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A New Participation Puzzle: Public Equity Ownership Through the Financial Crisis

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Keywords

Portfolio choice, Stock market participation, Financial crisis, Household finance

Disciplines

Business

A NEW PARTICIPATION PUZZLE:
PUBLIC EQUITY OWNERSHIP THROUGH THE FINANCIAL CRISIS

By

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A new participation puzzle: Public equity ownership through the financial crisis*

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Using the Survey of Consumer Finances, I document a new puzzle in household portfolio choice characterized by two phenomena. First, intertemporal changes in the distribution of wealth resulted in a decrease in public equity ownership after, but not during, the financial crisis. Second, holding fixed the level of wealth over time, the participation rate temporarily increased during the crisis, then returned to pre-crisis levels. I show that these results can be explained by, and serve as strong evidence for, decreasing relative risk aversion and portfolio inertia. I discuss implications of these findings for existing models of participation, including fixed costs and background risks.

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1 Introduction

Portfolio choice theory suggests that, given a positive equity risk premium, all risk-averse investors should participate in risky asset markets.[1] Despite this expectation, non-participation in such markets is a well-documented phenomenon that has persisted over decades (Mankiw & Zeldes, 1991; Bertaut & Haliassos, 1995).

This "participation puzzle" has prompted an entire body of literature seeking to explain it. One such explanation depends on the presence of participation costs, defined generally as either a fixed entry cost or recurring transaction costs (e.g., Vissing-Jørgensen, 2003). Another branch of the literature posits that background risks — for instance, risks from uninsurable labor income (e.g., Viceira, 2001) or housing wealth (e.g., Cocco, 2004) — explain non-participation. Some have used alternative preferences to explain the puzzle. Barberis, Huang, and Thaler (2006), for example, model stock market participation using first-order risk aversion and narrow framing. Despite the breadth of the literature on the topic, there remains no clear consensus.

Building on this extensive body of literature, I introduce a new empirical phenomenon and discuss its implications for household portfolio choice — principally, for the participation puzzle. Using data from the Survey of Consumer Finances (SCF) from 2001 to 2016, I examine participation in public equities and other financial assets through the recent financial crisis and across household characteristics. From this examination, I find two major empirical phenomena related to household wealth, depicted in Figure 4 and summarized as follows:

1. Across most of the wealth distribution, there was a decrease in public equity ownership after, but not during, the financial crisis.

2. Holding fixed the level of wealth over time, the participation rate temporarily increased during the crisis, then returned to pre-crisis levels.

[1] A powerful theorem by Arrow (1970) states this and is proven in Appendix B. A similar but more limited proof using the Merton (1969) life-cycle portfolio choice model is also included in Appendix C.

Furthermore, I find that these empirical findings are consistent with two well-documented phenomena: decreasing relative risk aversion (DRRA) and portfolio inertia. The former explains the apparent dependence of participation directly on wealth, while the latter explains the timing of the exit and the temporary increase characterizing the second empirical result. Specifically, I first establish that the decrease in the distribution of wealth is the major cause of the post-crisis decrease in participation. The fact that a decrease in wealth motivated an exit from public equities demonstrates that households exhibit DRRA. Moreover, the trading behavior of households during the crisis serves as evidence of portfolio inertia. These explanations are interdependent in the sense that in concert they can explain the empirical phenomena of this paper. I then look more specifically at the implications of all of these findings for existing models and theories of participation, paying particular attention to their consistency with my findings.

The main implications of the empirical results of this paper are summarized as follows:

1. The post-crisis exit from public equity markets was caused by a change in the distribution of wealth and is consistent with DRRA.
2. Both the timing of the exit and the temporary increase at fixed wealth levels in 2009 are consistent with portfolio intertia.
3. My findings are generally consistent with existing models of participation, but provide evidence against the importance of fixed entry costs and the claim that background risks can explain the relationship between wealth and participation.

To my knowledge, this is the first attempt to analyze household public equity participation using intertemporal evidence from the financial crisis. This period of great disturbance presents a useful natural experiment against which to test existing theories of household portfolio choice. In this sense, my findings contribute a novel piece of evidence to the literature from a different perspective.

The organization of the paper is as follows. Section 2 presents the main empirical results. Section 3 lays out the implications of these findings for household portfolio choice. Specifically, Section 3 investigates the connection between participation and wealth, explains the evidence for decreasing relative risk aversion and portfolio inertia, and discusses these findings in the context of existing models of participation. Section 4 concludes. The appendices contain information about the Survey of Consumer Finances and the main theoretical benchmarks off of which I base my empirical conclusions.

2 A new participation puzzle

2.1 Empirical results

Examining U.S. household financial data in the Survey of Consumer Finances (SCF), I track participation in public equity markets over time and across household characteristics. I restrict my analysis to households with positive wealth and use the seven surveys from 2001 to 2016, including the 2009 panel survey. Information about the SCF and its use in this paper, including variable definitions, can be found in Appendix A.

Figure 1 shows the participation rate of U.S. households in various financial assets over time. This plot in large part illustrates the first empirical result: there was a significant drop in the ownership rate of public equities from 2009 to 2010, but no change from 2007 to 2009. As I will demonstrate, this result is tied to the distribution of wealth. This trend is seemingly only present for public equities, but I do address the effect of owning other financial assets on household equity ownership.

I consider this phenomenon for households with positive wealth.[2] The first reason for this is that the result is more robust for these households. Figure 2 confirms that this is indeed the case. The second and principal reason is to allow for the application of a theoretical framework to this empirical result, as I will do in Subsection 3.2. It is worth noting that,

[2]Unless otherwise stated, the terms "wealth" and "net worth" are used interchangeably in this paper.

across surveys, the proportion of households with positive net worth is around 90%, so this is not a particularly impactful restriction.

This drop in the participation rate is robust to several household characteristics. The four panels in Figure 3 break down the participation rate across different categories. In Panel A, the trend is especially visible for households whose head has high school or some college as the highest level of education. There is also a drop in participation for households with the highest and lowest education levels. Panel B shows that there is no clear pattern in participation by age group; however, looking at the period of the crisis, all age groups except for the youngest exhibited the behavior that characterizes the trend. Panel C shows that the trend is very robust to marital status. Finally, Panel D shows that the trend is robust for households that do not own other financial assets. Notably, around 80% of households participating in equities do not own private businesses, investment real estate, or bonds. This robustness check is useful in showing that the trend was widespread across the population, and it will inform the corresponding regression analyses.

The two main empirical results of this paper become apparent when participation is examined with respect to wealth. Panel A of Figure 4 shows that the 2009 to 2010 drop in participation persists across the quantiles of wealth in each year. I denote these "dynamic quantiles" to express that these quantiles are changing each year. This confirms that the result seen in Figure 1 is robust across most of the wealth distribution. The exception here is the wealthiest subset of households, which showed little change.

Panel B of Figure 4, which looks at participation given fixed quantiles of wealth, provides a different perspective on the trend. I denote these "fixed quantiles" to express that the level of wealth is fixed at the 2007 quantiles across the whole time series. From this perspective, one sees a very different trend in the participation rate: holding fixed the level of wealth over time, there was a temporary increase in the participation rate in 2009, followed by a return to pre-crisis levels. As with Panel A, this trend is somewhat weaker for the wealthiest households

2.2 Regression analyses

I verify these results more rigorously by estimating regression models. Table 1 summarizes three fits to the SCF data. The first two models, a logistic regression and a probit regression, consider public equity participation as a binary variable and estimate the probability of a household participating. The third model, a tobit regression, estimates the logged value of public equity under the assumption that the variable is left-censored at zero. In all three models, the omitted category is households in 2007 that do not own other financial assets and whose head is married and has some college education.

