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Structural estimation of stock market participation costs

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This paper develops and estimates a dynamic model of stock market participation, where consumers' decisions regarding stock market participation are influenced by participation costs. The practical significance of the participation costs is considered as being a channel through which financial education programs can affect consumers' investment decisions. Using household data from the Panel Study of Income Dynamics, I estimate the magnitude of the participation cost, allowing for individual heterogeneity in it. The results show the average stock market participation cost is about 4–6% of labor income; however, it varies substantially over consumers' life. The model successfully predicts the level of the observed participation rate and the increasing pattern of stock market participation over the consumers' life cycle.

1. Introduction

Despite the theoretical prediction that all investors will participate in stock markets if the equity premium is positive, empirical evidence shows that a substantial number of consumers do not invest in stock markets either directly or indirectly (via pension account schemes, mutual funds, or similar institutions).[1] Over the past decade, the limited stock market participation puzzle has received growing attention in both the theoretical and empirical literature. One of its prevailing explanations is the existence of stock market participation costs that arise from the time and effort necessary for obtaining and processing financial knowledge and information, for following the current trends on financial markets, for paying sign-up fees, for filing the necessary paperwork associated with stock holdings, and so on (see Haliassos and Bertaut, 1995; Vissing-Jorgensen, 2002a; Gomes and Michaelides, 2003, 2005; Guiso et al., 2003). Stock market participation cost, however, is not observed by researchers, which constitutes a major difficulty in quantifying it. Yet using the data to reveal not only the magnitude of the participation cost but also its sources of heterogeneity are important for a number of reasons. First, participation cost is one of the parameters in some life-cycle models of portfolio allocation; therefore, its various magnitudes can lead to different implications and may result in different economic policy conclusions. Second, economic programs that aim to provide financial education to consumers may lead to reduced participation costs, thereby encouraging stock market participation. However, the effect of such programs is likely to differ for different groups of consumers. This paper develops and estimates empirically a dynamic model of stock market participation, in which

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[1] See, for example, Haliassos and Bertaut (1995), Heaton and Lucas (2000), and a collection of papers in "Household Portfolios" by Guiso, Haliassos, and Jappelli, Cambridge, MA: MIT Press, 2002.

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heterogeneous participation costs influence consumers' decisions regarding stock market participation. Using household data from the Panel Study of Income Dynamics, I estimate the magnitude of the stock market participation cost, allowing for individual heterogeneity in participation costs, represented by age, education, and participation experience.

Over the past century, average returns on equity have far exceeded the average returns on risk-free assets. In light of impressive equity premium over these years, the unwillingness to invest in stocks is arguably an investment mistake (Campbell, 2006; Calvet et al., 2007). The launching of financial education curricula via a number of economic policy incentives a decade ago acknowledged the importance of the promotion of consumer financial education.[2] Further, a growing concern in the literature and in economic policy debates reinforced the issue of limited stock market participation (see Guiso and Jappelli, 2005; Campbell, 2006; van Rooij et al., 2011). Recently, the debates resulted in a number of financial education programs designed to further increase and promote financial literacy among consumers.[3] Financial education and counseling is likely to alleviate the burden on consumers' time and effort necessary for making financial decisions and to reduce the objective cost of stock market participation.[4] In life-cycle models of portfolio allocation and wealth accumulation, participation cost may be viewed as a modeling tool that allows us to investigate whether financial education programs can influence consumers' financial choices and increase participation in financial markets.

Although stock market participation costs are not observed, the literature has collected supporting evidence that such costs are non-negligible. However, the literature finds little agreement on the size of the participation costs. Alan (2006) finds stock market entry costs equal about 2% of annual permanent income, whereas Haliassos and Michaelides (2003) obtain a wide range for entry costs, from 3% to 34% of mean annual income. The existing empirical estimates of per-period participation costs in Attanasio and Paiella (2011) and Paiella (2007) provide only a lower bound in units of nondurable consumption as low as 0.4% and 0.7% of consumption per year, arguing that the true costs of participation may exceed these levels in reality.[5] Although these empirical findings show that even a small fee can discourage investors from stock markets, the evidence on lower bounds of participation costs gives limited information for further analysis of economic welfare. A sharper estimate of participation costs can be beneficial for evaluation of policy interventions in models of lifetime consumption and portfolio choice.

One of the contributions of the paper is that it quantifies empirically the magnitudes of the participation costs, allowing for a rich set of heterogeneity in it. The paper adapts a standard life-cycle portfolio allocation model, such as in Gomes and Michaelides (2003) and similar macro-finance studies, to the empirical framework of discrete choice dynamic programming models of individual behavior.[6] In doing so, I shift the focus of the empirical analysis from the optimality conditions over the continuous choices (examples include consumption Euler equation and optimality condition for the share of wealth allocated to risky assets) to the optimality condition over the decision to participate in stock markets, which corresponds to the concept of the extensive margin. According to a standard portfolio allocation model, if a household decides to invest in stocks, it gives up stock market entry or participation cost. The focal point of the model environment is the consideration of the potentially forfeited participation cost, which prompts a household to make a decision to invest in stocks or not, a decision that belongs to the discrete choice. The per-period participation cost is a part of a model of stock market participation, which is estimated with the Conditional Choice Probability (CCP) estimator, developed by Hotz and Miller (1993) for estimation of dynamic discrete choice models. To my knowledge, the current study is the first to use the CCP estimator to estimate households' investment choices.[7,8]

The estimation results provide evidence that the participation cost, measured as a share of income, can be substantial. The average stock market participation cost is estimated to be between 4% and 6% of labor income, which is well inside the range used in the literature. Next, I present strong evidence that the participation cost varies dramatically over the consumer's life. I show that the life-time variation in participation cost stems from more than the humped shape of labor income. As Alan (2012) indicates, the magnitudes of the stock market participation cost can be different for consumers in different age and education groups. Following this indication, I allow the participation costs to depend on an investor's education as a proxy for the ability to collect and process information and on age and past participation as proxies for the accumulation of information and experience. In doing so, I go one step further by exploring the dependence of participation

[2] Examples are the Economic Growth and Tax Relief Reconciliation Act, and Money Smart, a program launched by the Federal Deposit Insurance Corporation.

[3] The latest incentive is the Dodd–Frank Wall Street Reform and Consumer Protection Act of 2010.

[4] van Rooij et al. (2011) find that stock ownership increases sharply with financial literacy. Moreover, Bernheim et al. (2001) and Bernheim and Garrett (2003) provide evidence that consumers who were exposed to financial education in high school or in the workplace reach stronger savings outcomes. However, the literature has yet to come to a consensus regarding whether financial education programs lead to a greater financial literacy (see Hathaway and Khatiwada, 2008).

[5] These estimates translate into a $72 bound for Attanasio and Paiella (2011) and a $130 bound for Paiella (2007). Vissing-Jorgensen (2002a) finds the bound of per-period fixed costs as low as $260 can explain the behavior of most nonparticipants.

[6] See Aguirregabiria and Mira (2010) for an excellent survey.

[7] The method is advantageous for estimation of complex models with sizable state spaces. Implementing estimation in steps is computationally easy, and allows for monitoring the quality of estimation at each step and for flexible modification of utility specification if needed. A common challenge to the estimators of dynamic discrete choice models is the insufficiently elaborate treatment of individual unobserved heterogeneity; however, CCP estimators are capable of handling this issue due to recent developments in Aguirregabiria and Mira (2007) and Arcidiacono and Miller (2011).

