Household Portfolio Allocation:
A Review of the Literature

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Abstract

The goal of this review is to provide the reader with insights into the state of knowledge about household portfolios around the world. We offer an assessment of the current state of the theory, an understanding of typical features of household portfolios, and an analysis of key differences between predictions of the theory and observed portfolio patterns in the world setting.

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As a preview, we find that a fairly comprehensive theory of household portfolio allocation has been developed over the last three decades, and we also focus on some exciting new work reaching fruition in just the last few years. Early studies found it difficult to derive theoretical predictions from the theory that matched key aspects of observed household portfolios, relying on a simplified two-asset view of the world. More recently, analysts have extended their models to include housing and borrowing constraints, and these approaches do a better job of modeling household portfolios than did the earlier studies. However there is still no tractable model which specifies the complex investment problem facing a typical household, which also takes into account both housing and retirement pensions as well as tax effects. While much has been learned, understanding how households allocate their wealth and how this pattern changes over the life-cycle remains very much a challenge for modern finance. This challenge has a bearing on more than just household portfolios: it is crucial in the study of asset pricing, and for understanding the risk-return trade-off in the economy.

In what follows, we first offer a brief survey of empirical evidence on household portfolio allocations. Household portfolios are found to vary significantly by age and wealth, and between different countries. Housing, relatively safe financial assets, and social security and

pensions are found to be very important parts of portfolios in virtually every country, with risky financial assets being relatively less important in most countries. Next we turn to an evaluation of the theoretical literature on this topic, covering the last 30 years. First we examine early models of household portfolios. We compare the predictions of these models with empirical observations. The study then examines extensions of these models which include incomplete markets, different preferences structures, and housing. We find that the inclusion of housing makes model predictions very much more realistic, but that the impact of incomplete markets and different preference structures are less important. Surprisingly, we find very few papers that have explicitly incorporated social security and occupational pensions, or tax effects.

Household Lifecycle Portfolio Allocations: Empirical Evidence

Three stylized facts emerge from an empirical survey of household portfolios. Firstly, it is immediately evident that the portfolios of different households are surprisingly diverse. Portfolios differ by wealth, by the country in which the household lives, and by various household characteristics – such as the age, education and birth years of the members. Secondly, in all countries, the average household's portfolio is typically invested mainly in safe or in only slightly risky assets, once residential housing is excluded. These low-risk assets might include bank accounts, such as savings and checking accounts, time deposits, and life insurance. This is even true in the US and the UK, where stockholding is traditionally high, but it is especially true in other countries. Finally, most households appear to keep their portfolios very simple, with fewer than five different assets or accounts, despite the tremendous proliferation of different asset types in the 1990's. The modal number of household assets in the US in 1998, for example,

was three (Bertaut and Starr-McCluer, 2002). Typical assets held by households across the world, as well as a rough division of these assets into various risk classes, are shown in Table 1.

Although very few asset surveys include the implicit value of state benefits such as old age pensions and medical insurance, it is probably fair to say that almost all families in developed countries have a large proportion of their wealth in these benefits.[1]

Variation in household portfolios by age and wealth

In most countries, the first risky asset that a household invests in is likely to be the family home.[2] Rates of home ownership vary greatly by country. In the US, some 66% of households owned their home in 1998, while in western Germany in 1993 only 46% of households did so. This pattern varies strongly by age, with younger household much less likely than average to own their home and older households much more likely than average to do so.

The richer households become, the more likely they are to hold risky assets in addition to their home. These might include a family business, stocks and shares (possibly held in a private retirement account), or property that is rented out. In almost every country, only very wealthy families would typically hold most of their assets in risky form. Combined with the very low holding of risky financial assets by less wealthy households, this fact means that in many

[1] For instance, Mitchell and Moore (1998) and Moore and Mitchell (2000) estimate that 40% of the value of the average US household portfolio for 56-61 year olds was held in the form of Social Security in 1992. Along with all other studies of household wealth, that study does not value old-age medical insurance provided by the US government. This would be an interesting extension.

[2] In many countries, houses are not generally perceived as a risky investment. This may be because average household tenure is very long, implying that changes in the retail value of the house are highly discounted. Since the value of the consumption stream provided by a house is not terribly variable (depending as it does on the discount rate of the owner and the physical state of the house), some readers may in this circumstance be justified in assuming that a house is not a risky asset. Here the convention that homes are risky assets will be adopted, as it is assumed that transactions costs of moving houses are low.

economies, but especially those with highly skewed wealth distributions (such as the UK and the USA), most privately-held risky financial assets are held by very wealthy families.[3]

Typically, few very young households invest in risky assets. As households age, they will typically first buy a house, and then later invest in risky financial assets. After that point, there is little evidence in most countries of substantial changes in the portfolio allocation as the household ages - although the size of the average portfolio typically increases with age until very old ages. In many countries, the proportion of the household portfolio held in risky assets increases slightly as the household ages. At older ages, some families may sell their risky assets and their homes and move their portfolios back into safe assets. At this point, some older households may also spend down their assets. Most of the variation in the average share of financial portfolios invested in risky assets with age seems to be due to changes in the proportion of households that invest in risky assets. Conditional asset shares in risky assets seem to be much more stable across age, but not across wealth.

The typical household portfolio pattern also varies along several other dimensions. Households whose members have more years of formal education tend to have a higher probability of holding riskier assets in most countries. There is also evidence of strong cohort effects in many countries. During the late 1980's and 1990's, across the developed world, many household of all ages increased their investments in risky assets such as stocks. This means that the portfolio of a typical household with given characteristics would have been quite different in 1980 and 2000. This change may reflect large changes in asset prices over this period, it might indicate a shift in expectations of future rates of return, or it might be the result of households responding to falling transactions costs and increased financial innovation over this period.

[3] This excludes the asset holdings of pension funds, which are indirectly held even by relatively poor households.

Stylised facts about household portfolios

Three stylized pictures of household portfolios should help further clarify patterns that can be synthesized based on available data. The first is the *average asset portfolio by wealth decile controlling on age*. Figure 1 depicts this for US asset portfolios ('92 US$000's) for age 50-59 Americans, as measured in the Health and Retirement Study in 1992. The Figure highlights a wide disparity in the size of asset portfolios, as well as the profound importance of pensions, social security, and housing for 90% of the older US population. In this case, pensions include both defined benefit (DB) and defined contribution (DC) pensions, while financial assets include stocks, bonds and bank account holdings. Of particular importance is the fact that financial assets make up less than one third of the asset portfolio of more than 90% of US households at this age.

Figure 1 here

A second Figure illustrates *portfolio composition by age controlling on wealth*. Since very few studies separate along these two dimensions, we have developed a stylized picture based on Netherlands 1997 data reported in Guiso *et al.* (2002). The values for housing and risky and safe financial assets are taken from household survey data, while the pensions and social security benefits have been imputed by the author.[4] Note again that financial assets are a relatively small proportion of household portfolios except for very young households. As the household ages, it accumulates pension and social security wealth, housing wealth and financial

[4] Social security and defined benefit pension wealth were imputed using typical benefit formulas from Watson Wyatt (2003). The intention is merely to give the reader an idea of how a portfolio might change with age when social security and pension wealth are included, rather than to give precisely accurate figures.

wealth. Older households spend down their assets, especially their accumulations in pensions and social security. Clearly portfolios do change with household age quite notably.

Figure 2 here

A third Figure to bear in mind elaborates how *the proportion of households that holds risky assets changes with age*. Figure 3 shows these quantities for the case of Italy,[5] and also how the proportion of risky assets in the household portfolios changes with age. It can be seen from the figure that most of the change in the fraction of financial wealth held in risky assets is due to changes in the fraction of households that hold risky assets. The share of financial wealth held in risky assets, conditional on owning any risky assets, is either relatively stable or increasing with age in most countries, as it is in Italy, except for very young and very old households. The proportion of people holding risky assets is often hump-shaped with age – increasing at younger ages, but falling at older ages, as it is here.

Figure 3 here

More detail on household portfolios for six OECD countries – the US, UK, Italy, Germany, the Netherlands and Japan –is available in the Appendix to this report. Housing as well as state and private pensions make up the bulk of household portfolios in most OECD countries: for example, in the US, housing and pensions (state and private) make up approximately 80% of the median wealth 55-year olds' portfolio.