I draw on the statistical analyses of two papers in the portfolio choice literature. Campbell (2006) fits a logistic regression to the 2001 SCF to examine the effects of changes in characteristics on the median household's participation in public equities. Wachter and Yogo (2010) fit a censored regression model to estimate the relationship between net worth and the portfolio share in risky assets. The key difference in my analysis is that I look explicitly at the effect of the given year on the dependent variable. I also fit multiple models to show robustness and present more than one interpretation of the result.

The three models yield virtually the same results for the effects of household characteristics on participation, consistent with other analyses in the literature. Participation and the value of public equity are increasing in net worth and decreasing in age. Note that the coefficient for log net worth of 2.7 in the tobit regression indicates that the portfolio share — the proportion of wealth in public equities — is also increasing in wealth. A higher level of education for the head of household indicates a greater likelihood of participating and a greater value of public equity. Participation is greater among married households. Finally, controlling for other characteristics, ownership of private business or investment real estate decreases the estimated probability of participating and the value of public equity. This is likely due to the fact that investment in these risky assets is a substitute to investment in public equities. Ownership of bonds increases these estimates, likely because, unlike the other two asset classes, this variable includes risk-free assets. These results are not crucial to the main result of this paper, but they do shed light on the nature of participation and allow for the controlled examination of wealth and year effects.

Both the logistic and probit models yield virtually the same result. Looking at the year variables, it is clear that the probability of participating in 2009 is statistically significantly greater than in 2007; at the same time, the probability of participating in 2010 is approximately the same as in 2007. This illustrates the second empirical result — that is, controlling for household characteristics and wealth, there was a temporary increase in participation in 2009. One sees the same result in the tobit regression, which estimates that the value of public equity for a given household at a given level of wealth is temporarily higher in 2009.

Figure 5 illustrates the results of the regressions and verifies both empirical results. In all four panels, the estimated values of the dependent variable are plotted for households in the omitted category whose head is the median age, 50 years old, at five different wealth percentiles. In Panel A and Panel C, these percentiles are dynamic; in B and D, they are fixed. Panel A and Panel B depict these results for the logistic regression, which are very similar to the probit results, while Panel C and Panel D depict them for the tobit regression. Evidently, both models tell the same story: in the dynamic case, there is a drop from 2009 to 2010, and in the fixed case, there is a temporary increase in 2009. These plots, and in turn the regressions from which they are derived, thus confirm the main empirical results of this paper.

The tobit model offers a useful interpretation that captures the intuition of several models of portfolio choice in the literature (e.g., Barberis et al., 2006). Let θ^* represent the optimal portfolio allocation as a proportion of total wealth W_t. The tobit model thus estimates the value of public equity in the form

$$\log\left(W_t\theta^* + 1\right) = \beta_0 + \beta_1 \log\left(W_t + 1\right) + \beta_2 \text{Age} + \varepsilon \tag{1}$$

where the value of the parameters β_0 depends on the given household characteristics and ε is an error term. This model assumes that if a household has $\theta^* \leq 0$, then it will not participate in the market and its allocation will be zero; thus, by assuming that the allocation is left-censored in the data, the tobit model estimates implicitly negative optimal allocations.

It is worth noting, however, that the primary purpose of this tobit regression is not to perfectly model the optimal allocation. While it does allow for negative estimates, the effect of the log transformation on the dependent variable $\log(W_t\theta^* + 1)$ makes it such that the estimated value of public equity $W_t\theta^*$ is necessarily bounded below at $-\$1$. The principal use of the tobit regression is to capture and verify the intertemporal and wealth-related effects that characterize the two main empirical results of this paper.

3 Implications for household portfolio choice

Having laid out the empirical phenomena of this paper, I now discuss implications for household financial decision-making. I first establish that the decrease in the distribution of wealth is tied directly to the decrease in participation post-crisis. I then state the evidence for DRRA utility and portfolio inertia that is present in these empirical results. Finally, I look more specifically at the implications of all of these findings for existing theories of participation, paying particular attention to consistencies and inconsistencies with my findings.

3.1 The role of wealth in participation

In this section, I establish that the first empirical phenomenon — the fact that post-crisis participation was significantly lower than pre-crisis participation across most of the wealth distribution — is directly related to changes in the distribution of wealth. This section seeks only to demonstrate that the difference between pre- and post-crisis levels is tied to a persistent change in wealth. Questions related to more specific issues like the timing of the exit and the causality of changes in wealth are addressed in the following subsections.

Looking broadly at the portfolio choice literature, there are several plausible factors that could affect a household's willingness to participate in the stock market. The most well-documented of these factors are changes in risk aversion, perceived changes in expected returns and volatility, and changes in wealth. Empirical evidence shows that, while many of these factors changed temporarily during the crisis, none of these changes persisted substantially beyond the crisis other than those of wealth.

There is compelling evidence that risk aversion and perceptions about risky asset markets do respond directly to negative macroeconomic events, but these responses are not persistent. Using survey data from an Italian bank's clients, Guiso, Sapienza, and Zingales (2018) find that measures of risk aversion increased substantially during the 2008 crisis. The fact that this paper uses investment data in the eurozone, which faced subsequent crises, prevents the authors from drawing a conclusion about whether changes in risk perceptions are persistent. Similarly, Malmendier and Nagel (2011) find that individuals who have experienced low stock market returns report lower willingness to take financial risk and are less likely to participate in the stock market; however, this analysis uses data only up to 2007. A more telling study of crisis-contingent risk-taking in the U.S. is conducted by Hoffmann, Post, and Pennings (2013), who examine perceptions and trading behavior of individual investors during the crisis. These authors find that risk aversion and perceptions about risks and returns changed during the crisis in a way that is consistent with both of these other studies. They also find, though, that both risk tolerance and investor perceptions recovered to pre-crisis levels toward the end of the recession.

Having ruled out other plausible explanations for the decrease in participation, I now turn to wealth. Table 2 summarizes the wealth level of households at five percentiles of the distribution in each year. For all percentiles other than the wealthiest, one can see that the negative shock to wealth during the recession persisted into the recovery. Thus, unlike factors like risk aversion and perceptions about the market, wealth changed permanently in response to the crisis. Notably, the fact that the wealth level of households at the 90th percentile recovered by 2010 strengthens the case that the decline in participation was directly tied to the decline in wealth. Looking at Panel A of Figure 4, one sees that the documented decline in participation occurred only for the bottom four quantiles — that is, for the subset of households that experienced a longstanding decline in net worth.

The main empirical results of this paper also illustrate this relationship between the declines in participation and wealth. Again looking at Figure 4, it is clear that, aside from a temporary increase in participation in 2009, the level of the participation rate contingent on fixed quantiles of wealth remained relatively constant before and after the crisis. This fixing of the wealth level in effect controls for changes in the wealth distribution, and in doing so it demonstrates that individuals exited public equities directly as a result of a persistent change in the level of their wealth.

3.2 Evidence for decreasing relative risk aversion

The fact that the decrease in participation was tied directly to a decrease in net worth points to an explanation of participation that relates one's decision to participate directly to one's wealth. In this section, I show that the empirical phenomena in this paper can be explained well by the assumption that households exhibit decreasing relative risk aversion.

I use as a benchmark the life-cycle portfolio choice theory outlined by Merton (1971). This model builds off of other seminal theories of portfolio choice (e.g., P. A. Samuelson, 1969; Merton, 1969). See Appendix C for an abridged derivation of this model under constant relative risk-averse (CRRA) utility.

