Why Do Household Portfolio Shares Rise in Wealth?*

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Abstract

In the cross-section of households, the portfolio share rises in wealth and has a non-decreasing age profile. The standard life-cycle model with homothetic utility and non-tradable labor income has the counterfactual implication that the portfolio share falls in both wealth and age. We develop a life-cycle model in which households have nonhomothetic utility over two types of consumption goods, basic and luxury. The nonhomothetic model predicts that the basic expenditure share falls in total consumption. When calibrated to match the cross-sectional variation in the basic expenditure share, this model explains the empirical evidence on portfolio choice.

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1. Introduction

Surveys of household finances reveal a striking fact: the share of household wealth in stocks, or risky assets more generally, rises in wealth. While poorer households are less likely to participate in the stock market, this fact alone does not account for the positive relation between wealth and the share of wealth invested in stocks (hereafter, the *portfolio share*). The portfolio share rises in wealth even among stockholders. While more educated households tend to have higher portfolio shares, the portfolio share rises in wealth even among stockholders with the same education.

The standard life-cycle model in which households have homothetic (or power) utility and non-tradable labor income predicts that the portfolio share falls in wealth (Bodie, Merton, and Samuelson, 1992). This prediction follows from the fact that the present value of future labor income acts as a non-tradable "bond" in the household's total wealth, which is the sum of financial wealth and human capital. Therefore, for a given level of human capital, optimal portfolio choice requires that the household allocate its first dollar of financial wealth to stocks. Only at a higher level of financial wealth does the household choose to allocate part of its portfolio to bonds.

This paper examines the role that nonhomothetic utility plays in explaining the observed relation between wealth and portfolio choice. We develop a life-cycle model in which the household consumes two types of goods. The utility function has higher curvature over a "basic good" than over a "luxury good". We calibrate and solve the model with a labor income process that is standard in the life-cycle literature (Carroll and Samwick, 1997; Gourinchas and Parker, 2002). We then simulate an economy of ex ante identical households who are subject to idiosyncratic income shocks. The model has three main testable predictions for the cross-section of household consumption and portfolio choice.

The first prediction is that the expenditure share falls in total consumption for some goods and rises for others. In the nonhomothetic model, households with higher permanent income allocate a lower share of their total consumption to the basic good. Using household consumption data from the Consumer Expenditure Survey (CEX), we identify basic goods as those goods whose expenditure shares fall in total consumption. We find a significant relation between the basic expenditure share and total consumption, even within the cross-section of stockholders. We use the variation in the basic expenditure share to guide our calibration of preferences in the life-cycle model. Our empirical findings imply significant differences in the utility curvature between basic and luxury goods.

The second prediction is that the portfolio share rises in wealth. In the nonhomothetic model, households with higher permanent income are less risk averse, and consequently, allocate a higher share of their wealth to stocks. As in the standard model with homothetic utility, the nonhomothetic model also implies that the optimal portfolio share falls in wealth, holding constant the level of permanent income. However, such transitory variation in wealth is a less important determinant of portfolio choice than the cross-sectional variation in permanent income, leading to a positive relation between wealth and the portfolio share. We confirm this prediction with household portfolio data from the Survey of Consumer Finances (SCF).[1]

The third prediction is that the portfolio share has a non-decreasing age profile. In the standard model with homothetic utility, the portfolio share falls in age because younger households have greater incentive to diversify their large endowment of non-tradable human capital. Although this incentive also operates in the nonhomothetic model, it is offset by a rising life-cycle income profile, which causes risk aversion to fall in age. The nonhomothetic model therefore produces a relatively flat age profile in the portfolio share, which is more consistent with the empirical evidence.