The Economic Theory of Household Portfolio Allocation

The simple facts about household portfolios presented above stand in stark contrast to what economic models of portfolio theory have predicted, particularly those models developed in

[5] In this case, the definition of 'risky assets' includes long-term government bonds. However, these assets make up a relatively small proportion of household portfolios in Italy.

the early days of this literature. Many models, particularly those which exclude housing, imply that most or all households will hold some equity. This is because these models do not model the decision to hold equities separately from the decision about how many equities to hold. The amount of equity that households are predicted to hold is also very much higher than what is actually observed. Models also fail to predict that the conditional share in equity increases or remains constant as people age: they usually predict that this proportion will decline with age. Very few theoretical models adequately explain the extensive cross-sectional heterogeneity in household portfolios observed as wealth increases; indeed, most models predict that households will have the same portfolio composition whether they are rich or poor. Finally, almost no economic models take account of household composition – for instance, whether there are children or grandparents living in the home – even though these may be very relevant to the portfolio decision.

The origin of portfolio theory helps to explain why the theoretical work suffers from such daunting shortcomings. Portfolio theory started out as a tool for understanding financial portfolio allocation, and therefore did not focus in much detail on other aspects of household wealth. More recent analysts have begun to consider housing, but very few of these take social security or company pensions into account. Furthermore, the presence of both means-tested benefits and old-age pensions is likely to exert considerable influence on household portfolios, and their omission is therefore striking. A further insight is that much of the literature was driven by an interest in asset pricing, in particular in the equity risk premium puzzle, rather than the empirical reality of household portfolios.

These early models have been used as a foundation for later models of portfolio development, which have resolved or reduced the importance of many of these issues. Newer

models have increased the number of assets households may invest in, have included restrictions on household portfolios and have incorporated aspects of households - such as the presence of labor income and costs to investing - that influence the portfolio that households choose to hold. However, even for many newer models, the gap between the theory and empirical results is still large.

In what follows, we discuss the history of portfolio theory and various attempts to cope with problems presented by empirical studies of household asset allocation behavior. After covering the foundations of the theory, we then move on to show how introducing labor income, incomplete markets, housing, other assets, and different preference structures alters models of portfolio choice and their implications.

Early Models: Markowitz, Merton, and Samuelson

The seminal paper on portfolio choice, by Markowitz (1952), set out to solve the relatively simple problem of an agent allocating a portfolio of financial assets who would consume his entire portfolio in one period's time. In that model, agents are assumed to care only about the expected return (mean) and the riskiness (variance) of the return on each asset, as well as how each asset's return covaries with the returns of the other assets available.[6] The key result of that paper was mean-variance analysis, now familiar to modern students of finance. The idea of a risk-free asset was introduced by Tobin (1958), who showed that all agents would hold the same portfolio of risky assets (called the market portfolio). He further demonstrated that these risky assets would make up a different proportion of their portfolios, depending on each agent's

[6] This assumption is equivalent to assuming that asset returns are jointly normally distributed, or to assuming that agents have quadratic preferences.

preferences for risk: more risk-averse investors would hold a greater proportion of their portfolios in the risky asset portfolio. This result is called the two-fund separation theorem.

Sharpe (1964) and others extended the model into what has been called the Capital Asset Pricing Model (CAPM), which was the first general equilibrium model of asset prices that incorporated risk. The CAPM predicts that all agents will hold the same portfolio, but in varying proportions; that this portfolio is the portfolio of all tradable securities; and that the prices of assets will be linearly related to their correlations with the market portfolio. Each of these predictions has been strikingly rejected by empirical studies of individual behavior and of asset prices: that is, much individual wealth is held in non-tradable assets; individual portfolios differ by age and total wealth; and the correlation of a security's price with the market portfolio explains only a small part of its value.[7]

One theoretical shortcoming of the CAPM, at least as far as portfolio theory was concerned, was that it only looked one period ahead. In practice, of course, individuals know that they can change their portfolio decisions in the future, which could potentially alter their portfolio decisions in the present. For this reason, authors such as Samuelson (1969) and Merton (1969) extended the portfolio allocation problem into multiple periods. It is worth nothing that multiple period portfolio decisions might not be the same as single period decisions for several reasons. If investment opportunities are constant across time, the effect of lengthening the time horizon can be split into two parts. First, the longer an agent's time horizon, the lower the impact on consumption a given dollar shock will be – and therefore the more likely an agent will choose to take such a risk. Second, the longer an agent's time horizon, the higher current wealth

[7] A good summary of this literature can be found in Campbell, Lo and MacKinlay (1995).

will be for a given level of consumption. Since risk aversion may change with wealth, this may affect the investment risk that an agent is willing to bear in the current period.

In related papers, Samuelson (1969) and Merton (1969) modeled a decisionmaker who can invest in two assets: a risk-free bond which pays a constant rate of return, and a risky stock with a constant equity risk premium. The agent was assumed to face no transactions costs, to be able to borrow and lend at the same rate, to have no portfolio restrictions, and to receive no labor income. That research concluded that investment decisions are independent of the time to the end of life – in other words, investors behave exactly as though the current period is the last one – under very special circumstances: if investment opportunities are constant and utility has a certain functional form (CRRA). This holds because for CRRA preferences, the two effects described in the previous paragraph exactly cancel each other out.

The two-fund separation theorem of Markowitz holds in this model: investors only need the risk free asset and one mutual fund (the market portfolio) and they will be able to achieve the optimal portfolio regardless of their risk aversion. In the CRRA case, agents consume a fraction of wealth in each period that depends on the time to retirement:

$$C^*(t) = \frac{W(t)}{T-t},$$

where T is the final time period and t is the current time. $W(t)$ is the wealth at time t. Agents will also invest a constant fraction of their wealth in the risky asset that is independent of their consumption:

$$w^*(t) = \frac{\alpha}{\gamma\sigma^2},$$

where α is the equity risk premium, γ is the CRRA co-efficient of risk aversion and σ^2 is the variance of stock returns.

This model can be used to derive optimal portfolio predictions using empirical equity returns and volatilities; this was done by Jorion and Goetzmann (2000) and results appear in Table 2. Values are shown for two different levels of risk aversion. Predicted proportions of household portfolios that will be held in equity appear unreasonably high, as compared to actual household portfolios in all these countries except in Italy. This is the portfolio theory version of the equity risk premium puzzle: given the historical trade-off between risk and reward on stock markets and known levels of risk aversion, *theoretically optimal* portfolios are much more heavily skewed toward equities than actual portfolios appear to be in practice. The traditional way of phrasing this puzzle is that equities seem to return much more than they would need to in economic equilibrium, given equity's observed risk characteristics and reasonable assumptions about investor preferences.

Table 2 here

The effect of changing assumed equity risk premiums can be seen by comparing the predicted optimal portfolios across different countries in Table 2: the lower the equity risk premium, the lower the proportion of the portfolio held in equities. Assuming an equity risk premium that is much lower looking forward than looking backwards, this is one way in which authors have tried to make the "fit" of this model more realistic. For instance, in Italy, the equity risk premium is much lower than in the US, and the volatility of equity is much higher – implying that the optimal portfolio proportion in equity is only 16% for a risk aversion level of 3. The table also shows that the optimal portfolio is extremely sensitive to the chosen risk premium – and the risk premium is a very difficult parameter to estimate precisely.[8] Some authors have

[8] This is because any estimate of the equity risk premium depends on past investment returns over a period of time, which are measured by comparing the level of a stock market index at the end of the period and at the beginning of the period. This means that there are really only two points that enter into the estimation equation – implying very

argued that the prospective equity risk premium in the US is much lower than the past observed risk premium – perhaps because investors have realized that equities are underpriced and altered their portfolios in response.[9]

Another way of solving the equity premium puzzle is to change the preference structure: the choice of utility function in these models is largely arbitrary and motivated by non-economic factors such as tractability. For instance, if a much higher risk aversion than 3 or 5 were assumed, the model would predict a much lower proportion of household portfolios invested in equity. However, many economists have estimated risk aversion in different ways and find values greater than about 5 to be unreasonable.[10]

Another problem with this model is that it cannot explain the pattern of changing portfolio allocation with wealth shown in Figure 1. This figure shows that wealthier households have a greater proportion of their wealth in equities, and can therefore be considered to be less risk averse. Utility functions with this property are called DARA (decreasing absolute risk aversion) utility functions. However, under DARA utility functions, the optimal investment mix is no longer independent of the time until the end of life. As individuals with this type of preference age, they would be predicted to hold more in risky assets and less in risk-free assets. While the conditional share of risky assets does increase with age in many countries, as shown in Figure 2, the unconditional share of risky assets either remains constant or declines at older ages. Therefore, introducing DARA utility functions into the model regrettably solves one empirical problem only at the expense of introducing others.