Consider the class of hyperbolic absolute risk-averse (HARA) utility functions of the form

$$U(C,t) = e^{-\rho t}\left(\frac{\gamma}{1-\gamma}\right)\left(\frac{\beta C_t}{\gamma}+\eta\right)^{1-\gamma} \tag{2}$$

where $\beta > 0$ and $(\beta C_t/\gamma) + \eta > 0$. At time t, the agent with horizon T consumes C_t and allocates wealth to a risky asset with return $\tilde{r}$, and a risk-free asset with return r_f. Merton (1971) finds that the optimal portfolio allocation to the risky asset θ^* for this agent can be stated explicitly as

$$\theta^* = \frac{E[\tilde{r} - r_f]}{\gamma\sigma^2} + \frac{\eta E[\tilde{r} - r_f]\left(1 - e^{r_f(t-T)}\right)}{\beta r_f \sigma^2 W_t}. \tag{3}$$

Suppose now that the agent exhibits decreasing relative risk aversion (DRRA), in which case we let $\eta < 0$ and $\gamma > 0$ with restriction $\gamma \neq 1$. If we assume that $t \neq T$ and that the expected risk premium and risk-free rate are positive, then the agent will participate if and only if $\theta^* > 0$, or, solving for wealth,

$$W_t > \frac{-\eta\gamma\left(1 - e^{r_f(t-T)}\right)}{\beta r_f} > 0. \tag{4}$$

In other words, a household will not participate if this inequality is violated. If we allow for cross-sectional heterogeneity of risk aversion via the parameter γ, then the lower bound in inequality (4), the threshold for participation, depends explicitly on a given household's risk aversion. Moreover, for a given household, a decrease in the level of wealth can induce an exit from the risky asset market. It is not necessarily the case that this model is a perfect determinant of whether a household participates. Still, its implications about the relationship between wealth and participation status serves as a very useful benchmark against which to assess the mechanism underlying my empirical findings.

This theoretical result shows that DRRA utility is a valid explanation of the trends in participation documented in this paper. During the recession, a persistent negative shock to W_t resulted in $\theta^* \leq 0$ and induced exit for a number of households. This explains the decrease in ownership of public equities following the crisis in the dynamic wealth case. Inequality (4) also suggests that, holding fixed the level of wealth, the decision to participate is contingent only on factors that are independent of wealth. This explains why a movement to a new level of wealth would lead households to reallocate their portfolios in such a way that the pre- and post-crisis participation rates would be the same at fixed wealth levels.

Several papers have corroborated this claim. Carroll (2002) proposes a model in which all agents have a common utility function with DRRA, and argues that this model explains the high participation rate and more aggressive asset allocation of wealthy households. Calvet and Sodini (2014) investigate risk-taking behavior within a large panel of Swedish twins and find strong evidence for DDRA. The use of twins allows them to control for latent factors and thus overcome an identification problem that is pervasive in the literature. The authors' analyses imply that wealth does not merely act as a proxy for information differences across investors; rather, both for the participation status and the risky share among participants, financial wealth has a direct impact on risk-taking, providing strong evidence that households exhibit DRRA.

3.3 Evidence for portfolio inertia

It may be clear that the drop in participation is tied to that of net worth; however, there still remain questions regarding the timing of this exit. First, why did households choose to exit after, as opposed to during, the recession? Second, why was there a temporary increase in the participation rate in 2009 at fixed wealth levels? I show that both of these questions can be answered by a phenomenon known as portfolio inertia.

I define portfolio inertia as the tendency of participating households to adjust their portfolio allocations infrequently and with a delayed response to changes in conditions. One way in which to think about the concept of portfolio inertia is as a manifestation of the more general concept of "status quo bias" in economic decision-making (W. Samuelson & Zeckhauser, 1988). This behavior has been documented extensively in the literature. Using the SCF and TIAA-CREF, Ameriks and Zeldes (2004) document very infrequent trading: over a nine-year period, almost half of the sample members made no active changes to their portfolio allocations. Several other papers have empirically corroborated this phenomenon (e.g., Agnew, Balduzzi, & Sunden, 2003; Mitchell, Mottola, Utkus, & Yamaguchi, 2006; Bilias, Georgarakos, & Haliassos, 2010).

Using the 2007-2009 Panel SCF, which reinterviewed participants and thus documents individual household decisions at the height of the crisis, I show that portfolio inertia was indeed present in 2009. Table 3 presents the median changes in wealth and the entry and exit rates of households from 2007 to 2009. Results are shown for households in each wealth quantile and in aggregate. Notably, the percentages of all household who entered and exited public equity markets are both very low and nearly equivalent. Consistent with the findings of Bilias et al. (2010), the vast majority of households either stayed in or stayed out of the stock market during this period.

Note that the values corresponding to the first two quantiles of household wealth are somewhat skewed, since I look only at households who continued to have positive net worth in 2009. These numbers hence exclude some households in the lowest quantiles that sustained losses in net worth large enough to make it negative. Overall, this is not a significant proportion of the sample and a re-calculation of the values in Table 3 with the inclusion of these negative net worth household only marginally affects the results.

There are several ways in which to plausibly explain this phenomenon in the context of the financial crisis. Illeditsch (2011) argues that investors' desire to hedge against ambiguity, also known as Knightian uncertainty, leads to portfolio inertia for risky portfolios. The paper concludes that, when faced with unexpected news, investors may not react to price changes even if there are no transaction costs or other market frictions. The events of the financial crisis fit well into this framework. Another potential explanation for a delayed exit might be the presence of fixed entry costs: if households faced the possibility of recovering wealth post-recession, they may have been inclined to wait until making the decision to exit. I elaborate on this hypothesis in the discussion of models with participation costs that follows in Subsection 3.4.1. Regardless of the underlying mechanisms, it is clear that portfolio inertia was present among households in 2009.

The fact that portfolio inertia was present at the height of the crisis, combined with the fact that the drop in participation was caused by a decline in wealth, allows us to answer the two key questions about the timing of the phenomena in this paper. In the first place, households largely exhibited portfolio inertia during the crisis, leading them to delay their wealth-related exit. This interpretation is in line with the finding of Brunnermeier and Nagel (2008) that households are almost as reluctant to rebalance following large wealth changes as they are after small wealth changes. In the second place, portfolio inertia in concert with widespread decreases in wealth explains why there was a temporary increase in 2009 participation at fixed quantiles of wealth. Participating households lost wealth and entered a new fixed quantile, artificially increasing the ownership rate. Table 3 helps to confirm this: the median change in wealth from 2007 to 2009 was very negative for most quantiles. These households then adjusted their portfolio allocations, choosing to exit or remain in, in such a way that the fixed-wealth participation level at each quantile returned to pre-crisis levels.

The presence of portfolio inertia fits well with the existence of decreasing relative risk aversion. In theory, a household that is continuously re-allocating its portfolio should exit if inequality (4) is violated. Hence, a decrease in wealth W_t or an increase in the risk aversion parameter γ in 2009 should have prompted an exit for many such households, followed by a re-entrance of some post-crisis. Introducing the phenomenon of portfolio inertia, we see that a household may only respond to a violation of (4) if it is persistent, as was the case with the decline in wealth. In the case of the wealthiest households, whose net worth largely recovered by 2010, we see this manifest itself as essentially no change in participation through the recession. For lower-wealth households, we see a delayed exit. In effect, portfolio inertia introduces a delaying of participation changes in response to shocks to wealth.

3.4 Implications for existing models

3.4.1 Participation costs

A prominent branch of the literature postulates that non-participation can be explained by the presence of participation costs, which can be defined generally as either a fixed entry cost or recurring transaction costs. Generally speaking, the literature has accepted that the inclusion of some kind of participation cost is necessary to explain low participation; however, as Bertaut and Haliassos (1995) and Vissing-Jørgensen (2003) point out, these costs alone are not sufficient to explain non-participation at higher wealth levels.[3]

The presence of such costs are both consistent with and informed by my findings. Specifically, these findings present two major implications for the effects of participation costs: first, a fixed entry cost is not a major barrier to entry; and second, entry and transaction costs may help to explain portfolio inertia and the timing of the exit from public equities.

