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Learning, ambiguity and life-cycle portfolio allocation ☆

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ABSTRACT

In the present paper I develop a life-cycle portfolio choice model where agents perceive stock returns to be ambiguous and are ambiguity averse. As in Epstein and Schneider (2005) part of the ambiguity vanishes over time as a consequence of learning over observed returns. The model shows that ambiguity alone can rationalize moderate stock market participation rates and conditional shares with reasonable participation costs but has strongly counterfactual implications for conditional allocations to stocks by age and wealth. When learning is allowed, conditional shares over the life-cycle are instead aligned with the empirical evidence and patterns of stock holdings over the wealth distribution get closer to the data.

1. Introduction

The last decade has witnessed a substantial surge of academic interest in the problem of households' financial decisions. A number of empirical facts have been documented regarding in particular the stockholding behavior of households. These include the fact that participation rates, even though increasing over the years, are still at about half of the population and the moderate share allocated to stocks by participants. It has also been documented that the share of financial wealth allocated to stocks is increasing in wealth and roughly constant or moderately increasing in age.[1] Equally important has been the development of quantitative research that, based on the precautionary savings model, has explored the same issue. The current paper joins this latter line of research by exploring the role of a class of nonstandard preferences.

More specifically, in this paper I present a model of life-cycle portfolio choice where agents perceive the return on one of the assets to be ambiguous and are averse to ambiguity. As in Epstein and Schneider (2005) ambiguity can be reduced over time through learning. The basic framework of the model is otherwise standard: agents have finite life and receive a stochastic earnings stream during working life, followed by a constant pension benefit in retirement. Agents cannot insure

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[1] Among the papers that have uncovered the patterns of household financial behavior are Ameriks and Zeldes (2004), Bertaut and Starr-McCluer (2000), Curcuru et al. (2004) and Heaton and Lucas (2000) for the US. The book of Guiso et al. (2001) documented the same facts for a number of other industrialized countries as well and the work by Calvet et al. (2007) has gone in much greater details to document stock-holding behavior among Swedish households.

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against earnings uncertainty, thus use savings as a self-insurance instrument. Beside that they save for the other usual reasons, that is, to finance consumption during retirement, to insure against uncertainty about the length of life and to leave a bequest. Saving can occur through two assets, a risk-free bond and a risky stock, and exogenous no borrowing and no short sale constraints are imposed. Trading in the stock requires payment of a fixed per period cost.

The model departs from the basic framework by assuming that agents perceive the stock return process to be ambiguous. This means that they think they cannot know the exact distribution governing that process, they only know that it lies in some set of distributions. Agents are averse to ambiguity according to the max–min utility model developed by Gilboa and Schmeidler (1989) in a static framework and extended to a dynamic setting by Epstein and Schneider (2003). It is also assumed that the ambiguity present in the stock return process can be reduced through the observation of the realized returns and that stock market participants have an advantage at doing so.

The model is solved numerically and its properties are analyzed under a broad set of parameters. It is shown that ambiguity aversion alone can generate moderate participation rates and conditional shares without resorting to large participation costs and it does so by assuming a fairly reasonable amount of ambiguity in the stock return process. On the other hand the model with ambiguity but no learning shows two counterfactual properties: stock shares for market participants are strongly declining in both age and wealth which is at odd with the empirical evidence. When learning is introduced, the model, while retaining reasonable average participation rates and conditional shares, generates a life-cycle profile of conditional stock allocation that is slightly increasing but with little variation as in the data. It also displays constant stock shares over wealth levels, thus moving a step in the right direction towards matching the empirically observed increasing pattern.

The intuition for these results is that under ambiguity — and with short-selling constraints — the equity premium that is relevant for the decision maker, henceforth called "worst case" equity premium, is the lowest given the distributions in the posterior set. With learning the set of posteriors shrinks over the life-cycle thus improving the "worst case" equity premium and inducing investors to hold a larger share of stocks in their portfolios as they age. Moreover, given the assumption that stock market participants have an advantage at learning, wealthier agents who have started to participate earlier will generally face a smaller set of posteriors, hence a higher "worst case" equity premium. This increases their demand of stocks. Quantitatively though, this does not go as far as allowing to fully match the wealth-share profile observed in the data.

The main contribution of the paper is to document the implications of ambiguity aversion and learning in an ambiguous environment for household life-cycle portfolio allocation and to show that these features may have an important role in explaining the observed pattern of household financial choices. In doing so it joins two very active lines of research. The first one is the literature on portfolio allocation in precautionary savings models. This literature was first explored by Heaton and Lucas (1997, 2000) and Haliassos and Michaelides (2003) in an infinite horizon setting and by Campbell et al. (2001), Cocco et al. (2005) and Gomes and Michaelides (2005) in a life-cycle setting. These papers documented the basic properties of this type of model and pointed out the difficulties it has to explain the low participation rates and conditional stock shares observed in the data.

More recently a number of papers and in particular the ones by Benzoni et al. (2007), Lynch and Tan (2009) and Wachter and Yogo (2009) have looked for explanations of patterns of household stock market investment over the life-cycle and over wealth levels. In particular Benzoni et al. (2007) assume that labor income and stock market returns are co-integrated and show that under this assumption human capital is more like a stock for young agents, lowering their demand of equity. Lynch and Tan (2009) obtain a similar result by allowing for correlation between stock returns and labor income growth and volatility. Wachter and Yogo (2009) assume the existence of both basic and luxury goods and show that under this assumption conditional portfolio shares of stocks are increasing in wealth. Contrary to those papers the current one retains both the assumption that labor earnings and stock returns are uncorrelated and that the utility function is homothetic. The major departure from the more traditional framework lies in the fact that stock returns are ambiguous, agents are averse to ambiguity and that ambiguity lessens over time through learning.

The second line of research to which this paper is related is the one that has studied the implications of model uncertainty in asset pricing and portfolio choice. Contributions in a dynamic framework go back to Epstein and Wang (1994). More recently Cao et al. (2005) explored the implications of heterogeneity in ambiguity aversion for stock market participation and the equilibrium equity premium in a static framework and Leippold et al. (2008) studied a dynamic Lucas-style exchange economy with both ambiguity and learning. While the three papers cited above used the max–min model of ambiguity aversion, Ju and Miao (2007) introduced the Klibanoff et al. (2006) smooth ambiguity model in a dynamic endowment economy with learning about the hidden state and showed that the model can match a wide set of asset pricing facts. Model uncertainty has also been studied in the alternative framework of robust control of which two applications to asset pricing are Maenhout (2004) in an endowment economy and Cagetti et al. (2002) in a business cycle model. Examples of explorations of the role of ambiguity aversion in portfolio choice models are Garlappi et al. (2006) that use a static mean-variance approach and Maenhout (2004). This latter paper is dynamic as the present one, however it omits labor income and uses the robust control approach.

The rest of the paper is organized as follows. In Section 2 I present the description of the model, in Section 3 I report the choice of parameters, in Section 4 I report the main findings of the analysis and finally in Section 5 some short conclusions are outlined. The paper is completed by two appendixes where a short but formal treatment of the learning model and a description of the numerical methods used to solve the model are provided.