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high uncertainty in the estimated value. Splitting the period into different pieces does not add any information. This is not the case for estimating the variance.

[9] See Telmer (1997) for a discussion of this point.

[10] See Halek and Eisenauer (2001) for a discussion of methods of obtaining estimates of risk aversion.

There are also problems with the assumptions made by the simple model; for instance, in the real world, investment returns fluctuate. Interest rates are not constant and the equity risk premium changes substantially over longer periods. Merton (1970) was the first to notice that this fact also implied that the multi-period investment problem solution would be different from the single-period solution. This is because investors in multiple periods would desire to hedge themselves against future changes in interest rates or future changes in the equity risk premium by changing their asset allocation. For instance, investors could hedge themselves against lower interest rates in the future by holding long-term bonds now. Then, if interest rates fell, the value of the long-term bonds would increase to compensate. This effect was called the "intertemporal hedging demand" for assets. In all the portfolio models discussed to this point, the two-fund separation theorem holds, as discussed above. This means that risk tolerant and risk averse investors hold the same portfolio of risky assets, but in different amounts. Merton showed that the intertemporal hedging demand created a demand for a third fund – the so-called covariance optimal portfolio. This portfolio is the portfolio that has the highest covariance with the underlying investment conditions. By taking a long (or a short) position in this portfolio, investors can hedge themselves against changes in investment conditions. Just as in simpler models, investors only need to hold two portfolios, in this model investors would only need to hold three portfolios – the risk free asset, the risky asset portfolio, and the covariance optimal portfolio.

A further extension to the simple portfolio model during this time was the inclusion of labor income. It was realized that if investors receive labor income – which most do – it would have a significant effect on their asset portfolios. In the very simple model, there are no portfolio restrictions, which implies that investors are allowed to consume future wages by borrowing

against them at the risk-free rate. This is permitted since these investors are not able to default on their debts and do not reduce their work effort when they have already spent next year's wages! In addition, financial markets are assumed to be complete - in other words all uncertainty can be traded away in markets - and labor income is assumed not to vary. In such a world, Merton (1971) found that rational investors would capitalize their wages at the risk-free rate and treat the sum as an addition to their portfolio invested in the risk-free asset. They would keep the asset mix of their total portfolio (their financial assets plus the implicit value of their future wages) the same as in the case where they had no labor income. This would push their financial portfolios even further into the risky asset. It would also cause them to shift their financial assets out of the risky asset much more rapidly as they aged. These two effects made the model fit even worse than it had before.

As an illustration, Figure 4 shows the portfolio composition of an agent in one of this model who faces parameter values shown in Table 2 for Japan, and who receives an annual income for 20 years, and then no income for the next few years. His initial wealth equals 5 times his annual income. The graph clearly shows the decline in the equity proportion as the implicit value of the non-risky labor income falls. Once the implicit value of labor income is zero, the optimal proportion of the portfolio in equity equals the optimal proportion without income, which is constant.

Figure 4 here

It is clear from the figure that the introduction of labor income to the simple model worsens the model's fit to actual data in several areas. First, most of the decline in risky asset proportions (conditional on owning any risky assets) occurs late in retirement in most countries, rather than prior to retirement as shown here. Conditional risky asset holdings tend to stay

constant or to increase slightly at most ages in most countries. Unconditional asset holdings observed in practice tend to increase slightly at early ages and decrease slightly at later ages. This model makes no distinction between conditional and unconditional risky asset holdings because all agents are predicted to hold equity, so it is difficult to know which empirical pattern to compare against the model's predictions. Also, the model's prediction that households should leverage themselves in order to invest in equity at younger ages is strikingly at odds with observed practice – in Japan at any rate.[11] In fact, with reasonable values for income and initial financial wealth, this simple model would generate leveraged equity portfolios in most of the countries in Table 2.

Another theoretically important extension to this type of model was published by Bodie, Merton and Samuelson (1992). That paper assumes that the investor can choose when he or she can stop working – different from the simple labor income model, where the investor's retirement date is set exogenously. The option to work further allows the agent to invest even more in equities when young – because if the equity investment turns out badly then the investor can just choose to work a little longer to make up the lost money. It therefore further worsens the fit of the model to empirical data.

All of the models discussed so far have the assumption in common that markets are complete. This means that the investors are able to trade away all the uncertainty they face by buying or selling stocks – whether this means taking on highly leveraged portfolio positions or not. In reality, households face risks that cannot be traded away – such as income risks, health risks, and mortality risks. They also face portfolio restrictions because lenders cannot trade away the risk that borrowers will default on their loans. Real-world investors also pay to trade in

[11] Although many households do leverage themselves at younger ages to invest in housing – which can be considered to be a risky asset. This point was first made by Bodie, Merton and Samuelson (1992).

markets – they face transactions costs – which implies that they will retain some risk even if they could trade it away completely. These three factors are all examples of market incompleteness.

How Incomplete Markets Influence Portfolio Allocation

The insight that incomplete markets might explain aspects of portfolio allocation behavior came out of the macroeconomic literature on consumption and saving. Here, incomplete markets were used to explain anomalous results in individual savings behavior. The macroeconomic literature was based on the Permanent Income Hypothesis (PIH),[12] which states that individuals choose an optimal consumption path looking forward over their whole lives. If they can borrow and save in the capital markets, this consumption will depend on their accumulated wealth and the sum of their lifetime labor income, but not on current income. This implies that there should not be a positive relationship between consumption and income. If the model is true, individuals will save when their income is high and dissave when their income is low.

By the late 1980's, macroeconomic and microeconomic evidence had been collected which suggested that observed consumption was actually positively related to income.[13] Further evidence suggested that consumer asset accumulation and asset allocation were extensively correlated with income over the lifecycle[14] – a further violation of the PIH. In an interesting paper, Deaton (1991) developed a model which showed that some of the unexplained aspects of the income-consumption relationship might be a rational response to unhedgeable income risk in the presence of borrowing constraints. If agents were impatient, and could not borrow, and if

[12] See Modigliani and Brumberg (1954), and Ando and Modigliani (1963) for the basis of the PIH.
[13] See Flavin (1981), Hall and Mishkin (1982) and Zeldes (1989) for some examples.
[14] See, for example, Summers and Carroll (1987).

their income shocks were persistent (but not too persistent), then they would hold a stock of assets to protect themselves against income shocks, but there would also be a positive relationship between income and consumption.

This work was extended to include the asset allocation decision by allowing agents to allocate their savings between stocks and bonds (the original work assumed that agents could only invest in bonds). This came into the consumption-savings literature from the asset-pricing literature – which had realized that the limited participation of individuals in the stock market might be able to explain the equity risk premium puzzle. This one idea spawned a whole new area of papers - spilling over into portfolio theory - which eventually included realistic life-cycle effects, aggregate and idiosyncratic income shocks, spells of unemployment, portfolio restrictions, borrowing constraints, and transactions costs, as well as an endogenous choice of risky and non-risky assets. In general, these models are not analytically tractable, and so have been solved numerically. This makes it difficult to compare the results of different models because the models are often parameterized differently.

Lifecycle effects are found to be strong in these models – because of the income effect illustrated in Figure 4. The effect of income driving younger agents into holding stocks persists whether income is risky or not: this is because even risky income typically has a floor that can be regarded as risk free and this portion is capitalized. The riskier is labor income, and the more highly correlated it is with the stock market, then the less the stock effect will be. The effect will be greater if agents face an exogenous retirement date after which their human capital falls to zero. The fact that rational investors with DARA utility will become less risk averse as they age - noted above - works against this effect, although which effect dominates probably depends on exact preferences and the size of income uncertainty facing individuals. Again, it is difficult

to know how well the predicted effect would match empirical evidence - the conditional proportion of stock in household portfolios tends to increase with age, but the proportion of households owning risky assets generally falls with age.

