the financial services industry in the US to target to a lesser extent minorities for activity related to the stock market.

The year dummy for the 1998 Survey relative to the 1995 Survey is positive and statistically significant, suggesting that conditions were overall more conducive to stock market participation at the end of the decade than in the middle. Combined with our computational results, the positive estimate suggests that adverse effects of increased overall participation on equity premia and volatility were either negligible or, at any rate, small relative to the beneficial effects of lower participation costs in mutual funds and in retirement accounts that were observed as the decade progressed.

6.3 Quantile Regression

6.3.1 Coefficient Estimates

As described in Section 4, an important advantage of quantile regression is that it gives information on the role of each variable at different percentiles, rather than information that applies only to the mean, of the distribution of gains conditional on covariates. Binary quantile regression estimates are plotted for each fifth percentile and regressor in Figures 9a and 9b. Probit estimates are plotted as a straight, dotted line, for comparison. The solid line in each panel is the zero line. The light- and dark-shaded areas represent the 90 percent and 95 percent confidence intervals, respectively. Confidence intervals were obtained by percentile bootstrap. In the range of percentiles for which the zero line lies within the chosen confidence interval, the coefficient estimates obtained by quantile regression methods are not statistically different from zero at the corresponding confidence level.

We find that income (Fig. 9b, LOGINC) has a statistically significant, positive, nonlinear effect virtually throughout the distribution of net gains from access to stocks. Estimated effects are larger between the 40th and 60th percentiles, suggesting that labor income has more powerful influence on stock market participation for investors with gains around the median than implied by standard probit estimates. Quantile regression point estimates are below probit estimates for most other income quantiles, excluding the two extremes.[29] These findings suggest that, ceteris paribus, income drops such as those often observed during a recession can have substantial downward effects on perceived net gains from stock market access among marginal investors on either side of the fence. Results for financial assets reinforce the possible role of economic downturns (Fig. 9b, LOGFIN). Financial assets have a consistently positive and significant effect on the net gain from stock market access regardless of the position in the distribution of gains. Indeed, for the most part (i.e., between the 30th and the 80th percentile), quantile regression estimates for financial assets are fairly constant and close to the probit estimate, though somewhat smaller.

Age has statistically significant, nonlinear effects on gains from access, virtually throughout the distribution of gains (Fig. 9a, AGE and AGESQ for the linear and quadratic age term, respectively). The linear age term is estimated to be positive, though statistically insignificant. The coefficient on the squared age term is negative and statistically

significant for all percentiles above the 40th. Figure 10 plots the age profile of net gains from stock market access for different percentiles using point estimates of coefficients of the linear and squared terms and setting the rest of the variables to their sample mean values. We observe that the age profile of net gains is concave and downward sloping at all percentiles, but also that the level and the curvature differ across percentiles in a way not captured by probit estimates. The level of the age profile is estimated to be higher than implied by probit around the middle of the distribution of gains, i.e. for households around the stockholding margin given other characteristics. It is estimated to be lower for those who stand to gain a lot from stock market access and much lower for those at the low end of the distribution of gains from access.

The importance of attitudes to risk found in standard regressions is confirmed by our findings (Fig. 9a, NORISK). The estimated coefficient is negative and statistically significant for virtually all percentiles. However, point estimates from quantile regressions suggest that this factor has bigger effects on gains perceived by households most likely to be contemplating entry (households between the 30th and 50th percentiles) than indicated by the probit estimate, though the probit estimate is within the confidence intervals for the quantile regression estimates in this range. Where quantile regression estimates are smaller in absolute value than the probit (and probit estimates lie outside the 90 and 95 percent confidence intervals) is for percentiles above the 60th. Thus, holding other factors constant, lack of willingness to undertake financial risk seems more important for gains perceived by households currently contemplating entry or exit than by those who stand to gain most from access to stocks. Adoption of a negative attitude to financial risk taking, as a result of a gloomy financial environment or media attention to investors who lost their fortunes, could have substantially bigger impact on households around the participation margin than on those at higher levels of the distribution of gains.

Strictly speaking, this result holds for changes in the attitude of a particular investor or group of investors not sufficient to alter the overall economic environment proxied by the 1998 year dummy. Fig. 9b (D1998) shows that, although regression quantile estimates for the 1998 dummy are consistently positive across quantiles, they are statistically significant only for low percentiles (up to the 35th) and marginally significant for households between the 40th and the 55th percentiles. This picture is quite different from the positive dummy coefficient estimate in probit regression. It implies that supply-side developments between 1995 and 1998, such as drops in participation costs and general euphoria about the stock market, were not sufficiently important to influence the participation decisions of those who stood to gain most from stock market access, but they may have influenced participation choices of stockholders with gains around the median. This suggests in turn that reversal of the overall positive climate to stockholding is unlikely to have major effects on participation of current stockholders, except insofar as it is reinforced by a worsening of their own household circumstances, such as income, wealth, attitude to financial risk taking or employment status. This last point is supported by our findings in Fig. 9a (NOTWORK), where significant negative effects are found for households above the 35th percentile.

The clear-cut role of education in standard probit and logit regressions is qualified by estimates based on quantile regression (Fig. 9b). Being college educated (COLL) is found to raise net gains from access to stocks, but the effect is seen to be statistically insignificant throughout the percentiles considered. Being a high-school dropout (LTHS) has a statistically insignificant effect on gains for many households, but those in the bottom thirty five percent of the distribution are found to be significantly discouraged by low educational attainment. This suggests that the negative probit estimate on low education may be due largely to the large negative effect of this factor on gains at the bottom part of the gains distribution. The tension between lower costs and more limited need for the equity premium uncovered in the computational section may be an important part of the explanation for these mixed findings on the role of education that should not be taken for granted across the distribution of gains.

Race and ethnic origin (Fig. 9a, NONWHITE) have negative effects, but statistically significant only for small potential investors up to the 25th percentile. The negative effect is marginally significant for those between the 30th and the 55th percentile. The fact that minority effects are not found to be significant at other points in the distribution suggests that the usual explanation for the negative race coefficient in probits, namely more limited targeting of minorities by the financial industry, may well be confined to those for whom stockholding is still a remote possibility, rather than to the marginal stockholders and those who stand to gain a lot from investing in stocks. Finally, households with self-employed heads (Fig. 9a, SELFEMP) tend to experience lower net gains from stock market access. Effects of self-employment are estimated to be bigger in absolute value for those around the margin and for those who stand to gain most from the stock market. This suggests that self-employment is likely to become progressively less important as a deterrent of participation as the stockholder base progressively expands. The next Section estimates the demographic composition and other relevant characteristics of households at different points in the distribution of gains, with emphasis on marginal stockholders and on most likely future entrants.

6.3.2 Demographics of Quartiles of the Gains Distribution

We follow the quantile-regression based approach described in Section 4 to classify households into percentiles of the distribution of gains from access to stocks, and we compute group demographics using population weights. Results are shown in Table 3.a where the top panel refers to 1995 and the bottom to 1998. The first column shows the population share of each group, and the second to the fifth columns show the corresponding shares in each quartile of the estimated gains distribution. Of particular interest are the two middle quartiles, as they are closest to the US participation margin of about 50%. The second quartile most likely includes the bulk of marginal investors, while the third includes those most likely to pass the participation threshold next. The top and bottom quartiles of the gains distribution can be used to gain more confidence in the results, insofar as they accord with intuition about the characteristics of those who stand to gain the most or the least from stock market access.

We find that demographics of the two extreme estimated quartiles are entirely consistent with established notions of who stands to gain the most and who the least from having access to the stock market. In 1995, the top quartile of the estimated gains distribution is comprised, almost exclusively, by the richest 50% of the population (in terms of financial assets or of income). Only 4 percent of the bottom quartile consists of those rich in financial assets and 19 percent of those who are income-rich. Households aged between 35 and 64 are overrepresented in the top quartile, compared to their population share, while this is true of the youngest and oldest ages in the bottom quartile. Minorities are underrepresented in the top and overrepresented in the bottom quartile of the distribution of gains. Non-working households and those reporting lack of willingness to undertake any financial risk are under-represented in the top quartile and seriously over-represented in the bottom. Representation of college graduates in the top quartile of gains is more than twice their population share, while in the bottom it is about one third. High school dropouts are absent from the top quartile, but they are seriously over-represented in the bottom. High-school graduates are under-represented in the top quartile, but their share of the bottom quartile is about as much as in the population. Results for 1998 are qualitatively similar and numerically quite close to those for 1995.

Comparison of the two intermediate quartiles can shed light on the obstacles that further spread of equity culture is likely to meet, in view of differences in the profile of new potential entrants compared to the set of potential investors that was available in the late 1980s and in the 1990s. Comparison of the third to the second quartile of gains shows that, in 1995, about half of the most likely future entrants had below-median financial assets and income, almost 90 percent belonged to the middle two quartiles of financial assets, and about two thirds to the middle two quartiles of income. This outlook changed little between 1995 and 1998, with the exception that in 1998 two thirds of likely entrants were in the middle two quartiles of income. The majority of likely future entrants were below 49 years old in 1995, dropping to 44 percent in 1998. Minorities were a slightly greater proportion of most likely future entrants than of marginal stockholders in 1995, but this was reversed in 1998. The employment status characteristics of likely future entrants were similar across 1995 and 1998, and quite similar to the pool of likely marginal stockholders.

Perhaps the most striking reversal occurs with respect to declared willingness to undertake financial risk. In 1998, almost two thirds of likely future entrants reported no willingness to undertake any financial risk, compared to only one quarter in the group that contains the likely marginal stockholders. Moreover, while the incidence of such responses dropped significantly in the population between 1995 and 1998, from 46 to 34 percent, it slightly increased among those most likely to be next in line for considering entry. Finally, the two lower education strata are more heavily represented among likely future entrants than among likely marginal stockholders, comprising three quarters in both years. This happens, despite a fall in their proportion in the 1998 population.

These findings can be compared to those based on probit and logit estimation that do not apply different estimated coefficients to households in different quantiles of the distribution of gains. Comparing Tables 3.b for probit and 3.c for logit, there is hardly any difference in the demographics of quartiles between these standard estimation methods. There are some differences with the demographics based on quantile regression (Table 3.a), but these occur mostly in the bottom two quartiles of gains and do not alter the general picture highlighted above.[30]

Whatever differences there are between quantile regression and standard methods result from small differences in classifying households to quartiles of the gains distribution. Recall that probit and logit apply the same set of coefficients to estimation of gains from access, regardless of the position of the household in the distribution of such gains, and this can can influence the ranking of households in terms of gains. A visual representation of differences is given in Fig. 11, which takes household groupings into quantiles derived from quantile regression estimates and computes for each quantile the weighted average of probabilities of participation implied by probit (or logit) estimates, using population weights. These are then compared to probabilities implied by quantile regression estimates. We see that, although predicted participation probabilities from all three methods are fairly consistent throughout the range of quantiles for which we have estimates, probit and logit average probabilities typically fall somewhat below those implied by quantile regression. The ranking between probit and logit average probabilities reverses as we go from those with more to those with less than fifty percent participation probability.

All in all, our findings in this section suggest that expansion of the stockholder base in the near future will have to face the challenges of more limited finances, younger ages, more limited education, and above all significantly less self-declared willingness to assume financial risk compared to marginal investors who have already passed the participation threshold.

7 Concluding Remarks

This paper has studied expected gains from access to stockholding opportunities net of entry or participation costs, the often conflicting effects of different factors in shaping gains, the potentially changing role of their determinants and the characteristics of household groups at different points in this distribution. We first solved a dynamic intertemporal model of household portfolio choice with non-diversifiable income risk, finite but uncertain lifetime, per-period participation costs in the stock market, and a retirement period. By solving variants with and without access to stockholding opportunities, we computed the difference in value functions attributable to stock market access, and showed the role of key determinants of gains from such access. We also computed monetary equivalents of gains from access, also interpretable as threshold fixed entry costs needed to discourage households of given characteristics from obtaining access. This exercise shed light on the channels through which demographics, attitudes, and stochastic processes exogenous to households influence gains from access, often in conflicting ways. We then applied modern binary quantile regression methods to pooled data from the 1995 and 1998 Surveys of Consumer Finances, and we contrasted our findings to those from standard probit and logit approaches that estimate determinants of mean gains from access and assume that these apply to all households regardless of their position in the gains distribution.

