Ignorance, Fixed Costs, and the Stock-Market Participation Puzzle*

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Abstract

While the existence of fixed costs in entering asset markets is the leading rationalization of the "participation puzzle" –the fact that most households do not hold stocks, despite the diversification gains and the significant risk-premium involved–, most motivations of these fixed costs are as incompatible with conventional portfolio theory as the non participation itself. Nevertheless, we believe that these motivations are empirically correct, and thus we are forced to explore alternatives to conventional portfolio theory. We find in Choquet expected utility theory a tool that is better equipped to deal with more complex forms of ignorance than expected utility is.

Within such model, we are able to express the idea that staying out of the market may be a rational response to the own ignorance. Within a Probit model for the 2001 Survey of Consumer Finances, we show suggestive evidence in its favor.

Keywords: non additive beliefs, ambiguity, ignorance, asset market participation.

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"Everybody is ignorant, only on different subjects." *Will Rogers*

"We fear things in proportion to our ignorance of them." *Titus Livius*

1 Introduction

It is a well known fact that most households do not hold stocks (Mankiw and Zeldes (1991), Haliassos and Bertaut (1995)) perhaps just as well known as that the paradoxical nature of this fact within conventional portfolio theory: an expected-utility maximizer would (almost) always hold some of every asset.

The prevalent rationalization argues that the typical household refrains from holding stocks because of the existence of fixed costs which must be incurred when entering the market. These fixed costs may have many sources, including trading commissions, trading time, learning costs regarding how the market operates, costs of choosing and monitoring the appropriate portfolio, information costs, and psychological costs derived from the risk involved, to name the most commonly mentioned in the literature.

Brennan (1975) offers an early treatment of portfolio theory with transaction costs of this sort. Allen and Gale (1994), on the other hand, point out that the limited participation that these fixed costs imply may help understand the excessive volatility of asset prices. Given such potential importance for understanding the functioning of the economy, it is not surprising that the subject has received much attention.

However, some authors (e.g., Yaron and Zhang (2000) and Vissing-Jørgensen (2002)) have emphasized that the level of fixed costs required to explain a big chunk of non participators' decision are actually very small. Vissing-Jørgensen (2002) for instance, concludes that US$50 would suffice to explain half of those decisions. The numbers these researchers arrive at are indeed small enough so that any effort to clarify and define with precision their sources seems vacuous.

Nonetheless, this article holds a contrarian view. Even if trading commissions alone were sufficient to explain a large part of non participants' decisions, we would not feel confident with such a theory at least because of the following:

1. Such theory would not explain why the households' educational level is a very significant explanatory variable in all individual-data studies (see for instance Guiso et. al. (2002), or our own measures in Section 5.) Some authors point out that this finding

would be consistent with monitoring costs that decrease with education. While we will elaborate more on this later on, we would like to stress that this finding cannot be reconciled with the transaction fee interpretation of the fixed costs.

2. Such theory would predict that participation would become universal should these fees disappear. We don't find this prediction palatable, at least because participation rates are very small even in countries where these fees are even lower or do not exist! (e.g., around US$5 in Chile.)

Moreover, as Vissing-Jørgensen (2002) remarks, the fact that so small fixed costs are sufficient to explain non participation of most households is a consequence of their small financial wealth. In contrast to most portfolio choice theories, however, financial wealth itself is endogenous to the individual's perception of value in his investment options. If most people have a negative perception of financial asset's worthiness, then they would choose to have low levels of financial wealth and we could therefore be mislead to believe that their choices are explained by the transaction fees instead of their perceptions.

Therefore, while fixed-cost modelling can plausibly match observed participation rates, and while trading commissions may in some countries/epochs match the implied fixed cost levels, it is clear that a fuller understanding of the non participation puzzle requires an in-depth analysis of the sources of these fixed costs beyond trading commissions.

For the first part, if we wish to retain portfolio theory, where assets are bundles of contingent consumption claims and investors are expected-utility maximizers with a given financial wealth, we need to dismiss psychological costs derived from the risk involved as a potential explanation, because it is already accounted for in the form of risk aversion. Risk aversion, as Section 2 shows, cannot explain non participation. We should also rule out information costs in general, and learning costs regarding how the market operates in particular, because an expected-utility maximizer always has a belief which rationalizes his participation. In particular, an expected utility maximizer always knows her environment in the sense that she can always imagine all possibilities, and holds probabilistic beliefs over them. If refining those beliefs by feeding them with information is worth the cost or not, is something that would explain whether she ends up knowing a lot or little (becomes "informed" or not) at the time the portfolio decision is made, but is not related to participation *per se*. Strictly speaking, the same should be said of the costs of choosing and

monitoring the appropriate portfolio, the word "appropriate" being the key. The investor can always choose carelessly, and hold (without monitoring) until the money is needed; if she chooses not to behave in this fashion is because she finds it worthwhile to incur these costs, and hence they do not rationalize non participation. The fixed cost theory, then, is only coherent with a trading commission interpretation.

We find it intuitive, on the other hand, to explain non participation on the grounds of ignorance. Ignorance is a common motive, in ordinary life, to avoid some actions whose outcome seems uncertain. Most people avoid getting involved in projects about which they lack experience, knowledge or understanding, especially when they are perceived as risky. The fact that most households do not hold stocks might be just a leading example of this: many people are not familiar with stocks or, more generally, with sophisticated classes of asset, and as a consequence avoid them. Modern financial markets seem to be the arena of "experts," and the lay person seems to feel uncomfortable intruding.

There are many levels this ignorance can take. In the extreme, the person might be unaware of the existence of stocks. Or, having a good idea of what stocks are, might not know the basic mechanics (where to buy or sell, how to check prices, how to monitor, when to sell). Or knowing all of the above, feel unconfident on the sources of risk, and distrustful on his choices (for instance, because she is aware of the fact that she cannot read financial statements). Financial illiterate people who are aware of their illiteracy may fall in this category. Observe that all these cases may fall under some of the categories mentioned in the literature: learning costs regarding how the market operates, costs of choosing and monitoring the appropriate portfolio, information costs, and psychological costs derived from the risk involved. What, then, are we contending?

Our main point is the following: While we think ignorance (i.e., lack of knowledge) is indeed a strong determinant of the observed non-participation rates worldwide, we must stress that this cannot be said within an expected-utility based theory, like conventional portfolio theory. The reason is that expected utility theory cannot describe certain forms of ignorance, like the a state in which an individual knows so little that he cannot even imagine sensible meanings for words like stocks, yield, and the like (a phenomenon which is currently studied under the name of unawareness,) nor for that matter can describe certain reactions to the awareness of the own ignorance, like the avoidance of activities where the individual feels particularly ignorant (a behavior related to the notion of ambiguity aversion.)

Hence, taking ignorance seriously as a determinant of behavior seems to require the abandonment of expected utility theory (or its extension, if the reader prefers.) We do so in Section 3, and remark (as Dow and Werlang (1992) showed) that ambiguity aversion can explain non participation. Ambiguity aversion since its conception has been informally related to the subject's awareness of her lack of relevant information, i.e., awareness of the own ignorance. Recently, this connection has also been formalized (Ghirardato (2001)).