The empirical results of this paper suggest that the decision to participate in equities does not depend significantly on fixed entry costs. Suppose that a one-time entry cost is a major impediment to participation. A corollary to this premise would be that, even following some event like a decline in wealth, participating households would not exit the market. Specific to the financial crisis, the null hypothesis associated with this expectation would be that, at fixed levels of wealth, the post-crisis participation rates would be higher than the pre-crisis rates. Households that have already paid the entry cost would have no reason to exit. Evidently, that was not the case: households at new wealth levels reallocated their portfolios in such a way that the pre- and post-crisis ownership rates were nearly identical in all quantiles. There must be some other mechanism playing a larger role in participation decisions. I propose that this mechanism is decreasing relative risk aversion. Note that this conclusion does not suggest that entry costs are not a factor at all and says nothing about the effects of transaction costs.

The presence of entry and transaction costs do present a potentially useful explanation of the timing-related aspects of this paper. In the first place, recurring transaction costs can help explain portfolio inertia among participants. The participation cost literature implies that there exists a theoretical justification for infrequent trading if there are costs associated. Based on a formulation of the benchmark Merton (1971) theory with transaction costs, Duffie

[3] A diverse set of household portfolio choice papers depend on the inclusion of participation costs. Calvet, Gonzalez-Eiras, and Sodini (2004) examine the effects of financial innovation on market participation given a fixed entry cost. Gomes and Michaelides (2005) show that a model with incomplete markets can explain participation if there is a fixed entry cost and heterogeneity in risk aversion. Calvet, Campbell, and Sodini (2007) conclude that non-participating households invest inefficiently, lowering the magnitude of the participation costs necessary to explain their participation status. Other literature, looking specifically at the effect of real estate on investment in risky assets, concludes that housing can crowd out equities if households face participation costs (Cocco, 2004; Yao & Zhang, 2004).

and Sun (1990) show that there exits an optimal interval of time between trades and that this interval is fixed and independent of time and wealth. Abel, Eberly, and Panageas (2007) attempt to model exactly what this optimal period of inactive investing is and show that even a small observation cost (one basis point of wealth) implies a substantial (eight-month) decision interval. These theories, based in the same benchmark model as my findings, may help explain portfolio inertia at all levels of net worth. They are supplemented nicely by behavioral explanations like that of Illeditsch (2011).

As I alluded to in Subsection 3.3, a fixed entry cost may also help to explain the delayed timing of the exit. If an entry cost exists, that may make exit from the stock market potentially costly if a shock to wealth is temporary. Suppose that the agent faces a decrease in wealth and, as a result, deems that participating in the public equity market is no longer optimal ($\theta^* \leq 0$). If the agent, facing uncertainty about wealth in future periods, expects that wealth may increase to a level that would warrant re-entry into the market, he or she may be better off waiting for resolution of that uncertainty to avoid the possibility of paying the entry cost again. This explanation is not entirely in line with the phenomenon of portfolio inertia generally, but it may serve to explain part of the delay. While this is a plausible explanation for the phenomenon, I qualify it by noting my assertion above: the pre- and post-crisis participation rates do suggest that entry costs are not especially relevant to allocation decisions.

3.4.2 Background risks

Another prominent branch of the literature posits that background risks can explain low participation. These risks may come from idiosyncratic labor income (Viceira, 2001; Cocco, Gomes, & Maenhout, 2005; Gomes & Michaelides, 2005), housing wealth (Cocco, 2004; Yao & Zhang, 2004), or private business equity (Heaton & Lucas, 2000). While the presence of background risks in itself is not contradictory to my findings, some models that depend on background risks to explain participation may be seen as contradictory.

An implication of the presence of background risks is a precautionary savings motive that suggests that risk-averse households would accumulate more wealth (Haliassos & Michaelides, 2003; Gomes & Michaelides, 2005). Gomes and Michaelides (2005) propose a model that relies on uninsurable labor income risk and moderate risk aversion in the presence of a fixed entry cost. Based on this model, a strong precautionary savings motive implies that households that are wealthy enough to enter the market are more risk-averse than non-participating households. Thus, this framework suggests that heterogenous risk aversion, not wealth itself, explains the relationship between wealth and participation. This is evidently at odds with my finding of DRRA utility.

Generally speaking, empirical research suggests that there is a positive correlation between wealth and risk-taking in the cross-section of households (Carroll, 2002; Calvet et al., 2007). As Calvet and Sodini (2014) point out, this can be interpreted in two ways. The first is that investors have heterogeneous CRRA utilities and risk tolerance coefficients that are positively correlated to socioeconomic status in the cross-section. This is, generally speaking, the argument of Gomes and Michaelides (2005). In this case, an exogenous wealth change should not alter individual asset allocations. The alternative interpretation is DRRA, in which case an exogenous wealth change should alter the asset allocation. The use of a twin panel allows Calvet and Sodini (2014) to disentangle the two interpretations and conclude that the latter is true. My findings corroborate this finding as well: the fact that households exited public equities as a direct result of a wealth shock is evidence for the DRRA interpretation and thus evidence against the explanation of Gomes and Michaelides (2005).

4 Conclusion

This paper presents a new phenomenon in the participation choice literature using evidence from the financial crisis. These phenomena corroborate well-documented theories about household financial decision-making. The main results of this paper, which include two empirical results and three implications, can be summarized as follows:

1. Across most of the wealth distribution, there was a decrease in public equity ownership after, but not during, the financial crisis.

2. Holding fixed the level of wealth over time, the participation rate temporarily increased during the crisis, then returned to pre-crisis levels.

3. The post-crisis exit from public equity markets was caused by a change in the distribution of wealth and is consistent with DRRA.

4. Both the timing of the exit and the temporary increase at fixed wealth levels in 2009 are consistent with portfolio intertia.

5. My findings are generally consistent with existing models of participation, but provide evidence against the importance of fixed entry costs and the claim that background risks best explain the relationship between wealth and participation.

The financial crisis remains a rich source for the study of financial markets and, even more fundamentally, the ways in which individuals and households make decisions related thereto. This paper capitalizes on this moment in history and, in turn, presents new evidence from a novel perspective.

Appendix

A Survey of Consumer Finances

Conducted by the Board of Governors of the Federal Reserve every three years, the Survey of Consumer Finances (SCF) presents a repeated cross-section of household finances in the U.S. In my analyses, I use the seven surveys from 2001 to 2016, including the 2007-2009 Panel Survey of Consumer Finances. This 2009 survey re-interviewed the households in the 2007 survey, primarily to document changes related to the financial crisis. All SCF data used is available in the extract file of the full public dataset.

The SCF is conducted using a dual-frame sample design, as a result of which there is an over-sampling of high-wealth households. To correct this bias and biases associated with non-response, the surveys contain sample weights (SCF codebook name WGT). I use these weights consistently throughout the paper.

Variable definitions and corresponding codebook names are as follows.[4] The value of a household's wealth or net worth (NETWORTH) is equivalent to its financial and non-financial assets less its debt. I restrict most of my analyses to households for which this variable is positive. Ownership status, defined as a binary variable, is available for public equity (HEQUITY), private business equity (HBUS), investment real estate (HNNRESRE), and bonds (HBOND). The corresponding variables for the dollar values of these financial assets are also available (respectively, EQUITY, BUS, NNRESRE, and BOND). Public equity is defined as stock held either directly or indirectly via mutual funds, retirement accounts, trusts, and other managed investment accounts. Business equity is net equity in all types of privately owned businesses, farms or ranches, professional practices, and partnerships. Investment real estate includes residential and nonresidential property that is not primary residence and not owned through a business. Bonds include both risk-free and risky bonds, which (Bertaut & Starr-McCluer, 2002) define as corporate bonds (X7634), foreign bonds

[4] Much of this overview is adapted from Wachter and Yogo (2010).

(X7633), and mortgage-backed bonds (X3906).