We found sizeable effects of financial resources (income and wealth) on gains from stock market access, and the importance of non-linear effects was confirmed in quantile regression. Estimated effects of income and financial assets, as well as switches to the status of not working are significant for marginal investors, suggesting that economic downturns could seriously affect participation decisions of households around the participation margin. We also found two conflicting effects of education on net gains: a positive effect from a reduction in participation costs for more educated households, but also a negative one from a reduced need to build up assets due to smaller variance of income shocks and steeper age-income profile. Although standard econometric techniques find strong positive effects of education on participation, quantile regression techniques suggest that strong effects are confined mainly to less than high-school education and to the bottom thirty percent of the distribution of gains.

The size of risk aversion of the felicity function was shown in the computational model to be quite distinct from willingness to engage in stockholding, due to a conflict between precautionary motives and determinants of the optimal portfolio mix. The data report willingness to undertake financial risk directly, and this is estimated to encourage participation, regardless of estimation method. Comparison of computational and econometric results reinforces the view that attitudinal responses in the SCF should be interpreted as statements about the risk aversion of the value function, that takes into account not only preferences but also constraints and processes facing the household. Worsening of attitudes to financial risk taking was shown to have significant discouragement effects on stock market participation. The computational model also confirmed that decreases in the equity premium and increases in stock market volatility reduce gains from stock market access. Comparing 1995 and 1998, we find econometrically that statistically significant positive year effects on gains are confined to the bottom end of the distribution.

All in all, our findings indicate that gains from stock market access have multiple determinants whose roles are often conflicting and not the same for households at different points in the gains distribution. It is difficult to avoid the conclusion that growth in stock market participation is likely to pose considerable challenges, in view not only of recessions and stock market downturns, but also of more limited finances, younger ages, more limited education, and above all significantly less self-declared willingness to assume financial risk by those most likely to consider entry compared to marginal investors who have already passed the participation threshold.

A Appendix: Numerical Dynamic Programming

In this Appendix, we describe briefly the algorithm Haliassos and Mavridis developed for solving finite-horizon portfolio choice models under short sales constraints. The corresponding single-asset saving models needed for computation of gains from stock market access were solved by converting into MATLAB Chris Carroll's Mathematica code described in Carroll (2002). Our MATLAB code for the portfolio model benefits from some of Carrol's proposed computational shortcuts for the saving model, but extends them to multi-asset models in a somewhat different direction from that proposed by Carroll, as described in this Appendix.

The policy functions for the portfolio model with two short sales constrains essentially contain three regions: a low range of normalized cash on hand in which both constraints are binding; an intermediate range in which the household faces a binding constraint that prevents it from borrowing at the riskless rate; and an open-ended range of normalized cash on hand in which

neither short sales constraint is binding. We handle these ranges in reverse order. We solve first for the penultimate period of life, $T-2$, and then go backwards in time.

A.1 Unconstrained Range

In this range of cash on hand, the FOC for the portfolio share in the second-to-last period of life, α_{T-2}, is

$$s_{T-2}\ E_{T-2}\left\{G_{T-1}^{-\rho}\left(\widetilde{R}_{T-1}-R_{T-1}\right)U'(x_{T-1})\right\}=0 \tag{45}$$

since the household consumes all cash on hand in the last period of life, $c_{T-2}=x_{T-2}$, and since there are no shocks to the permanent component of income during retirement ($N\equiv 1$). Using the transition equation for cash on hand, this can be written as

$$s_{T-2}\ E_{T-2}\left\{(G_{T-1})^{-\rho}\left(\widetilde{R}_{T-1}-R_{T-1}\right)U'\left(\left[R_{T-1}+\left(\widetilde{R}_{T-1}-R_{T-1}\right)\alpha_{T-2}\right]s_{T-2}\frac{1}{G_{T-1}}+U_{T-1}\right)\right\}=0 \tag{46}$$

Carroll's proposed computational shortcut is based on the observation that a FOC such as this is an equilibrium relationship between optimal choices (here α_{T-2} and s_{T-2}). Generalized to many controls, the approach is to specify a grid of possible optimal values for one control (here: savings values s_{T-2}^{i}, $i=1,...,n$) and find the corresponding optimal values for the remaining controls (portfolio shares), using grids for transitory income shocks, U_{T-1}, shocks to the permanent component of income, N_{T-1}, and stock returns, $\widetilde{R}_{T-1}$ obtained by discretizing their corresponding distributions. In our paper, we used 100 grid points for s, and 50 grid points for each of U, N, and $\widetilde{R}$. In Caroll's consumption-saving case with only one control, consumption can be found by mere evaluation of the FOC. When controls are more than one (as here), one can solve the FOCs using a non-linear solver.

The minimum admissible value in the savings grid is (slightly above) what would be required to produce zero consumption in the final period, c_T, under the worst possible configuration of income and stock return shocks, and no less than zero (since borrowing is not allowed):

$$s_{T-2}^{Min}\geq \max\left(\frac{-U_{T-1}^{Min}G_{T-1}\ N_{T-1}^{Max}}{\widetilde{R}_{T-1}^{Min}}+\varepsilon,0\right) \tag{47}$$

where ε is small. For each savings value in the grid, we use MATLAB's nonlinear equation solver to solve the FOC for the optimal portfolio share that would correspond to it. We thus come up with a set of pairs $(\alpha^i_{T-2}, s^i_{T-2})$. For the time being, we consider only the pairs that do not violate either short sales constraint, namely those that satisfy $0 < \alpha_{T-2}(s_{T-2}) < 1$. For such pairs, the FOC for saving

$$\begin{aligned} U'(c_{T-1}) &= \widehat{\beta}\ E_{T-2}\{(G_{T-1})^{-\rho}\left[R_{T-1} + (\widetilde{R}_{T-1} - R_{T-1})\alpha_{T-2}\right] \cdot \\ &\quad U'\left(\left[R_{T-1} + \left(\widetilde{R}_{T-1} - R_{T-1}\right)\alpha_{T-2}\right] s_{T-2}\frac{1}{G_{T-1}} + U_{T-1}\right)\} \end{aligned} \tag{48}$$

and the assumption of CRRA felicity allow evaluation of the corresponding optimal consumption level for each $(\alpha^i_{T-2}, s^i_{T-2})$:

$$\begin{aligned} c^i_{T-2} &= [\widehat{\beta}\ E_{T-2}\{(G_{T-1})^{-\rho}\, R_{T-1} + (\widetilde{R}_{T-1} - R_{T-1})\ \alpha^i_{T-2}] \cdot \\ &\quad U'\left(\left[R_{T-1} + \left(\widetilde{R}_{T-1} - R_{T-1}\right)\ \alpha^i_{T-2}\right]\ s^i_{T-2}\frac{1}{G_{T-1}} + U_{T-1}\right)\}]^{-\frac{1}{\rho}} \end{aligned} \tag{49}$$

This determines triplets of optimal consumption, savings, and portfolio shares $(c^i_{T-2},\ s^i_{T-2},\ \alpha^i_{T-2})$, from which the corresponding normalized cash on hand level can easily be computed by noting that $x^i_{T-2} = c^i_{T-2} +\ s^i_{T-2} +\ f_{T-2}$, where f denotes the fixed participation cost. Consumption, saving, and portfolio shares are thus mapped to the levels of normalized cash on hand for which they would be optimal. Policy rules $c_{T-2}(x_{T-2})$, $s_{T-2}(x_{T-2})$, and $\alpha_{T-2}(x_{T-2})$ for the range of normalized cash on hand where the short sales constraints are not binding are computed through (linear) interpolation between these points.

A.2 Binding Constraint on Borrowing at the Riskless Rate

In principle, there are two types of portfolio share-savings pairs that violate the borrowing constraints. One exhibits $\alpha^i_{T-2}(s^i_{T-2}) < 0$. This type is not relevant for our problem, as we are assuming zero correlation between stock returns and income shocks and it will not be optimal for households to short stocks in order to invest in the riskless asset. The second type, $\alpha^i_{T-2}(s^i_{T-2}) > 1$, is relevant and represents cases where the household would like to borrow at the riskless rate to invest in stocks. To solve for policy rules in this range, we first use the procedure described in the previous subsection to compute the normalized cash on hand that would correspond to each such pair in the absence of the borrowing constraint. This pinpoints the levels of normalized cash on hand for which constrained solutions should be sought.

Now, we know that constrained solutions involve saving (exclusively) in stocks and that the short sales constraint is not binding, unlike the borrowing constraint at the riskless rate. Thus the FOC for stocks is:

$$U'(x_{T-2} - s_{T-2}) = \widehat{\beta}\ E_{T-2}\left\{(G_{T-1})^{-\rho}\,\widetilde{R}_{T-1}\ U'\left(\widetilde{R}_{T-1}\ s_{T-2}\frac{1}{G_{T-1}} + U_{T-1}\right)\right\}.$$

Using MATLAB's nonlinear solver, we solve this FOC for the optimal saving (in stocks), s^i_{T-2}, that corresponds to the x^i_{T-2} computed in the previous step. This allows us also to compute consumption as $c^i_{T-2} = x^i_{T-2} -\ s^i_{T-2} -\ f_{T-2}$. Since the constrained portfolio share is 1, this completes the solution for the particular x^i_{T-2}. We can repeat this procedure for a number of levels of normalized cash on hand, but it is advisable to find first the lower limit of this constrained range. This is the minimum level of normalized cash on hand, x^*_{T-2}, for which the FOC for investment in stocks still holds, while the constraint on borrowing at the riskless rate is binding. Below this level, both constraints are binding.

To determine x^*_{T-2}, we use the FOC for investment in stocks, since households simply choose to hold no stocks (in the limit) as opposed to being prevented from short-selling stock:

$$U'(X^*_{T-2} - F_{T-2}) = \widehat{\beta} E_{T-2} \left\{ \widetilde{R}_{T-1} U'(Y_{T-1}) \right\}. \tag{50}$$

Upon normalization, this can be used to evaluate x^*_{T-2} as follows:

$$x^*_{T-2} = \left[\widehat{\beta} E_{T-2} \left\{ \widetilde{R}_{T-1} U'(G_{T-1} U_{T-1}) \right\} \right]^{-\frac{1}{\rho}} + f_{T-2} \tag{51}$$

A.3 Both Constraints Binding

In the range of low cash on hand up to x^*_{T-2}, the household ends up consuming its resources. This pinpoints the solution fully, as $c_{T-2} = x_{T-2} - f_{T-2}$, $s_{T-2} = 0$, and the portfolio share is strictly not defined for non-savers. The policy rule in this range can be plotted simply by drawing the 45-degree line between the point (x^*_{T-2}, x^*_{T-2}) and the origin (or, more strictly, point (U^{Min}, U^{Min}), since normalized cash on hand cannot follow below U^{Min} in this model). This extends a suggestion to this effect by Carroll for the saving model.

Thus, a complete solution for all three relevant ranges of normalized cash on hand has been derived for period $T-2$. Solutions for periods prior to this can be obtained recursively in a similar fashion, with one modification. Instead of imposing that $c_{t+1} = x_{t+1}$, which can be assumed for the entire range of normalized cash on hand only for $t = T-2$, we must use instead the policy function computed in the previous round, $c_{t+1}(x_{t+1})$, interpolating between points as needed. Value functions are then computed using the Bellman equation and the policy rules. Given that we need to compute differences between value functions from the portfolio and from the single-asset models, we adopt a relatively fine grid of 1000 points for evaluating (and comparing) value functions.

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Notes

[1]See Guiso, Haliassos, and Jappelli (2001a, b) and the contributions therein. Among them, Bertaut and Starr-McCluer (2001) focus especially on the US, and Carroll (2001) on portfolios of the rich in the US.

[2]For an excellent study of trends in the United States mutual fund industry, see Rea and Reid (1998).