In search of a test that could disentangle between trading commissions and ignorance-based solutions to the puzzle, we observe that the former implies heterogeneity exclusively in the level of wealth, while the latter on the level of ignorance itself. Financial illiteracy is unobservable (at least in the data available to us, namely the 2001 Survey of Consumer Finances.) However, since ignorance and formal education seem to be related, we suggest that this theory can rationalize the strong empirical connection between education and participation, which we further document. Although we are not able to perform a direct test to compare these theories, we believe the evidence indeed points strongly towards an ignorance-based theory of non participation.

The rest of the paper is organized as follows. Section 2 states the fact, and shows within a model why it is puzzling. It also shows within the same model why information acquisition is not a proper motivation of the fixed costs the literature on rationalizing the puzzle introduces. Section 3 briefly introduces the idea of ambiguity aversion, and its representation through non-additive beliefs. This section contains a rudimentary, basic exposition of the theory, and hence it can be safely skipped by the reader already familiarized with it. Section 4 delineates a model for non-participation within those lines. Section 5 discusses the evidence through the lens of a probit model for the participation decision. Section 6 concludes.

2 The puzzle

Typical households do not hold stocks. For instance, only 19% of US households had any stocks in their portfolios in 1998, according to the Survey of Consumer Finances (henceforth SCF). The figure rises to 21% in the 2001 survey, in the peak of the technology bubble. Stock in the SCF means directly held stock. Many households, however, hold stock indirectly, through stock mutual funds, investment retirement accounts (IRAs), Keoghs

(tax-deferred retirement plans for self-employed individuals) invested in stock, thrift-type retirement accounts invested in stock, or other managed-assets with equity interest (annuities, trusts, MIAs). The union of these assets is called equity in the SCF. Again, considering equity, participation rates are still far from universal; in the 2001 survey, for instance, 52% of households held any equity. Moreover, it is only safe to think that some of these households may be unaware of the fact that they are indirectly holding stocks. Overall, these figures are similar to those obtained from other sources, and are likely to be much smaller in countries with less developed asset markets.

This fact is a puzzle within conventional portfolio theory, which is built on three major assumptions: (a) investors are expected utility maximizers, (b) investors are price-takers, and (c) assets are viewed as contingent promises of future consumption.

Suppose there are K risky assets, indexed by $k = 1, 2, ..., K$, and one riskless asset, call it asset $k = 0$. There are two dates, $t = 0, 1$, and S possible states of Nature, $s = 1, ..., S$, contemplated for date $t = 1$, each with a probability π_s. Each asset is completely characterized by its contingent payment flow, r_{sk}. If the price of asset k is labeled q_k, then $\rho_{sk} \equiv \frac{r_{sk}}{q_k}$ is the gross ex post return of asset k in state s. We write μ_k for $E[\rho_k]$, and μ_0 for the risk free gross rate of return. Also, say that a_k is the number of units of security k the investor holds in his portfolio, and W_0 his initial wealth, and define $\alpha_k \equiv \frac{a_k q_k}{W_0}$ as asset k's portfolio weight. Investing $\$W_0$ in the portfolio $\left(1 - \sum_{k=1}^{K} \alpha_k, \alpha_1, \alpha_2, ..., \alpha_K\right)$ yields a date-1 consumption of $W_0 \left[\mu_0 + \sum_{k=1}^{K} \alpha_k (\rho_k - \mu_0)\right]$. Then, the familiar portfolio problem is:

$$\max_{\{\alpha_1, ..., \alpha_K\}} E\left[u\left(W_0\left[\mu_0 + \sum_{k=1}^{K} \alpha_k (\rho_k - \mu_0)\right]\right)\right] \tag{1}$$

with an associated first-order condition:

$$W_0 E\left[u'(c)(\rho_k - \mu_0)\right] = 0 \tag{2}$$

If zero holdings of the risky assets $k = 1, ..., K$ were optimal, we would have for each of them:

$$E[\rho_k] - \mu_0 = 0 \tag{3}$$

This is to say, an investor would not participate in the risky assets market if and only if he perceived a null risk premium. It is also clear that for any asset k, Equation (2)

admits a unique solution (observe that risk aversion implies that $u'(c)$ is monotonically decreasing and therefore Equation (2) has a unique, continuous solution) which only by a curious coincidence would be exactly 0.

This results derives from the fundamental assumptions mentioned above. Indeed, by (c) assets have an instrumental demand; this marks a severe difference from the theory of demand for regular goods, which are demanded by themselves. By (a) we know that at a riskless position every expected utility maximizer, no matter how risk averse, is locally risk neutral. Coupled with (b) these assumptions imply that the existence of any risk premia would induce the investor to bear risk.

Understanding the generality of this result, it may be preferable to continue our discussion within a particular example. We will consider the case of negative-exponential utility function, two assets (a risky and a riskless one) where the gross return of the risky asset is normally distributed with mean μ_1 and variance σ^2. In such a case, the expected utility of investing a fraction α_1 of W_0 on the risky asset is given by[1]:

$$E\left[-e^{-Ac}\right] = -\exp\left(-AW_0\left(\left(1-\alpha_1\right)\mu_0 + \alpha_1\mu\right) + \frac{A^2}{2}\alpha_1^2 W_0^2\sigma^2\right) \tag{4}$$

which is maximized at

$$\alpha_1^* = \frac{\mu_1 - \mu_0}{AW_0\sigma^2} \tag{5}$$

Again, it is clearly the case that the investor would decides not to participate in the risky-asset's market only if the perceived risk premium $(\mu - \mu_0)$ were zero.

The existence of a fixed cost to enter the risky asset market rationalizes non-participation: if it costs δ to have the right to buy any of it, then staying out is preferred as long as the benefit overweights the cost, that is, if:

$$-\exp\left(-\frac{1}{2}\frac{2\mu_0 A\left(W_0-\delta\right)\sigma^2 + \left(\mu_0-\mu_1\right)^2}{\sigma^2}\right) \leq -\exp\left(-AW_0\mu_0\right) \tag{6}$$

which occurs if:

$$\delta \geq \frac{1}{2}\frac{\left(\mu_1-\mu_0\right)^2}{\mu_0 A\sigma^2} \tag{7}$$

The required risk-premium to participate is now bounded away from zero: it must be larger than $\sqrt{2\delta\mu_0 A\sigma^2}$. Hence, in the presence of fixed participation costs, the portfolio

[1] An expression arrived at by using the characteristic function of the normal distribution.

weight given to the risky asset is given by:

$$\alpha_1^* = \begin{cases} \frac{\mu-\mu_0}{A(W-\delta)\sigma^2} & \text{if } \delta \leq \frac{1}{2}\frac{(\mu_0-\mu)^2}{\mu_0 A\sigma^2} \\ 0 & \text{otherwise} \end{cases} \tag{8}$$

However, motivating this δ by making reference to information acquisition costs is not correct within this model. If we were to explicitly incorporate the possibility of information acquisition , we could indeed characterize a situation in which information is not worth its cost and therefore not acquired. However, the optimum portfolio in the absence of this information would not be riskless.

To see this, consider the following example. Suppose the investor, prior to buying his portfolio, could pay (or more generally incur a total cost of) δ in order to observe the value of the random variable $\widetilde{x}$. Observing it is valuable because it constitutes a (noisy) signal of the true ex post return on the asset. In particular, suppose $\widetilde{x}$ and the ex-post return on the asset $\widetilde{\rho}$ have a joint normal distribution, and that its marginal probability density function with respect to the asset's return (the prior) has a mean μ_1 and variance σ^2, as before. For simplicity, further assume the following structure:

$$\widetilde{\rho} = \widetilde{x} + \widetilde{\varepsilon} \tag{9a}$$

$$\widetilde{x} \sim N\left(\mu_x, \sigma_x^2\right) \tag{9b}$$

$$\widetilde{\varepsilon} \sim N\left(0, \sigma_\varepsilon^2\right) \tag{9c}$$

where $\widetilde{x}$ and $\widetilde{\varepsilon}$ are independent.