B A basic theory of participation

The following theorem by Arrow (1970) serves as a basis for the participation puzzle. Suppose there is a risk-free asset with return r_f and N risky assets, each with return $\tilde{r}_j$, $j = 1, \ldots, N$. A risk-averse agent faced with a two-period portfolio choice problem has wealth next period

$$\begin{aligned}\tilde{W} &= \sum_{j=1}^{N} \theta_j (1 + \tilde{r}_j) + (W_0 - \sum_{j=1}^{N} \theta_j)(1 + r_f) \\ &= W_0(1 + r_f) + \sum_{j=1}^{N} \theta_j (\tilde{r}_j - r_f)\end{aligned}$$

where θ_j is the allocation of wealth to risky asset j and W_0 is initial wealth. This is the budget constraint. The first-order condition is thus

$$\begin{aligned}&\frac{\partial}{\partial \theta_j} Eu(\tilde{W}) = 0 \\ \implies\ &E[u'(\tilde{W})(\tilde{r}_j - r_f)] = 0 \quad \forall j.\end{aligned}$$

Now assume that θ_j^*, the optimal allocation, exists. Assume also that there is a positive probability that $\tilde{r}_j$ is greater or less than r_f. The following theorem follows:

Theorem (Arrow (1970))**.** *Suppose* $N = 1$*. Then* $\theta^* > 0 \iff E\tilde{r} > r_f$*.*

Proof. The proof of the theorem requires the mean value theorem (MVT), stated as follows:

Theorem (MVT)**.** *Suppose* f *is differentiable on* $(a, b) \subset \mathbb{R}$*. Then* $\exists c \in (a, b)$ *such that*

$$f(a) - f(b) = (b - a)f'(c).$$

Hence, if $\hat{\theta}$ is between 0 and θ^*, the MVT implies that

$$\left.\frac{dEu}{d\theta}\right|_{\theta^*} - \left.\frac{dEu}{d\theta}\right|_0 = (\theta^* - 0) \left.\frac{d^2Eu}{d\theta^2}\right|_{\hat{\theta}}.$$

Suppose now that $E\tilde{r} > r_f$, then the first-order condition implies that

$$\underbrace{\left.\frac{dEu}{d\theta}\right|_{\theta^*}}_{=0} - \underbrace{\left.\frac{dEu}{d\theta}\right|_0}_{>0} = (\theta^* - 0) \underbrace{\left.\frac{d^2Eu}{d\theta^2}\right|_{\hat{\theta}}}_{<0}$$

so $E\tilde{r} > r_f \implies \theta^* > 0$. Similarly, if $\theta^* > 0$, then the MVT and first-order condition imply that

$$\left.\frac{dEu}{d\theta}\right|_0 > 0$$
$$\implies E[\tilde{r} - r_f] > 0$$

so $\theta^* > 0 \implies E\tilde{r} > r_f$. ■

So, we conclude that the agent should have a positive allocation to the risky asset if and only if the expected return on the risky asset is greater than the risk-free rate.

C A benchmark model for participation in continuous-time

For consistency and clarity, I present an abridged proof of the theory used as a benchmark in this paper. Additionally, I show that, given constant relative risk aversion (CRRA), this theory implies full participation. For a more complete proof, see Merton (1969).

Consider an agent with positive wealth and CRRA utility. Suppose the agent lives for T years and chooses a portfolio at time t_0 for the next period, $t \equiv t_0 + h$. Then:

Proposition. *Suppose $N = 1$ and the agent exhibits CRRA. Then θ^* is independent of the agent's wealth and age and $E\tilde{r} > r_f \implies \theta^* > 0$.*

Proof. The agent's budget constraint can first be expressed as

$$\tilde{W}_t - W_0 = \left[\sum_{j=1}^{N} \theta_j (e^{g_j(t_0)h} - 1)\right] (W_0 - C_0 h) - C_0 h$$

where $g_j(t_0)h \equiv log(1 + \tilde{r}_j)$, the rate of return on asset j. In discrete time, we assume $g_j(t_0)h = (E[1+\tilde{r}_j] - \frac{\sigma_j^2}{2})h + \Delta Y_j$, where $Y_j(t) - Y_j(t_0) \equiv \Delta Y_j = \sigma_j Z_j(t)\sqrt{h}$ is the stochastic difference equation of a Gaussian random-walk $Y_j(t)$. This yields four key equations:

$$\tilde{W}_t - W_0 = \left[\sum_{j=1}^{N} \theta_j (e^{(E[1+\tilde{r}_j]-\sigma_j^2/2)h+\Delta Y_j} - 1)\right] (W_0 - C_0 h) - C_0 h \tag{5}$$

$$E_0[\tilde{W}_t - W_0] = \left[\sum_{j=1}^{N} \theta_j E[1+\tilde{r}_j] W_0 - C_0\right] h + 0(h^2) \tag{6}$$

$$E_0[(\tilde{W}_t - W_0)^2] = \sum_{i=1}^{N}\sum_{j=1}^{N} \theta_i \theta_j E_0[\Delta Y_i \Delta Y_j] W_0^2 + 0(h^2) \tag{7}$$

$$\mathring{W}_0 \equiv \lim_{h\to 0} \left[\frac{\tilde{W}_t - W_0}{h}\right] = \sum_{j=1}^{N} \theta_j E[1+\tilde{r}_j] W_0 - C_0 \tag{8}$$

where $0(x)$ means "of the same order as x." We can now generalize the budget constraint, the first of these equations, to continuous-time by letting $h \to 0$:

$$dW = \left[\sum_{j=1}^{N} \tilde{\theta}_j(t) E[1+\tilde{r}_j]\tilde{W}_t - \tilde{C}_t\right] dt + \left[\sum_{j=1}^{N} \tilde{\theta}_j(t)\sigma_j Z_j(t)\tilde{W}_t\right]\sqrt{dt} \tag{9}$$

Now, consider two assets, one risk-free and one risky. In order, the five equations above reduce to:

$$\tilde{W}_t - W_0 = \left[\theta(e^{(E[1+\tilde{r}]-\sigma^2/2)h+\Delta Y} - 1) + (1-\theta)(e^{r_f h} - 1)\right] (W_0 - C_0 h) - C_0 h \tag{10}$$

$$E_0[\tilde{W}_t - W_0] = ((\theta E[\tilde{r}_j - r_f] + r_f) W_0 - C_0)\, h + 0(h^2) \tag{11}$$

$$E_0[(\tilde{W}_t - W_0)^2] = \theta^2 W_0^2 \sigma^2 h + 0(h^2) \tag{12}$$

$$\mathring{W}_t = (\tilde{\theta}(t) E[\tilde{r}_j - r_f] + r_f)\tilde{W}_t - \tilde{C}_t \tag{13}$$

$$dW = [(\theta E[\tilde{r}_j - r_f] + r_f)W_0 - C_0]dt + [\tilde{\theta}(t)\sigma Z(t)\tilde{W}_t]\sqrt{dt} \tag{14}$$

Subject to the last of these equations, the agent solves the following problem:

$$\max \left\{ \int_0^t e^{-\rho t} U(\tilde{C}_t) dt + B(\tilde{W}_T, T) \right\}$$

where $B(\tilde{W}_T, T)$ is the bequest valuation function and ρ is a subjective discount factor. Restating this problem in a dynamic programming form $I(\tilde{W}_t, t)$ and noting that $I(\tilde{W}_T, T) = B(\tilde{W}_T, T)$, the problem becomes

$$\max_{\{C_s, \theta_s\}} \left\{ E \left[\int_{t_0}^t e^{-\rho s} U(\tilde{C}_s) ds + I(\tilde{W}_t, t) \right] \right\}.$$

Apply Taylor's theorem and the MVT to $I(W_{t_0}, t_0)$ for some $\hat{t} \in (t_0, t)$, then subtract $I(W_{t_0}, t_0)$ from both sides to attain the Bellman-Dreyfus fundamental equation of optimality:

$$0 = \max_{\{C_t, \theta_t\}} \left\{ e^{-\rho t} U(\tilde{C}_t) + \frac{\partial I_t}{\partial t} + \frac{\partial I_t}{\partial W}((\tilde{\theta}(t) E[\tilde{r}_j - r_f] + r_f)\tilde{W}_t - \tilde{C}_t) + \frac{1}{2}\frac{\partial^2 I_t}{\partial W^2} \tilde{\theta}^2(t) \tilde{W}_t^2 \sigma^2 \right\}$$

for any $t \in [0, T]$, subject to feasibility and the boundary condition. For simplicity, we rewrite this equation as $0 = \max_{\{C_t, \theta_t\}} \phi(\theta, C; W; t)$. Taking the first-order conditions implies that the optimality conditions can be re-written as two algebraic equations and one partial differential equation, subject to feasibility and the boundary condition.