[3]The starting point for this literature is the stockholding participation puzzle, based on the theoretical point made by Arrow (1974) that an expected utility maximizer will find it optimal to invest an amount ε in the asset with the expected return premium. Limited stockholding participation in the early to mid 1980s was documented in US data by King and Leape (1984), Mankiw and Zeldes (1991), and Haliassos and Bertaut (1995). The factors that determine whether participation occurs or not have been explored by a number of authors. See, for example, Haliassos and Bertaut (1995), Cocco, Gomes and Maenhout (1997), Heaton and Lucas (1997, 2000), Storesletten, Telmer, and Yaron (1998), Gollier (2001), Campbell and Viceira (2002), Haliassos and Michaelides (2003). International comparisons are to be found in Guiso, Haliassos, and Jappelli (2001b).

[4]On the potential role of participation costs, see Haliassos and Bertaut (1995), Luttmer, (1996), Vayanos (1998). Guiso, Haliassos and Jappelli (2003) utilize cross-country variation in participation rates in household-level data from 6 European countries and the US, and produce evidence in favor of a cost-based explanation of participation patterns internationally.

[5]See the contributions in Guiso et al., 2001a.

[6]For infinite-horizon examples of zero stockholding generated by short sales constraints, see Heaton and Lucas (1997) and Haliassos and Michaelides (2003). The classic paper in the single-asset saving literature that generated zero saving by use of a no-borrowing constraint is Deaton (1991).

[7]Although V_t^S is obviously a function of the assumed sequence of per period participation costs, $\{f_s\}_{s\geq t}$, we will drop this sequence from the list of arguments for notational simplicity.

[8]Note that our computations refer to gains, monetary equivalents, or threshold costs associated with maintaining access to (if not positive holding of) stocks until the end of life. While this allows for entry and exit from *holding* stocks, it does not cover the possibility that households who have gained access to the stock market subsequently decide to ignore the presence of stockholding opportunities altogether and resume solving the single-asset saving model. To allow for such voluntary restriction of the asset menu, one needs to solve a multiperiod model with per period participation costs paid only if the household maintains access. This task is even more challenging computationally than introduction of per period participation costs in the intertemporal portfolio model that we have pursued here, and has never been done to the best of our knowledge.

[9]Carroll (1992) estimates variances of idiosyncratic shocks for total US household population using data from the *Panel Study of Income Dynamics*, and finds 0.01 percent per year both for σ_u^2 and for σ_n^2.

[10]Education may also affect household preferences and constraints in various other, less observable ways, such as making them less averse to undertaking financial risk. The effects of risk aversion are discussed separately below.

[11]Of course, in the absence of per period participation costs, gains from stock market access cannot be negative, as the household always has the option not to hold any stocks. Indeed, in calibrations we performed abstracting from the per period participation cost, gains continue to be inversely related to education even at age 70.

[12]Note also that the curves depicting monetary equivalents start at higher levels of normalized cash on hand for high-school dropouts than for the other categories. For levels below the starting point of each of these curves, the household would be willing to borrow in order to pay the fixed entry cost to the stock market, but is unable to do so because of the borrowing constraints.

[13]Although a positive relationship between risk aversion and stockholding has also been found in infinite-horizon models, the age-variations uncovered by a model with finite lives and retirement periods are quite striking. For infinite-horizon models with this property, see Heaton and Lucas (1997) and Haliassos and Michaelides (2003).

[14]Less importantly, these remaining future periods are discounted less by the older household than when it was younger.

[15]An exception to negativity is shown in comparing gains at age 25 and 35. The cause for higher gains at age 35 is that during the period 25 to 35, stockholding is expected to be low relative to the participation cost, so committing early results in lower gains compared to gaining access later.

[16]Note that it is conceivable that fixed costs of entry also drop with age, as the household becomes more knowledgeable about its work and financial environment in the course of its working life and thus finds it easier to figure out how to begin investing in stocks.

[17]The reason for the portfolio shift away from stocks as the household ages is that it relies more heavily on its portfolio of accumulated assets and less heavily on its human wealth to finance future consumption. As a result, it becomes progressively less willing to invest a large portion of its wealth in the risky asset. (See also Cocco, Gomes, and Maenhout, 1999.) Interestingly, this model prediction is in accordance to the advice given to households by financial advisors, not necessarily with the same motivation.

[18]Thus, borrowing constraints may contribute towards explaining the absence of clear negative age effects on portfolio shares noted in empirical studies. See, for example, Guiso et al. (2003) and the country studies in Guiso et al. (2001a). Note that as other portfolio models in this class, the model implies high optimal portfolio shares of stocks for small investors. The rationale is that small investors rely mostly on their income and less on their portfolio to provide for future consumption and can thus afford to bear risk in order to take advantage of the equity premium. At any rate, this feature does not appear to yield implausibly large levels of predicted gains from stock market access.

[19]A class of general equilibrium models that compare steady states with limited stock market participation to those with full participation imply that asset returns are not likely to change much in response to more extensive participation (see Basak and Cuoco, 1998; Heaton and Lucas, 1999; Polkovnichenko, 2000). This is mainly because marginal stockholders tend to invest much less in stocks than incumbents, since marginal stockholders tend to exhibit higher risk aversion, more limited wealth and other characteristics that limit their demand for stocks. There are also models in which increased participation is associated with reductions in the equity premium (e.g., Peress, 2001; Calvet et al., 2001). However, differences in characteristics of newcomers relative to incumbents could even cause a rise in the premium, e.g. if marginal stockholders are on average more risk averse than incumbents.

[20]Campbell et al. (2001) find that the idiosyncratic volatility of single stocks in the United States has increased significantly over the past 30 years. Over the same time span, also the volatility of the price/earnings ratio of the Standard&Poor 500 index has increased (Herrera, 2001).

[21]New entrants increase market liquidity by bringing previously untapped funds into the stock market. In equilibrium, higher liquidity implies that sellers short of cash can more easily trade with buyers with excess cash. This tends to reduce market volatility (Pagano, 1989; Allen and Gale, 1994). Herrera (2001) points out that if new stockholders are more risk averse than previous stockholders, then their stock demand is less responsive to current stock prices and this can lead to higher price volatility. Peress (2002) points to two conflicting considerations. Although the entry of new investors spreads risks across a bigger pool and this enhanced risk sharing by itself tends to lower volatility, it also reduces incentives to acquire costly information, which exerts upward pressure on volatility. The net effect depends on the number of shareholders. Interestingly, if there is an exogenous reduction in the entry cost to the market for widely held stocks, then volatility increases, because new entrants do not purchase information and they also reduce the incentives of incumbents to purchase information.

[22]An intriguing further finding is that even differences in the degree of optimism about issues unrelated to the stock market are significant predictors of participation.

[23]The normalization that the coefficient of a regressor has absolute value equal to 1 is used by Horowitz (1992). It is assumed that this regressor has probability distribution conditional on the other regressors that is absolutely continuous with respect to the Lebesgue measure. The two normalizations are basically equivalent.

[24]See Horowitz (1998, 2002).

[25]Interestingly, the increasing pattern of direct and indirect participation has continued even beyond the end of the 1990s, despite the reversal in stock market performance. Aizcorbe et al. (2003) report a total stockholding participation rate of 51.9 percent in 2001, up by three whole percentage points compared to 1998. Direct participation rose to 21.3 versus 19.2 percent in 1998; mutual fund participation rose to 17.7 percent versus 16.5 percent in 1998; and participation in retirement accounts rose from 48.9 percent in 1998 to 52.2 percent in 2001.

[26]See the contributions in Guiso et al. (2001a).

[27]See, for example, Guiso and Paiella (2001) for an attempt to measure risk aversion by reference to a hypothetical lottery offered to respondents.

[28]Note that, in the computational model, access to the stock market does not necessarily imply positive stockholding. In survey data, we observe current stock market participation rather than access. Thus, we

implicitly identify those in the sample who held no stocks with households that did not pay the costs for stock market access because they perceived negative gains from such access. This is unwarranted for any households that paid the costs of figuring out whether they should invest in stocks but found it optimal not to do so. We doubt that such cases are quantitatively important in our sample, since we are focusing on a period of stock market euphoria and spreading equity culture, in which households that paid the costs of access to the stock market tended to include stocks in their portfolios.

[29]Probit estimates, however, typically lie within the confidence bands of quantile estimates, though this is not the case for the computed intervals below the 20th percentile.

[30]Quantile-regression-based demographics imply more limited representation of households with below-median financial assets among most likely entrants than probit/logit. They also imply more limited presence of very young households and of those not willing to undertake any financial risk in this category. As for the bottom quartile (least likely to gain from stock market access), SBQR-based demographics imply more limited presence of the poorest (in financial assets or income), of whites, and of those willing to take financial risk in 1995. In 1998, SBQR implies greater presence of minorities, of those not willing to take any risk, and of college graduates.

Variable	Description	Mean	Std. Dev.	25th	median	75th	95th
				Percentiles			
DSTOCKS	Indicator for holding stocks directly	0.15	0.01	0.00	0.00	0.00	1.00
STOCKS	Level of direct stock holding	15103.60	1336.47	0.00	0.00	0.00	21357.70
DEQUITY	Indicator for direct or indirect stock holding	0.40	0.01	0.00	0.00	1.00	1.00
EQUITY	Level of indirect stock holding	39442.98	2146.27	0.00	0.00	8543.08	128146.20
DINDHOL	Indicator for indirect stock holding	0.35	0.01	0.00	0.00	1.00	1.00
INDHOL	Level of indirect stock holding	24339.38	1477.63	0.00	0.00	5339.43	101449.08
NONWHITE	Indicator for being non-white or hispanic	0.22	0.01	0.00	0.00	0.00	1.00
NOTWORK	Indicator for not working	0.06	0.00	0.00	0.00	0.00	1.00
SELFEMP	Indicator for being self-employed	0.10	0.01	0.00	0.00	0.00	1.00
NORISK	Indicator for reporting refusal to undertake any financial risk	0.46	0.01	0.00	0.00	1.00	1.00
AGE	Age of household head	48.46	0.67	35.00	45.00	62.00	79.00
LTHS	Household head is a high-school dropout	0.19	0.01	0.00	0.00	0.00	1.00
COLL	Household head has college degree or more	0.31	0.01	0.00	0.00	1.00	1.00
LOGINC	Log of total income	10.18	0.11	9.71	10.40	10.91	11.68
LOGFIN	Log of financial assets	8.47	0.11	7.00	9.31	10.93	12.69

Variable	Description	Mean	Std. Dev.	25th	median	75th	95th
				Percentiles			
DSTOCKS	Indicator for holding stocks directly	0.19	0.01	0.00	0.00	0.00	1.00
STOCKS	Level of direct stock holding	30169.10	2126.25	0.00	0.00	0.00	60000.00
DEQUITY	Indicator for direct or indirect stock holding	0.48	0.01	0.00	0.00	1.00	1.00
EQUITY	Level of indirect stock holding	70738.62	3358.38	0.00	0.00	22000.00	234500.00
DINDHOL	Indicator for indirect stock holding	0.44	0.01	0.00	0.00	1.00	1.00
INDHOL	Level of indirect stock holding	40569.52	1986.29	0.00	0.00	14500.00	160150.00
NONWHITE	Indicator for being non-white or hispanic	0.18	0.01	0.00	0.00	0.00	1.00
NOTWORK	Indicator for not working	0.05	0.00	0.00	0.00	0.00	1.00
SELFEMP	Indicator for being self-employed	0.26	0.01	0.00	0.00	1.00	1.00
NORISK	Indicator for reporting refusal to undertake any financial risk	0.34	0.01	0.00	0.00	1.00	1.00
AGE	Age of household head	50.18	0.60	37.00	48.00	63.00	79.00
LTHS	Household head is a high-school dropout	0.13	0.01	0.00	0.00	0.00	1.00
COLL	Household head has college degree or more	0.44	0.01	0.00	0.00	1.00	1.00
LOGINC	Log of total income	10.89	0.12	10.00	10.76	11.66	14.00
LOGFIN	Log of financial assets	10.02	0.13	8.07	10.54	12.57	15.62

Table 1: Descriptive statistics for the 1995 (N=4299) and 1998 (N=1998) subsamples, computed using SCF survey weights.