Cocco *et al.* (2001) extend this model by introducing borrowing constraints; their baseline parameters appear in Table 3. Note that their agents are relatively impatient to consume (their implicit discount factor is larger than the risk free rate), that risk aversion is extremely high, and that the equity risk premium has been set at 4% (in their model, this is given by $\mu - \overline{R}_F$), which is historically very low for the US. Their income variability numbers are lower than most other estimates from this data set. These parameter choices will have the effect of lowering the risky income effect, of delaying saving until fairly late in the life cycle, and of increasing the model's predicted bond investment.

Table 3 here

Two effects are important in this model. The first is the capitalization of income, risky or not, which causes the proportion of risky assets to decline as individuals age, similar to the effect shown in Figure 4. The second effect is the change in the present value of risky income over life – the authors claim that this increases at younger ages and then falls at older ages. These effects together produce the optimal investment in equities over the life cycle shown in Figure 5. Note that in their model there are no pure horizon effects as they assume that agents have CRRA utility.

Figure 5 here

Despite their assumptions of a low equity risk premium and high risk aversion, agents hold more than 60% of their wealth in stocks over most of the life cycle. Their model also fails to predict the observed asset mix over the wealth distribution, with all agents holding the same

portfolio allocation regardless of wealth. In addition, in this model, all agents hold equity over the whole life cycle, again contrary to observed portfolios.

Cocco *et al*. (2001) do find that a lower proportion of equities could be explained by their model if there is a significant positive correlation between income shocks and equity returns. Most studies have not found much evidence of this correlation, however. Davis and Willen (2002) find positive correlations between occupation-level income shocks and stock returns for some occupations and industries, and note that small businessmen and individuals with a great deal of company stock may have income that is highly positively correlated with risky asset returns, called 'proprietary risk'.[15] Significant proprietary risk will drive down the proportion of the portfolio held in risky assets over much of the lifecycle, although it is not clear how many people actually have significant amounts of this risk.[16]

An unusual property of this model is that the portfolio proportion invested in equities is dependent on the size of the individual's financial wealth and the proportion that this makes up of his total wealth. The more he has in financial wealth, as a proportion of the total wealth, the lower the investment in equities will be – regardless of the age of the individual. This can cause some unusual effects, such as the equity proportion of retired individuals rising the older they get – because pensions are a decreasing fraction of their total wealth. This contrasts with much of the evidence we have offered above. An obvious way to extent the model would be to account for limited participation in the stock market. One way of doing this might be to model costs of

[15] This issue is also examined by, amongst others, Heaton and Lucas (2000) and Polkovnichenko (1998), and was first mentioned by Bodie, Merton and Samuelson (1992).

[16] Davis and Willen (2002) examine a life-cycle model that permits borrowing but in which there is a wedge between the cost of borrowing and the return on lending. They find that there is a significant reduction in equity holdings over the lifecycle as the cost of borrowing increases, and that if the cost of borrowing is higher than the return on equities, little or no equities are held during much of the lifecycle. However, this is because agents build up little or no wealth over these periods: most liquid wealth in their model is still held in equities, a direct contradiction of empirical findings.

participation in the stock market, which will have the effect of constraining poorer people more than rich people. But it turns out that unrealistically high costs must be assumed for this to be effective: agents invest in stocks precisely because the equity risk premium is so high.[17] Typically, models of this kind will have all households investing in the equity market by age 40, if the costs of equity market participation are remotely reasonable.

How Preferences Affect Portfolio Allocations

Several authors have also sought to enrich the model by moving away from the simple CRRA formulation described above. One approach allows the parameters driving inter-temporal smoothing of consumption to differ from those influencing risk aversion in one time period. Risk aversion is the desire of individuals for consumption to be similar in different states of the world. The inter-temporal elasticity of substitution refers to people's desire to smooth consumption across different time periods.

CRRA-type preferences constrain these two parameters to be multiplicative inverses, but Epstein and Zin (1989) introduced a preference function which allows them to be specified independently.[18] Gomes and Michaelides (2002b) adopt this formulation and assume a finite-horizon model that is an extension of the model of Cocco *et al.* (2001) depicted in Figure 5. Agents in this model must pay fixed costs before they can invest in the stock market, as discussed above, they can invest in long-term bonds (interest rates are variable) as well as in cash and equities (see Table 4). By modeling preference heterogeneity, they can replicate several

[17] Authors who have followed this route include Gomes & Michaelides (2002a, 2002b), Heaton & Lucas (1996), Saito (1995) and Basak and Cuoco (1998). Saito (1995) reports that the equity market participation costs required to result in some agents holding only bonds range from 3% to 54% of average wealth, depending on the assumed risk aversion and the size of the equity premium.

[18] Many authors have used Epstein-Zin preferences (see Table 4) in the infinite horizon context. See, for example, Campbell, Chan and Viceira (2003) and Campbell and Viceira (1999, 2001).

stylized facts about household portfolios. Risk-tolerant households do not accumulate assets in their model, and therefore they do not invest in equities. More risk-averse households accumulate assets and therefore are able to pay the fixed costs of equity investment. Once they do so, their conditional equity participation is fairly low because of their high risk aversion. The Epstein-Zin preference structure is crucial for this result because high risk aversion is not necessarily associated with an acceptance of highly variable consumption paths. These authors argue that, by assuming a heterogeneous population, they are able to generate conditional equity shares and participation rates that look reasonable in comparison with the empirical evidence cited earlier. This can be seen by examining the key results from their paper shown in Table 4: both equity market participation (shown in the first column) and average stock holding for stock market participants (shown in the second column) compare reasonably with observed household portfolios.

Table 4 here

Another way in which the classical preference structure has been changed is by introducing habit formation. Habit formation preferences take into account the difference between the current level of consumption and the level of consumption that agents are accustomed to. Most authors have found that habit formation has worsened the fit of these models to empirical portfolios. For instance, Gomes and Michaelides (2002a) report that because habit formation models attach greater weight to ensuring smooth consumption over time, agents accumulate more wealth earlier to protect themselves against fluctuations in income. This implies that agents are able to pay the fixed cost of equity market participation earlier than for

time-additive preferences, and so invest in stocks much earlier. In addition, once the agents participate in the stock market, they invest virtually all their funds in stocks.[19]

The Role of Housing Wealth in the Household Portfolio

None of the models discussed so far has successfully replicated the entire household portfolio, because none includes housing as an asset. Yet as illustrated above, for most households, housing is an extremely important asset. One *ad-hoc* method of including housing in a model of portfolio demand would be to include it as the risky asset, by recalibrating existing models (but that would require excluding equities), a point made by Bodie *et al.* (1992). Yet housing has some special characteristics as an investment that equity investment does not have. It is one of the few investments that people are permitted to borrow to invest in; there are significant transactions costs involved in buying and selling a house; the investment is relatively undiversified; and housing is simultaneously both a consumption and an investment good. There is also a parallel market for housing: households can choose to rent or to buy, and an accurate model should reflect this option.

In an important paper, Cocco (2000) examines the asset allocation decision in the presence of housing. His agents face risky income, are finite-lived, can invest in cash and stocks (which have a constant equity premium) and can borrow to finance the purchase of the house. They pay a higher rate than the risk-free rate on the mortgage. House prices are risky, houses depreciate over time, and buying and selling houses involve significant transactions costs. He assumes a fixed cost of participating in the equity market. His agents derive utility from both

[19] Other authors such as Heaton and Lucas (1997) and Polkovnichenko (2003) find similar results. Heaton and Lucas (1997) report that the portfolio strategy is very dependent on the habit stock, while Polkovnichenko (2003) shows that agents with habit formation preferences accumulate too many assets.

housing and non-durable consumption, but there is no rental market and they are forced to invest in housing from the first period.

Table 5 here

Using the parameters shown in Table 5, Cocco finds that houses crowd out the equity share of investors, especially younger investors, whose housing wealth is close to their total financial wealth. The presence of housing also implies that the size of the transaction cost to enter the equity market that is required to generate realistic equity market participation is much lower than it would be without housing. Over time, the proportion of portfolios invested in housing declines as agents accumulate other wealth. Despite the absence of a rental market in property, the model makes reasonably realistic predictions about asset portfolios. The model's predictions are shown in Table 5. Younger agents borrow money and invest almost everything in housing. As they age, they pay off their mortgages and begin to invest in the equity market. By the time they retire, most household have some equity market participation, but most of the portfolio is still invested in housing. By allowing for some preference heterogeneity, this model can generate very realistic patterns of asset accumulation indeed.