We build on an active literature that studies the consumption and portfolio implications of life-cycle models with realistic labor income processes. One branch of this literature focuses on the life-cycle profile in wealth accumulation and portfolio choice (e.g., Bertaut

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[1] The fact that the portfolio share rises in wealth has been documented in various household surveys. Early empirical evidence can be found in the 1962 and 1963 Surveys of the Financial Characteristics of Consumers and Changes in Family Finances (Blume and Friend, 1975; Friend and Blume, 1975). Guiso, Haliassos, and Jappelli (2002, Table I.7) contains a summary of the international evidence for five countries.

and Haliassos, 1997; Heaton and Lucas, 1997; Gakidis, 1998; Viceira, 2001; Davis and Willen, 2002; Cocco, Gomes, and Maenhout, 2005). Another branch focuses on the potential role that fixed costs play in explaining non-participation in the stock market. In particular, Cocco (2005), Hu (2005), and Yao and Zhang (2005) find that housing crowds out stocks in the household's portfolio and can explain non-participation in the presence of fixed costs. Gomes and Michaelides (2005) find that low risk aversion, paired with a low elasticity of intertemporal substitution, leads to a low saving motive and can explain non-participation in the presence of fixed costs. Instead of non-participation, we focus on a puzzle that has received relatively little attention: the fact that the portfolio share rises in wealth conditional on participation.

Our work is also related to that of Carroll (2000, 2002), who proposes nonhomothetic utility in which wealth at the end of life is a luxury good. Carroll's model has the potential to explain the high savings rate and the portfolio behavior of the very wealthy (i.e., the top first percentile of the wealth distribution).[2] Nonhomothetic utility also plays an important role in the work of Aït-Sahalia, Parker, and Yogo (2004), who develop a representative household model with utility over two goods. They find that the consumption of luxury goods, constructed from data on the sales of luxury retailers, is consistent with the high historical equity premium. Unlike these previous studies, this paper calibrates and solves a life-cycle model to generate quantitatively testable implications for household consumption and portfolio choice. In addition, while these previous studies have focused on households at the very peak of the wealth distribution, our work aims to explain consumption and portfolio choice for the entire cross-section of stockholders.

The remainder of the paper proceeds as follows. Section 2 presents the empirical evidence on household consumption, and Section 3 presents the empirical evidence on household portfolio choice. Section 4 develops a life-cycle model with nonhomothetic utility and describes

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[2] In related work, Roussanov (2008) develops a model in which the household's preferences for social status is effectively a luxury good, which explains why wealthier households own portfolios with undiversified private equity.

the preference and income parameters used in the calibration. Section 5 solves the model and describes the policy functions for consumption and portfolio choice. Section 6 compares the consumption and portfolio behavior of simulated households to that of actual households in the survey data. Section 7 concludes. The appendices contain details on the survey data as well as numerical methods used in solving the life-cycle model.

2. Evidence on Household Consumption

2.1 Consumer Expenditure Survey

Data on consumption are from the repeated cross-section of U.S. households in the CEX for the period 1982–2003. We focus on the sub-sample of stockholders in all of our analysis. Appendix A contains details on our use of the data, including a description of the relevant categories of nondurable goods and services.

2.2 Basic versus luxury consumption

In this section, we perform standard consumer demand analysis to categorize various nondurable goods and services into basic and luxury goods (Working, 1943; Stone, 1954; Prais and Houthakker, 1955; Leser, 1963). We estimate a censored regression model to characterize the relation between the expenditure share and total consumption for stockholders. The outcome variable is the expenditure share for the various categories of nondurable goods and services. The latent variable depends on age group, log total (nondurable and service) consumption, log total consumption interacted with age group, marital status, household size, and interview-year dummies. The omitted category is households with four members, whose head is aged 46–55 and married. We use consumption, rather than wealth, as a regressor because consumption data are more complete and reliable than financial data in the CEX. However, we have verified that our main findings are robust to using wealth.

Table 1 reports our results for nondurable goods. For food at home, the coefficient on log consumption is -8.05, which shows that its expenditure share falls in total consumption for the 46–55 age group. The magnitude of the coefficient means that, for an average household in the 46–55 age group, a 100% rise in total consumption is associated with a 8.05 percentage point fall in the expenditure share. The coefficient on the interaction between log consumption and age group is 0.50 for the 36–45 age group, which implies a $-8.05 + 0.50 = -7.55$ percentage point change in the expenditure share for a 100% rise in total consumption. The coefficient on the interaction between log consumption and age group is 0.28 for the 56–65 age group. In other words, the negative relation between the expenditure share for food at home and total consumption is weaker for younger and older households, although these differences are not statistically significant.