	Probit Model			
Variable	Coefficient	Normalized Coef.	Std. Err	t-stat
Intercept	-0.0429		0.00196	-21.9
Household head is not white or Hispanic	-0.225	-0.229	0.0494	-4.56
Household head is not working	-0.497	-0.506	0.101	-4.92
Household head is self-employed	-0.468	-0.476	0.0459	-10.2
Not willing to take any financial risk	-0.481	-0.489	0.041	-11.7
Age of household head	0.0198	0.0202	0.00651	3.05
Age-squared	$-3.55e-4$	$-3.62e-4$	$6.08e-5$	-5.85
Less-than high-school education	-0.165	-0.168	0.0609	-2.71
College degree or more	0.1	0.102	0.0394	2.54
Log of total income	0.0669	0.0681	0.0137	4.89
Log of financial wealth	0.385	0.391	0.011	34.9
Dummy for 1998 survey	0.168	0.171	0.0356	4.73
	Logit Model			
Variable	Coefficient	Normalized Coef.	Std. Err	t-stat
Intercept	-0.076		0.0035	-21.7
Household head is not white or Hispanic	-0.369	-0.217	0.0858	-4.3
Household head is not working	-0.872	-0.513	0.179	-4.86
Household head is self-employed	-0.805	-0.474	0.0814	-9.89
Not willing to take any financial risk	-0.819	-0.482	0.0705	-11.6
Age of household head	0.0302	0.0178	0.0114	2.66
Age-squared	$-5.82e-4$	$-3.42e-4$	$1.07e-4$	-5.46
Less-than high-school education	-0.279	-0.165	0.106	-2.64
College degree or more	0.167	0.098	0.0687	2.42
Log of total income	0.126	0.0743	0.0242	5.2
Log of financial wealth	0.682	0.401	0.0203	33.5
Dummy for 1998 survey	0.288	0.17	0.0625	4.61

Table 2: Probit and Logit Results for Participation in Direct or Indirect Stockholding

		SBRQ Distribution of Gains			
Household Characteristic	1995 sample	(0%, 25%)	[25%,50%)	[50%,75%)	[75%,100%)
Lower 25% of financial assets		0.65	0.00	0.00	0.00
Between 25% and 50% of financial assets		0.31	0.50	0.24	0.00
Between 50% and 75% of financial assets		0.04	0.37	0.54	0.25
Upper 25% of financial assets		0.00	0.12	0.22	0.75
Lower 25% of income		0.49	0.18	0.04	0.01
Between 25% and 50% of income		0.32	0.37	0.20	0.07
Between 50% and 75% of income		0.16	0.30	0.45	0.25
Upper 25% of income		0.03	0.15	0.31	0.67
Of age less than 34	0.248	0.30	0.21	0.24	0.18
Age between 35 and 49	0.335	0.25	0.31	0.43	0.43
Age between 50 and 64	0.211	0.18	0.18	0.21	0.26
Age more than 65	0.206	0.27	0.31	0.12	0.13
Household head is not working	0.064	0.14	0.02	0.01	0.01
Household head is self-employed	0.102	0.10	0.10	0.10	0.11
Household head is an employee	0.834	0.76	0.88	0.89	0.88
Household head is white, non-hispanic	0.776	0.68	0.76	0.80	0.96
Non-white or hispanic	0.224	0.32	0.24	0.20	0.04
Willing to undertake financial risk	0.544	0.30	0.38	0.75	0.98
Not willing to undertake any financial risk	0.456	0.70	0.62	0.25	0.02
Less than high school education	0.186	0.35	0.16	0.09	0.00
High-school education	0.507	0.53	0.60	0.52	0.36
College degree or more	0.307	0.13	0.25	0.39	0.64

		SBRQ Distribution of Gains			
Household Characteristic	1998 sample	(0%, 25%)	[25%,50%)	[50%,75%)	[75%,100%)
Lower 25% of financial assets		0.68	0.00	0.00	0.00
Between 25% and 50% of financial assets		0.28	0.47	0.30	0.00
Between 50% and 75% of financial assets		0.04	0.40	0.47	0.28
Upper 25% of financial assets		0.00	0.13	0.23	0.72
Lower 25% of income		0.57	0.25	0.05	0.03
Between 25% and 50% of income		0.27	0.41	0.26	0.11
Between 50% and 75% of income		0.13	0.27	0.37	0.26
Upper 25% of income		0.03	0.08	0.32	0.60
Of age less than 34	0.233	0.31	0.19	0.24	0.15
Age between 35 and 49	0.334	0.26	0.25	0.39	0.43
Age between 50 and 64	0.230	0.17	0.20	0.24	0.27
Age more than 65	0.203	0.26	0.36	0.14	0.14
Household head is not working	0.051	0.12	0.02	0.01	0.02
Household head is self-employed	0.256	0.11	0.09	0.08	0.14
Household head is an employee	0.693	0.78	0.89	0.90	0.84
Household head is white, non-hispanic	0.824	0.64	0.78	0.74	0.95
Non-white or hispanic	0.176	0.36	0.22	0.26	0.05
Willing to undertake financial risk	0.659	0.33	0.36	0.75	0.97
Not willing to undertake any financial risk	0.341	0.67	0.64	0.25	0.03
Less than high school education	0.125	0.41	0.22	0.16	0.00
High-school education	0.432	0.46	0.54	0.53	0.39
College degree or more	0.443	0.13	0.23	0.32	0.61

Table 3a: Demographic composition of each quartile of the distribution of gains from stock market access. Quartiles were constructed using coefficient estimates from our binary regression quantiles, decomposed by 1995 (upper panel) and 1998 (lower panel) subsamples. For the method of construction, see text.

		Probit Distribution of Gains			
Household Characteristic	1995 sample	(0%, 25%)	[25%,50%)	[50%,75%)	[75%,100%)
Lower 25% of financial assets		0.81	0.13	0.00	0.00
Between 25% and 50% of financial assets		0.18	0.57	0.25	0.00
Between 50% and 75% of financial assets		0.01	0.25	0.52	0.25
Upper 25% of financial assets		0.00	0.04	0.23	0.75
Lower 25% of income		0.61	0.20	0.07	0.01
Between 25% and 50% of income		0.28	0.39	0.24	0.06
Between 50% and 75% of income		0.10	0.29	0.42	0.26
Upper 25% of income		0.01	0.12	0.27	0.67
Of age less than 34	0.248	0.28	0.27	0.25	0.17
Age between 35 and 49	0.335	0.24	0.31	0.38	0.45
Age between 50 and 64	0.211	0.17	0.18	0.20	0.26
Age more than 65	0.206	0.31	0.24	0.17	0.12
Household head is not working	0.064	0.15	0.06	0.01	0.01
Household head is self-employed	0.102	0.09	0.11	0.12	0.09
Household head is an employee	0.834	0.76	0.83	0.87	0.90
Household head is white, non-hispanic	0.776	0.61	0.77	0.84	0.94
Non-white or hispanic	0.224	0.39	0.23	0.16	0.06
Willing to undertake financial risk	0.544	0.20	0.44	0.71	0.96
Not willing to undertake any financial risk	0.456	0.80	0.56	0.29	0.04
Less than high school education	0.186	0.43	0.17	0.08	0.01
High-school education	0.507	0.50	0.61	0.52	0.37
College degree or more	0.307	0.07	0.22	0.40	0.62

		Probit Distribution of Gains			
Household Characteristic	1998 sample	(0%, 25%)	[25%,50%)	[50%,75%)	[75%,100%)
Lower 25% of financial assets		0.86	0.21	0.00	0.00
Between 25% and 50% of financial assets		0.14	0.52	0.33	0.00
Between 50% and 75% of financial assets		0.01	0.23	0.46	0.26
Upper 25% of financial assets		0.00	0.03	0.21	0.74
Lower 25% of income		0.68	0.31	0.11	0.02
Between 25% and 50% of income		0.23	0.37	0.30	0.11
Between 50% and 75% of income		0.08	0.24	0.35	0.26
Upper 25% of income		0.01	0.08	0.24	0.61
Of age less than 34	0.233	0.29	0.27	0.27	0.14
Age between 35 and 49	0.334	0.26	0.26	0.34	0.45
Age between 50 and 64	0.230	0.17	0.21	0.19	0.29
Age more than 65	0.203	0.29	0.26	0.21	0.13
Household head is not working	0.051	0.13	0.05	0.03	0.01
Household head is self-employed	0.256	0.09	0.12	0.11	0.12
Household head is an employee	0.693	0.78	0.83	0.86	0.87
Household head is white, non-hispanic	0.824	0.55	0.77	0.81	0.91
Non-white or hispanic	0.176	0.45	0.23	0.19	0.09
Willing to undertake financial risk	0.659	0.22	0.40	0.73	0.95
Not willing to undertake any financial risk	0.341	0.78	0.60	0.27	0.05
Less than high school education	0.125	0.50	0.27	0.11	0.03
High-school education	0.432	0.43	0.52	0.57	0.37
College degree or more	0.443	0.08	0.21	0.32	0.60

Table 3b: Demographic composition of each quartile of the distribution of gains from stock market access. Quartiles were constructed using probability estimates from our *Probit* runs, decomposed by 1995 (upper panel) and 1998 (lower panel) subsamples. For the method of construction, see text.

		Logit Distribution of Gains			
Household Characteristic	1995 sample	(0%, 25%)	[25%,50%)	[50%,75%)	[75%,100%)
Lower 25% of financial assets		0.81	0.13	0.00	0.00
Between 25% and 50% of financial assets		0.18	0.58	0.25	0.00
Between 50% and 75% of financial assets		0.01	0.25	0.53	0.25
Upper 25% of financial assets		0.00	0.04	0.23	0.75
Lower 25% of income		0.62	0.20	0.07	0.01
Between 25% and 50% of income		0.27	0.40	0.24	0.06
Between 50% and 75% of income		0.10	0.29	0.42	0.25
Upper 25% of income		0.01	0.12	0.27	0.67
Of age less than 34	0.248	0.28	0.28	0.25	0.17
Age between 35 and 49	0.335	0.24	0.31	0.38	0.44
Age between 50 and 64	0.211	0.17	0.18	0.20	0.26
Age more than 65	0.206	0.31	0.24	0.17	0.12
Household head is not working	0.064	0.15	0.06	0.01	0.01
Household head is self-employed	0.102	0.09	0.11	0.12	0.09
Household head is an employee	0.834	0.76	0.83	0.87	0.90
Household head is white, non-hispanic	0.776	0.62	0.77	0.83	0.94
Non-white or hispanic	0.224	0.38	0.23	0.17	0.06
Willing to undertake financial risk	0.544	0.20	0.44	0.71	0.96
Not willing to undertake any financial risk	0.456	0.80	0.56	0.29	0.04
Less than high school education	0.186	0.43	0.17	0.08	0.01
High-school education	0.507	0.50	0.61	0.52	0.37
College degree or more	0.307	0.07	0.22	0.41	0.62

		Logit Distribution of Gains			
Household Characteristic	1998 sample	(0%, 25%)	[25%,50%)	[50%,75%)	[75%,100%)
Lower 25% of financial assets		0.86	0.21	0.00	0.00
Between 25% and 50% of financial assets		0.14	0.53	0.32	0.00
Between 50% and 75% of financial assets		0.01	0.23	0.47	0.26
Upper 25% of financial assets		0.00	0.03	0.20	0.74
Lower 25% of income		0.68	0.31	0.11	0.02
Between 25% and 50% of income		0.23	0.37	0.30	0.11
Between 50% and 75% of income		0.08	0.24	0.35	0.26
Upper 25% of income		0.01	0.08	0.24	0.61
Of age less than 34	0.233	0.29	0.27	0.26	0.14
Age between 35 and 49	0.334	0.26	0.26	0.34	0.45
Age between 50 and 64	0.230	0.17	0.21	0.19	0.29
Age more than 65	0.203	0.29	0.26	0.21	0.13
Household head is not working	0.051	0.14	0.05	0.03	0.01
Household head is self-employed	0.256	0.09	0.12	0.11	0.12
Household head is an employee	0.693	0.77	0.83	0.86	0.87
Household head is white, non-hispanic	0.824	0.55	0.77	0.82	0.91
Non-white or hispanic	0.176	0.45	0.23	0.18	0.09
Willing to undertake financial risk	0.659	0.22	0.40	0.73	0.95
Not willing to undertake any financial risk	0.341	0.78	0.60	0.27	0.05
Less than high school education	0.125	0.49	0.27	0.11	0.03
High-school education	0.432	0.43	0.52	0.57	0.37
College degree or more	0.443	0.08	0.21	0.32	0.60

Table 3c: Demographic composition of each quartile of the distribution of gains from stock market access. Quartiles were constructed using probability estimates from our *Logit* runs, decomposed by 1995 (upper panel) and 1998 (lower panel) subsamples. For the method of construction, see text.