Table 6 here

A very recent paper by Yao and Zhang (2003) extends Cocco (2000) by modeling both the rental market and the home purchase market. Baseline parameters of their model, which is quite complicated, are shown in Table 6. Their results are strikingly different to those of Cocco (2000). This may be because their model includes a rental market for property, or it might arise because no fixed cost of equity participation is modeled. In particular, they do not find that

housing crowds out stock holdings - in fact, in their model, homeowners have a greater proportion of their liquid assets invested in stocks than do renters.[20]

That paper does conclude that important determinants of whether to buy or rent are the wealth-income ratio of the household, and the age of the household. The wealth-income ratio is important because wealthier households are less liquidity constrained and therefore more able to make the down payment required in order to purchase a house, while age is important because younger households expect their incomes to increase in the future and therefore wish to delay house purchase until they can afford a bigger house that they will live in for longer. This is because the costs of moving house are assumed to be high. These effects are illustrated in Figure 6, which shows the value of the ratio of wealth to income at which households are indifferent between buying and renting as a function of age for households who do not own houses. As expected, richer households (relative to wages) buy and poorer households (relative to wages) rent. For pre-retirement households, the cut-off ratio decreases with age, reflecting the importance of anticipated wage increases and the costs of moving house, while after retirement, the bequest motive begins to be important and households need to be richer in order to purchase houses to justify the liquidation cost which is assumed to occur on death before any bequests.

Figure 6 here

Other papers that examine housing are Grossman and Laroque (1990), Campbell and Cocco (2003), and Hu (2003).[21] Of course the studies differ in their exact specifications: some include endogenous and exogenous moving probabilities and allow a rental market for housing.

[20] This paper is still under review. For this reason, details of the model's predicted portfolios will not be discussed in detail, particularly as Hu (2003) concurs with Cocco (2000) on the effect of housing on stock holding.

[21] Campbell and Cocco (2003) use their model to examine the choice between fixed and adjustable rate mortgages. Hu (2003) extends Cocco (2000) by including a rental market for housing. Unfortunately, the paper is currently under revision and includes no tables of results. Hu (2003) concurs with Cocco (2000) on the effect of housing on stock holdings.

The overall conclusions of the housing literature - with the exception of Yao and Zhang (2003) - are that housing crowds out risky asset holdings. In particular, this is true for younger agents who are still saving up to buy houses and for lower-wealth households, but it is also true of agents who own their houses and who are paying off mortgages. The insight behind this result is that these agents wish to protect themselves against default on the mortgage in bad income states. The conclusions of these models are sensitive to the transaction costs and moving probabilities assumed. Higher transaction costs generally imply that agents are reluctant to buy and to trade houses, while higher exogenous moving probabilities tend to decrease the tendency of agents to purchase rather than to rent.

Flavin and Yamashita (2002) examine the portfolio decision of households conditional upon their housing decision using data from the Panel Study of Income Dynamics. They use a one-period mean-variance-type analysis. They find that housing crowds out "younger" households into bonds because it forces them to adopt a highly leveraged and highly risky position. Only older household are free to invest in stocks, but the risk involved in owning a house also forces these households to invest less in stocks.

The effect of the inclusion of housing into models of portfolio choice on the accuracy of model predictions is striking evidence of the importance of housing in individual portfolios. The presence of housing, in most models, reduces the equity market participation of households to levels that are closer to those observed empirically. The age pattern of predicted equity market portfolios is also made more realistic by the inclusion of housing. However, these models have only been calibrated to the United States. It would be interesting to assess the predictions of these models in other economies such as Japan and continental Europe where home ownership patterns are strikingly different to those in the United States.

Other Influences on the Household Portfolio Decision

Other papers have examined the optimal holdings of long-term bonds in an environment where interest rates vary over time. These papers find that there is an intertemporal hedging demand which causes households to hold long-term bonds to hedge themselves against falls in the real rate of interest.[22]

There has also been accumulating evidence since the 1980's that a part of equity returns is predictable in the medium to longer term.[23] In general, optimal solutions to the consumption-investment problem will be affected by this predictability – investors will change their portfolios to take advantage of any predictable part of asset returns. These effects will be more important for investors with longer time horizons. Asset return predictability adds another 'layer' to the optimal portfolio decision for long-horizon investors. This branch of the literature concludes that investors with longer time horizons will tend to invest more in equities than those with shorter time horizons as a result of this effect, although the exact investment strategy will depend on the predicted equity and bond returns in the future.[24]

Finally, there is the impact of pensions and social security. Surprisingly, very few papers have examined the influence of these on household portfolios, despite their observed importance. McCarthy (2003) examines defined benefit pensions in a lifecycle context but does not explicitly examine the impact of these on the portfolio decision. It is likely that the presence of a riskless

[22] Papers include Brennan *et al*. (1997), Campbell and Viceira (2001), Campbell, Chen and Viceira (2003), Lynch and Balduzzi (1997), and Brennan and Xia (2002). Gomes and Michaelides (2002b), which also allows investment in long-term bonds, is discussed earlier.
[23] See, for example, Campbell and Shiller (1988), and Fama and French (1989), who show that the dividend price ratio predicts excess returns on the market. Poterba and Summers (1988) present evidence that the variance of stock returns is reduced at long-term horizons – implying that investment opportunities vary with time.
[24] See, for example, Brennan *et al*. (1997), Balduzzi and Lynch (1999), and Barberis (2000).

social security pension would drive households to invest more in risky assets, but very few papers have explicitly studies this effect.

Conclusions

This review has examined the development of the theory and empirical evidence about portfolio allocation over the lifecycle. Theoretical models emphasize the importance of the preferences of the agent, the presence of labor income and background risk, borrowing constraints, and housing on the optimal portfolios of households. Most models have assumed a particular form for investor preferences, CRRA utility, which implies that agents do not become more or less risk averse as their time horizons lengthen, and that household portfolios should be independent of the level of household wealth. CRRA utility also embodies a specific and undesirable structure of preferences for inter-temporal substitution; by contrast, newer research is using Epstein-Zin preferences, which relax this last restriction. Combined with a moderate degree of preference heterogeneity, these newer models have been relatively more successful at modeling household asset portfolios without housing.

Many of the early models predicted that the presence of labor income would exert a significant influence on household portfolios. Agents would be predicted to capitalize most of their income at close to the risk-free rate, and simply treat it as an addition to their current holdings in the risk-free asset. This would be predicted to boost the proportion of financial portfolios invested in the risky asset at younger ages, and cause these risky asset holdings to decline rapidly as agents age. The extent of this effect depends on the correlation between income shocks and the risky asset. If they are positively correlated, then the effect will be less pronounced than if they are uncorrelated. In fact, the opposite of this effect is generally observed

in developed countries: that is, portfolio riskiness increases with age at most ages, and it is a surprising finding, especially given the extremely high income shocks and low correlation between income shocks and stock returns that US empirical studies have revealed. The absence of a strong income effect is usually ascribed to borrowing constraints, to high fixed costs of equity market participation, and to the effect of housing on asset portfolios.

Introducing housing into theoretical models reduces predicted risky asset holdings dramatically, bringing these closer to what is empirically observed. It also causes predicted equity investment to increase with age, as financial wealth increases - consistent with what is observed in practice. Allowing agents to invest in housing also lowers the transactions costs that need to be assumed to keep equity market participation at reasonable levels. Housing has these effects because it is a risky asset and therefore crowds out holdings in equity. It also lowers equity investment for individuals who do not yet own houses - because these individuals are saving to make a down payment on a house and therefore have very short time horizons. Virtually all households are predicted to buy houses in most models that permit housing investment. Individuals can borrow to invest in housing (unlike the case of equity), and people derive both consumption and investment value from housing - both factors which have been modeled and which make housing preferable to equity as a first investment choice for most people. Epstein-Zin preferences have not yet been used to model household portfolios once housing has been included.