[8] Simulation-based methods are also used in estimation of the individual portfolio choice problems. Examples include Asea and Turnovsky (1998), who use the method of simulated moments to study risk-taking behavior under taxation of capital income, and Alan (2006, 2012), who uses a simulated minimum distance technique to quantify stock market participation cost and to investigate its determinants.

costs from previous stock market participation, which constitutes another novelty of the paper. I find the evidence that the participation costs are substantially smaller for households that continue to be stock market participants. The results suggest per-period costs decrease by more than 3% of income when households participate in previous periods. The estimated model also implies that the stock market participation costs are larger for first-time investors. The empirical estimates provide evidence that the participation costs are less for more educated investors and decrease as consumers become older. The results also suggest that, all other factors being fixed, per-period participation costs are smaller for young consumers and the consumers who are closer to the retirement stage, whereas middle-age consumers face the largest stock market participation costs. Overall, the estimation results on stock market participation costs not only support the previous findings on the magnitudes of the participation costs in empirical literature, but also are in accordance with the fixed entry costs used in theoretical literature.

The rest of the paper is organized as follows. Section 2 outlines the model. Section 3 discusses the empirical implementation. Section 4 describes data sample construction. Section 5 contains the empirical findings, discusses robustness checks, and illustrates the model fit to the data. Section 6 concludes.

2. Model

2.1. Model framework

A generic household has preferences defined over a sequence of states, each of which has two components: a vector of state variables for a household in period t, denoted s_t, and a period t decision to invest in stocks or not, denoted by d. Every period, the household observes the vector of state variables s_t and chooses optimally by maximizing an expected discounted intertemporal utility:

$$\mathbb{E}_t \sum_{\tau=t}^{T} \beta^{\tau-t} U(s_t, d), \tag{1}$$

where the expectation is taken conditional on the information available to the households at time t, $\beta \in (0,1)$ is the subjective time-discount factor, and $U(\cdot)$ is the per-period utility payoff. In addition to making optimal consumption and savings choices (not explicitly modeled), the household decides how to reallocate savings between risky and riskless assets. In each period, the household decides to either invest in stocks, denoted by $d=1$, or to not invest and instead keep all savings in the riskless assets, in which case $d=0$. If a household decides to invest in stocks in the current period, it gives up a per-period participation cost. Consideration of the potentially forfeited participation cost prompts a household to make a decision to invest in stocks or not. The current decision also affects the household's future choices and outcomes. The expression (1) is maximized by a Markov decision rule that gives the optimal choice conditional on s_t. Then the state vector s_t transitions into s_{t+1} with probability $F(s_{t+1}|d, s_t)$.

Denote $V(s_t)$ the value function of the problem (1). Denote $V_1(s_t)$ and $V_0(s_t)$ the conditional values associated with the decision to invest and not invest in stocks, respectively. Let d_t^o be the optimal stock market participation decision at date t. The optimal participation decision rule involves comparing value functions associated with each participation choice:

$$d_t^o \equiv \arg\max_{d \in \{0,1\}} \{V_0(s_t), V_1(s_t)\}. \tag{2}$$

Using the Bellman principle, the value $V_0(s_t)$ of choosing not to invest in stocks can be written as

$$V_0(s_t) = U(s_t, d=0) + \beta \int V(s_{t+1})\, dF(s_{t+1}|d, s_t), \tag{3}$$

subject to

$$w_t = R_t^p w_{t-1} + y_t - c_t,$$

whereas the value $V_1(s_t)$ of choosing to invest in stocks is

$$V_1(s_t) = U(s_t, d=1) + \beta \int V(s_{t+1})\, dF(s_{t+1}|d, s_t), \tag{4}$$

subject to

$$w_t = R_t^p w_{t-1} + y_t - c_t - \rho_t,$$

where y is the household's income, c is consumption, w is total liquid wealth (stocks, bonds, cash accounts, and similar liquid assets), R^p is the real return on the household's portfolio, and ρ is a per-period participation cost.

The key component of the analysis of participation cost is the intertemporal utility cost and benefit that arises with different participation strategies. Stock market participation costs have a direct effect on savings. They are also connected to the share of wealth households that choose to invest in stocks. On the one hand, the participation cost reduces savings today – a risk a household takes in the hopes of receiving a greater expected return on its portfolio and a corresponding increase in wealth in the next period. On the other hand, households may choose not to invest in stocks today, but instead keep all savings in risk-free assets. In the next period, however, the household receives a risk-free return on wealth, which also includes the not-foregone participation cost. The estimation of the participation costs relies on comparison of the value functions associated with the two participation strategies.

2.2. Participation cost

The empirical studies necessarily adopt a broad definition of the participation costs, which include both pecuniary (financial) and non-pecuniary (behavioral) components, because insufficient data usually hinder separate identification of these components. The notable exception is the work of Andersen and Nielsen (2011), whose unique data allow for separation of the effects of financial and behavioral costs. They find that limited stock market participation is not likely to be driven by financial constraints, but rather by behavioral, cognitive, and psychological barriers. Non-financial factors in determining the asset allocations are demonstrated to be strong in Barnea et al. (2010), and Kaustia and Torstila (2011). Duflo and Saez (2003) and Hong et al. (2004) investigate how one's peers affect participation, offering additional evidence in favor of behavioral motives and cognitive abilities as barriers to stock market participation. Grinblatt et al. (2011) show a link between IQ and stock market participation. Although the structural model developed in this paper does not directly connect to this strand of the literature, the flexible form of participation costs enables me to account for both financial and non-financial barriers to stock market participation and evaluate the cohort effects in participation. In doing so, I allow the participation costs to depend on investor's education as a proxy for the ability to collect and process information and on age and past participation as proxies for the accumulation of information and experience.

The participation cost incorporates the cost of time and effort of acquiring information and knowledge necessary for investing in stocks. As such, it is related to the opportunity cost of time and therefore is typically modeled as a fraction of income. Following the convention, the participation cost ρ is modeled to be proportional to the household's labor income as a monetary measure of the opportunity cost.

Taking into account these considerations, the participation cost is defined as a function of the household's characteristics and labor income:

$$\rho_t = y_t^l(\delta_1+\delta_2 d_{t-1}+\delta_3 edu+\delta_4 age_t+\delta_5 age_t^2) \tag{5}$$

where y^l is labor income (after-tax labor earnings plus transfers), and $(\delta_1, \ldots, \delta_5)$ is a set of the parameters.

2.3. Preferences

Analysis of the (discrete) participation choices is facilitated by the random utility model framework, where household preferences are specified as a combination of the observed (deterministic) and unobserved (random) components. For this reason, I distinguish between two subsets of the state variables: $s_t = (x_t, \varepsilon_t)$, where the subvector x_t corresponds to the observed elements of the state vector s_t, and the subvector ε_t is the component of the state vector observed only by the household, and not by the economist. The latter component is usually interpreted as an unobserved choice-specific utility shock, which is revealed to the household at the beginning of period t.

In every period, the household receives a utility payoff that is additively separable in the observed and unobserved components:

$$U(s_t, d) = u(x_t, d)+\varepsilon_t(d), \tag{6}$$

where $\varepsilon_t(d)$ is a zero mean random variable with unbounded support. The observed component of the utility payoff $u(x_t, d)$ consists of several elements that are discussed in what follows.

Households derive utility from the consumption good. Furthermore, they also may receive a non-pecuniary payoff from investment choices. In regards to the utility of consumption, I consider two specifications, quadratic utility of consumption (7) and constant relative risk aversion (CRRA) utility (8):

$$u_t^c = c_t - \xi_t c_t^2, \tag{7}$$

and

$$u_t^c = \xi_t \frac{c_t^{1-\psi}}{1-\psi}, \tag{8}$$

where ξ_t is a taste shifter that can be a function of a household's demographic characteristics.