We now assume that the agent has CRRA utility, of the form

$$U(C) = \frac{C^{1-\gamma}}{1-\gamma}.$$

The optimality conditions at time t become:

$$0 = \left[\frac{\gamma}{1-\gamma}\frac{\partial I_t}{\partial W}\right]^{(1-\gamma)/\gamma} e^{-\rho t/\gamma} + \frac{\partial I_t}{\partial t} + \frac{\partial I_t}{\partial W} W r_f - \frac{E[\tilde{r}_j - r_f]^2}{2\sigma^2}\frac{[\partial I_t/\partial W]^2}{[\partial^2 I_t/\partial W^2]} \tag{15}$$

$$C^* = \left[e^{-\rho t}\frac{\partial I_t}{\partial W}\right]^{1/\gamma} \tag{16}$$

$$\theta^* = \frac{-E[\tilde{r}_j - r_f][\partial I_t/\partial W]}{\sigma^2 W[\partial^2 I_t/\partial W^2]} \tag{17}$$

subject to $I(W_T, T) = [\epsilon^\gamma e^{-\rho T} W_T^{1-\gamma}]/(1-\gamma)$ for $0 < \epsilon << 1$. It can now be shown that a trial solution $\bar{I}_t$ solves these optimality conditions, and it follows from this that the optimal portfolio allocation is

$$\theta^* = \frac{E[\tilde{r}_j - r_f]}{\gamma\sigma^2}.$$

Notice that this allocation is independent of time and wealth, meaning the agent's allocation is independent of wealth and age. We know γ and σ^2 are positive, so

$$E[\tilde{r}_j - r_f] > 0 \implies \theta^* > 0.$$

■

Merton (1971) generalizes this model from CRRA to HARA utility. This is the result I use in this paper.

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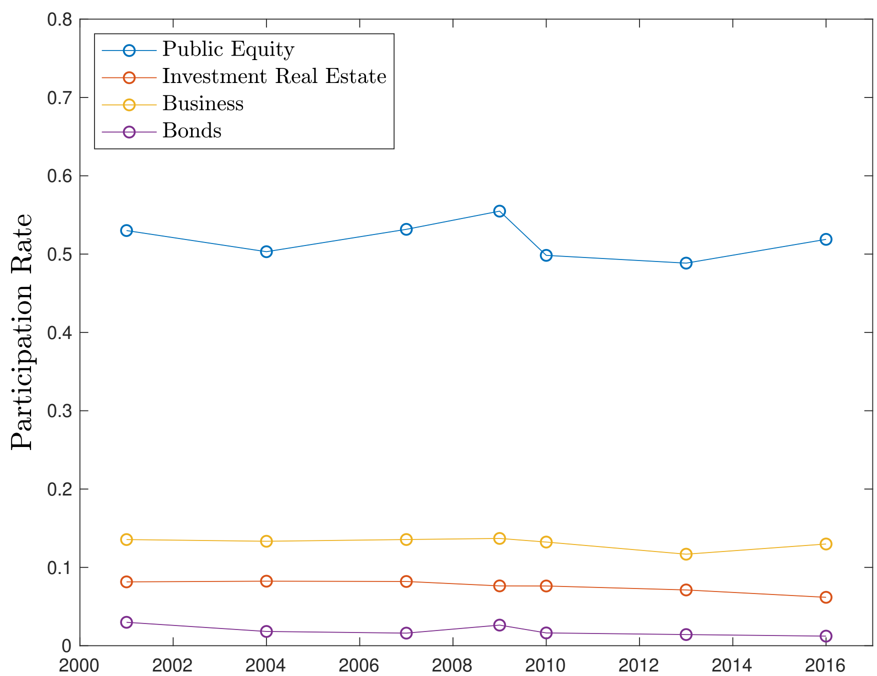
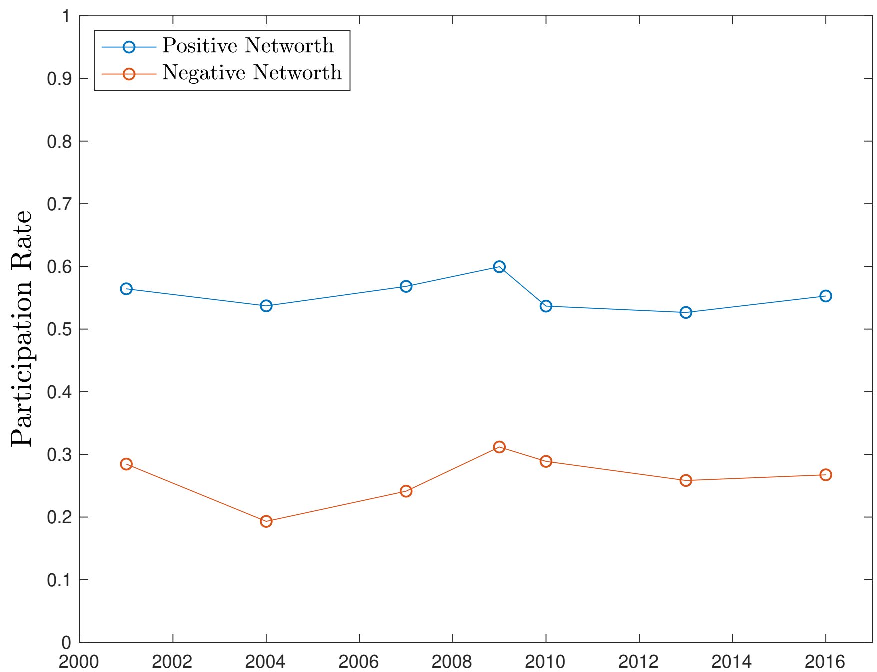
Figure 1: Participation rates for financial assets