Learning the value of x does not affect the asset's return but helps predicting it, for the updated belief over $\widetilde{\rho}$ becomes:

$$\rho|x \sim N\left(\frac{\mu_1\sigma_x^2 + x\sigma_\varepsilon^2}{\sigma_x^2+\sigma_\varepsilon^2}, \frac{\sigma_x^2\sigma_\varepsilon^2}{\sigma_x^2+\sigma_\varepsilon^2}\right) \tag{10}$$

which is different from the prior:

$$\rho \sim N\left(\mu, \sigma_x^2+\sigma_\varepsilon^2\right) = N\left(\mu, \sigma^2\right) \tag{11}$$

Hence, if the investor had access to this information, he would use it, that is, his asset demand would depend on the realization x, as follows:

$$\alpha_1^*(x) = \frac{\frac{\mu\sigma_x^2+x\sigma_\varepsilon^2}{\sigma_x^2+\sigma_\varepsilon^2} - \mu_0}{AW\frac{\sigma_x^2\sigma_\varepsilon^2}{\sigma_x^2+\sigma_\varepsilon^2}} \tag{12}$$

resulting in an expected utility, conditional on x, of

$$E\left[u|x\right] = -\exp\left(-\frac{1}{2}\frac{2\mu_0 AW\frac{\sigma_x^2\sigma_\varepsilon^2}{\sigma_x^2+\sigma_\varepsilon^2} + \left(\mu_0 - \frac{\mu\sigma_x^2+x\sigma_\varepsilon^2}{\sigma_x^2+\sigma_\varepsilon^2}\right)^2}{\frac{\sigma_x^2\sigma_\varepsilon^2}{\sigma_x^2+\sigma_\varepsilon^2}}\right) \tag{13}$$

Hence, the value of acquiring information from an ex-ante perspective is given by:

$$E_x\left[\max_{\alpha(x)} E_{\rho|x}\left[u|x\right]\right] - \max_{\alpha} E_\rho\left[u\right] \tag{14}$$

If this difference is larger than the information cost δ, the investor would acquire the information, otherwise he would not. Yet, in this latter case, he would not stay out of the market. Rather, he would choose the best portfolio as judged by his prior beliefs given by (11), and will spend the fraction α_1^* of his wealth given by (5) on the risky asset.

As a matter of fact, in this model any uncertainty –i.e., ignorance– about how the market operates, what the asset payoffs' structure is, and so on, ultimately translates into uncertainty about the final consumption to be obtained with or without the asset. All those uncertainties are built into the prior beliefs. To say that it is obviously the case that one must get information before entering the market is equivalent to say that δ is low relative to (14) for any investor, a situation in which all pay the cost and participate (with the exception of the knife-edge case in which the perceived risk-premium is zero). Otherwise, some are informed, some are not, but still all participate.

Therefore, the fixed-cost used in the literature to solve the puzzle cannot originate in information-acquisition activities.

When looking for alternative sources of transaction costs, payments to intermediaries obviously stand out. However, the observed structures of commissions and transaction fees around the globe do not seem to accommodate the fixed-cost pattern; on the contrary, they generally are an increasing function of volume. In view of this, one is forced to look for alternative explanations.

Section (4) below will attempt to reconstruct the idea that ignorance (or the costs of abandoning it) is indeed a plausible account of the Participation Puzzle. Yet, building the argument requires a departure from EU theory, which the next section describes.

3 Non additive beliefs[2]

This section describes briefly the main idea and tools of the theory of Choquet Expected Utility. There are other theories that rationalize non-additive beliefs as well (for a survey, see Ghirardato 1993). The reader who is familiar with this theory may prefer to jump to Section 4.

The case for generalizing expected utility theory to non-additive beliefs is, perhaps, best motivated through Ellsberg's paradox. A version of it considers an individual who is presented two urns (A and B) with 100 chips each, either red (r) or blue (b). The individual is told that urn A contains exactly 50 red and 50 blue chips, and that urn B also contains only red and blue chips, but he is not told in which proportions. The individual is supposed to bet on a color: one chip is extracted, and if it matches the color of his choosing, he wins a prize of value x. If the color is different, he gets 0. Before betting on the color, however, he is asked to choose the urn from where the chip will be extracted.

Most individuals in experiments like this declare to be indifferent about the color to bet on, but prefer to bet in urn A, the one with known composition. This behavior is inconsistent with expected utility. To see this, let us compute the expected utilities of each alternative. The following list indicates the expected utility of betting in urns A, B and colors r, b :

$$E[u](A;r) = P(r_A)u(x) + P(b_A)u(0) \tag{15a}$$

$$E[u](A;b) = P(r_A)u(0) + P(b_A)u(x) \tag{15b}$$

$$E[u](B;r) = P(r_B)u(x) + P(b_B)u(0) \tag{15c}$$

$$E[u](B;b) = P(r_B)u(0) + P(b_B)u(x) \tag{15d}$$

If the individual is indifferent between colors in both urns, he must associate a 50% chance to obtaining each color from either urn:

$$E[u](A;r) = E[u](A;b) \Rightarrow P(r_A) = P(b_A) = \frac{1}{2} \tag{16a}$$

$$E[u](B;r) = E[u](B;b) \Rightarrow P(r_B) = P(b_B) = \frac{1}{2} \tag{16b}$$

This implies, however, that he must associate the same utility level to both urns.

$$\Rightarrow E[u](A) = \frac{1}{2}[u(x) + u(0)] = E[u](B) \tag{17}$$

[2] This section draws shamelessly from Zurita (2004).

Hence, the individual must be indifferent among both urns, contrary to what is typically observed. Taken from a different perspective, the indifference between colors in A means:

$$E\left[u\right](A) = \frac{1}{2}\left[u(x) + u(0)\right] \tag{18}$$

On the other hand, the utility of choosing urn B is given by:

$$E\left[u\right](B) = \max\left\{P(r_B)u(x) + P(b_B)u(0), P(r_B)u(0) + P(b_B)u(x)\right\} \tag{19}$$

Thus, if $P(r_B) < \frac{1}{2}$, the individual would prefer to bet on blue and $E\left[u\right](B) = P(r_B)u(0) + (1 - P(r_B))\,u(x) > \frac{1}{2}\left[u(x) + u(0)\right]$. If $P(r_B) > \frac{1}{2}$, the individual would prefer to bet on red and $E\left[u\right](B) = P(r_B)u(x) + (1 - P(r_B))\,u(0) > \frac{1}{2}\left[u(x) + u(0)\right]$. Therefore, there is no scenario we can think of in which urn A is preferred to urn B if the individual associates a 50% chance to each color on A. If he is indifferent between colors in B, he must be indifferent among urns. If he is not indifferent between colors in B, then he must prefer B, contradicting the evidence.