In contrast to food at home, food away from home as a share of total consumption rises in total consumption within each age group. The fact that the expenditure share rises in total consumption is consistent with introspection, which suggests that dining out frequently is a luxury that mainly wealthier households can afford. Clothing and shoes as a share of total consumption rises in total consumption within each age group. Fuel oil and coal as a share of total consumption falls in total consumption for the 46–55 age group, but this relation does not hold for other age groups. Gasoline as a share of total consumption falls in total consumption within each age group. Other nondurable goods as a share of total consumption falls in total consumption within each age group.

Table 2 reports our results for services. Housing as a share of total consumption rises in total consumption within each age group. Household operation as a share of total consumption falls in total consumption within each age group. Transportation as a share of total consumption rises in total consumption within each age group. Personal care as a share of total consumption rises in total consumption for the 46–55 age group, but this relation does not hold for other age groups. Personal business (e.g., accounting, banking, and tax services) as a share of total consumption rises in total consumption within each age group. Recreation as a share of total consumption rises in total consumption within each age group.

Tables 1 and 2 map out the household Engel curves, that is, the variation in expenditure shares as a function of total consumption. Our working definition of luxury goods are those nondurable goods and services whose expenditure shares rise in total consumption for all age groups. Those goods and services that are rising in total consumption for some age groups, but not others, are characterized as basic goods. Based on these definitions, we construct basic and luxury consumption as the sum of the appropriate categories of expenditure as summarized in Table 3.

3. Evidence on Household Portfolio Choice

3.1 Survey of Consumer Finances

Data on wealth and portfolio choice are from the repeated cross-section of U.S. households in the SCF for the period 1989–2004. Like the CEX, the SCF is a nationally representative sample of households. We focus on the sub-sample of stockholders in all of our analysis. Appendix B contains details on our use of the data, including the definitions of net worth, financial assets, risky assets, and public equity.

3.2 Portfolio share by age and wealth

We estimate a censored regression model to characterize the relation between the portfolio share and wealth for stockholders. The outcome variable is the portfolio share, defined as the share of net worth invested in risky assets. The latent variable depends on age group, log net worth, log net worth interacted with age group, marital status, household size, and interview-year dummies. The omitted category is households with four members, whose head is aged 46–55 and married.

In our main specification reported in Table 4, the coefficient on log net worth is 3.56, which shows the portfolio share rises in net worth for the 46–55 age group. The magnitude of the coefficient means that, for an average household in the 46–55 age group, a 100% rise in net worth is associated with a 3.56 percentage point rise in the portfolio share. The coefficient on the interaction between log net worth and age group is −1.72 for the 36–45 age group, which implies a $3.56 - 1.72 = 1.84$ percentage point change in the expenditure share for a 100% rise in net worth. The coefficient on the interaction between log net worth and age group is 0.32 for the 56–65 age group. In other words, the positive relation between the portfolio share and net worth is weaker for younger households and stronger for older households.

As emphasized by Ameriks and Zeldes (2004), the fact that age, time, and cohort effects are not separately identified complicates the interpretation of household portfolio behavior. A standard practice in the literature is to interpret the age profile in household portfolios by assuming that there is no cohort effect (see Bertaut and Starr-McCluer, 2002; Campbell, 2006). In our main specification, we follow this practice and analyze the relation between wealth and the portfolio share, controlling for age and interview year. In a second specification reported in Table 4, however, we include cohort dummies instead of interview-year dummies to examine the robustness of our findings. The relation between the portfolio share and net worth is entirely robust to controlling for birth cohort.

Our primary measure of the portfolio share is the share of net worth invested in risky assets. A narrower measure of the portfolio share, sometimes used in the literature, is the share of financial wealth invested in public equity. We focus on the broader measure for a closer correspondence to the portfolio share that enters the intertemporal budget constraint of the life-cycle model. In a third specification reported in Table 4, however, we use the narrower measure of the portfolio share as our outcome variable to examine the robustness of our findings. We still find a statistically significant relation between the portfolio share and net worth. For an average household in the 46–55 age group, a 100% rise in net worth is associated with a 1.58% rise in the portfolio share.