The use of quadratic utility of consumption is appealing because it renders the estimation problem as linear. In particular, one of its advantages is the ease of replicability comparable to that of the reduced form models, while returning the parameter estimates with the structural interpretation. It also has another important advantage of being robust to potential measurement errors in variables if estimated with the instrumental variable techniques and the choice of proper instruments. A potential drawback is that the quadratic utility does not rule out the negative marginal utility of consumption. Therefore, once the estimation of the utility parameters is achieved, ruling out parameter values that allow marginal utility of consumption to be negative for all possible values of consumption data is important.

Quadratic preferences, although analytically and computationally convenient, have arguably undesirable risk-aversion characteristics. CRRA utility is considered the alternative to quadratic preferences as a standard preference specification used widely in the literature on stock market participation choices.[9] Some examples of the recent applications of CRRA preferences include the papers on portfolio choices of wealthy consumers in Carroll (2002) and Guvenen (2007), calibration of life-cycle portfolio choices under uninsurable labor income risk and borrowing constraints (Cocco et al., 2005) and under the house price risk (Cocco, 2005), studies that reveal preference heterogeneity among stock market participants and nonparticipants (Attanasio et al., 2002; Brav et al., 2002; Vissing-Jorgensen, 2002b), and papers that address the existence of stock market participation costs (Alan, 2006, 2012; Paiella, 2007; Attanasio and Paiella, 2011). As a more conventional choice of the preferences, the CRRA utility renders the non-linear estimation model, which is substantially less amenable to the measurement error issue. As Amemiya (1985) shows, the presence of measurement error in a nonlinear framework may seriously inhibit the ability to obtain consistent estimates of the parameters.

Recent empirical findings suggest that stock market participation is associated not only with a higher expected increase in wealth, but also with acquiring non-monetary payoffs. The latter can be characterized by the differences in attitudes between stock market investors and non-investors. In particular, the Survey on Health, Aging and Retirement in Europe (SHARE) provides evidence that stock market investors on an average have higher life satisfaction compared to non-investors (Laakso, 2010).[10] Higher life satisfaction may not be picked up solely through potentially higher consumption expenditures and greater utility of the stock market investors. Allowing for non-pecuniary benefits of stock market participation adds flexibility not only to the utility specification, but also to the estimation of the participation cost. First, the significance of this benefit can be empirically tested. Second, ruling out potentially significant benefits may result in restricting the participation cost to smaller magnitudes to offset the non-participation value for the participants.

Apart from the non-pecuniary benefit related to the decision to participate in stock markets, the empirically observed inactivity in portfolio adjustments for individual investors sparked interest in testing for and quantifying the costs of portfolio adjustment for households-stockholders. Evidence from the survey data and the recent empirical analysis of Brunnermeier and Nagel (2008) and Bonaparte and Cooper (2009) assure that the costs of portfolio adjustment are non-negligible for individual investors. Building on these findings, I allow for a utility cost of adjusting the share of wealth invested in risky assets. Therefore, the non-pecuniary utility payoff from investment choices is specified as

$$u_t^d = \gamma_0 d_t + \gamma_1 \alpha_t \alpha_{t-1}, \tag{9}$$

where α is a share of household wealth allocated to stock holdings, γ_0 is the choice-specific utility shifter, which measures the non-pecuniary benefit of stock market participation, and γ_1 is the parameter of adjusting portfolio share invested in stocks between time $t-1$ and t, which measures the costs of portfolio adjustment. The latter coefficient determines the degree of intertemporal non-separability in the portfolio allocation choices. I also investigate an alternative specification for the adjustment costs, employed by Bonaparte and Cooper (2009), where the portfolio adjustment cost depends on the absolute distance between shares invested in stocks in current and previous periods.

Summing up all contemporaneous utility payoffs, described by the observed characteristics, the total contemporaneous deterministic utility is defined as

$$u(x_t, d) = u_t^c + u_t^d, \tag{10}$$

and depends on consumption, current and past investment choices, and demographic characteristics.

3. Estimation

3.1. Empirical implementation

Empirical implementation of the model employs panel data; therefore, let $i = 1, \ldots, N$ index households and $t = 1, \ldots, T$ index time periods. Let z_{it} be a vector of exogenous covariates for a household i at time t. Income is treated as exogenous as well as forecastable and is a part of the vector of exogenous covariates. Define $\tilde{w}_{it-1} = R_{it}^p w_{it-1}$ as the period t value of household i's accumulated wealth. Then the observed state vector for household i at time t is given as $(\alpha_{it-1}, \tilde{w}_{it-1}, z_{it}')$. The information set x_{it} is composed of the observed state variables, and the (unobserved) individual heterogeneity statistic ν_i and aggregate shock ω_t, so that $x_{it} = (\alpha_{it-1}, \tilde{w}_{it-1}, z_{it}', \nu_i, \omega_t)'$.

The optimality condition (2), can be elaborated further, such that a household optimally chooses to invest in stocks, which corresponds to $d_t^o = 1$, when $V_1(x_t) + \varepsilon_t(d=1) \geq V_0(x_t) + \varepsilon_t(d=0)$. In other words, a household participates in stock markets if the conditional value associated with participation is greater than the conditional value of non-participation. Under the assumption that $\varepsilon_t(d)$ are identically and independently distributed over households and time as Type 1 extreme value random variables, Hotz and Miller (1993) prove the existence of a mapping, by which the difference in conditional value functions $V_1 - V_0$ can be represented as a function of conditional choice probabilities: $V_1(x_t) - V_0(x_t) = \log\, p_1(x_t) - \log\, p_0(x_t)$, where p_1 is the conditional probability of participating in stock markets, p_0 is the conditional probability of not participating in stock markets. This result allows for transformation of the optimality condition (2) into an expression, where the log odds ratio of participation and non-participation is

[9] Epstein-Zin preferences are also used as a flexible alternative to CRRA preferences (see Gomes and Michaelides, 2005).

[10] Similar although only indirectly related evidence in Hong et al. (2004) points to a negative link between being in a depressed state and participating in the stock market.

equated to the differences in conditional value functions (4) and (3). Furthermore, Theorem 1 in Arcidiacono and Miller (2011) proves that the conditional value functions (and the differences between them) can be expressed in the form of the current and future utility payoffs, functions of conditional choice probabilities, and the corresponding state transition probabilities. This result allows for the elimination of the conditional value functions from the estimating equation. Finally, as Altug and Miller (1998) show, and as Arcidiacono and Miller (2011) further formalize, finding two sequences of current and future choices may be possible, such that the two sequences of choices result in the identical vectors of state variables at some future date τ. This property of the model, which is called finite dependence, leads to a significant simplification of the estimator.