Schmeidler's observation is that we may disassociate indifference between colors –no reason to prefer one color over another– from indifference between urns. Instead of associating a "probability" to each event, let us say that the individual associates a degree of confidence to the occurrence of a state, not necessarily represented by a probability:

$$E\left[u\right](A;r) = v(r_A)u(x) + (1 - v(r_A))\,u(0) \tag{20a}$$

$$E\left[u\right](A;b) = (1 - v(b_A))\,u(0) + v(b_A)u(x) \tag{20b}$$

$$E\left[u\right](B;r) = v(r_B)u(x) + (1 - v(r_B))\,u(0) \tag{20c}$$

$$E\left[u\right](B;b) = (1 - v(b_B))\,u(0) + v(b_B)u(x) \tag{20d}$$

Indifference between colors implies:

$$E\left[u\right](A;r) = E\left[u\right](A;b) \Rightarrow v(r_A) = v(b_A) \tag{21a}$$

$$E\left[u\right](B;r) = E\left[u\right](B;b) \Rightarrow v(r_B) = v(b_B) \tag{21b}$$

However, urn A is preferred to urn B as long as $v(r_A) > v(r_B)$:

$$E\left[u\right](A;r) > E\left[u\right](B;r)$$

$$\Leftrightarrow \left[v(r_A) - v(r_B)\right]u(x) > \left[v(r_A) - v(r_B)\right]u(0) \tag{22}$$

The interpretation given to the $v(\cdot)$ function is that it represents both, a degree of confidence in the occurrence of an event and a measure of the ambiguity that the decision-maker perceives in the decision problem. Urn A represents a less ambiguous choice than urn B, because the individual has more information and hence more confidence in his beliefs, even though in neither case he has a reason to believe that one color is more likely than the other one.

The difference with respect to expected utility theory is that $v(r_A) + v(b_A) \neq 1$, that is, the belief is not additive. Mathematically, the belief is not represented by a **probability** function but by a **capacity**. Let S denote a set of states of nature, and 2^S the set of all subsets (called "events") of S. A capacity v is a function that associates to each possible event a number in $[0,1]$, $v : 2^S \to [0,1]$, with the following properties:

1. $v(\emptyset) = 0,\ v(S) = 1.$
2. $A \subset B \Rightarrow v(A) \leq v(B) \qquad \forall A, B \in 2^S.$

A probability function is a capacity that satisfies the additional property of additivity: $v(A \cup B) = v(A) + v(B) - v(A \cap B)$.

A behavioral foundation for using probabilities as representation of beliefs comes from Savage's (1957) seminal work. Savage considered the case of a decision maker who does not know the consequence of each decision available to him, but is capable of imagining a set of alternative states of the world S, and a set of possible consequences C from his acts, F. Each act is a map from S to C, that is, the individual associates to an act a list of conditional consequences, one for each state. Savage makes a series of assumptions about behavior, and proves that the preferences of an individual that satisfies them have an expected utility representation:

$$f \succ g \Longleftrightarrow \int u(f)dP > \int u(g)dP \tag{23}$$

where $u(c)$ is the standard Bernoulli utility index and P is a probability measure over S.

Choquet Expected Utility can be obtained by relaxing one of Savages's axioms, independence, requiring it to hold only for comonotonic acts, that is, those acts that induce the same ranking of states. Under co-monotonic independence, the preference relation over acts has an expected utility representation, as:

$$f \succ g \Longleftrightarrow \int u(f)dv > \int u(g)dv \tag{24}$$

E	$v(E)$
$\emptyset$	0
$\{1\}$	$\frac{1}{4}$
$\{2\}$	$\frac{1}{4}$
$\{1,2\}$	1

Table 1: A Capacity

where the integral is not taken over a probability but over a capacity v.

The lack of additivity, however, implies that the usual integral cannot be applied here. The appropriate integral concept is that of Choquet (which explains the name of the theory). Let $f(C) = \{c_1, ..., c_n\}$ be the set of consequences under act f, where $u(c_i) \geq u(c_{i+1})$ for all i. The Choquet integral is given by:

$$\int u(f)\, dv = \sum_{i=1}^{n-1} [u(c_i) - u(c_{i+1})]\, v\left(\bigcup_{j=1}^{i} A_j\right) + u(c_n) \tag{25}$$

where $A_j = f^{-1}(c_j)$ is the event in which consequence c_j obtains under act f.

In the two-state urn example that introduced this section, this definition means that as long as $v(r.) + v(b.) < 1$, the higher-utility scenario is weighted by $v(\cdot)$ and the lower-utility scenario by $1 - v(\cdot)$, that is, the degree of confidence in its occurrence **plus** all non-assigned weight.

If there are two events, this implies indifference curves over risky consumption profiles that are kinked (an hence non differentiable) at the certainty line. For instance, let $S = \{1, 2\}$ and $C = IR_+$. Then, each act is a bundle (c_1, c_2). Suppose beliefs have the form

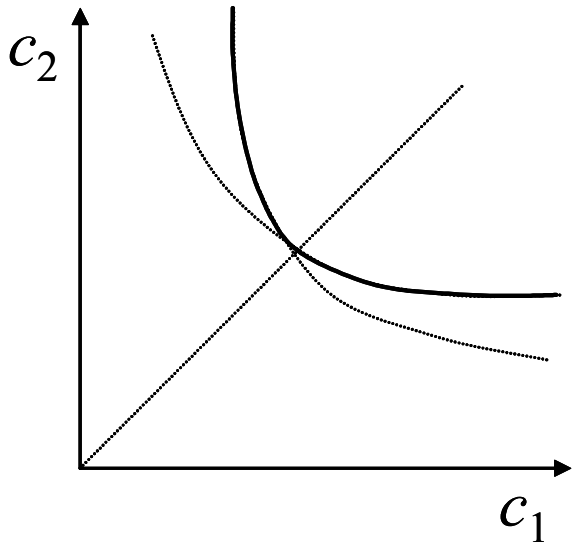
Then, if f is such that $c_1 > c_2$,

$$\begin{aligned} \int u(f)\, dv &= [u(c_1) - u(c_2)]\, v(1) + u(c_2) \\ &= v(1)\, u(c_1) + [1 - v(1)]\, u(c_2) \\ &= \frac{1}{4} u(c_1) + \frac{3}{4} u(c_2) \end{aligned} \tag{26}$$

However, if f is such that $c_2 > c_1$,

$$\int u(f)\, dv = \frac{3}{4} u(c_1) + \frac{1}{4} u(c_2) \tag{27}$$

The Choquet integral, then, adds the unassigned weight $1 - v(A) - v(A^c)$ to the worst possible outcome. The certainty line separates the cases where state 1 is associated to the worst outcome from the cases where it is state 2. This is depicted in Picture 1.



Picture 1: CEU indifference curves.

The kink is the feature of the model that will be exploited here, for it implies that there is a range of state prices at which the ambiguity averse individual will not be willing to take any risks.