3.3 Portfolio share by education

More educated households tend to be wealthier, and more educated investors tend to have a higher share of their wealth invested stocks (see Campbell, 2006). Therefore, the relation between net worth and the portfolio share may be explained, at least partly, by education. To address this issue, Table 5 repeats the analysis in Table 4 separately by education group. The four education groups are households whose head is not a high school graduate, whose head is a high school graduate, whose head has some college education, and whose head is a college graduate. Even after controlling for eduction, there is a strong positive relation between the portfolio share and net worth, comparable to that reported in Table 4.

4. A Life-Cycle Model of Consumption and Portfolio Choice

4.1 Nonhomothetic utility

Suppose the household consumes two types of nondurable goods, denoted by B and L (for reasons that will be clear in what follows). We assume that the household's intratemporal utility is given by the addilog (additive logarithmic) function,

$$V(B,L) = \left(B^{1-\lambda} + \frac{\alpha(1-\lambda)}{1-\phi} L^{1-\phi}\right)^{1/(1-\lambda)}, \tag{1}$$

where $\alpha > 0$ is the utility weight on L (Houthakker, 1960). The curvature parameters satisfy the restriction $\lambda \geq \phi > 1$. Although there are many goods and services in practice, the two-good addilog model is a tractable simplification that captures the key features of the data for our application. We embed the addilog function in the household's intertemporal utility as

$$U(B,L)=\frac{V(B,L)^{1-\gamma}}{1-\gamma}, \tag{2}$$

where $\gamma > 1$. This specification is a tractable parametric model that permits both nonhomotheticity and non-separability across goods. Since Houthakker (1960), this utility function has been applied in a number of settings to model the fact that as households grow wealthier, they spend relatively more on some goods than on others (e.g., Deaton and Muellbauer, 1980; Ogaki, 1992; Bils and Klenow, 1998; Aït-Sahalia, Parker, and Yogo, 2004; Pakoš, 2004).

The household's intratemporal allocations are determined entirely by the properties of intratemporal utility. Let Q denote the relative price of L in units of B. Optimal relative consumption of the two goods is determined by the first-order condition

$$\frac{V_L}{V_B}=\frac{\alpha L^{-\phi}}{B^{-\lambda}}=Q. \tag{3}$$

The elasticity of substitution between the two goods is

$$\frac{d\log(B/(QL))}{d\log Q}=\frac{1/B+1/(QL)}{\lambda/B+\phi/(QL)}. \tag{4}$$

Let $C = B + QL$ denote total consumption. The first-order condition (4) implies the expenditure shares

$$\frac{B}{C} = \frac{1}{1+\alpha^{1/\phi}Q^{1-1/\phi}B^{\lambda/\phi-1}}, \tag{5}$$

$$\frac{QL}{C} = \frac{1}{1+\alpha^{-1/\lambda}Q^{1/\lambda-1}L^{\phi/\lambda-1}}. \tag{6}$$

The level of expenditure for both B and L rises in total consumption. However, the expenditure share for B falls, and the expenditure share for L rises in total consumption. We therefore refer to B as the "basic good" and L as the "luxury good".

By substituting the expenditure shares (5) and (6) into utility function (2), we can express household utility as a function of total consumption and the relative price of the luxury good. We denote the so-called indirect utility function as

$$\begin{aligned} \widetilde{V}(C,Q) &= \max_{B+QL=C} V(B,L), & (7) \\ \widetilde{U}(C,Q) &= \frac{\widetilde{V}(C,Q)^{1-\gamma}}{1-\gamma}. & (8) \end{aligned}$$

4.1.1 Decreasing relative risk aversion

An important implication of nonhomothetic utility is decreasing relative risk aversion (Stiglitz, 1969). By Hanoch (1977, Theorem 1), we can calculate the household's relative risk aversion as

$$\begin{aligned} \text{RRA} &= -\frac{(BU_B + LU_L)(U_{BB}U_{LL} - U_{BL}^2)}{U_B^2 U_{LL} - 2U_B U_L U_{BL} + U_L^2 U_{BB}} \\ &= \left(\frac{1}{\lambda}\frac{B}{C} + \frac{1}{\phi}\frac{QL}{C}\right)^{-1} \left(B + \frac{1-\lambda}{1-\phi}QL\right)^{-1} \left(\frac{\gamma}{\lambda}B + \frac{\xi(1-\lambda)}{\phi(1-\phi)}QL\right), \qquad (9) \end{aligned}$$

where

$$\xi = \frac{\gamma(1-\phi) + \phi - \lambda}{1-\lambda} < \gamma. \qquad (10)$$

When the household is poor, it consumes mostly basic goods, and its relative risk aversion is close to γ. As the household becomes wealthier, it consumes more luxury goods, and its relative risk aversion falls toward ξ.