There are many important factors that have been omitted from models of portfolio choice up to this point. These include the expectation of bequests that are often received by younger households, the effect of changes in health status, and the effect of changing preferences towards work in later years. None of the models considered here contains more than a rudimentary

description of state benefits such as old-age pensions, healthcare and long term care benefits, and means-tested social assistance, which are ubiquitous in much of the developed world. Similarly, taxation has also been ignored in much of this literature. Taken together, these additional factors no doubt exert a large influence on investment, consumption and saving choices, yet they have found their way into few of the main models of portfolio choice presented here.[25]

One further issue is the nascent literature on the effects of psychological biases on economic behavior. This literature has already raised significant challenges to the traditional preference-based economic models presented here. We expect that this will influence the way economists choose to model the portfolio decision, although the precise way that this will happen is not yet clear.[26]

In sum, it is perhaps not surprising that no single model has successfully modeled the vast array of different observed household portfolios and how these change with age and wealth, let alone how they differ by country. This review demonstrates that the literature to date has exposed some of the key themes in household portfolio allocation. We further conclude that many key issues still need to be worked out before it can be said that economists have a full understanding of household portfolio allocation patterns as they vary by age and wealth. Surely including housing, public pensions, and private pensions are an essential next step in the analysis.

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[25] See Hubbard, Skinner and Zeldes (1995) for a study on the effect of means-tested benefits on predicted asset accumulation in the United States.

[26] See Mitchell and Utkus(2004, forthcoming) and Barberis *et al* (2001) for discussions of how prospect theory and other insights from psychology may influence saving and asset allocation outcomes.

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Appendix: Further Detail on Household Portfolios in Selected OECD Countries

This appendix describes and compares household portfolios in 6 OECD countries: the United States, the United Kingdom, Italy, Germany, the Netherlands, and Japan. We have constructed the findings from a number of sources, including Banks *et al* (2002); Guiso *et al* (2002); and Iwaisako (2003). We find it noteworthy that most previous analyses focus mainly on the stock-bond decision, and other assets – such as residential housing, pension benefits, and social security payments – have received a much lower priority (if they are addressed at all).

One interesting result is that people appear to make the decision to invest in a particular asset *separately* from the decision about how much to invest in that asset. This suggests that there are significant costs to investing in most asset classes. Further, the analysis shows that the factors underlying each of the two decisions appear to be different. There are significant cohort effects in virtually all the countries examined. This affects both the participation decision and the investment decision. Overall, in most countries, there has been a shift towards holding risky assets: more households do so than they did 20 years ago, and they hold more of them than they used to. Households are also growing wealthier, in most of the countries considered here. There is also a significant correlation between the age of a household and its wealth - in most countries, older households are also wealthier than younger households, except after retirement. This is the result of cohort effects and the fact that household generally accumulate assets until they retire.

Unconditional Portfolio Structure

Table A1 illustrates average US and UK portfolios in 1994 and 1995. Here we see that households in the UK hold much more of their portfolios in residential housing than households in the US. This is likely to hold for the conditional proportion of portfolios invested in housing.

Table A1 here

Table A2 shows average household portfolios by broad asset classes in the Netherlands, the US, and Italy. The proportion in housing is shown net of mortgage debt and all consumer debt has been netted off safe financial asset holdings. Safe financial assets include bank accounts, currency, employer savings plans, short-term bonds, CD's and cash life insurance. Risky financial assets include stocks, bonds, retirement accounts and mutual funds. Other non-financial assets include investment real estate, business equity and durable assets (such as motor vehicles).

Table A2 here

Households in the US hold far less of their wealth in their home than do households in either the Netherlands or Italy, and far more in risky financial assets (mainly stocks and mutual funds). In addition, households in the US hold more non-financial assets such as business equity and investment property than households in the Netherlands, but about the same quantity of these assets as households in Italy. Italians hold fewer financial assets than households in the US or the Netherlands. Comparison with Table A1 shows that households in the UK hold more assets in their own home than Italians, and around the same quantity of financial assets as households in the Netherlands.

Table A3 shows household portfolios in the US, the Netherlands and Italy, for households separated by wealth quartile, and separately of the top 5% of households. In every country in Table A3, non-financial assets make up more than half of the total portfolio of households at every wealth level. The United States and the Netherlands have much higher risky

financial asset shares than Italy. In none of these three countries are portfolios of the wealthy merely scaled up versions of the portfolios of the poor.
Table A3 here

Participation Decisions

Table A4 shows the proportion of households at each age that hold stocks directly or indirectly in each of the countries considered. There are significant differences between countries. In the United States, for example, 61% of 50-59 year old households hold some stocks indirectly or directly, while in Germany there is no age group at which more than 22% of households do so. In every country, however, there is a hump-shaped pattern of ownership by age. Fewer very young and very old households tend to hold equity than middle-aged households.
Table A4 here

Table A5 shows the proportion of households of each wealth quartile that hold stocks either directly or indirectly. Due to the strong correlation between age and wealth, households in the fourth column of Table A5 will be much older on average than households in the first column, which will have its own effect on the portfolio the household chooses to adopt. Table A5 shows that richer households do not hold scaled-up versions of poorer households' portfolios, in any country. Table A5 also shows that in most countries, most equity wealth is held by the richest households. Most of the difference in stockholdings between countries can be explained by the difference between richer households in those countries. Poorer households tend to be much more similar across countries in their propensity to hold stocks.
Table A5 here

A similar analysis of the role of housing in portfolios is difficult to find for any countries other than the US, UK and Japan. Table A6 reports the proportion of households in those countries who own their homes by age.
Table A6 here

Home ownership is higher in the United Kingdom at younger ages than in the United States and Japan, although at older ages more households in the US own their home than in the UK or Japan. The proportion of households owning their home increases at most ages in all three countries. At older ages the proportion of households owning their homes starts to decline, although this may be the result of cohort effects, particularly in the United Kingdom. Table A7 shows the proportion of households in each country who own certain major asset classes. This gives only a very broad picture of what portfolios look like as results are not disaggregated by age or wealth. Also, definitions differ slightly from country to country and different assets have different prominence in different countries - possibly because of different regulation or different preferences.
Table A7 here

Home ownership is high in every country - especially in the US, Italy, and the UK. It is somewhat lower in Germany and the Netherlands and lowest in Japan. Life insurance is surprisingly popular in most countries, especially in Germany. Retirement accounts are popular in the UK, the US and the Netherlands, but not held elsewhere in significant amounts.

Investment Decisions

Table A8 shows the proportion of financial assets invested directly and indirectly in stocks, conditional on owning some stocks. It can be seen that the asset share invested in risky assets is constant or increasing with age in most countries.

Table A8 here

This is a surprising result, given that there are many theoretical reasons, discussed in the main body of this report, which would lead one to expect a strong age-portfolio effect. This may be partly the result of the distortion caused by the correlation between age and wealth discussed above. Even more surprisingly, Table A9 shows that the conditional portfolio proportion held in stocks does not differ significantly by wealth in most countries, although it should be noted that the sample sizes in the first and second quartiles are small in most countries.

Table A9 here

Information on financial portfolios in the UK is surprisingly sparse. This gap is partially corrected by Table A1, which shows the average unconditional household portfolio composition in the US and the UK in 1995.

Conclusions

Household ownership patterns for assets differ markedly by country and by wealth level. In most countries, the portfolios of the rich are very different from those of the poor, and in most countries, the rich own most of the risky assets in the economy. Home ownership differs dramatically by country and by age. Surprisingly, the proportion of assets that is invested in risky assets, conditional on owning some risky assets, does not seem to vary very much by age or by wealth level, although it does differ by country. The proportion of households that own some risky assets exhibits a hump-shaped pattern by age in most countries. Data on asset holdings varies in quality between countries. One missing piece of data is a description of household portfolios controlling for both age and wealth, essential for fuller understanding inasmuch as the two are so likely to be correlated in most countries.

Table 1: Assets and Risk Classes

Risk Class	Assets
Safe	Cash
	Liquid accounts (checking, saving, money market accounts)
	Certificates of deposit (time accounts)
Fairly safe	State old-age pensions
	Life insurance
	Annuities
Risky	Residential housing
	Mutual funds (except money market accounts)
	Stocks (domestic and foreign, directly held and indirectly held)
	Long-term government bonds
	Long-term corporate bonds
	Investment real estate
	Business Equity

Source: Author's analysis.
Note: Any division into risk classes is arbitrary to a certain extent, as the riskiness of different assets may vary along many axes - including regulation, economic circumstances, and the country, bank or other financial institution issuing the asset.