One may object that, after all, this is just a limiting form of risk aversion; that even though such a range cannot be obtained under EU theory, it could well be approximated by a strong curvature of the indifference curve. However, the CEU model presents a big difference: a risk-averse EU-maximizer is risk-averse in every dimension –this is, regarding any risks or states–, while a CEU needs not hold equally non-additive beliefs in every respect. In effect, the same individual may hold non-additive beliefs with respect to one variable and additive with respect to another. The model can thus rationalize the behavior of a person that bets heavily on a casino and at the same time buys life and health insurance. For instance, consider the case of a person who entertains the following possibilities about the following day: {it rains-there is an earthquake, it rains-there isn't an earthquake, it doesn't rain-there is an earthquake, it doesn't rain-there isn't an earthquake}$\equiv \{RE, RN, DE, DN\}$. The following capacity is additive with regard to the possibility of rain, but non-additive with regard to the possibility of an earthquake (the 3-state events are omitted for short):

In this example, the individual associates a probability of 70% to rain (the event $\{RE, RN\}$) and 30% to not rain (the event $\{DE, DN\}$), and therefore he will behave as a regular EU-maximizer if faced with decisions whose consequences depend solely on whether

Event	$v(E)$	*Event*	$v(E)$
$\emptyset$	0	$\{RE, RN\}$	.7
$\{RE\}$	.07	$\{DE, DN\}$	.3
$\{RN\}$	.1	$\{RE, DE\}$	.2
$\{DE\}$	.03	$\{RN, DN\}$	.3
$\{DN\}$	.1	$\{RE, RN, DE, DN\}$	1

Table 2: Another capacity

it will rain or not. However, his degree of confidence in an earthquake happening is 20% (the event $\{RE, DE\}$), while an earthquake not happening of 30% (the event $\{RN, DN\}$), and hence he will behave as a CEU-maximizer in decisions whose consequences depend on the occurrence of an earthquake. The remaining 50% can be interpreted as the degree to which the situation seems ambiguous to him. While this person will behave as very risk averse in situations that depend on the occurrence of an earthquake, he will not do so in situations that depend on the rain. Hence, this example illustrates that the generalization presented by CEU is not trivial.

This in an important dimension of CEU theory to the present paper, because it allows us to represent a situation in which people are knowledgeable or ignorant in different dimensions. In particular, we are interested in the comparison of behavior between financial-literate and financial-illiterate individuals.

4 The model

Dow and Werlang (1992) proved that there is a range of state prices at which a CEU-maximizer does not participate in the market of a risky security whose payoffs depend on events that are ambiguous to him. In the present section, we exploit this idea to represent an economy formed by an heterogeneous group of investors, who differ in their wealth and in the extent of their ignorance regarding the risky asset (henceforth referred simply as ignorance or financial illiteracy).possibly because of differences in their abilities to read financial statements, understanding of the workings of the market, their participants and risks, the applicable tax structure, and the like.

To fix ideas, consider a two-date economy ($t = 0, 1$), and two[3] payoff-relevant states,

[3]We would have preferred to retain the model used in Section 2. However, to the best of our knowledge there is no tractable counterpart to the normal-exponential setting with non-additive beliefs. In particular,

$S = \{s_1, s_2\}$. There are two assets, $k = 0, 1$, described by the date-2 payoff matrix of dimension $S \times K$:

$$R = \begin{pmatrix} r & r_1 \\ r & r \end{pmatrix} \tag{28}$$

Asset 1, whose date-1 payoffs correspond to the first column of R, is risk-free, while asset 2, whose date-1 payoffs appear in the second column of R, is risky. Assume for concreteness that $r_1 > r$. We denote by q_k the date-0 price of asset k as before, and normalize $q_0 = 1$, so that r is the risk-free rate. Observe that these prices admit no arbitrage opportunities if and only if $q_1 \in \left(1, \frac{r_1}{r}\right)$. The aggregate (per capita) supply of the risky asset is 1.

Hence, a date-0 wealth of $\$W$ spent on a portfolio $\begin{pmatrix} 1-\alpha & \alpha \end{pmatrix}$ yields a contingent consumption profile of:

$$\begin{aligned} c_1 &= W\left((1-\alpha)\frac{r}{1} + \alpha\frac{r_1}{q_1}\right) \\ c_2 &= W\left((1-\alpha)\frac{r}{1} + \alpha\frac{r}{q_1}\right) \end{aligned} \tag{29}$$

in states 1 and 2, respectively.

There is a continuum of risk-averse individuals with Lebesgue measure 1. Individual $i \in I$ maximizes the following Choquet-expected utility from date-1 consumption:

$$E_i\left[u\left(c_1^i, c_2^i\right)\right] = \begin{cases} v^i(s_1)\, u\left(c_1^i\right) + \left(1 - v^i(s_1)\right) u\left(c_2^i\right) & if \quad c_1^i > c_2^i \\ \left(1 - v^i(s_2)\right) u\left(c_1^i\right) + v^i(s_2)\, u\left(c_2^i\right) & if \quad c_1^i < c_2^i \\ u\left(c_1^i\right) & if \quad c_1^i = c_2^i \end{cases} \tag{30}$$

where c_s^i refers to consumption by individual i at date 1, contingent on state s materializing. All individuals have the same Bernoulli function $u(\cdot)$, which in what follows will be assumed to be negative exponential. They differ in their beliefs, represented by the convex capacity $v^i(\cdot)$.

We would like to speak of "ignorance" as the variable that characterizes individuals, and to relate it to the degree of non additivity of the individuals' beliefs. This association is both, intuitive and theoretically justifiable. Recent research by Ghirardato (2001) shows that the behavior of an individual who lacks a complete description of the state

tractable models can be built with E-capacities wich are defined over compact spaces (Eichberger and Kelsey (1999)), whereas the normal distribution has an unbounded support. Hence, we chose a finite state space as a second best.

space (because he is unaware of some variables or facts, i.e. ignorant) and is aware of his unawareness, can be represented by a maximization of an expected utility with respect to a non additive belief over the complete state space. One example of such non additive belief would be a convex capacity, which expresses ambiguity aversion. This special case corresponds to one of the possible behavioral reactions to the own ignorance, the one that Titus Livius describes in the opening quotation. We are thus tempted to write something of the following sort:

$$v^i(s_1) = \frac{1}{2}(1-i) = v^i(s_2) \tag{31}$$

whereby the more ignorant, the less additive the investor's belief:

$$1 - v^i(s_1) - v^i(s_2) = i \tag{32}$$

However, we also find it helpful to relate the variables included in the model more directly to the variables we can observe in the available data that next section describes. Clearly, general ignorance (if there is such thing) is not observable, much less the particular ignorance relevant to the portfolio decision we are thinking of. The closest variable in the dataset is actually formal education (whether or not the individual completed high school or college) which is clearly unspecific for our purposes. Yet, these variables should be positively related (a fuller discussion is postponed till next section.) For this reason, we will speak instead of education ($e \in [0,1]$), treat it as lack of ignorance, and consequently relate it to the degree of nonadditivity of beliefs as:

$$v^e(s_1) = \frac{1}{2}e = v^e(s_2) \tag{33}$$

Hence, an investor with education e chooses his portfolio according to:

$$\max_{\{\alpha\}} E[u(c_1,c_2)] = \begin{cases} \frac{1}{2}e(-\exp(-Ac_1)) + \left(1-\frac{1}{2}e\right)(-\exp(-Ac_2)) & if \quad c_1 > c_2 \\ \left(1-\frac{1}{2}e\right)(-\exp(-Ac_1)) + \frac{1}{2}e(-\exp(-Ac_2)) & if \quad c_1 < c_2 \\ -\exp(-Ac_1) & if \quad c_1 = c_2 \end{cases} \tag{34}$$

The extreme cases are given by $e = 1$, an investor with the highest education who has additive beliefs and is therefore a regular expected utility maximizer; and $e = 0$ at the other extreme, an investor who has maximally nonadditive beliefs, whose preferences collapse to:

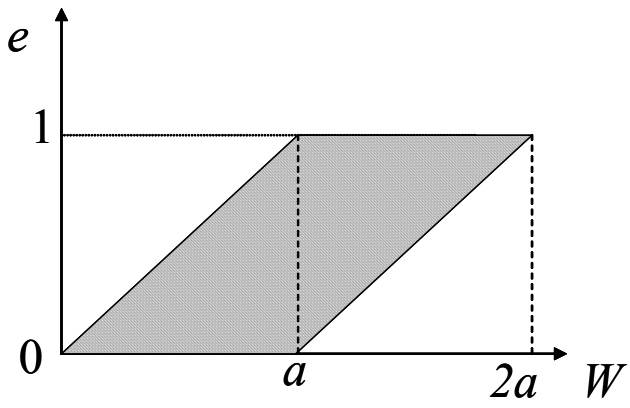
$$E[u(c_1,c_2)] = \min\{c_1,c_2\} \tag{35}$$

This is to say, she chooses by looking at worst-case scenarios.