4.1.2 Homothetic utility as a special case

When $\lambda = \phi$, nonhomothetic utility (1) collapses to the homothetic utility function,

$$V(B,L) = \left(B^{1-\lambda} + \alpha L^{1-\lambda}\right)^{1/(1-\lambda)}. \qquad (11)$$

This specification is also referred to as constant elasticity of substitution utility because the elasticity of substitution between the two goods is constant at $1/\lambda$. The household's indirect utility is

$$\widetilde{V}(C,Q) = C(1+\alpha^{1/\lambda}Q^{1-1/\lambda})^{1/(1/\lambda-1)}. \tag{12}$$

This expression for the indirect utility function shows that the assumption of homotheticity leads to power utility over one composite consumption good, which is the benchmark model in the life-cycle literature. Homothetic utility implies constant relative risk aversion. We calibrate and solve the homothetic model to highlight the distinct implications of the nonhomothetic model.

4.2 Life-cycle problem

We solve a life-cycle consumption and portfolio-choice problem for a household with nonhomothetic utility (2). The household starts adult life with initial wealth W_1. The household enters each period $t = 1, \ldots, T$ with cash-on-hand W_t, which is composed of financial assets and labor income Y_t. The household's total consumption is $C_t = B_t + Q_t L_t$, which is optimally allocated between basic goods B_t and luxury goods L_t. Wealth remaining after consumption, $S_t = W_t - B_t - Q_t L_t$, is saved either in bonds or stocks. Bonds have a constant gross rate of return R_f, and stocks have a stochastic gross rate of return R_{et}. The household is subject to a borrowing constraint, so that $S_t \geq 0$. Following a standard assumption in the life-cycle literature, the household is subject to a short-sales constraint, so that the portfolio share must satisfy $a_t \in [0, 1]$.

The household dies with certainty in period $T + 1$, leaving behind wealth W_{T+1}. The household has bequest utility over terminal wealth, $b\widetilde{U}(W_{T+1}, Q_{T+1})$, where $b > 0$ determines the strength of the bequest motive. We specify the bequest utility to be of the same functional form as the household's indirect utility (8), so that the curvature of the utility function is continuous from period T to $T+1$. Therefore, we are able to distinguish our mechanism from that of Carroll (2002), in which wealth left as a bequest is a luxury good relative to consumption during lifetime.

Let $\beta \in (0,1)$ denote the household's subjective discount factor. The household's problem is to choose consumption and the portfolio share in each period to maximize the expected discounted sum of future utility flow,

$$\mathbf{E}_1 \sum_{t=1}^{T} \beta^{t-1} U(B_t, L_t) + \beta^T b \widetilde{U}(W_{T+1}, Q_{T+1}). \tag{13}$$

The household is subject to the intertemporal budget constraint,

$$\begin{aligned} W_{t+1} &= R_{t+1}(W_t - B_t - Q_t L_t) + Y_{t+1}, & (14)\\ R_{t+1} &= R_f + a_t(R_{e,t+1} - R_f), & (15) \end{aligned}$$

for $t = 1, \ldots, T$.

4.3 Calibration of the model

Following Carroll (1997), we calibrate the model to a 50-year life cycle. The household works and earns labor income from ages 26 through 65 (i.e., $t = 1, \ldots, 40$). The household is retired and earns retirement income from ages 66 through 76 (i.e., $t = 41, \ldots, 51$). At age 76, the household dies and leaves the remaining wealth as a bequest. Table 6 summarizes the parameters in the benchmark calibration, which we now discuss in more detail.