To exploit this useful property, I define a set of choices beginning from period t, where one choice starts with participation in stock markets with the corresponding conditional value $V_1(x_{it})$, and another choice starts with non-participation with the corresponding conditional value $V_0(x_{it})$. Under the first sequence, the household chooses to participate in the stock markets at date t (with the initial state vector being transformed into period $t+1$ state vector $x^{(k)}_{it+1}=(\alpha_{it},\tilde{w}^k_{it},z'_{it+1},\nu_i,\omega_{t+1})$), but chooses non-participation in period $t+1$. Note that in period $t+1$, a household faces a realization of the rates of return on stock holdings that is uncertain when participation choice is made at time t. The uncertain return on stock holdings affects the return on household portfolio at time $t+1$, R^p_{it+1}, and the return adjusted wealth, $\tilde{w}^k_{it}$. The superscript k denotes a point in the discretized distribution of the stock returns. Under the second sequence, the household chooses non-participation in the stock markets at date t (so that in period $t+1$, the corresponding state vector becomes $x^{(0)}_{it+1}=(0,\tilde{w}_{it},z'_{it+1},\nu_i,\omega_{t+1})$), and then does not participate in period $t+1$. (The superscripts 0 and k allow for a distinction between $t+1$ period state vectors that result from different initial choices.) If the choice of wealth held in riskless assets in period $t+1$ is the same under both strategies, the state vectors for both strategies in period $t+2$, given by $x_{it+2}=(0,\tilde{w}_{it+1},z'_{it+2},\nu_i,\omega_{t+2})$, do not differ either in wealth or in portfolio allocation. The terms in the conditional value function become inconsequential beyond time period $t+1$ from the point of view of optimization. The important implication of this construction is that the model can satisfy the one-period finite dependence property.

The resulting estimator is obtained as

$$\ln\frac{p_1(x_{it})}{p_0(x_{it})}=u(x_{it},1)-u(x_{it},0)+\beta\sum_{k=1}^{K}[(u(x^{(k)}_{it+1},0)-u(x^{(0)}_{it+1}),0)-\ln(p_0(x^{(k)}_{it+1}))+\ln(p_0(x^{(0)}_{it+1}))]\mathcal{F}^k_{t+1}, \tag{11}$$

where $p_0(x^{(k)}_{it+1})$ is the probability of not participating in stock markets in period $t+1$ conditional on participation in the previous time period and receiving one of the possible K realizations of return on the investment in stocks, and $p_0(x^{(0)}_{it+1})$ is the probability of not participating in the stock markets in period $t+1$ conditional on non-participation in period t. Transition probabilities are set to be independent of individual investor characteristics, so that $F(x^{(k)}_{it+1}|x_{it})=\mathcal{F}^k_{t+1}$.

3.2. Estimation procedure

Estimation of Eq. (11) follows a three-step strategy. Steps one and two estimate nuisance parameters, which consist of the estimates of fixed effects (estimates of unobserved individual heterogeneity), estimates of aggregate shocks, and estimates of conditional choice probabilities. Estimating these parameters precedes the estimation of the parameters of the utility and the participation cost. In particular, fixed effects and aggregate shocks are included in a set of covariates to estimate conditional choice probabilities. The estimates of conditional choice probabilities are then incorporated into Eq. (11), which estimates parameters of the utility and the participation cost.

3.2.1. Earnings equation

The estimated earning's equation (reported in Table 1) serves two purposes. It is used to evaluate individual-specific permanent heterogeneity. The estimated income process is further used in the simulation exercise.

Consistent estimation of conditional choice probabilities hinges on the proper account for permanent unobserved heterogeneity. I adopt the Altug and Miller (1998) approach of an auxiliary regression for estimation of unobserved effects, and use the earnings equation to estimate individual unobserved effects.[11] In estimation of the earnings equation, I use labor income data (after-tax labor earnings plus transfers) for the period 1981–2007, because a larger time dimension is needed to reduce the small T bias in fixed effects.[12] A dynamic earnings equation is estimated using standard panel-data estimation techniques for dynamic models (see Arellano and Honoré, 2001, for details of constructing a Generalized Method of Moments (GMM) estimator). The same earnings equation allows me to estimate aggregate effects as well (not reported).

3.2.2. Conditional choice probabilities

Conditional choice probabilities are estimated nonparametrically using a kernel estimator. I use sample frequencies and subsequent outcomes from observations, and compute conditional choice probabilities with the help of non-linear regressions of the participation index d on the covariates of the state vector. The set of covariates for estimation of conditional choice probabilities includes past wealth, past share in wealth invested in stocks, return on household portfolio,

[11] More recent studies by Aguirregabiria and Mira (2007), Kasahara and Shimotsu (2009), and Arcidiacono and Miller (2011) propose alternative ways through finite mixture distributions. Identification requirements for these methods require the longer time dimension of a panel compared to the data used in the current study.

[12] Bi-annual data (odd years) is used to agree with the bi-annual nature of the main estimation sample.

income, age, education, occupation, family size, and marital status as well as estimated individual effects and time dummies from the earnings' equation.

3.2.3. Utility parameters and participation cost

Eq. (11) is the basis for construction of the moment condition to be estimated. The parameters of the model are estimated using the empirical counterpart to the resulting moment condition. These parameters include the utility parameters γ_0, γ_1, ξ, the risk aversion parameter ψ in case of CRRA utility, and the parameters of the participation cost $\boldsymbol{\delta}$. I fix the value of the time-discount factor β at 0.90, which corresponds to 0.95^2, to agree with the bi-annual format of the data, and estimate the remaining parameters conditioning on β. The estimation is achieved by the GMM, as proposed by Hotz and Miller (1993) for a CCP framework.

4. Data

Wealth supplement of the Panel Study of Income Dynamics (PSID) is a longitudinal data set that covers all age cohorts, which makes it suitable for studying dynamic stock market participation of prime-age consumers.[13] Starting in 1999, the wealth supplement of the PSID is available on a bi-annual basis. In my analysis, I use observations on household liquid wealth, income, and demographic characteristics for five time periods, from 1999 through 2007.

Household stock market participation is a result of a complicated decision-making process that involves taking into consideration various background risks and other investment opportunities. Risky labor income may cause a crowding out of stock market investments (Benzoni et al., 2007). Heaton and Lucas (2000) argue private business assets substitute for public equity. Homeownership and changes in housing may result in household portfolio shifting away from direct stock holdings (Grossman and Laroque, 1990; Flavin and Yamashita, 2002; Chetty and Szeidl, 2007). Finally, deep changes in family composition affect household financial portfolio as well (Love, 2010). To focus on stock market participation in the current study, I try to minimize the potential influence of these factors, and consider households that satisfy the following conditions: (i) do not invest in business and/or farm, (ii) do not experience changes in housing, and (iii) have the same head of household for the whole observation period. Table 2 shows summary statistics for the data I use in my analysis.

Consumption expenditure is a central ingredient in life-cycle models. Although data on wealth and income are available from the PSID, the survey does not report total household consumption. To circumvent this problem, I compute the measure of a household's consumption from income and wealth information.[14,15,16]

The construction of households income for the consumption measure follows closely the definition of the measure of disposable income in Browning and Leth-Petersen (2003). Household income is defined as the sum of labor income, financial income, public and private transfers minus taxes.[17] The measure of household income includes wages of the head of the household and the spouse, bonus payments, overtime payments, tips, commissions and earnings, net pension payments, working compensation, financial income (interest, dividends, income from trust fund), pubic transfers (value of food stamp benefits, TANF, and other state program transfers, Supplemental Security Income payments, as well as other public welfare payments), and other money inflow (child support, help from relatives, rent).

Total liquid wealth is computed as a sum of direct non-IRA stock holdings, money in checking or savings accounts, money market funds, certificates of deposit, government savings bonds, Treasury bills, other bond holdings, and money in other savings or assets, such as bond funds. The value of households' direct investment in stocks consists of the value of stock shares in publicly held corporations, shares of stock held through mutual funds, or investment trusts, and does not include stocks in employer-based pensions.[18] The value of liquid wealth that is not invested in stocks is considered a risk-free asset.

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[13] Other high-quality wealth data used in household finance are the US Survey of Consumer Finances (SCF), and the US Health and Retirement Survey (HRS); however, the use of these data is not suitable for the current study due to the lack of a panel component in SCF and the emphasis on older cohorts in HRS. For the alternatives beyond the aforementioned US data sets, see the review on comparability of the existing micro-data on household wealth in Sierminska et al. (2006).