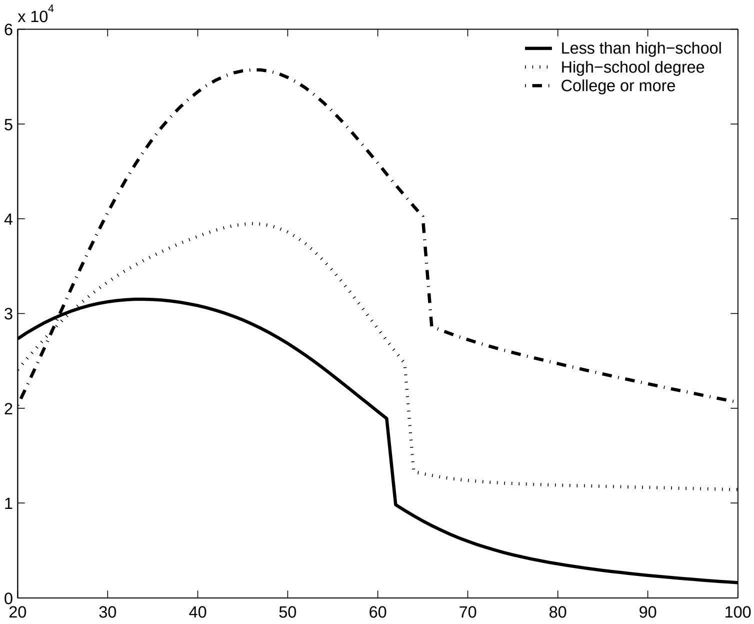

Figure 1: Age income profiles by education category.

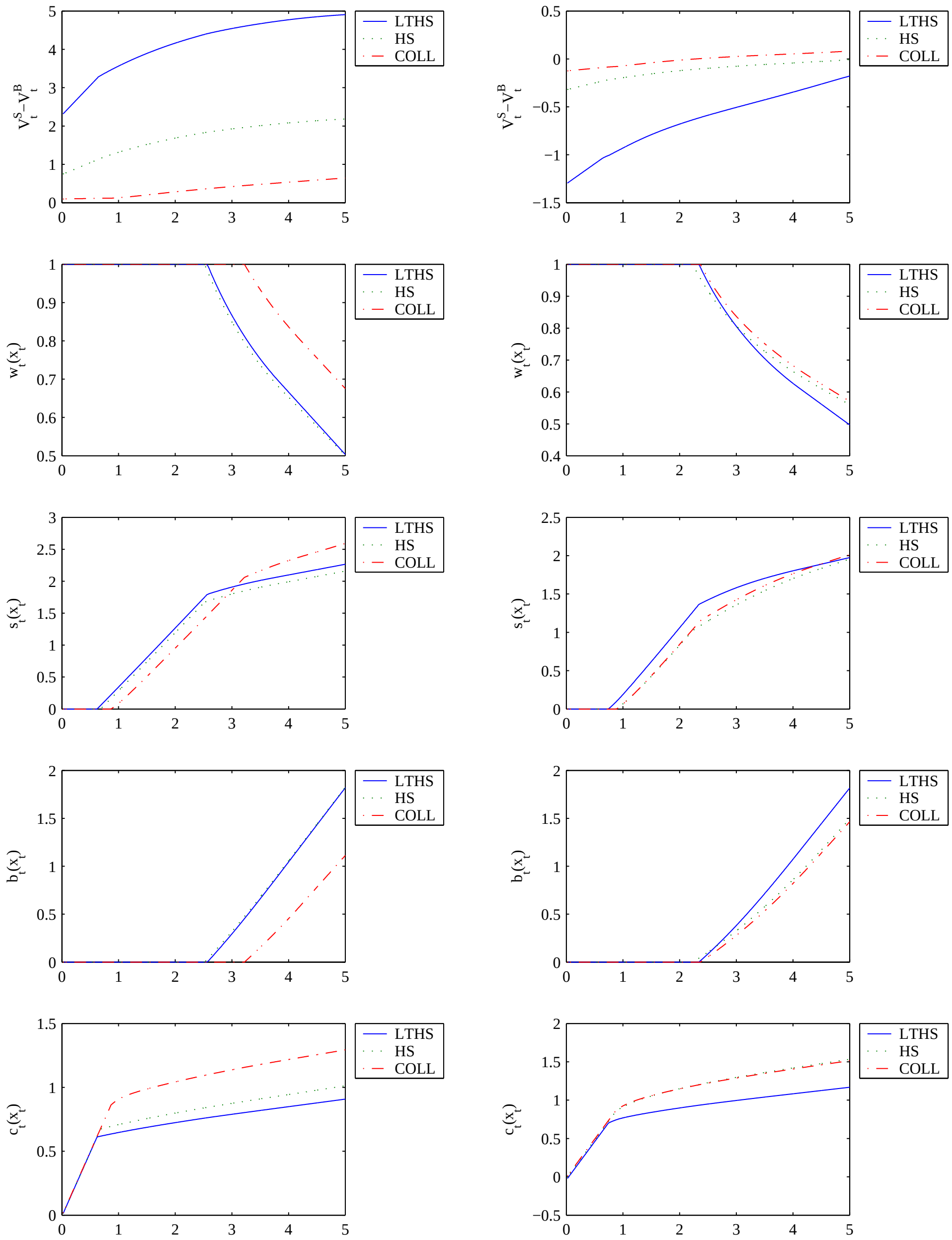

Figure 2: Effects of education on gains from stock market access and on underlying policy rules. Education levels are high-school dropouts (LTHS), high-school graduates (HS), and holders of College degree or more (COLL). Policy rules are for the risky portfolio share, the amount of risky asset holdings, the amount of riskless asset holdings, and consumption. The solution on the left is for (working) age 45, and on the right for (retirement) age 70.

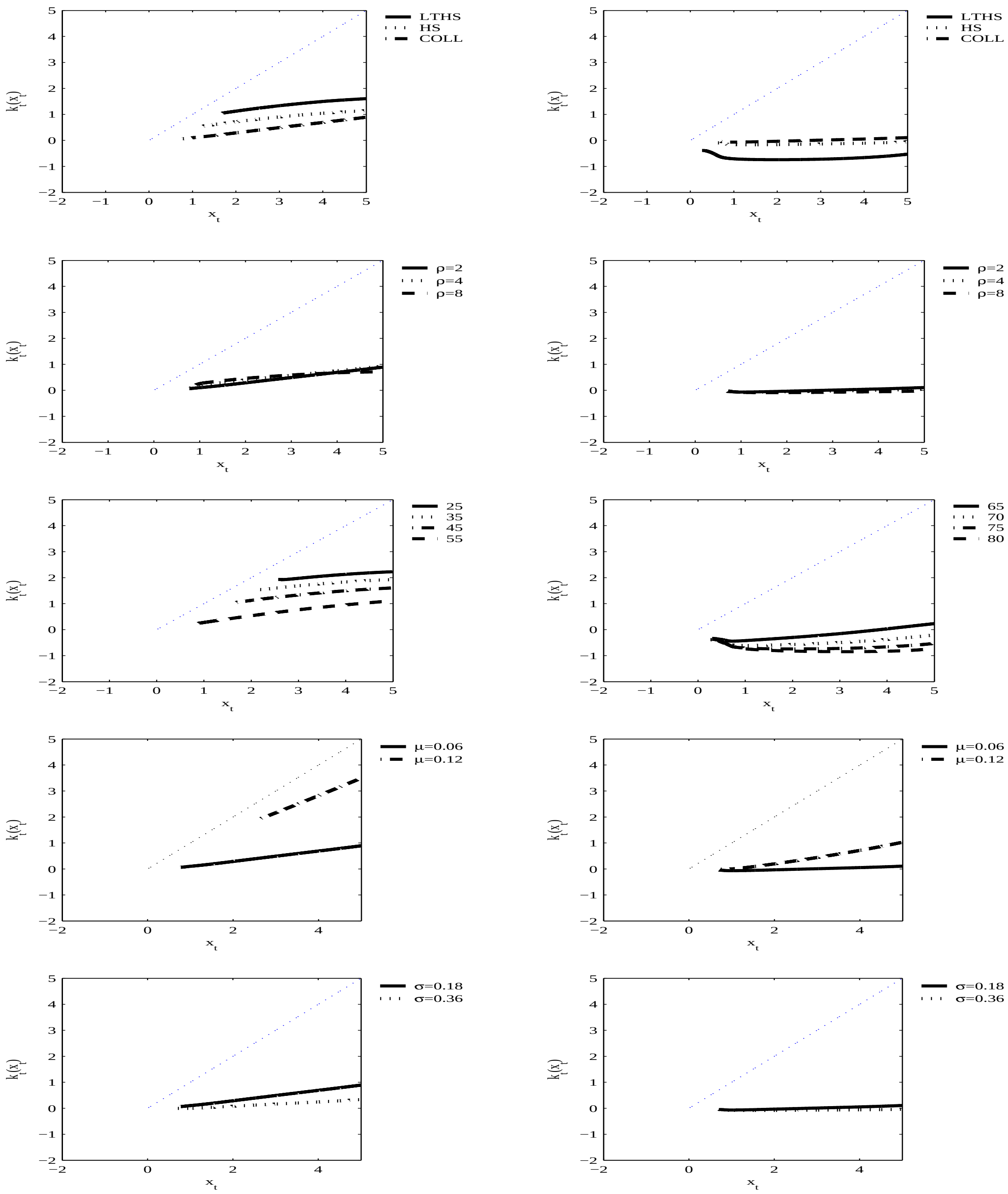

Figure 3: The monetary equivalent of gains from stock market access as a function of normalized cash on hand, *with embedded fixed per-period participation costs*. The effect of education, risk aversion of the felicity function, and age are summarized in the top three rows, with the effect of an equity premium and volatility increase to follow in the fourth and fifth row, respectively.