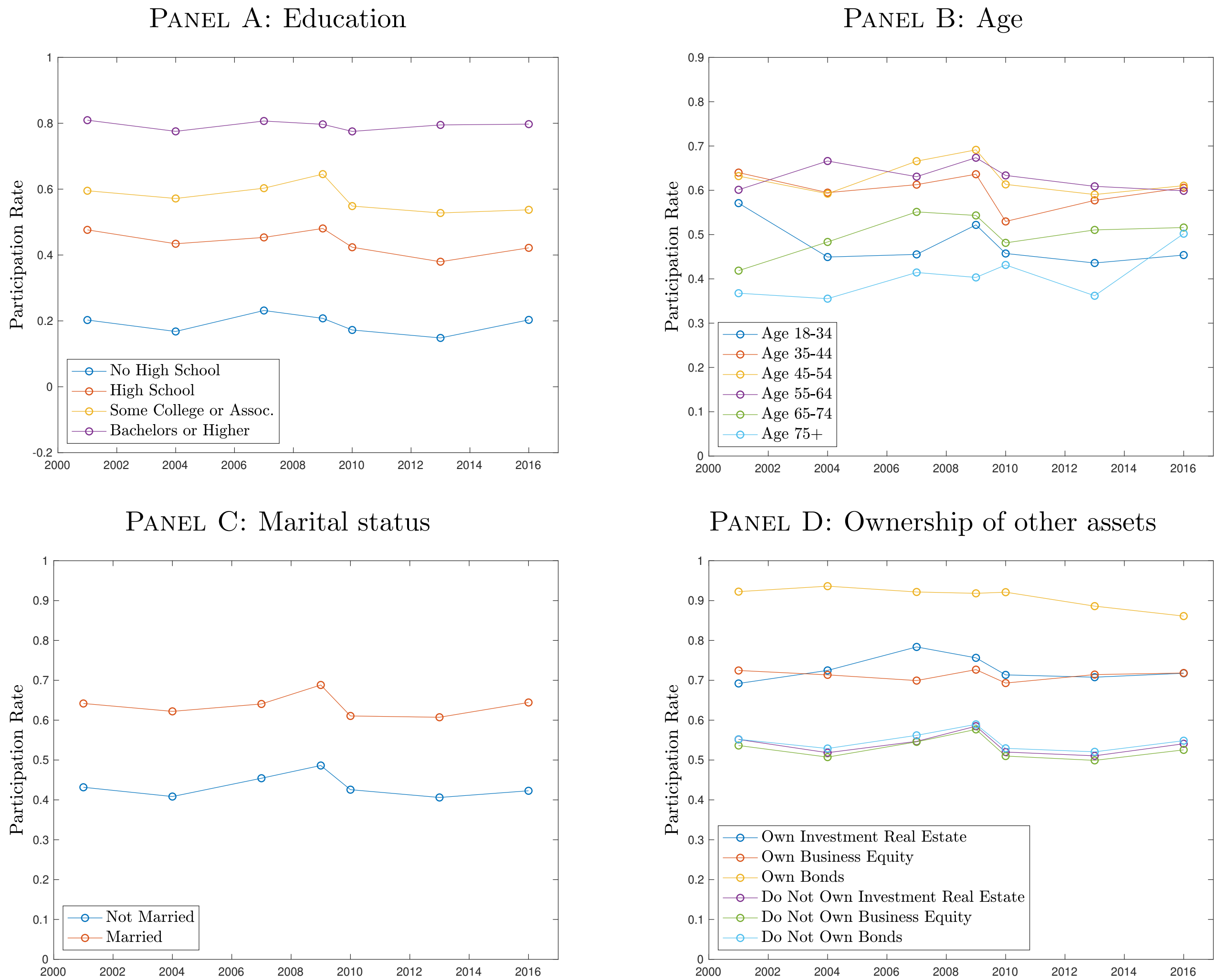
Notes: The figure shows the participation rate of all U.S. households in public equities, investment real estate, private business equity, and bonds. Rates are calculated using the Survey of Consumer Finances and are adjusted according to the weights provided in the extract file of the full public dataset. See Appendix A for more comprehensive variable definitions.

Figure 2: Public equity participation rates by sign of net worth



Notes: The figure shows the participation rate of U.S. households in public equities, classified into two bins for positive and negative net worth. Rates are calculated using the Survey of Consumer Finances and are adjusted according to the weights provided in the extract file of the full public dataset. Public equity is defined as stock held either directly or indirectly via mutual funds, retirement accounts, trusts, and other managed investment accounts.

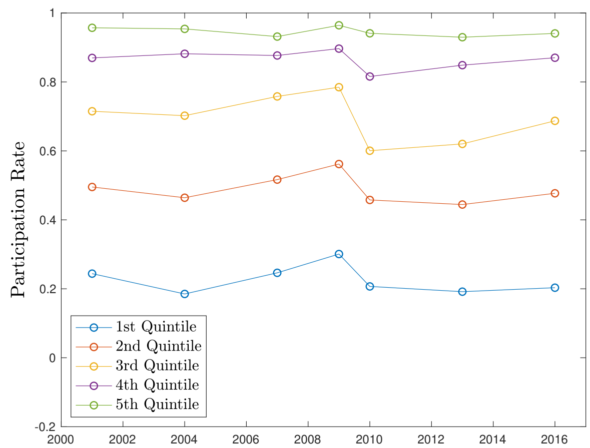
Figure 3: Public equity participation rates by household characteristics



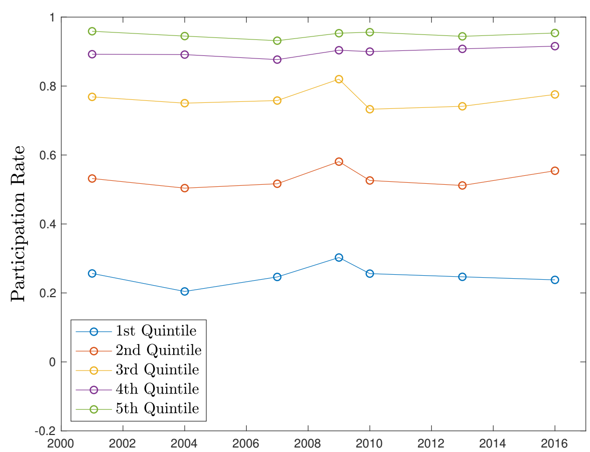
Notes: The figure shows the participation rate of positive net worth U.S. households in public equities, classified according to four household characteristics. Panel A separates households according to the highest level education of the household's head. Panel B categorizes households according to the age of the household's head. Panel C breaks down households by marital status — a household is deemed to be "married" if the head of household is married or living with a partner. Panel D classifies households according to whether they own other financial assets. Rates are calculated using the Survey of Consumer Finances and are adjusted according to the weights provided in the extract file of the full public dataset. Public equity is defined as stock held either directly or indirectly via mutual funds, retirement accounts, trusts, and other managed investment accounts.