[14] A comparable imputation has been previously done with the PSID data (see Ziliak, 1998). Other studies that methodologically justify the imputation of consumption expenditure based on the information on income and wealth include Browning and Leth-Petersen (2003) and Koijen et al. (2011). The latter study provides further evidence that the imputation of consumption from the budget constraint may overcome measurement deficiencies present in survey-based consumption, especially for the wealthy.

[15] The precision of the imputed consumption necessarily depends on the quality of income and wealth data. The studies of Browning and Leth-Petersen (2003) and Koijen et al. (2011) take advantage of the accuracy of the administrative data to produce a reliable measure of consumption. Due to the shortage of administrative data on wealth for the US households, the accuracy of the imputed consumption relies on the quality of survey-based wealth data. The inquiry into wealth data of Bosworth and Smart (2009) suggests an equal grade of wealth data in the PSID and other credible surveys, the US HRS and the US SCF, with the divergence for only the top 5% of households. I exclude the extremely wealthy consumers from the data sample used in the analysis; therefore, the imputed consumption can be considered a reliable measure of true consumption.

[16] The imputed measure of consumption expenditures compares well with the results of the food-based imputation of Blundell et al. (2008). The estimation of the demand for food on the resulted total expenditure, prices, demographic, and socioeconomic characteristics of the household with the same set of covariates and instruments as in Blundell et al. (2008) (with the only difference in the studied period, 2001–2007) produces budget elasticity of 0.5 and the food price elasticity of -1.5, both parameters are significant, have the right signs, and magnitudes comparable to those in Blundell et al. (2008). The demographics also have the expected sign. Full results are available from the author upon request.

[17] Taxes are accounted for with the help of TAXSIM (Feenberg and Coutts, 1993).

[18] An increasing number of individuals invest in stocks through various pension schemes, which may result in an ambiguous effect on direct stock holdings. On the one hand, having stock holdings in pension accounts may affect the share of liquid wealth held in stocks through diversification. On the other hand, the experience of investing in stocks through pension accounts may create a spillover effect and reduce the objective cost of stock market

Table 1
Panel estimates of the earnings equation:

$$\log\, y^l_{it} = \phi \log\, y^l_{it-1} + z'_{it}\boldsymbol{\kappa} + \omega_t + \nu_i + e_{it}$$

Parameter	Estimate
ϕ	0.856 (0.038)
κ's:	
family size	0.202 (0.037)
*edu*age*	0.577 (0.063)
age^2	−0.863 (0.088)

Standard errors are in parentheses. Number of households in the sample is 7744. Instruments include a constant, age of head of household squared at time t, and labor income at time $t-2$.

Table 2
Summary statistics.

Year	1999	2001	2003	2005	2007
Observations	1332	1424	1382	1481	1524
Income and Wealth[a]					
Income	39,420.6	39,532.9	38,748.0	40,040.0	40,252.8
Nonparticipants	34,716.9	35,363.8	35,698.1	36,913.2	36,965.0
	(19,885.0)	(21,087.4)	(21,198.6)	(22,709.3)	(22,290.0)
Participants	50,740.6	50,243.1	46,938.1	49,565.4	51,530.6
	(29,623.8)	(27,695.0)	(29,134.3)	(30,019.2)	(29,623.2)
Wealth	21,525.4	21,974.9	23,793.2	22,864.0	21,859.5
Nonparticipants	10,407.1	10,725.3	11,440.3	10,338.6	10,532.2
	(23,649.3)	(25,346.4)	(27,277.2)	(22,870.9)	(25,020.8)
Participants	48,283.5	50,874.2	56,965.1	61,022.1	60,714.7
	(58,981.7)	(64,580.2)	(71,231.2)	(74,778.4)	(71,578.9)
Wealth change		2,898.2	−925.2	1,111.7	1,466.5
		(41,388.7)	(42,124.4)	(39,780.3)	(37,894.2)
Consumption change[b]			−933.2	958.1	−921.2
			(27,197.7)	(30,822.9)	(24,997.3)
Stock holders	0.29	0.28	0.27	0.25	0.22
Share of wealth in stock	0.61	0.58	0.53	0.55	0.57
Stock holdings of participants	32,883.1	32,979.9	32,451.9	37,838.5	37,270.7
Demographic data					
Age	43.3	44.3	45.1	46.1	46.0
Nonparticipants	42.6	43.7	44.6	45.4	45.4
Participants	44.8	46.0	46.5	48.3	48.0
Family size	3.03	3.00	2.93	2.94	2.89
Nonparticipants	3.10	3.02	2.97	2.99	2.92
Participants	2.87	2.94	2.82	2.80	2.78
Education	13.7	13.6	13.6	13.7	13.7
Nonparticipants	13.3	13.3	13.3	13.4	13.4
Participants	14.6	14.6	14.5	14.6	14.7
Marital status	0.70	0.70	0.70	0.71	0.71
Nonparticipants	0.69	0.67	0.67	0.68	0.68
Participants	0.74	0.78	0.76	0.79	0.79
Occupation[c]	n.a.	n.a.	0.16	0.17	0.16
Nonparticipants			0.13	0.15	0.14
Participants			0.23	0.23	0.26

[a] Standard deviation is reported in parenthesis.
[b] Imputed data.
[c] Equals to 1 if related to management, business operation, or financial specialist; 0 otherwise.

(*footnote continued*)
participation, because the knowledge gained by investing in stocks through pensions can facilitate the decision about allocation of liquid wealth into stocks. However, pension wealth differs substantially from liquid wealth, and therefore, I exclude it from the analysis. Unlike direct stock and bond holdings, which, if needed, could be turned into cash, pension wealth can mainly be accessed at retirement. Further, according to Choi et al. (2002),

I remove extreme outliers by excluding observations for wealth and income above the 99th percentile and below the 1st percentile.[19] Data on income and wealth are deflated using the CPI for the end of the year before the interview was conducted. The CPI deflator is taken from the consumer price index releases of the Bureau of Labor Statistics.

Accounting for individual heterogeneity in portfolio returns has important implications for computation of the total consumption (see Koijen et al., 2011). The itemized composition of household wealth makes computing the measure of household-specific portfolio return possible. If R^s is the real return on the risky assets held by the household and R^f is the return on the riskless assets, then the combination of these returns gives the return on the portfolio $R_t^p = \alpha_{t-1}R_t^s + (1-\alpha_{t-1})R_t^f$, where α is a share of wealth allocated to stock holdings. The PSID data do not allow for a computation of the exact return on stock holdings due to the lack of information about specific types of risky assets in household portfolios. The return on stock holdings is measured by the SP500 index for the period. Therefore, the heterogeneity in the household portfolio return arises from the variation in the share of wealth invested in stocks. Notice that for the majority of households that do not participate in stock markets and hold liquid wealth in risk-free and alike assets, the return on household portfolio equals the risk-free rate.

Uncertainty about returns on risky assets plays an important role in dynamic decisions about participation and portfolio composition. The probabilities of future stock market participation conditional on current participation choices and outcomes capture the dynamics of stock market participation. The outcome is the realization of wealth. Once a household decides to invest in risky assets, household wealth at time $t+1$ depends on the realization of the rates of return on stock holding, which is unknown to a household when it makes participation choices at time t. To integrate over the uncertain returns on risky portfolio allocations, I discretize the realizations of the returns on stock holdings to allow for up to three states conditional on investing, generally described as high, moderate, and low realizations. Moderate return falls inside one standard deviation from the observed average return on stock holdings, and a high (low) realization of return falls above (below) one standard deviation from the average return. The probabilities of future stock market participation are computed conditional on realization of wealth in the three aforementioned states. The distribution of the rate of return on stock holdings is evaluated using the information on the SP500 index from 1953 to 2007, whereas current realizations of the index are taken for the period 2001–2007. The real risk-free rate is constructed based on a seasonally adjusted deflated average six-month Treasury bill.