Education and wealth will be assumed to be (exogenously) correlated in the population. The exogeneity is imperative once we resign not to model explicitly the education decision. We are forced to do so because unfortunately there is no obvious counterpart to Bayes' rule within non additive beliefs that would allow the study of belief change yet (although significant progress has been made, as exemplified by Gilboa and Schmeidler (1993) and Cohen et al (1999)). In particular, we assume the following distribution:

$$f(e,W)=\begin{cases}\frac{1}{a} & \text{if } e\in\left[\max\left\{0,\frac{W}{a}-a\right\},\min\left\{\frac{W}{a},1\right\}\right]\\ 0 & \text{otherwise}\end{cases} \tag{36}$$

This distribution is uniform-like, except for the fact that its support is a parallelogram, as shown in Picture 2:



Picture 2: The support of $f(a,W)$

Notice that the parameter a defines the covariance between education and wealth, as $Cov(e,W)=\frac{1}{12}a$. The choice of this distribution obeys exclusively to tractability.

Assuming $c_1\geq c_2$ (a condition that will be satisfied in equilibrium), each investor's problem becomes:

$$\max_{\{\alpha\}}-\frac{1}{2}e\exp\left(-A\left(W\alpha\frac{r_1}{q_1}+W(1-\alpha)\frac{r}{1}\right)\right)\\ -\left(1-\frac{1}{2}e\right)\exp\left(-A\left(W\alpha\frac{r}{q_1}+W(1-\alpha)\frac{r}{1}\right)\right)$$

which is maximized at

$$\alpha^*=\frac{q_1}{AW(r_1-r)}\ln\left(\frac{(r_1-rq_1)e}{r(q_1-1)(2-e)}\right) \tag{37}$$

Since $\alpha^* \geq 0$ if and only if

$$e \geq 2r\frac{q_1 - 1}{r_1 - r} \equiv k, \tag{38}$$

$e \geq k$ is a necessary and sufficient condition for an investor to participate in the risky asset market. The critical value k is independent of wealth because of the special nature of the negative exponential function. This is unrealistic but considerably simplifies computations. Thus, the proportion of participants is:

$$2\int_{ak}^{a}\int_{k}^{\frac{W}{a}} \frac{1}{a} dedW + \int_{a}^{a+ak}\int_{k}^{1} \frac{1}{a} dedW \equiv 1 - k \tag{39}$$

and the aggregate asset demand is given by:

$$\begin{aligned} & \int_{k}^{1} \frac{1}{A\left(r_1 - r\right)} \ln\left(\frac{\left(r_1 - rq_1\right)e}{r\left(q_1 - 1\right)\left(2 - e\right)}\right) de \\ = & \frac{-1}{\left(r_1 - r\right)A} \ln\left(\frac{\left(r_1 - rq_1\right) r \left(q_1 - 1\right)\left(-2 + k\right)^2 k^k \left(-r_1 + rq_1\right)^k}{\left(-r_1 + rq_1\right)^2 r^k \left(-2 + k\right)^k \left(q_1 - 1\right)^k}\right). \end{aligned} \tag{40}$$

In a Walrasian equilibrium q_1 satisfies:

$$\frac{-1}{\left(r_1 - r\right)A} \ln\left(\frac{\left(r_1 - rq_1\right) r \left(q_1 - 1\right)\left(-2 + k\right)^2 k^k \left(-r_1 + rq_1\right)^k}{\left(-r_1 + rq_1\right)^2 r^k \left(-2 + k\right)^k \left(q_1 - 1\right)^k}\right) = 1, \tag{41}$$

and hence the equilibrium risky-asset price is:

$$q_1^* = \frac{1}{2}\left(\frac{r_1 + r}{r}\right) - \frac{1}{2}\left(\frac{r_1 - r}{r}\right)\sqrt{1 - \exp\left\{-\left(r_1 - r\right)A\right\}} \leq \frac{r_1}{r} \tag{42}$$

It is easily verified that q_1^* doesn't admit arbitrage opportunities, that it is independent of a (the average wealth), and that it is decreasing in A, the degree of risk-aversion.

Evaluating, we have that the equilibrium cut-off educational level is given by:

$$k^* = 1 - \sqrt{1 - \exp\left\{-\left(r_1 - r\right)A\right\}}, \tag{43}$$

clearly bounded away from zero and decreasing in A. This latter result may seem unintuitive, but it is easily understood once one realized that A increases the expected return on the risky asset, increasing participation.

In turn, for a fixed wealth level W, the participation rate is monotonically nondecreasing:

$$\begin{cases} 0 & \text{for } W \leq ak^* \\ 1 - k^*\frac{a}{W} & \text{for } W \in [ak^*, a] \\ \frac{a(1-k^*)}{2a-W} & \text{for } W \in [a, a\left(1 + k^*\right)] \\ 1 & \text{for } W \geq a\left(1 + k^*\right) \end{cases}$$

Within this equilibrium, we also have that:

- education and wealth are positively correlated,
- participation increases with education for a fixed level of wealth, and hence they are conditionally-positively correlated, and
- participation increases with education, and hence they are unconditionally-positively correlated.

All these features are found in the data, as Section 5 describes. There is an extra feature of the data which is absent from the present model: the fact that for a fixed level of education, the participation rate is increasing in wealth. This absence is the combined consequence of not modelling explicitly the education decision, and assuming a constant absolute risk aversion Bernoulli function. The present section, however, has shown that we can think of asset market equilibria where the remaining features are the result of heterogeneity in ignorance (education) and an ambiguity-aversion that is increasing in ignorance (decreasing in education), without an explicit recourse to fixed costs, and in particular to transaction fees.

5 Some evidence

Empirical studies of participation have relied mostly on discrete choice models like Logit and Probit, run with data from the Survey of Consumer Finances (SCF) and the Panel Study on Income Dynamics in the case of the U.S. We will examine data from the SCF. The SCF is a survey of the balance sheet, pension, income, and other demographic characteristics of approximately 4,500 U.S. families, selected with procedures that assure representation of all economic strata[4] . The first survey was conducted in the early 1960s and has been conducted triennially since 1983, with the sponsorship of the US Department of Treasury and the Federal Reserve Board. The reported data consists really of five complete datasets, as missing data are multiply imputed. We did not have access to the raw data, so all statistics reported in this section correspond to the union of the five imputations, from the 2001 survey.

Table 3 sketches the characteristics of households holding different types of financial assets: directly-held stocks, equity and liquid assets (transaction accounts). Arguably, the

[4] For a description of the methodology, see Kennickell (1998, 1999).