4.3.1 Preferences

For the nonhomothetic model, we calibrate the parameters in intratemporal utility (1) to match the basic expenditure share in the CEX. We set $\alpha = 2.2$ to match the median basic expenditure share for the median household in the 46–55 age group, which is 49%. We set

$\lambda = 2.0$ and $\phi = 1.1$, which determines the elasticity of substitution between the two goods (see equation (4)). These parameter values are chosen to match the variation in the basic expenditure share for the 46–55 age group, which is 59% for the lowest consumption quartile and 37% for the highest quartile.

We specify the relative price of the luxury good as

$$Q_t = Q_1 e^{qt}, \tag{16}$$

where $Q_1 = 1$ and $q = -8\%$. The basic expenditure share rises as the relative price of the luxury good falls because the income effect dominates the substitution effect (see equations (5) and (6)). This specification allows us to match the flat profile in the basic expenditure share over the life cycle, from 48% for the 26–35 age group to 53% for the 66–75 age group. Our model, in which α is constant and Q varies over the life cycle, is isomorphic to one in which Q is constant and α varies over the life cycle. In other words, life-cycle variation in α and Q are not separately identified. Consequently, we treat q as a preference parameter for the purposes of calibration.

We set the subjective discount factor to $\beta = 0.96$, which is a standard choice in the life-cycle literature. As shown in equation (9), the relative risk aversion depends on γ, together with the other preference parameters. We choose the level of risk aversion to match the level of stockholding in the SCF. Specifically, given the choices for the other preference parameters described above, $\gamma = 38$ matches the portfolio share for the median household in the 46–55 age group, which is 30%. Finally, we calibrate the strength of the bequest motive to match the wealth-income ratio for the median household in the 66–75 age group, which is 8.7.

For the homothetic model, we also set the discount factor to $\beta = 0.96$. We choose the level of risk aversion, given by γ in this model, to match the level of stockholding in the SCF. Specifically, we set $\gamma = 7$ to match the portfolio share for the median household in the 46–55 age group. Finally, we calibrate the strength of the bequest motive to match the wealth-income ratio for the median household in the 66–75 age group. For simplicity, we assume that the relative price of the luxury good is constant over the life cycle for the homothetic model. Even if the relative price were to vary, homotheticity necessarily implies a basic expenditure share that is constant in wealth.

4.3.2 Labor income

Following Carroll (1997) and Zeldes (1989), we model the household's stochastic labor income as

$$
\begin{aligned}
Y_t &= P_t \epsilon_t, && (17)\\
P_{t+1} &= G_{t+1} P_t \eta_{t+1}, && (18)
\end{aligned}
$$

given an initial level P_1. The variable P_t denotes "permanent income" in period t, defined as the labor income that would be earned in the absence of transitory shocks (i.e., $\epsilon_t = 1$).

Permanent income has a deterministic component that grows at the rate G_t in each period. In order to calibrate the deterministic component, we follow Gourinchas and Parker (2002) and estimate average life-cycle income using CEX data on disposable income. We regress log disposable income on a third degree polynomial in age, which is interacted with a dummy variable for whether or not the household is retired. The regression also includes dummy variables for marital status, household size, and birth cohort. We use the estimated coefficients to build the life-cycle income profile for a "typical" household that works from ages 26 through 65 and is retired from ages 66 through 75. (At retirement, labor income is estimated to fall by 25% relative to the previous period.) We calibrate the growth rate to that of a household with four members, whose head is born in the 1945–1949 cohort and married. Further details are available from the authors upon request.

During the household's working life (through age 65), permanent income is subject to an i.i.d. shock

$$\log \eta_t \sim \mathbf{N}\left(-\frac{\sigma_\eta^2}{2}, \sigma_\eta^2\right), \tag{19}$$

where $\mathbf{N}$ denotes the normal distribution. The permanent shock has mean $\mathbf{E}[\eta_t] = 1$. Labor income is also subject to an i.i.d. transitory shock

$$\epsilon_t = \begin{cases} 0 & \text{with probability } p \\ \widetilde{\epsilon}_t & \text{with probability } 1-p \end{cases}, \tag{20}$$

$$\log \widetilde{\epsilon}_t \sim \mathbf{N}(\mu_\epsilon, \sigma_\epsilon^2). \tag{21}$$

Unemployment occurs with probability p. The parameter μ_ϵ is chosen so that the transitory shock has mean $\mathbf{E}[\epsilon_t] = 1$. In our benchmark case, we set the probability of unemployment to zero so that $\mu_\epsilon = -\sigma_\epsilon^2/2$ (as in the benchmark calibrations of Cocco, Gomes, and Maenhout (2005) and Gomes and Michaelides (2005)). We calibrate the variance of the income shocks to $\sigma_\eta^2 = 2.12\%$ and $\sigma_\epsilon^2 = 4.40\%$, which are standard parameters in the life-cycle consumption literature (Carroll and Samwick, 1997; Gourinchas and Parker, 2002).