Table 2: Merton-Samuelson Asset Allocation for 6 OECD Countries

	Germany	Italy	Japan	Netherl.	UK	US
Period	1/1950-12/1996	12/1928-12/1996	4/1949-12/1996	1/1921-12/1996	1/1921-12/1996	1/1921-12/1996
Real return	7.6%	3.2%	7.2%	2.8%	3.6%	5.5%
Volatility	2.4%	6.6%	3.6%	2.2%	2.5%	2.5%
Equity portfolio share ($\gamma = 3$)	104%	16%	67%	42%	49%	73%
Equity portfolio share ($\gamma = 5$)	62%	10%	40%	25%	29%	44%

Source: Author's calculations derived using parameter values from Jorion and Goetzmann (2000). Returns and volatilities measured in local currency in real terms.

Table 3: Baseline Parameters, Cocco *et al.* (2001)

Description	Parameter Value
Retirement Age (K)	65
Discount Factor (δ)	.96
Risk Aversion (γ)	10
Variance of Transitory Shocks (σ_ε^2)	0.0738
Variance of Permanent Shocks (σ_u^2)	0.0106
Correlation with Stock Returns (ρ)	0
Riskless rate ($R_F - 1$)	.02
Mean return on stocks ($\mu - 1$)	.06
Std. stock return (σ_R)	.157

Source: Cocco *et al.* (2001), Table 5.

Table 4: Participation and Stock Holdings Under Alternative Preference Formulations

Preference distribution	Proportion of participants holding stocks	Average stock holding for stock market participants
50% (ρ = 1.2 and ψ = 0.2) 50% (ρ = 5 and ψ = 0.2)	46.02%	40.32%
50% (ρ = 1.2 and ψ = 0.6) 50% (ρ = 5 and ψ = 0.2)	47.90%	40.21%
20% (ρ = 1 and ψ = 0.2) 20% (ρ = 1.5 and ψ = 0.2) 20% (ρ = 2 and ψ = 0.2) 20% (ρ = 3 and ψ = 0.2) 20% (ρ = 5 and ψ = 0.2)	54.56%	58.08%

Source: Gomes and Michaelides (2002b), Table 6. Parameter values are those from an Epstein-Zin formulation as follows:

$$V_t = \{(1-\beta p_t)C_t^{1-1/\psi} + \beta p_t (E_t[V_{t+1}^{1-\rho}])^{\frac{1-1/\psi}{1-\rho}}\}^{\frac{1}{1-1/\psi}},$$

where V_t is the discounted utility at time t, β is the discount factor, p_t is the survival probability, conditional on being alive at time 0, ρ is the coefficient of relative risk aversion and ψ is the elasticity of intertemporal substitution.

Table 5: Parameters of Cocco (2000)

Description	Parameter	Value
Risk Aversion	γ	5
Discount factor	β	.96
Preference for housing	θ	.10
Down payment	d	.15
Depreciation rate	δ	.01
Transaction Cost	λ	.08
Riskless rate	$\overline{R}_F - 1$	.02
Mortgage rate	$\overline{R}_D - 1$	.04
Mean stock return	$exp(\mu + \sigma_\eta^2/2) - 1$	.10
Std of log stock return	σ_η	.1674
Fixed cost	F	$1,000

Source: Cocco (2000), Table 2.

Table 6: Predicted Asset Portfolios by Age, Including Housing

	Age Band			
Asset	<35	35-50	50-65	>65
Stocks	0.000	0.008	0.091	0.066
Bills	0.004	0.002	0.002	0.010
Liquid Assets	0.004	0.010	0.093	0.076
Real Estate	0.127	0.150	0.207	0.675
Financial Assets	0.131	0.160	0.300	0.751
Human Capital	0.869	0.840	0.700	0.249
Total Assets	1.000	1.000	1.000	1.000
Debt	0.085	0.073	0.029	0.192
Stock Mkt Part.	0.008	0.153	0.692	0.766

Source: Adapted from Cocco (2000), Table 4

Table A1: Structure of US and UK household portfolios

	US (1994)	UK (1995)
Net Home Equity	34%	60%
Other Real Estate	18%	10%
Net Vehicle Wealth	8%	4%
Tangible Assets	*61%*	*75%*
Stocks and Mutual Funds	22%	10%
Liquid Assets	15%	13%
Other Financial Assets	7%	5%
Other Debts	5%	2%
Net Financial Assets	39%	25%
Total Wealth	1995 US $131600	1995 US $90800

Source: Banks *et al* (2002)

Table A2: Average household portfolios, broad asset classes

	US	Netherlands	Italy
Safe financial	7.4	14.0	5.1
Risky Financial	36.4	18.9	5.8
Home	20.5	49.3	50.9
Other non-financial	35.7	17.8	38.1
TOTAL	100.0	100.0	100.0

Source: Author's calculations, based on Guiso *et al* (2002)

Table A3: Household portfolio structure by wealth decile

US	0-25	25-50	50-75	75-100	95-100
Safe financial	-45.6	-0.8	10.4	8.2	5.2
Risky financial	26.3	20.6	24.1	38.7	40.0
Own property	25.1	49.8	44.1	15.8	6.8
Other non-financial	94.2	30.4	21.4	37.3	47.9
TOTAL	100.0	100.0	100.0	100.0	100.0
Netherlands	0-25	25-50	50-75	75-100	95-100
Safe financial	184.1	37.9	17.4	5.6	8.1
Risky financial	-12.2	14.5	8.4	11.8	36.9
Own property	18.7	13.3	60.2	19.7	26.1
Other non-financial	-90.5	34.3	14.1	62.9	28.9
TOTAL	100.0	100.0	100.0	100.0	100.0
Italy	0-25	25-50	50-75	75-100	95-100
Safe financial	24.7	12.0	6.1	6.1	4.4
Risky financial	2.3	2.2	1.9	3.2	5.5
Own property	12.6	55.5	63.1	53.4	35.5
Other non-financial	60.3	30.3	28.9	37.3	54.6
TOTAL	100.0	100.0	100.0	100.0	100.0

Source: Author's calculations, based on Guiso *et al* (2002)

Table A4: Households holding stock in OECD countries, by age

Proportion of households with:	Under 30	30-39	40-49	50-59	60-69	70 and over
Direct and Indirect Stockholding						
United States	34	52	58	61	47	32
United Kingdom	20	32	37	41	35	22
Netherlands	12	26	34	40	39	36
Germany	19	22	22	21	17	12
Italy	12	28	24	23	16	8
Japan	9	16	25	36	35	n.a.

Source: Guiso *et al*. (2002), Iwaisako (2003)

Table A5: Households holding stock in OECD countries, by wealth quartile

Proportion of households with:	Quartile I	Quartile II	Quartile III	Quartile IV
Direct and Indirect Stockholding				
United States	4	38	66	87
United Kingdom	5	12	38	71
Netherlands	4	17	37	76
Germany	7	18	22	29
Italy	3	11	20	39
Japan	n.a.	n.a.	n.a.	n.a.

Source: Guiso *et al* (2002), Iwaisako (2003)

Table A6: Household owning own home in OECD countries, by age

Proportion of households with:	Under 30	30-39	40-49	50-59	60-69	70 and over
Own home						
United States	28	53	70	81	87	77
United Kingdom	42	67	76	78	72	62
Japan	8	34	56	63	62	n.a.

Source: Iwaisako (2003) and Banks *et al* (2002)

Table A7: Assets held by households, OECD countries

	US 1998	UK 1996	Italy 1998	Germany (W) 1993	Netherlands 1998	Japan 1999
Financial Assets	93				95	
Liquid Accounts	91	78	83	99	93	
Govt Bonds		25	15	11	4	
Life Insurance		38	23	62	23	
Mutual Funds	17	12	11	12	22	5
Retirement Accounts	48	30	7		18	
Stocks	19	22	7	12	15	24
Primary Residence	66	60	66	47	51	39
Investment Real Estate	19		26		4	
Business Equity	12		12		5	
Mortgage	43	32		27	43	
Credit cards	44					
Other debt	49	14				

Source: Guiso *et al* (2002), Iwaisako (2003)

Table A8: Conditional share in stocks for OECD countries, by age

Conditional asset share in:	Under 30	30-39	40-49	50-59	60-69	70 and over
Direct and Indirect Stocks						
United States	52	53	61	61	61	58
Netherlands	30	38	43	55	62	59
Germany	21	19	17	19	26	33
Italy	48	53	52	56	53	59
Japan	33	31	31	32	27	n.a.