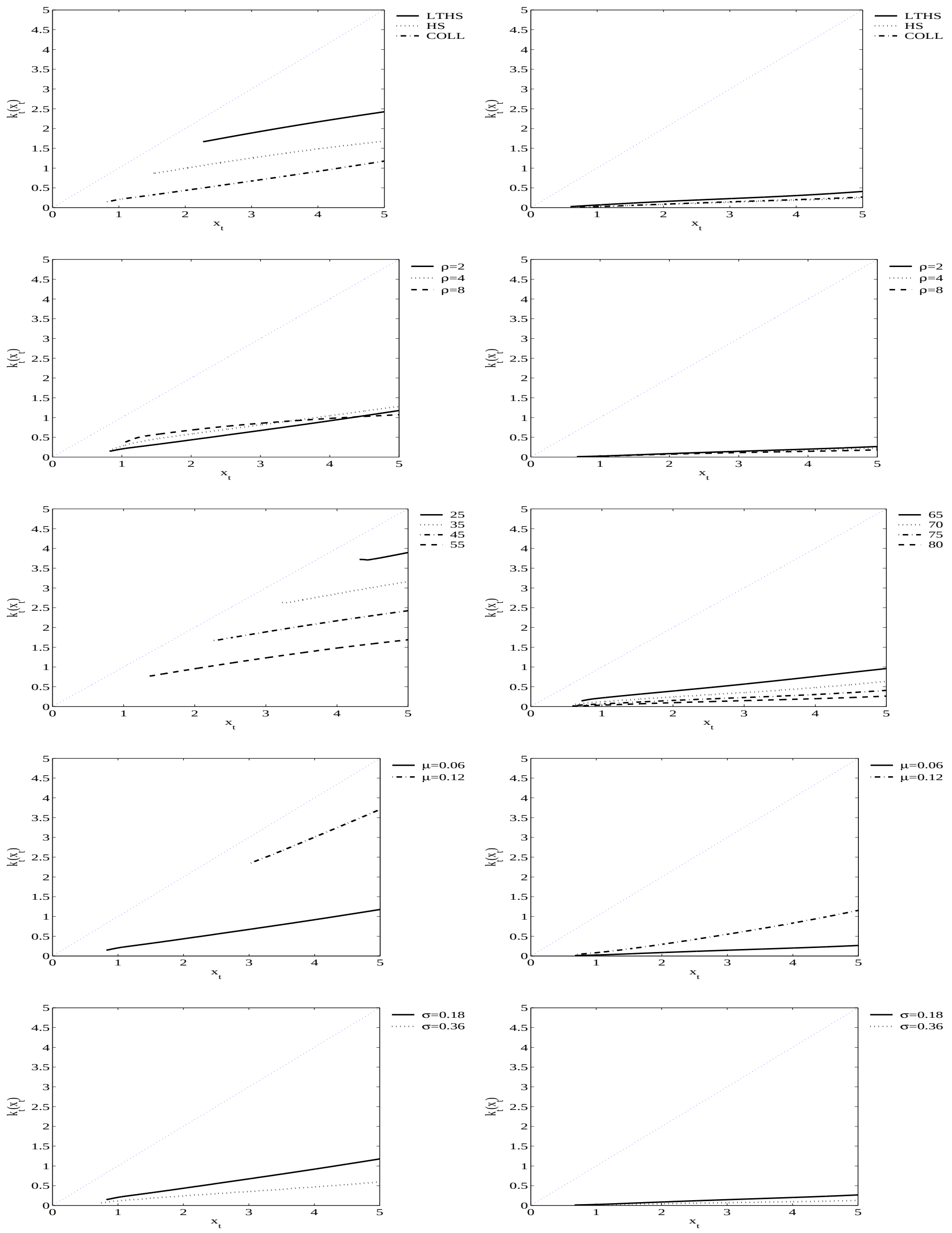

Figure 4: The monetary equivalent of gains from stock market access as a function of normalized cash on hand *without embedding any fixed per-period participation costs*. The effect of education, risk aversion of the felicity function, and age are summarized in the top three rows, with the effect of an equity premium and volatility increase to follow in the fourth and fifth row, respectively.

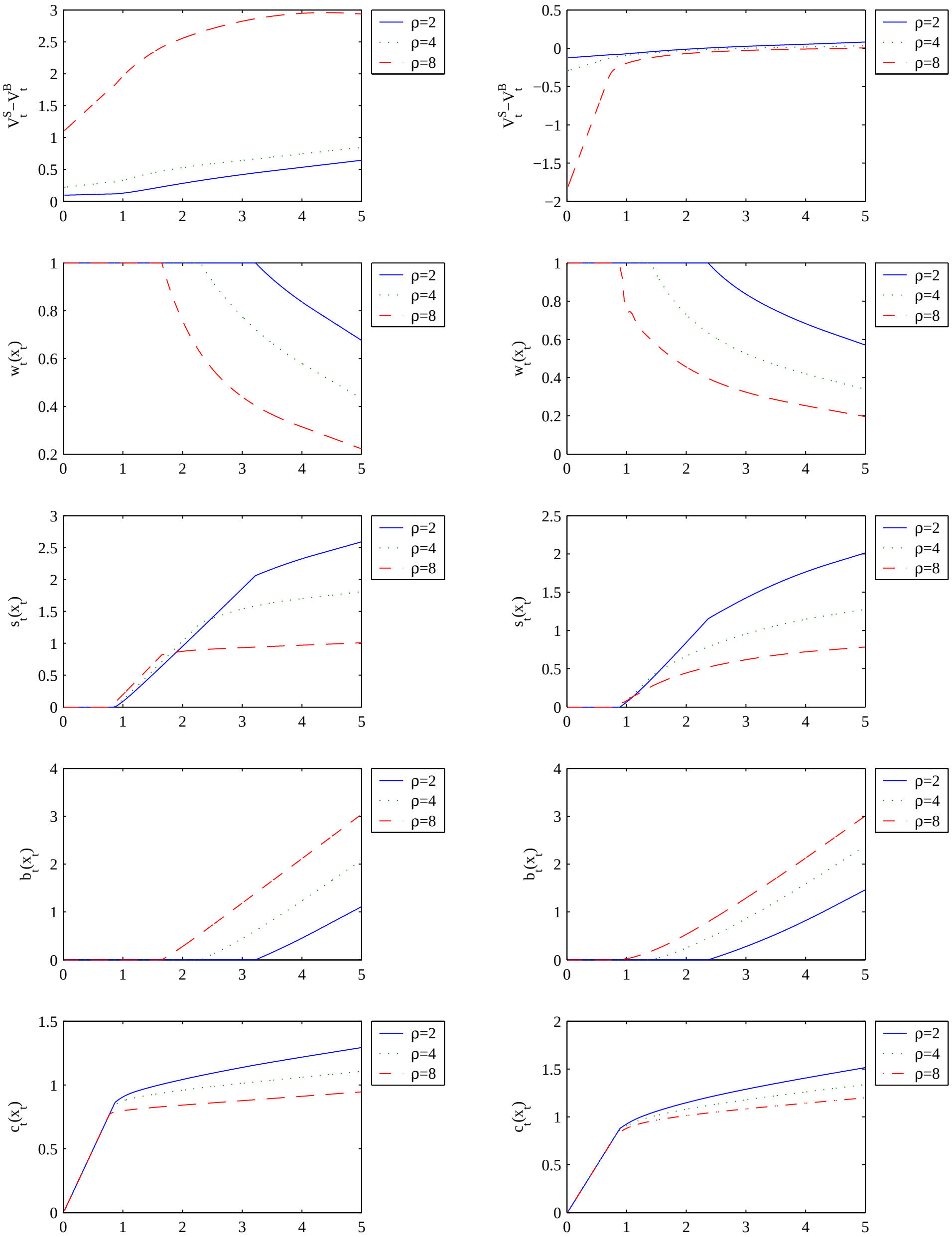

Figure 5: Effects of risk aversion of felicity function on gains from stock market access and on underlying policy rules. Policy rules in order of appearance are for the risky portfolio share, the size of risky asset holdings, the size of riskless asset holdings, and consumption. The solution depicted on the left is for age 45, and on the right for (retirement) age 70. Results are for the education group of College graduates.

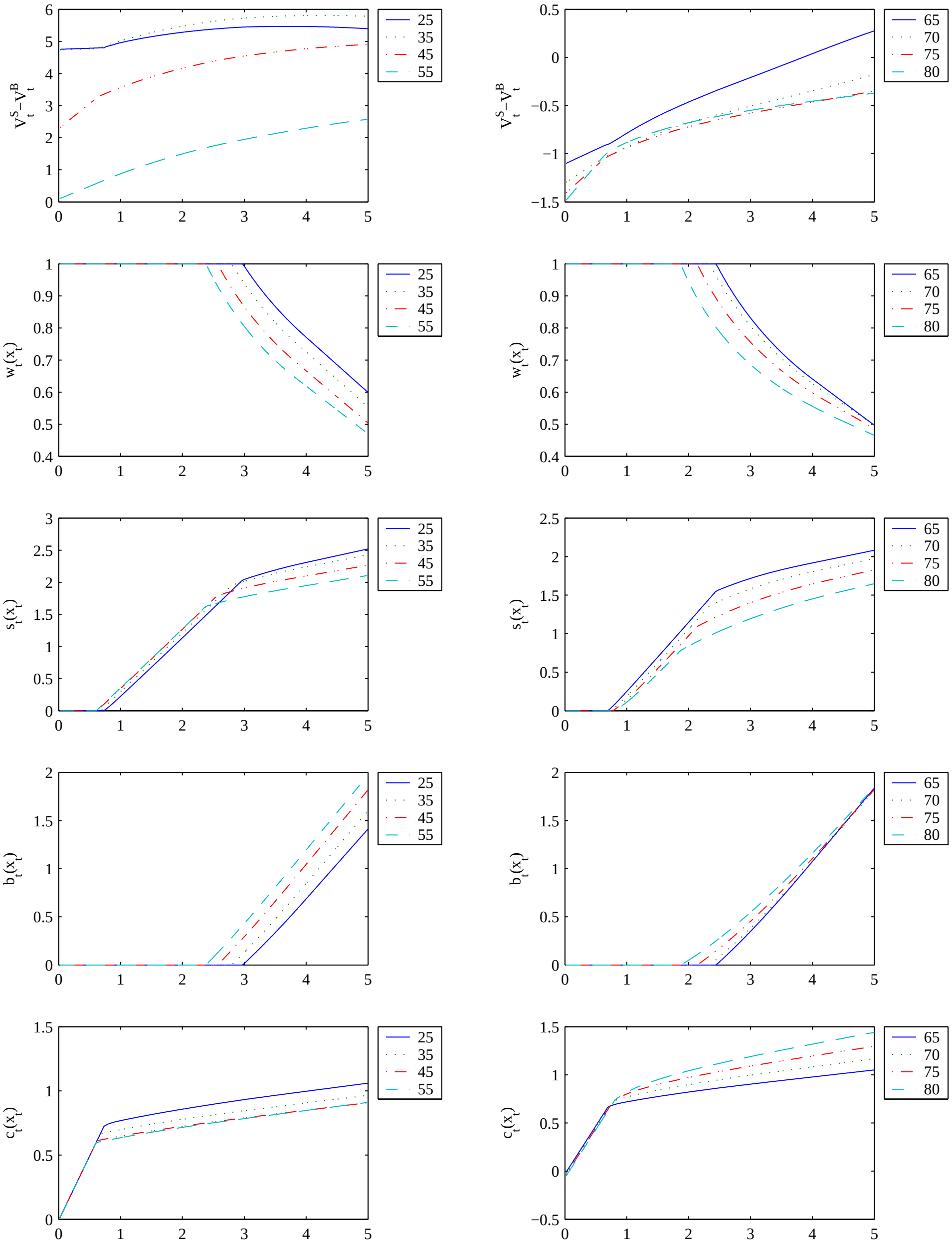

Figure 6: Age effects on gains from stock market access and on underlying policy rules. Policy rules in order of appearance are for the risky portfolio share, the size of risky asset holdings, the size of riskless asset holdings, and consumption. On the left panel we depict ages from working life, whereas on the right panel a selection of retirement ages is shown. Results are for households with less than high-school education.