	Age (Years)	Education (Years)	Annual Income	Networth	Financial Assets	Non Financial Assets
All families						
Median	47	13	40,089	86,100	21,930	97,500
Mean	49	13	69,122	395,827	190,651	259,691
Stockholders (1)						
Median	48	16	77,093	385,200	180,860	231,300
Mean	50	15	144,242	1,105,464	603,710	602,526
Equity holders (2)						
Median	46	14	62,703	201,320	80,780	163,000
Mean	48	14	103,093	661,510	341,109	401,982
Liquid asset holders (3)						
Median	47	13	30,000	104,700	43,172	111,150
Mean	49	13	209,086	432,661	74,228	282,697

Table 3: Characterization of financial market participants by instruments held (2001 dollars)

Source: Constructed from information contained in the 2001 Survey of Consumer Finances.

(1): Households having financial assets invested in directly-held stocks

(2): Households having financial assets invested in stocks (including directly-held, stock mutual funds, IRAs/Keoghs invested in stock).

(3): Housholds having liquid financial assets, defined as all types of transactions accounts (checking accounts, saving accounts, money-market accounts, and call account at brokerages).

level of financial knowledge required to correctly understand these assets is the highest for stocks and the lowest for transaction accounts, the simplest type of financial asset included in the SCF. As expected, large differences exist between these groups. Median stockholders have higher levels of networth, financial wealth[5] and education than median holders of equity or liquid assets. This is coherent with the evidence found in previous studies. On the other hand, education is highly correlated with both wealth and networth.

Table 4 characterizes stockholders by quintiles of networth. Some interesting results emerge. In the first column we see that the percentage of stockholders is monotonically increasing in the quintiles of networth, the highest quintile having a participation rate 10 times higher than the first. However, in the second column we see that average stock's load in portfolios is much more homogeneous. On the other hand, education and networth

[5] All measures of networth and wealth include only physical and financial assets, excluding human capital or the future income flows associated to it.

	% Stock-holders	Stocks/Financial assets	Stocks/ Networth	Stocks (dollar value)	Average education		% of college graduates	
					Stockholders	Non	Stockholders	Non
All households	21.3	31.8	17.4	192,078	14.7	12.7	59.2	27.2
Quintile 1	4.5	29.8	-35.2	2,654	13.9	11.8	37.5	15.5
Quintile 2	8.0	29.7	17.6	4,519	13.8	12.4	36.6	19.6
Quintile 3	13.0	29.0	15.7	14,579	14.1	12.7	48.7	27.7
Quintile 4	27.2	20.2	9.8	24,411	14.1	13.3	50.8	36.6
Quintile 5	53.9	32.5	17.8	363,457	15.2	14.3	71.2	50.3

Table 4: Characterization of Stock Holders by Quintiles of Networth (2001 dollars)
Source: Constructed from information contained in the 2001 Survey of Consumer Finances.

are monotonically, positively and strongly related to each other. More interestingly for our purposes, for each quintile stockholders are in average more educated than non stockholders, both in terms of years of formal studies and in their likelihood of being college graduates. Thus, a positive marginal relationship between education and the participation rate is apparent even after controlling for networth. As we will see shortly, this relationship persists in the econometric analysis after controlling for a set of additional variables.

Finally, Table 5 presents the share of stockholders by educational level, splitting the sample in deciles of networth. As in Table 4, for a given decile the proportion of stockholders increases (although not monotonically) with education. For example, while 0% of the households that did not complete high school in the first decile hold stocks, the share raises to 10% among college graduates. Notice also that the same applies for a given educational level as networth rises.

Much in line with previous studies (Bertaut and Starr-McCluer, 2000; Bertaut and Haliassos, 1996), we estimate several Probit models for the households' decision of directly holding stocks or equity to see whether the relations found in Tables 2-5 are robust. In these models, the decision is taken to be determined by wealth, education, work type and variables that describe demographically the household.

The fact that missing data are multiply imputed obliges some extra care when handling the dataset Multiple Estimation is a procedure for handling missing data that provides information that can be used to estimate the extra variability due to unknown missing variables. The technique uses stochastic multivariate methods to replace the missing values with two or more values that are generated to simulate their distribution. As described by

	No high school diploma	High school diploma	Some college	College degree
Decile 1	0.0	7.2	5.5	10.3
Decile 2	0.5	3.3	5.0	10.1
Decile 3	2.1	3.5	9.5	12.6
Decile 4	4.2	7.6	12.5	15.2
Decile 5	1.7	6.8	19.6	18.3
Decile 6	11.3	10.8	10.8	22.8
Decile 7	19.0	14.7	23.8	18.9
Decile 8	12.4	33.0	24.8	38.8
Decile 9	25.9	30.6	38.9	52.9
Decile 10	38.5	43.4	62.1	68.9

Table 5: Percentage of Stock Holders by Deciles of Networth and Educational Level (2001 dollars)
Source: Constructed from information contained in the 2001 Survey of Consumer Finances.

Phillips Montalto and Sung (1996), multiple imputation increases efficiency in estimation, as well as reducing the non-response bias. The use of multiply imputed data provides a basis for more valid inference and tests of significance. If only one of the five datasets (implicates) contained in the survey were used, the variance estimate would underestimate the variance, and estimated coefficients would be biased. Thus, a combined estimation of the five implicates is required. Rubin (1987) proposes a methodology to derive estimates from datasets containing several implicates. Roughly speaking, the method estimates separate regressions for each of the five implicates. The best point estimate for the parameter is the simple average of the point estimates derived independently for each of the five implicates. The best variance estimate is the average of the variance estimates derived independently from each of the five implicates (which is labeled as the "within" imputation variance), plus an estimate of the "between" imputation variance, adjusted due to the use of a finite number of imputations.

Several regressions, using Probit estimations with robust Huber/White covariances with data taken from the 2001 SCF, are presented in Table 6. The dependent variables are dummies that take the value of 1 if the household has the corresponding asset in his financial portfolio (equity or stocks). In all estimations, households that do not hold liquid assets (transaction accounts) are excluded, as we are interested in households that, holding a simple type of financial asset in their portfolio, choose to hold (not to hold) a more sophisticated

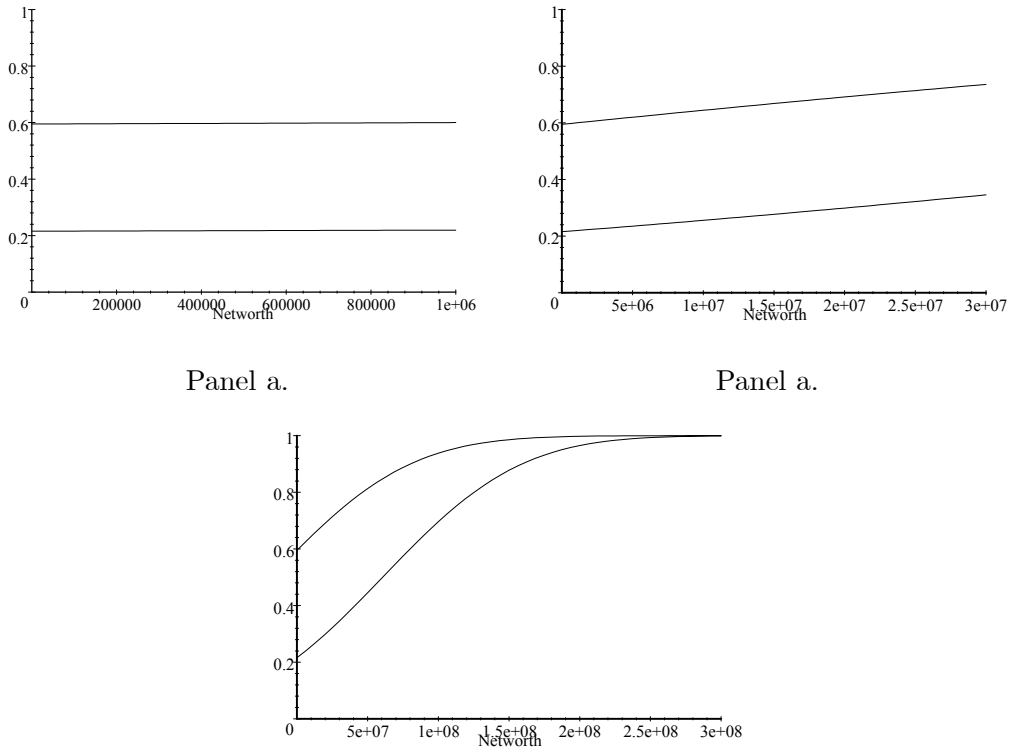
asset .