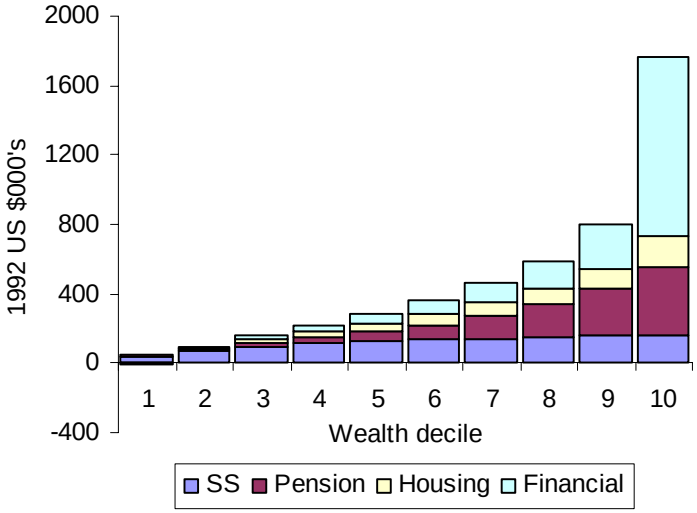
Source: Guiso *et al* (2002), Iwaisako (2003)

Table A9: Conditional share in stocks for OECD countries, by wealth quartile

Conditional proportion of portfolio in:	Quartile I	Quartile II	Quartile III	Quartile IV
Direct and Indirect Stockholding				
United States	41	45	49	60
Netherlands	40	33	37	55
Germany	27	22	21	22
Italy	54	51	50	50

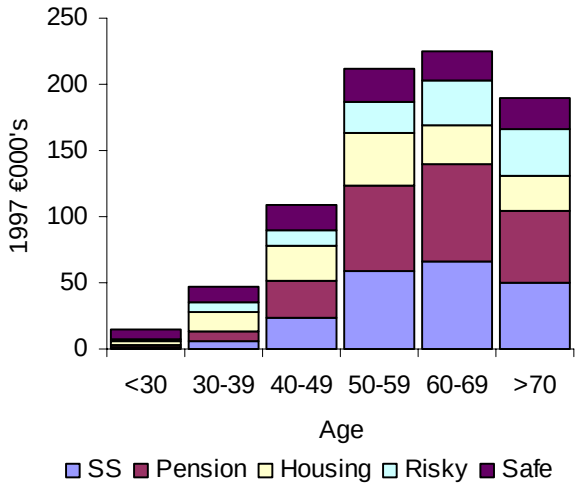
Source: Guiso *et al* (2002)

Figure 1: Portfolios of 56 year-olds in the US in 1992



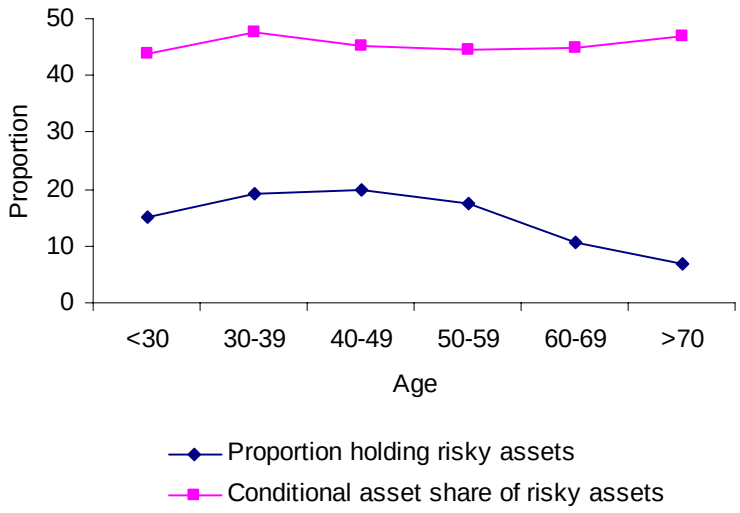
Source: Mitchell and Moore (1998)

Figure 2: Stylized Portfolios of Average Wealth Holders in the Netherlands



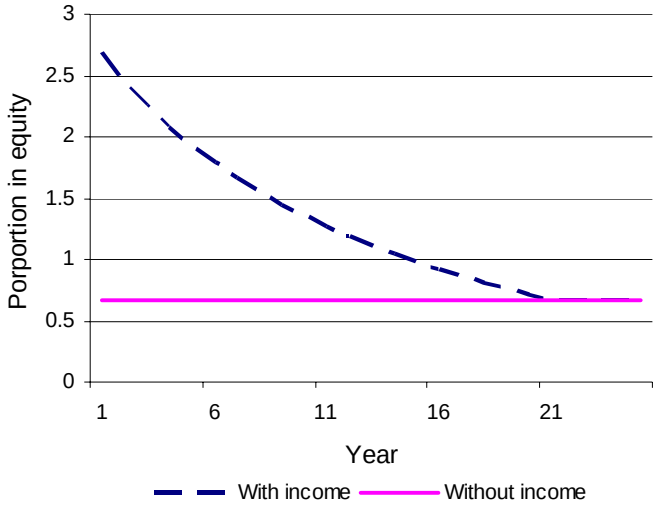
Source: Guiso *et al* (2002) and author's imputations.

Figure 3: Observed Proportion of Population Holding Risky Assets and Conditional Share of Assets in Risky Assets in Italy



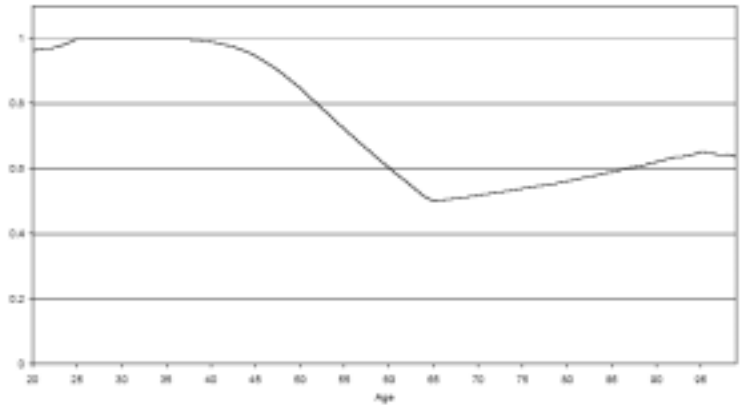
Source: Guiso *et al.* (2002)

Figure 4: Effect of Labor Income on Portfolio Allocation



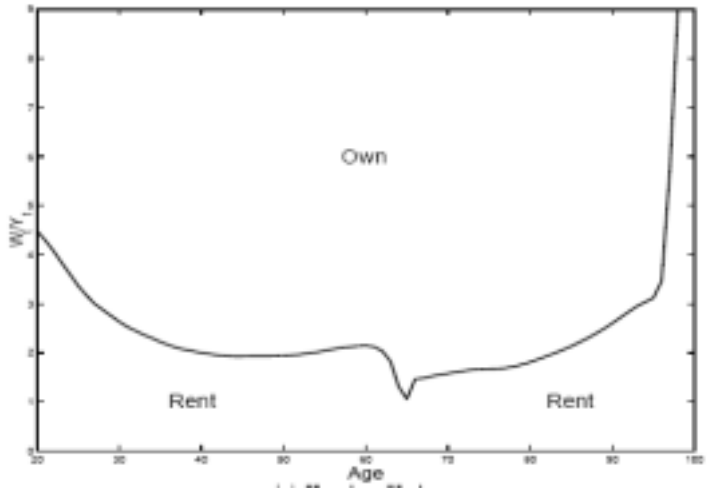
Source: Author's calculations. Individual faces equity returns and variances equal to Japanese values in Table 2, has risk aversion of 3, and receives an annual income of 1/5 of his initial financial portfolio for 20 years. Individuals discount factor is assumed to equal the real risk-free rate of interest.

Figure 5: Optimal Share in Risky Asset: Benchmark Case



Source: Cocco *et al.* (2001), Figure 3a.

Figure 6: How the Housing Rent-Own Threshold Varies With Age



Source: Hao and Zhang (2002), Figure 1(a)