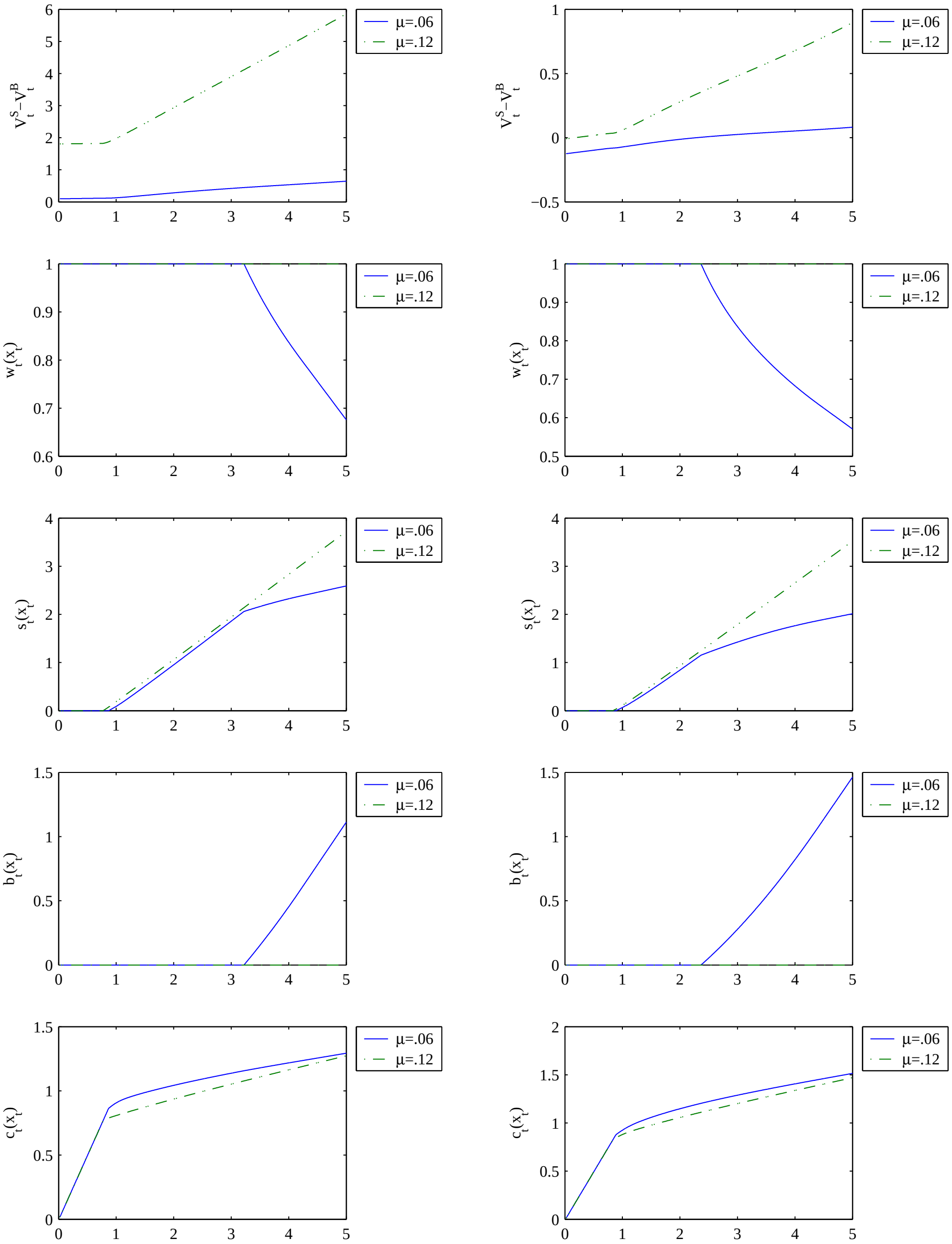

Figure 7: Effects of the size of equity premium on gains from stock market access and on underlying policy rules. Policy rules in order of appearance are for the risky portfolio share, the size of risky asset holdings, the size of riskless asset holdings, and consumption. The solution depicted is for (working) age 45 and (retirement) age 70, on the left and on the right panel, respectively. Results shown are for College graduates.

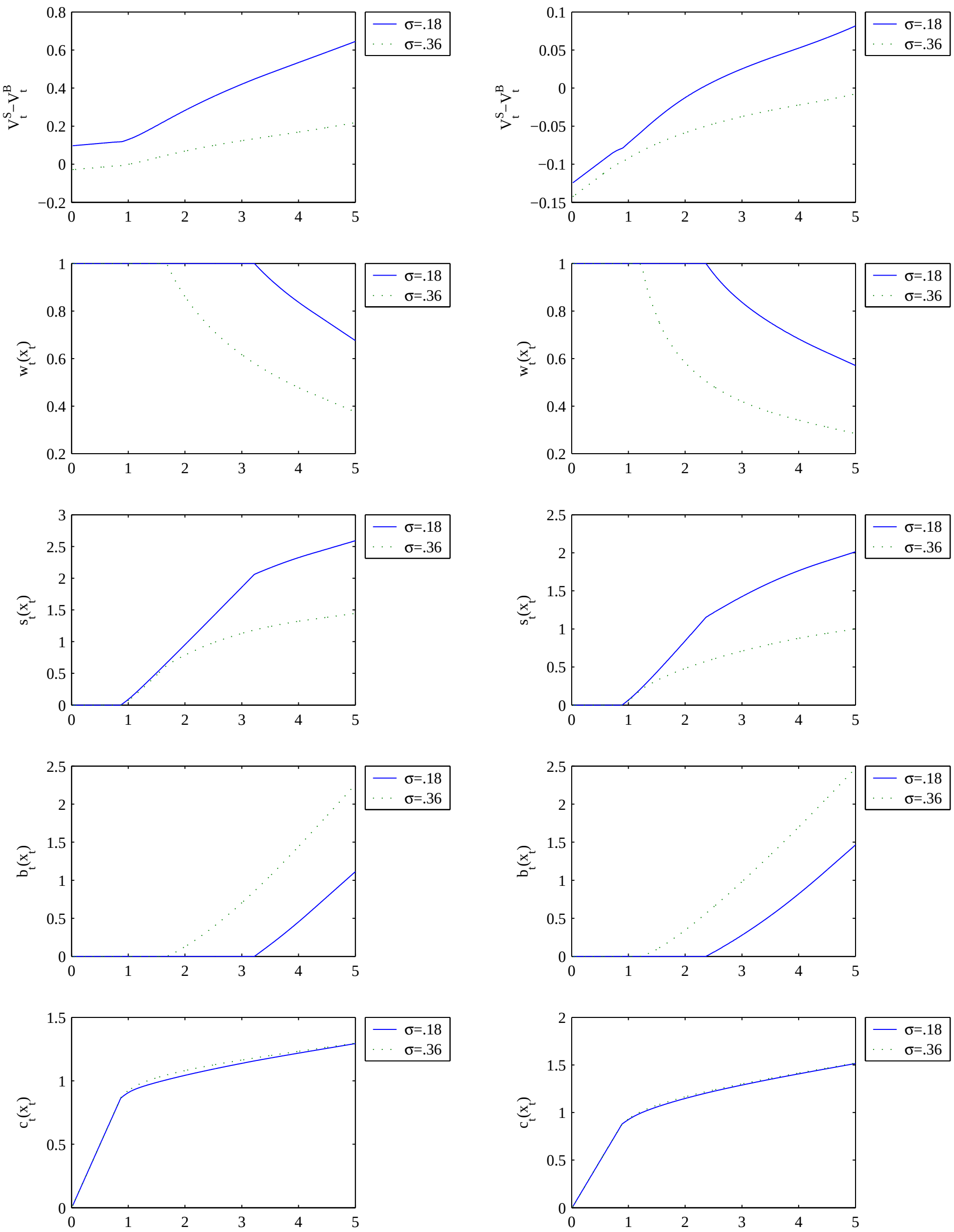

Figure 8: Effects of an increase in volatility of risky asset return on gains from stock market access and on underlying policy rules. Policy rules in order of appearance are for the risky portfolio share, the size of risky asset holdings, the size of riskless asset holdings, and consumption. The solution depicted is for (working) age 45 and (retirement) age 70, on the left and on the right panel, respectively. Results shown are for education group of high-school dropouts.

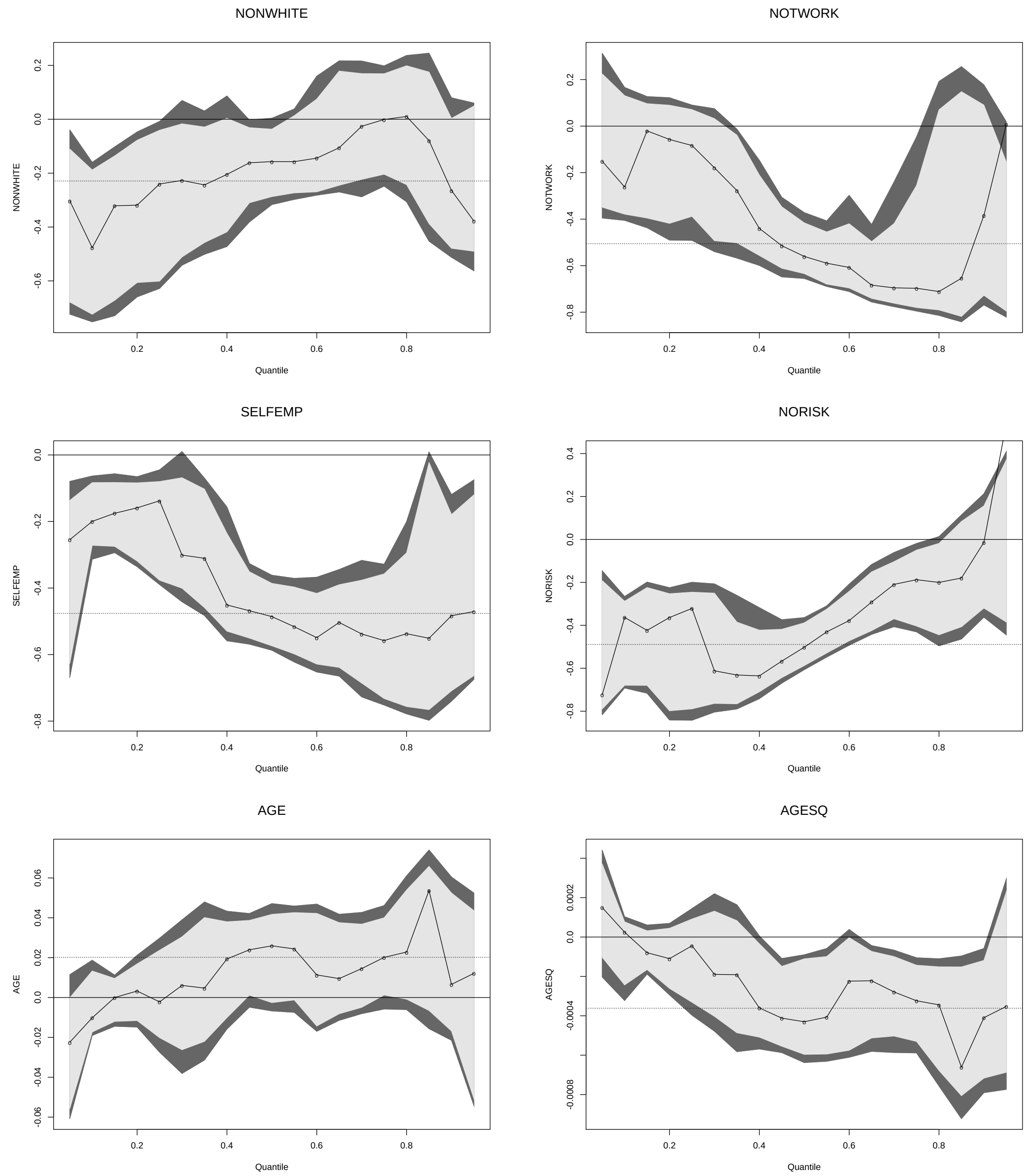

Figure 9a: Smoothed Binary Quantile Regression. The light- and dark-shaded areas represent the 90% and 95% confidence intervals, respectively, and the line portrays the smoothed binary quantile regression coefficient. The zero level is indicated with a continuous line, whereas the normalized Probit coefficient with a dotted line. The Probit and Logit normalized coefficients virtually coincide. (figure continued next page).