Table 2 shows the dramatic difference in both income and wealth between participants and nonparticipants. On an average, nonparticipants have a lower income. The accumulated wealth of nonparticipants is substantially lower as well. However, larger standard deviations accompany the greater average income and wealth of stock market participants. Table 2 shows differences in demographic characteristics of participants and nonparticipants. Demographic characteristics include age, education, and occupation of the head of the household, as well as marital status and family size. Individual consumption and savings behavior differs depending on the consumer's stage of life: in prime working age or at retirement. This study mostly considers prime-age consumers and excludes households whose head is either younger than 22 or older than 65 over the period of the estimation. I also exclude households whose marital status changed over the sample period. On an average, participants are two to three years older and more educated. Their occupation is typically more related to management, business operations, or finance. More married individuals are among stock market participants compared to nonparticipants. The difference in family composition is not substantial.

The data sample is constructed as an unbalanced panel of 299 households observed over three periods: 2001, 2003, and 2005. Two other time periods (1999 and 2007) are lost while taking one lag and one lead. I observe these households participating in stock markets in the current period. Whereas the utility parameters are estimated using information on stock market participants, the construction of the estimator allows me to fully use the information on nonparticipants in the estimation of the individual effects and the conditional choice probabilities in the first two stages of estimation; therefore, I incorporate this information into the estimation of the final stage through the estimates of unobserved effects and the conditional choice probabilities. Also, I construct the third-stage estimator from an identity equation that holds equally for participants and nonparticipants.

The set of model covariates includes past and current wealth, the past and current share of wealth invested in stocks, current and future income, current demographic characteristics, as well as estimates of the conditional choice probabilities, and transition probabilities, computed from the empirical distribution of returns on stockholdings. The instrument set for orthogonality conditions includes variables from the state vector: the past share of wealth invested in stock, past portfolio allocation, return on household portfolio, income, and family characteristics.

5. Empirical findings

5.1. Estimation results

Tables 3 and 4 contain the estimation results for the parameters of stock market participation cost and the utility parameters for two utility specifications, quadratic utility (7) and CRRA utility (8). Recall that quadratic preferences render

(*footnote continued*)
the allocation of pension wealth into stocks is usually not an active decision, but rather a passive following of the default allocation offered by the employer. Therefore, although the majority of the survey respondents with existing pension funds keep a part of it in stocks, modeling of allocation of pension funds into risky assets as an active decision would likely result in erroneous model predictions.

[19] The portfolio choice of the rich is not in the scope of the current study; however, it deserves special attention because risky-asset allocation for the wealthy is strikingly different from the one for the remaining population (see Carroll, 2002).

Table 3
Participation cost and utility parameters. Quadratic utility of consumption.

Parameters	(1)	(2)	(3)	(4)	(5)	(6)
Participation cost $\rho_t = y_t^l(\delta_1 + \delta_2 d_{t-1} + \delta_3 edu + \delta_4 age_t + \delta_5 age_t^2)$						
δ_1	0.061 (0.019)	0.377 (0.093)	0.043 (0.221)	0.042 (0.019)	0.352 (0.108)	0.0344 (0.3124)
δ_2		−0.0246 (0.0137)	−0.0284 (0.0139)		−0.0322 (0.0154)	−0.0363 (0.0194)
δ_3		−0.0163 (0.0049)	−0.0180 (0.0050)		−0.0158 (0.0058)	−0.0157 (0.0072)
δ_4		−0.0007 (0.0009)	0.0170 (0.0096)		−0.0005 (0.0011)	0.0146 (0.0130)
δ_5			−0.00021 (0.00011)			−0.00019 (0.00015)
Utility parameters $(c_t - \xi_t c_t^2) + \gamma_0 d_t + \gamma_1 \alpha_t \alpha_{t-1}$						
	$\xi_t = \xi_1$			$\xi_t = \xi_1 + \xi_2 age_t$		
γ_0	24.414 (3.829)	34.174 (4.653)	33.183 (5.403)	20.588 (3.852)	30.590 (4.896)	25.337 (7.122)
γ_1	11.535 (7.739)	−5.906 (8.998)	−5.344 (9.680)	11.112 (7.898)	−0.501 (7.082)	2.110 (8.336)
ξ_1	0.00051 (0.00015)	0.00046 (0.00015)	0.00046 (0.00015)	−0.00028 (0.00071)	−0.00036 (0.00084)	−0.00009 (0.00083)
ξ_2				0.000016 (0.000013)	0.000019 (0.000016)	0.000015 (0.000016)

Standard errors in parentheses.

Table 4
Participation cost and utility parameters. CRRA utility of consumption.

Parameters	(1)	(2)	(3)	(4)
Participation cost $\rho_t = y_t^l(\delta_1 + \delta_2 d_{t-1} + \delta_3 edu + \delta_4 age_t)$				
δ_1	0.044 (0.002)	0.083 (0.003)	0.097 (0.001)	0.085 (0.001)
δ_2		−0.059 (0.002)	−0.059 (0.004)	−0.032 (0.0.01)
δ_3			−0.045 (0.002)	
δ_4				−0.039 (0.009)
Utility parameters $(\xi_1 + \xi_2 age_t)\frac{c_t^{1-\psi}}{1-\psi} + \gamma_0 d_t + \gamma_1 \alpha_t \alpha_{t-1}$				
$1-\psi$	0.700 (0.012)	0.452 (0.012)	0.595 (0.015)	0.502 (0.006)
γ_0	21.139 (0.501)	20.931 (0.499)	23.354 (0.667)	27.440 (0.463)
γ_1	4.792 (0.184)	3.693 (0.168)	−5.519 (0.287)	−4.079 (0.298)
ξ_1	0.001 (0.001)	0.160 (0.006)	0.038 (0.003)	0.166 (0.011)
ξ_2	−0.00011 (0.00001)	−0.00274 (0.00016)	−0.00064 (0.00005)	−0.00272 (0.00019)

Standard errors in parentheses.

the estimation problem as linear, whereas CRRA preferences result in a non-linear model, whose estimation is far more computationally costly. For this reason, the specification of the participation cost for quadratic preferences is somewhat more flexible compared to the specification estimated with CRRA preferences. Nevertheless, for both utility specification I estimate the average stock market participation cost and test how stock market participation cost varies with age, education and stock market participation in the previous period. Columns (1)–(4) of Table 4 report estimates for the model with CRRA utility of consumption, where specifications of the model differ only by composition of the participation cost. Columns (1)–(3) of Table 3 report estimates for the model with the simple quadratic utility of consumption, and columns (4)–(6) report estimates for the model with age-augmented quadratic utility of consumption. As in the case of the model with CRRA utility, in estimation of the model with quadratic preferences, I also allow for various specifications of the participation cost.

I will show that both utility specifications deliver a decent fit to the data. In addition to the main estimation, I carry out several robustness checks. Despite the conventional adoption of the CRRA preferences for the models of portfolio choice, I chose the quadratic preference specification as the base for the robustness checks. The choice is motivated by the computational ease of estimation of the model with quadratic preferences and its amenability to the measurement error problem.