Figure 4: Public equity participation rates by wealth quantiles

Panel A: Dynamic quantiles

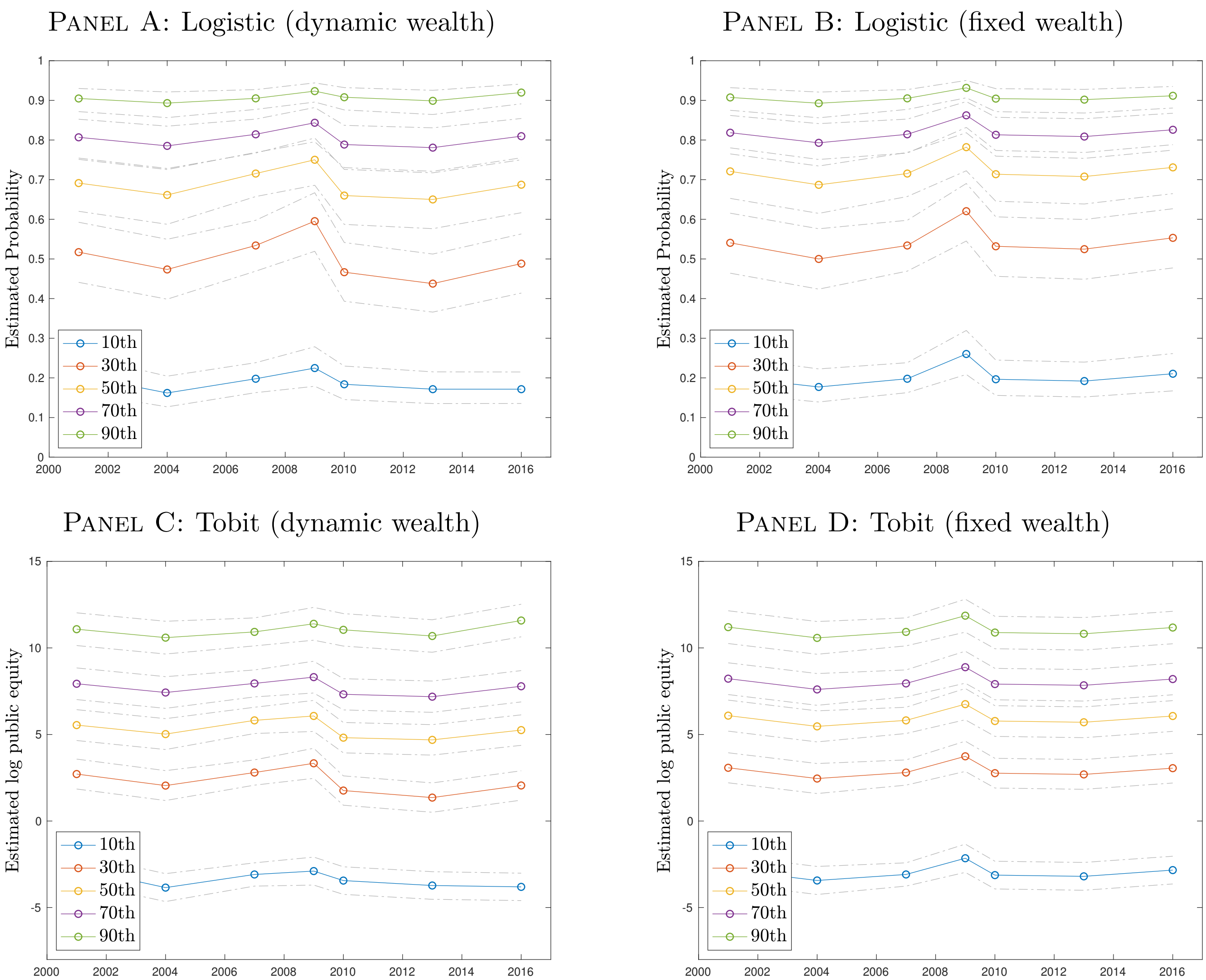


Panel B: Fixed quantiles



Notes: The figure shows the participation rate of positive net worth U.S. households in public equities, classified according to quantiles of wealth. In both panels, the quantiles are indexed in increasing order (i.e., the first quantile contains households within the lowest 20% of wealth). Panel A uses quantiles that are changing each year; I denote these "dynamic quantiles." Panel B uses only the quantile ranges from 2007 and applies them across the whole time series; I denote these "fixed quantiles." Rates and quantiles are calculated using the Survey of Consumer Finances and are adjusted according to the weights provided in the extract file of the full public dataset. Public equity is defined as stock held either directly or indirectly via mutual funds, retirement accounts, trusts, and other managed investment accounts.

Figure 5: Regression estimates by wealth quantiles



Notes: The figure plots estimates from regressions in Table 1 for the omitted category whose head is the median age, 50 years old, at five different wealth percentiles. The omitted category is households in 2007 that do not own other financial assets and whose head is married and has some college education. In each panel, I plot a 95% confidence interval around the estimates for each percentile. Panels A and C show the results for dynamic percentiles while B and D show results for fixed percentiles — see the notes for Figure 4 for a definition of dynamic and fixed wealth. Panels A and B show logistic regression estimates of the probability of households participating in public equities. Panels C and D show the tobit regression estimates of the logged value of public equity $\log(W_t\theta^* + 1)$. Rates and percentiles are calculated using the Survey of Consumer Finances and are adjusted according to the weights provided in the extract file of the full public dataset. Public equity is defined as stock held either directly or indirectly via mutual funds, retirement accounts, trusts, and other managed investment accounts.

Table 1: Regression results

Dependent variable:	Public equity ownership		Log public equity
	Logistic	Probit	Tobit
Log net worth	0.714***	0.412***	2.739***
	(0.005)	(0.003)	(0.014)
Age	−0.030***	−0.017***	−0.091***
	(0.0004)	(0.0002)	(0.001)
Year:			
2001	0.027	0.019	0.274***
	(0.024)	(0.014)	(0.070)
2004	−0.136***	−0.080***	−0.347***
	(0.024)	(0.014)	(0.070)
2009	0.355***	0.208***	0.937***
	(0.026)	(0.015)	(0.074)
2010	−0.008	−0.005	−0.037
	(0.023)	(0.013)	(0.066)
2013	−0.037	−0.026*	−0.109
	(0.023)	(0.013)	(0.067)
2016	0.078***	0.045***	0.253***
	(0.023)	(0.013)	(0.066)
Education:			
No high school	−1.311***	−0.788***	−5.409***
	(0.023)	(0.013)	(0.075)
High school	−0.414***	−0.249***	−1.548***
	(0.016)	(0.009)	(0.049)
College graduate	0.499***	0.295***	1.353***
	(0.017)	(0.010)	(0.048)
Financial assets:			
Owns private business	−0.577***	−0.339***	−2.110***
	(0.019)	(0.011)	(0.052)
Owns inv. real estate	−0.192***	−0.115***	−0.725***
	(0.024)	(0.014)	(0.063)
Owns bonds	0.633***	0.356***	0.532***
	(0.067)	(0.036)	(0.117)
Not married	−0.315***	−0.193***	−1.013***
	(0.013)	(0.008)	(0.039)
Constant	−6.140***	−3.524***	−22.572***
	(0.054)	(0.031)	(0.157)
Observations	162,445	162,445	162,445

Notes: See next page.

Table 1: Regression results (continued)

Notes: The table reports three regression fits for two dependent variables. In the case of all three models, log net worth is calculated as $\log(W_t + 1)$ for a given level of wealth W_t. The logistic regression (the left panel) and probit regression (the middle panel) take public equity ownership, a binary variable indicating a household's participation status, as the dependent variable. The tobit regression (right panel) estimates the logged value of public equity, and can be expressed in the form

$$\log(W_t\theta^* + 1) = \beta_0 + \beta_1 \log(W_t + 1) + \beta_2 \text{Age} + \varepsilon$$

where $W_t\theta^*$ is the dollar value of public equity, ε is an error term, and β_0 depends on the year, education level, ownership status for other financial assets, and marital status. Standard errors are presented in parentheses beneath coefficient estimates. The omitted category is households in 2007 that do not own other financial assets and whose head is married and has some college education. Coefficients significant at 10% are denoted by *, at 5% by **, and at 1% by ***. Values are calculated using the Survey of Consumer Finances and are adjusted according to the weights provided in the extract file of the full public dataset. Public equity is defined as stock held either directly or indirectly via mutual funds, retirement accounts, trusts, and other managed investment accounts.

Table 2: Percentiles of household wealth over time

Percentile	2001	2003	2007	2009	2010	2013	2016
10th	24,076	20,857	23,325	21,600	16,912	15,879	17,105
30th	52,257	51,404	59,638	51,455	41,344	36,585	41,400
50th	146,749	152,220	179,145	139,675	126,118	123,565	133,100
70th	350,906	366,007	390,549	316,832	314,694	307,269	335,441
90th	1,108,802	1,164,155	1,157,741	975,390	1,225,858	1,104,878	1,342,275

Notes: The table shows the value of wealth (net worth) at each of five percentiles in each year. To be consistent with the rest of the paper, I consider only households with positive net worth. Values are derived from the Survey of Consumer Finances and are adjusted according to the weights provided in the extract file of the full public dataset.

Table 3: Wealth and entry and exit dynamics of households from 2007 to 2009

	Quintile					
	1st	2nd	3rd	4th	5th	Total
Median Δ wealth ($)	324	-6,304	-30,516	-71,553	-280,158	-12,921
Entered (%)	13.01	12.22	11.43	6.17	3.90	9.33
Exited (%)	5.02	8.93	9.61	6.76	6.16	7.29
Stayed in (%)	17.43	39.27	46.91	73.32	83.57	52.12
Stayed out (%)	64.54	39.57	32.05	13.75	6.37	31.26

Notes: The table shows the median change in wealth as well as the rates of participation status changes from 2007 to 2009. Values are calculated for all households and for each of five quantiles of 2007 net worth. To be consistent with the rest of the paper, I consider only households with positive net worth in both 2007 and 2009. Entry and exit rates and rates of staying in and staying out refer to ownership of public equities. Values are calculated using the 2007-2009 Panel Survey of Consumer Finances and are adjusted according to the weights provided in the extract file of the full public dataset. Public equity is defined as stock held either directly or indirectly via mutual funds, retirement accounts, trusts, and other managed investment accounts.