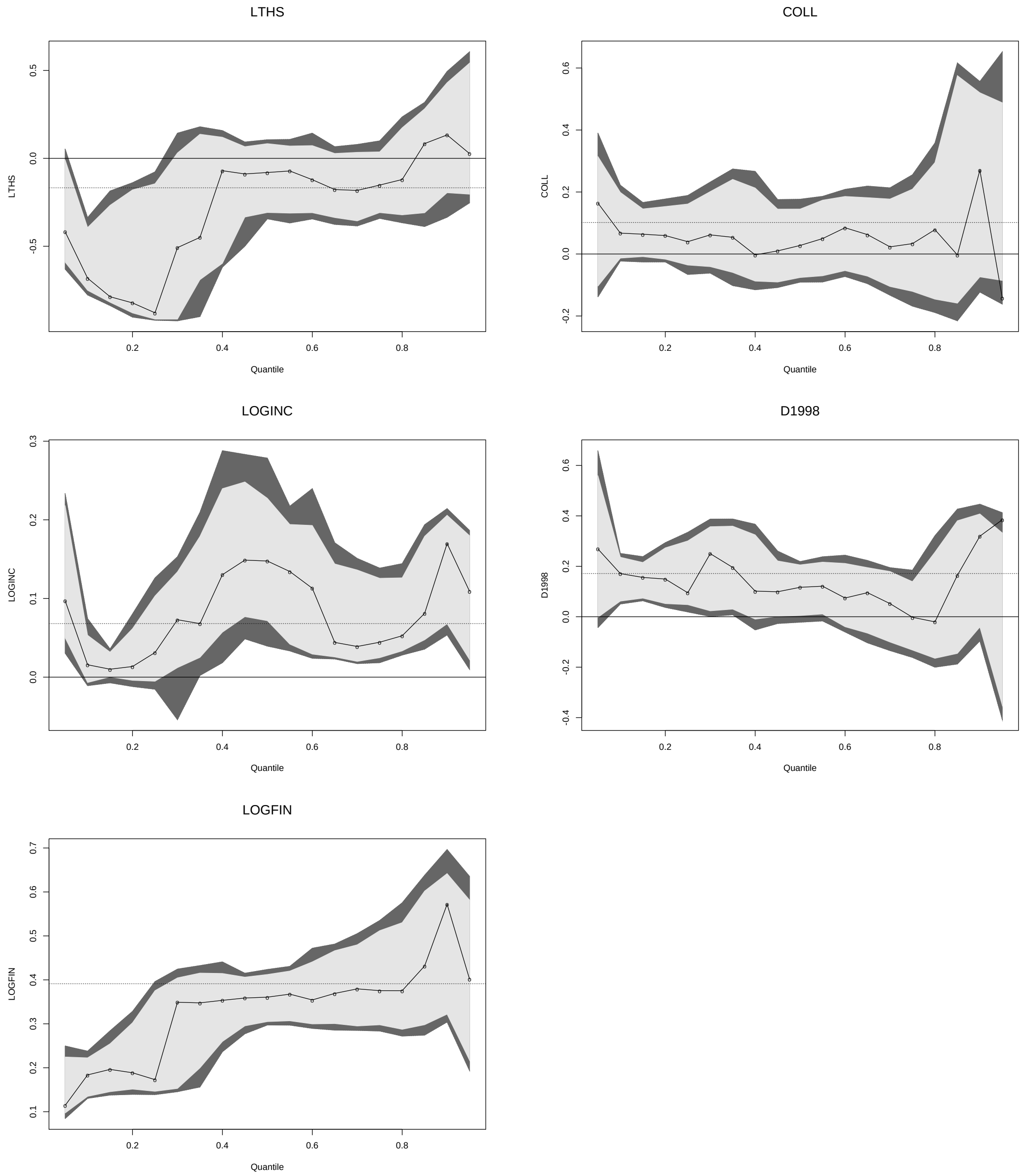

Figure 9b: Smoothed Binary Quantile Regression (cont'd.)

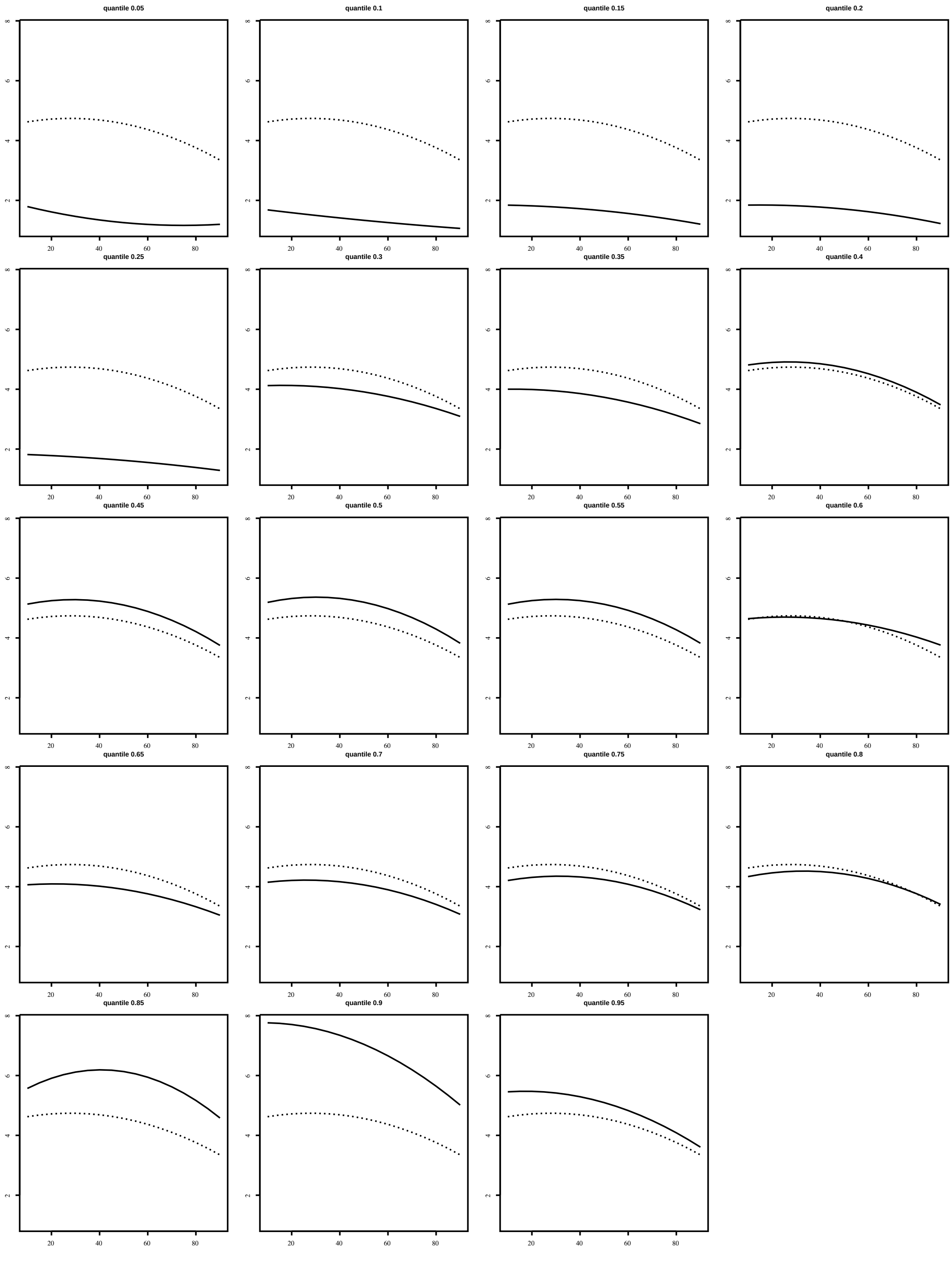

Figure 10: Estimated Effects of Age on Gains from Stockmarket Participation Across Quantiles. The dotted line represents the Probit estimated profile, whereas the continuous line is the Smoothed Binary Quantile Regression estimated profile for that particular quantile.

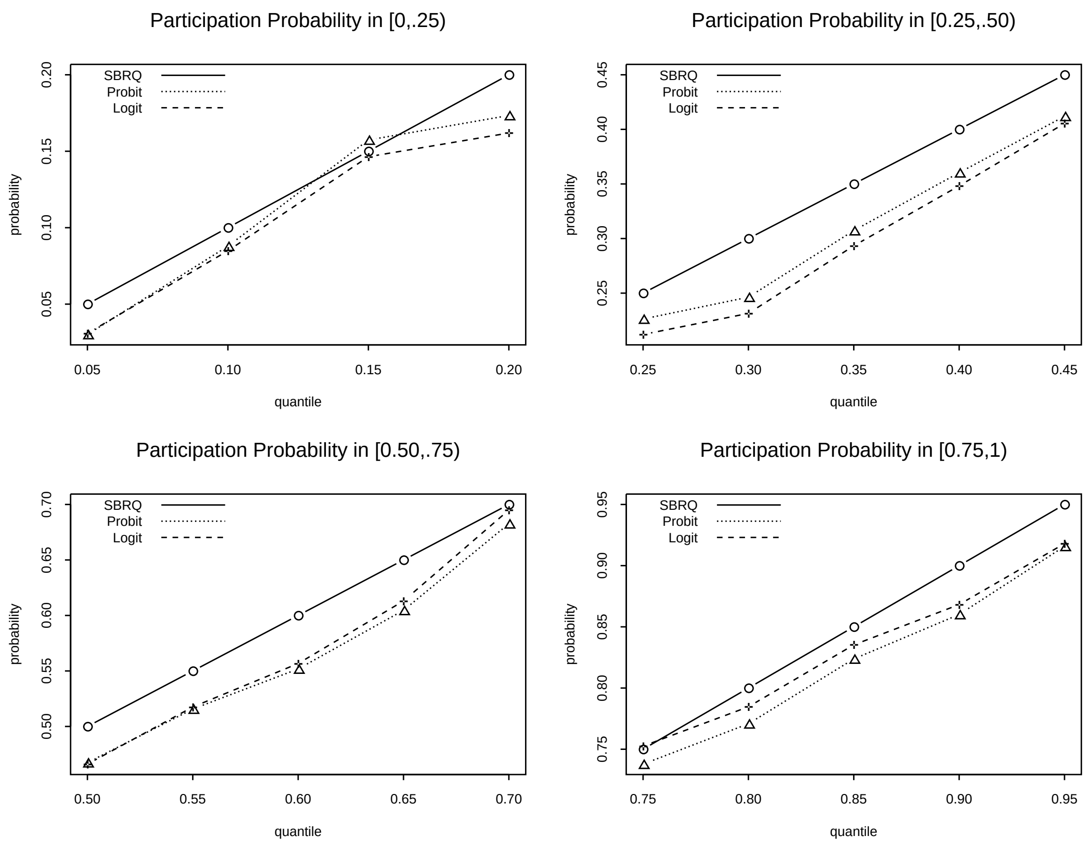

Figure 11a: Estimated probabilities of participation by quantile of the distribution of gains for the 1995 subsample. For each quantile the mean Probit and Logit probabilities are compared with the probability implied by the quantile regression estimates. The method for assigning households to quantiles is described in the text.

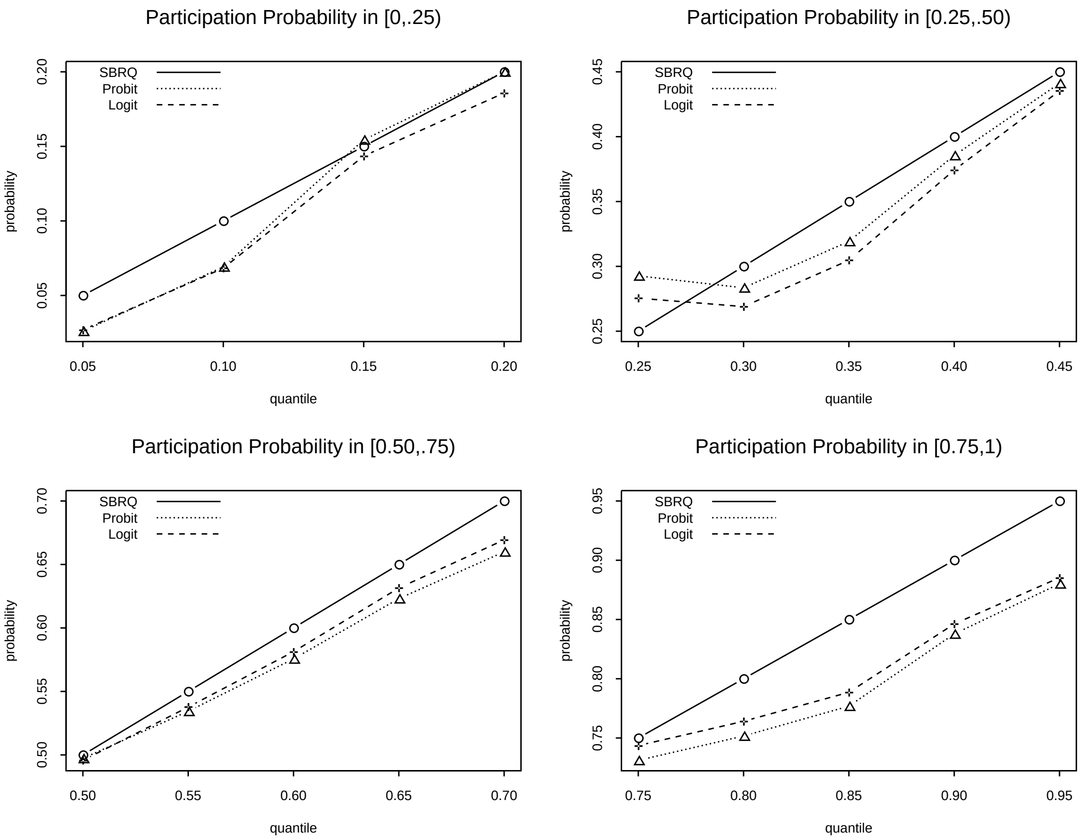

Figure 11b: Estimated probabilities of participation by quantile of the distribution of gains for the 1998 subsample. For notes, see Figure 11a.