5.1.1. Participation cost

The estimation results for the participation cost seem to be intuitive and agree with previous findings. First, Gomes and Michaelides (2003) rationalize limited participation by the existence of the participation cost. Second, empirical findings of Bertaut and Starr-McCluer (2002), Guiso and Jappelli (2002), and Banks and Tanner (2002) show that individual characteristics such as age and education can explain participation in stock markets. Finally, past participation also affects current and future participation. Alessie et al. (2002, 2004) and Munoz (2006) empirically confirm this dynamic dependence. The estimation results in the current study relate to these findings and show that the participation cost is significantly different from zero and varies with household characteristics.

Tables 3 and 4 indicate that the empirical results are in striking agrement regarding the average magnitudes of the cost and quantitative contribution of each factor (age, education, past participation) to the cost for different utility specifications. The results of the estimation of the participation cost in columns (1) and (4) of Table 3 and column (1) of Table 4 show the participation cost is on an average about 4–6% of labor income. Given that the labor income profile is not flat over the life-cycle, but admits the hump-shaped pattern, the variation of the participation cost over the life-cycle is determined by the hump-shaped profile of labor income. Further estimation results in columns (2)–(3) and (5)–(6) of Table 3 and columns (2)–(4) of Table 4 indicate that, even holding labor income fixed, age, education, and previous participation significantly affect participation costs. In contrast to the results in Alan (2012), who finds per-period participation costs are larger for older and more educated groups of consumers, the current empirical estimates provide evidence that the participation costs are less for more educated investors and decrease as consumers become older. The coefficient on age is estimated as negative and significant in Table 4; however, it is not precisely estimated in columns (2) and (5) of Table 3. Age squared is included in columns (3) and (6) of Table 3 as a determinant of the participation cost. Here, the participation cost is estimated as increasing and concave in age, with the turning point evaluated around ages 35–40. In a life-cycle prospective, the estimated participation cost, evaluated for each age with other demographic characteristics fixed at their sample average levels, never exceeds 10% of labor income, but can also decrease to negligible values for older stock market participants.

The estimation results for both utility specifications provide evidence that the participation cost is smaller for households that participated previously in stock markets. The coefficient δ_2 on the dummy of previous period stock market participation is estimated negative and highly significant for all model specifications that include it. The empirical findings suggest that current per-period participation costs are substantially smaller if a household invested in stocks in the previous period. On an average, participation costs are about 3% less for investors with previous stock market participation experience. This finding implies first-time participants face larger participation costs that potentially include a fixed entry cost. Overall, the estimated per-period participation cost gives an empirical support to the existence of the fixed entry costs mostly used in the theoretical papers (e.g., Gomes and Michaelides, 2003; Haliassos and Michaelides, 2003, and related studies).

The fixed entry cost theory assumes that if a consumer faces only fixed entry costs while making a decision to invest in stocks, quitting the stock market in the current period and investing in stocks in later periods is not costly for him. In this case, the consumer has already incurred the cost and the information he obtained when entering the stock market the first time never depreciates. The per-period participation cost can measure the ongoing effort to gather the information related to investment in stocks, and the knowledge an investor gained in previous periods may still be relevant in the current period. However, the further in the past an investor obtained the knowledge, the less applicable and relevant this information can be to the current state of the stock market. The per-period participation cost can, therefore, capture the effect of the diminishing relevance of previous knowledge and experience.

Because of the limitations along the time dimension of the panel data, I allow for only one lag of the participation dummy to affect the current participation cost. In general, one can test the relevant importance of the entry cost and per-period cost with the flexible form of the participation cost by allowing for more lags in the participation. This addition is possible at the expense of the reduction of the time dimension in the panel used in estimation. I defer the extension of the model along this line of research for future work.

As discussed previously, the knowledge gained by investing in stocks through various pension schemes can facilitate the decision about direct stock holdings. The experience of investing in stocks through pension accounts may create a spillover effect and reduce the participation cost. As a robustness check, I estimate a model specification, in which participation cost accounts for a dummy equal to 1 if a household owns stock holdings through employer-based pensions or individual retirement accounts. The results, while quantitatively similar along the dimension of the other parameters, do not reveal that indirect stock holdings have any effect on the reduction of the stock market participation cost.[20] Nonetheless, the interdependence of investment choices in stocks directly and through pension vehicles is still an open and interesting research question and deserves some further investigation.

5.1.2. Utility parameters

The estimated utility parameters include the parameters of the taste shifter in the utility of consumption, the risk aversion parameter in case of the CRRA utility, the utility shifter for stock market participants, and parameters of the adjustment of portfolio allocation.

[20] Results are available from the author upon request.

Table 5
Robustness check for utility cost of adjusting portfolio allocation.

Parameters	(1)	(2)
Participation cost		
$\rho_t = y_t^l(\delta_1 + \delta_2 d_{t-1} + \delta_3 edu + \delta_4 age_t + \delta_5 age_t^2)$		
δ_1	0.006 (0.099)	0.058 (0.079)
δ_2	−0.027 (0.008)	−0.036 (0.006)
δ_3	−0.017 (0.002)	−0.015 (0.001)
δ_4	0.018 (0.004)	0.013 (0.003)
δ_5	−0.00022 (0.00004)	−0.00017 (0.00005)
Utility parameters		
$(c_t - \xi_t c_t^2) + \gamma_0 d_t + \gamma_1 \lvert\alpha_t - \alpha_{t-1}\rvert$		
	$\xi_t = \xi_1$	$\xi_t = \xi_1 + \xi_2 age_t$
γ_0	35.842 (2.5382)	28.251 (2.227)
γ_1	−5.270 (2.867)	−4.482 (2.275)
ξ_1	0.00046 (0.00002)	−0.00001 (0.00008)
ξ_2		0.000013 (0.000001)

Standard errors in parentheses.

All model specifications in Tables 3 and 4 suggest the existence of a positive utility shifter for the households that participate in stock markets. This result gives an empirical support to the aforementioned evidence on higher life satisfaction of stock market investors compared to the non-investors.

I estimate the parameter on the cost of portfolio adjusting, using two specifications: the main specification with intertemporal non-separability as in (9) and, as a robustness check, the alternative formulation as absolute value of the difference between current and past portfolio shares. Although not modeled explicitly in the current study, conditional on household's participation in stock markets, portfolio share in stocks α_t is a household's continuous choice. Linear and difference specification of portfolio adjustment cost imply that the portfolio share in stocks in period $t-1$ does not affect the marginal utility with respect to the share in stocks. A household that invests a larger share in stocks in period $t-1$ might keep a higher (lower) share in stocks in period t. The evidence on this intertemporal dependency can be inferred by allowing for intertemporal non-separability in the current and past portfolio allocation and testing if the individual's marginal utility of share of wealth in stocks in period t is an increasing (decreasing) function of period $t-1$ portfolio share. The absolute value of a difference in the current and past portfolio shares assumes that regardless of the direction, any change in portfolio is costly, and the more so, the further away the new portfolio allocation is from the previous one. I discuss the results for these two specifications in turn.

According to Table 3, the parameter of the portfolio adjustment cost for the specification as in (9) estimated for quadratic preferences is not significantly different from 0. The results on this parameter for CRRA preferences are mixed. The parameter γ_1 is positive in case of simpler specification of the participation cost (columns (1)–(2) of Table 4), whereas it is estimated as negative for the remaining specifications. Note that the positive estimate of γ_1 indicates a complementarity effect of past portfolio allocation on current portfolio allocation. However, the current estimation outcome for non-separable adjustment cost does not allow a revelation of such an effect in a precise and unambiguous way. Unlike in the case of non-separable specification, the robustness check estimation of the parameter on the cost of adjusting portfolio allocation for the absolute distance specification is estimated negative, although only marginally significant (see Table 5). The results along the dimension of the other parameters are similar to the results in columns (3) and (6) of Table 3. This finding provides a moderate support and aligns with the conclusion in Bonaparte and Cooper (2009) who argue that the costs of adjusting portfolio may be substantial.