Results across estimations are pretty robust. Most results are also coherent with previous studies'.

Networth appears as a major determinant of stock and equity holding. Interestingly, however, its importance decays as one focuses on more complex financial assets (i.e., equity vs. stocks) or as one restricts attention to equity holders.

Perhaps next in importance, (formal) education raises the chance of holding stocks or equity. Not surprisingly, Bertaut and Starr-McCluer (2000) indicate that it is one of the most robust variables in regressions for stockholding after controlling for all potential determinants. Agents who did not complete high school, controlling for all other determinants, tend to hold less stocks that comparable agents who received a high school diploma. Graduating from college increases significantly the probability of observing equity (stocks) among the agent's assets. This holds true for all regressions.

The plots in Figure 3 show the effects of networth and education in the estimated probability of holding stocks from Regression (2). The upper line corresponds to college-graduated household, while the lower curve to a household with incomplete high-school. The horizontal axis corresponds to networth. The variables that are not displayed are evaluated at its median value. At a null networth, the estimated probabilities of holding stocks are 22% for high school dropouts and 59% for college graduates. As networth increases, these probabilities eventually approach 1. Contrast Panels a, b and c in Figure 3; they only differ on the range of networth considered. Hence, education is a strong determinant of stockholding, but its importance decreases till it vanishes at the highest levels of networth.



Panel a. Panel a.

Panel a.

Figure 3 : Estimated probability of holding stocks

With regard to personal characteristics, the probability of holding stocks and equity increases with age, and is higher for white-race, married households who do not have kids. Work characteristics are less important. The dummy for certainty on future income, a coarse measure of non-financial income risk, is not robust, being - as expected - positive in the regressions involving to hold equity/stocks, but reversing its sign for the decision of holding stocks for equity holders.

We fear that some variables other than formal education might be capturing part of our unobserved financial literacy. Consider, for instance, the value of the household's house as a share of total assets, which has a negative impact on the probability holding equity or stocks. Houses are illiquid and indivisible, and so in some sense they restrict the capability of investing in the financial market. However, it is plausible that individuals with a higher share of their wealth invested in their house choose such concentration because they face higher ambiguity when dealing with financial assets. Or consider, for that matter, the dummy "professional occupation?" whose positive sign could be interpreted as suggesting

that households whose occupation is probably associated to higher capacity in processing information are indeed more inclined to hold stocks. Unfortunately, our inability to observe financial-specific knowledge prevents us from leaving our speculative position in this regard.

The positive connection between education and stockholding is, nonetheless, clear and strong.

Regression	(1)			(2)			(3)			(4)		
Dependent variable	Has equity?			Has stocks?			Has stocks?			Has stocks?		
Sample: Hoseholds with...	Liquid. financial assets			Liquid. financial assets			Equity			Liquid. financial assets in highest networth decile		
Sample size: (per imputation)	4127 observations			4127 observations			2749 observations			1403 observations		
	Coeff.	Std.Dev.	p-value	Coeff.	Std.Dev.	p-value	Coeff.	Std.Dev.	p-value	Coeff.	Std.Dev.	p-value
Constant	-1.604	0.209	0.000	-2.056	0.233	0.000	-0.763	0.287	0.004	0.074	0.697	0.457
Personal characteristics												
Age	0.038	0.008	0.000	0.019	0.009	0.019	2.8E-4	0.011	0.49	0.006	0.022	0.396
Age squared	-3.4E-4	8.1E-5	0.000	-1.0E-4	8.7E-5	0.114	1.1E-4	1.0E-4	0.153	-1.3E-4	-1.9E-4	0.257
White race?	0.379	0.062	0.000	0.364	0.070	0.000	0.220	0.085	0.053	0.490	0.167	0.002
Married?	0.417	0.052	0.000	0.370	0.054	0.000	0.247	0.066	0.000	0.087	0.115	0.224
Has kids?	0.022	0.053	0.341	-0.084	0.051	0.051	-0.072	0.059	0.112	-0.144	0.092	0.058
Wealth												
Networth (dollars)	2.7E-8	1.5E-8	0.036	1.3E-8	3.4E-9	0.000	8.9E-9	2.3E-9	0.000	7.6E-9	2.3E-9	0.000
House value (% of total assets)	-0.046	0.083	0.291	-0.309	0.155	0.023	-0.573	0.110	0.000	-0.771	0.276	0.003
Has a professional occupation?	0.233	0.058	0.000	0.138	0.053	0.005	0.045	0.060	0.225	-0.009	0.086	0.457
Work												
Certain of future income?	0.289	0.053	0.000	0.050	0.050	0.157	-0.098	0.059	0.049	0.042	0.084	0.306
Owns business?	0.264	0.076	0.000	0.311	0.060	0.000	0.217	0.061	0.000	-0.342	0.086	0.000
Education												
Has a college degree?	0.580	0.055	0.000	0.585	0.051	0.000	0.423	0.059	0.000	0.417	0.094	0.000
Did not complete high school?	-0.713	0.082	0.000	-0.442	0.097	0.000	0.044	0.141	0.376	0.047	0.260	0.428

Table 6: Probit regressions
Source: Authors' estimation with data from the 2001 Survey of Consumer Finances.
All questions are dummy variables that take the value 1 if the answer is "yes" and 0 otherwise.
The dummy "Certain of future income?" corresponde to the question "At this time, do you have a good idea of what your income for next year will be?"

6 Concluding remarks

This paper has argued that although the existence of information acquisition costs is not a plausible solution to the Participation Puzzle within the framework provided by EU theory, it may be so within the framework of CEU theory. Information costs *per se* are not capable of explaining the observed widespread low stockholdings, but ambiguity aversion can.

Unfortunately, at the moment it is not possible to write down a full-blown model of information acquisition within this generalization of EU theory, mostly because a full understanding of belief updating that parallels that of Bayes' rule is yet to come. The approach, however, seems promising, as our model suggests.

The empirical evidence, on the other hand, hints strongly towards an explanation of this sort, as (formal) education is strongly related to participation in the samples analyzed, even when using proper controls. Equity-market participants tend to be more educated than non participants. Although more refined data that allows for a clearer identification of equity-market related knowledge is a must in order to gain assurance on the results, what this paper has shown strongly suggest the empirical plausibility of the argument.

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