The estimates of the curvature parameter for the CRRA utility, as reported in Table 4, imply that the risk aversion parameter is estimated between 0.3 and 0.5. This parameter is estimated precisely and varies only slightly over considered model specifications. The values of the implied risk aversion indicate that households are only moderately risk averse. The estimated values of risk aversion are lower than the values suggested by the empirical and theoretical intertemporal choice life-cycle literature with the typical magnitudes of risk aversion often substantially greater than 1. Yet the magnitude of the constant relative risk aversion of about 0.5 is a typical finding in studies on individual decision making even with high payoffs.[21] As reported further, to evaluate the sensitivity of the participation in stock markets to higher values of risk aversion, I conduct a counterfactual simulation exercise with the parameter of risk aversion typically used in life-cycle literature.

[21] See, for example, a discussion in Holt and Laury (2002).

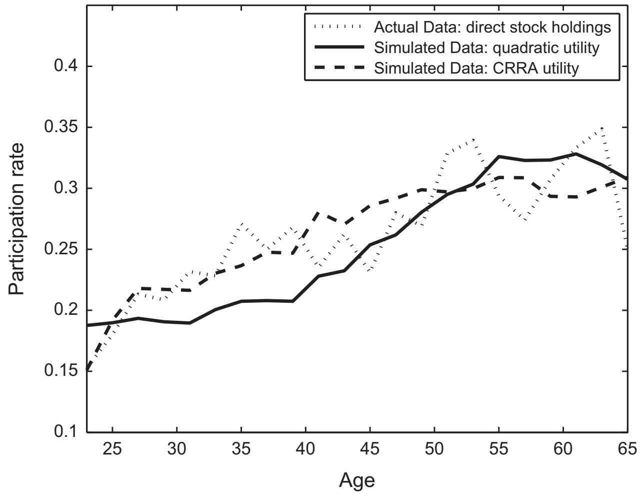

Fig. 1. Participation rate: Data vs Simulation.

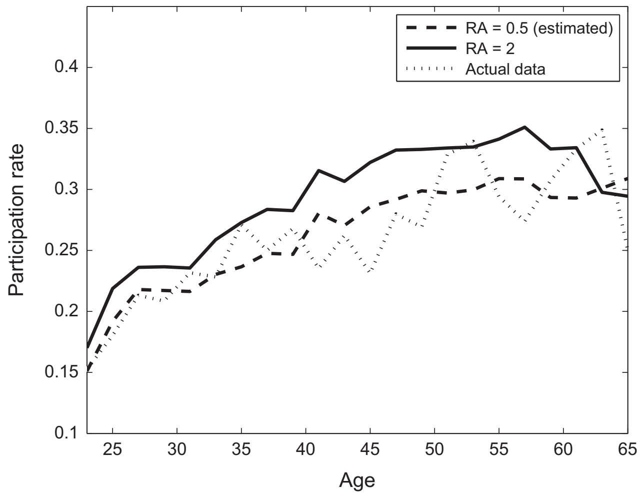

Fig. 2. Participation rate: Data vs Simulation.

5.2. Model fit

The simulation exercise is aimed to show how the estimated model fits the stock market participation pattern observed in the data. I solve the model via backward induction using the estimated parameters reported in column (3) of Table 4 for CRRA utility and column (6) of Table 3 for quadratic preferences. Because the estimation uses biannual data, I also solve the model recursively on a biannual basis. To align with the estimation set-up that considers households prior to retirement (i.e., before age 65), I simulate households up to the retirement stage.

To solve for the optimal share of wealth invested in risky assets and total wealth, I first define a fine grid on state variables that include past share of wealth invested in risky stocks and past wealth with earned rate of return, as well as income. I achieve the interpolation off the grid with the second-order polynomial regression of the value function at each point of the grid on the corresponding state space vector.[22] This regression provides an accurate approximation to the value functions off the grid with R^2 in the range of 0.98–0.99.

Once the solution is obtained, I simulate the model, producing 5000 replications.[23] I choose no participation in stock markets as a starting condition for all simulated individuals. Conditional on the state variables, I compute the conditional choice value function for each combination of the choice variables from the grid, using the interpolation coefficients obtained at the solution as well as the draws of extreme value random variables. Then I select the maximal conditional choice value function and find the optimal choice of participation decision, portfolio choice, and wealth associated with the maximal value function. If a simulated consumer finds participating in stock markets is optimal, he receives the rate of return of stock holdings, drawn randomly as low, moderate, or high return with corresponding probabilities used in estimation as transition probabilities.

[22] I also tried higher-order polynomial regression; however, it produces less accurate predictions.

[23] A greater number of simulations makes little difference.

Fig. 1 compares (1) the average age-specific participation rate computed from the data, (2) participation rate, predicted by the structural model with quadratic utility, and (3) participation rate, predicted by the structural model with CRRA utility. As shown in Fig. 1, both structural models with quadratic and CRRA utilities and explicit accounting for participation costs successfully predict the stock market participation rate observed in the data. The model with CRRA preferences visually traces the participation rate in the data closer relative to the participation rate predicted by the quadratic preferences. Both models also produce an increasing pattern of stock market participation over the life cycle.

As a robustness check, I conduct a counterfactual simulation exercise in which the estimated parameter of risk aversion in the model with CRRA utility is replaced by the one typically used in life-cycle literature. Fig. 2 plots the stock market participation rate implied by the estimated CRRA preferences together with the participation rate implied by the model with the higher risk aversion parameter of 2. The two simulated series of participation rate are compared to the average age-specific participation rate computed from the data. Although the change in risk aversion from 0.5 to 2 seems substantial, it does not result in a dramatic change in the stock market participation rate. The participation rate implied by higher risk aversion is still close to the actual data and traces the observed pattern well. Fig. 2 also supports the conclusion in Gomes and Michaelides (2005), who find the increase in the risk aversion results in a greater participation rate.

6. Conclusion

This paper is the first analysis of stock market participation that allows for a connection between two types of stock market participation costs: the fixed entry cost and the per period participation cost. The paper quantifies empirically the magnitudes of the per-period participation costs, allowing for a rich set of heterogeneity in it, including age, education and past participation history. The empirical evidence suggests the participation costs decrease with previous stock market participation experience, which implies first-time participants face larger participation costs, which potentially include a fixed entry cost.

I find the average stock market participation cost estimated between 4% and 6% of labor income, which is well inside the range used in the literature. In addition, I find stock market participation costs decrease as consumers become older. If age is considered as a proxy for the accumulation of information and experience, the finding of the smaller participation cost for older and possibly more experienced consumers greatly supports my result that the participation costs are substantially smaller for consumers with previous participation experience.

Finally, the model provides a way of showing that extending financial education to consumers may have an effect on their stock market participation. There is a significant literature on the effect of financial literacy on stock market participation, however, there is no consensus regarding whether financial education programs are effective in alleviating the burden of consumers' financial decision making and increasing stock market participation. Although I do not have access to data on whether households take part in specific financial education programs, I find that stock market participation costs are less for investors with greater levels of general education. Importantly, my results indicate on partial substitution between stock market participation experience and education. While this evidence suggests that extending investor's education may have a positive effect on stock market participation, the effectiveness of the specific financial education programs is an important issue to be further explored. This is beyond the scope of this paper, primarily due to data limitations, and is left for future research.

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