During retirement, we assume that labor income is subject to the same transitory shocks as during working life, but is not subject to the permanent shocks. The transitory shocks are meant to capture idiosyncratic risk in retirement, such as medical expenditures (Hubbard, Skinner, and Zeldes, 1995). In practice, the transitory shocks make little difference to the results except to make the level of wealth accumulation in retirement higher, which is more consistent with that observed in the SCF.

4.3.3 Asset returns

We calibrate asset returns using a standard specification in the life-cycle portfolio-choice literature (Gomes and Michaelides, 2005). We set the bond return to 2% per year and the equity premium to 4% per year. Stock returns are distributed as

$$R_{et} = \overline{R}_e \nu_t, \tag{22}$$

$$\log \nu_t \sim \mathbf{N}\left(-\frac{\sigma_\nu^2}{2}, \sigma_\nu^2\right). \tag{23}$$

The shock to stock returns has mean $\mathbf{E}[\nu_t] = 1$ and standard deviation $\sigma_\nu = 18\%$. We set the correlation between the shocks to stock returns and permanent income to $\rho = \mathbf{E}[(\log \nu_t)(\log \eta_t)]/(\sigma_\nu \sigma_\eta) = 0.15$, as estimated in the prior literature (Campbell, Cocco, Gomes, and Maenhout, 2001; Gomes and Michaelides, 2005).

4.4 Discussion of the model

In our benchmark model, it is always optimal for the household to own some stocks, regardless of the level of wealth. In reality, however, a significant share of the population does not own stocks (Mankiw and Zeldes, 1991; Haliassos and Bertaut, 1995). There are various proposed explanations for non-participation, including fixed costs of participation (Cocco, 2005; Gomes and Michaelides, 2005; Hu, 2005; Yao and Zhang, 2005) and investor mistakes (Calvet, Campbell, and Sodini, 2007). Because non-participation is outside the scope of our study, we interpret our model as a description of stockholders (i.e., those that have already paid the fixed cost and are making optimal decisions). In comparing the model to the data, we focus on the sub-sample of stockholders in the CEX and the SCF.

In modeling household consumption and portfolio choice, we have made several simplifying assumptions. The assumptions allow us to focus on the portfolio implications of the nonhomothetic model in the simplest setting. We now discuss three of these assumptions briefly and provide some intuition for how modifications of these assumptions are likely to affect our results.

4.4.1 Uncertainty in the relative price of luxury goods

We assume that the relative price of luxury goods is a deterministic function of age. Uncertainty in the relative price can have a significant impact on portfolio choice through correlation with stock returns. In fact, Aït-Sahalia, Parker, and Yogo (2004) find that the growth rate of the price of luxury goods is highly positively correlated with stock returns. In the presence of such correlation, a wealthy household with a higher expenditure share for luxury goods has an incentive to hold stocks to partially hedge the price risk of luxury goods. Therefore, such correlation can magnify the positive relation between wealth and the portfolio share, making it easier for the nonhomothetic model to explain the data.

4.4.2 Heterogeneity in labor income

Following a standard practice in the life-cycle literature, we calibrate the model to estimates of the labor income process on the entire population, rather than estimates on the subsample of stockholders. A defense of this practice is that there is no empirical evidence for income heterogeneity between stockholders and non-stockholders. Heaton and Lucas (2000, Table A2) report that the standard deviation of income growth for stockholders is 31%, while the standard deviation for non-stockholders is 35%.

There is some empirical evidence for income heterogeneity across education. To verify that income heterogeneity is not critical for our results, we have calibrated the model separately by education group in a previous version of this paper. Carroll and Samwick (1997, Table 1) report the variance of permanent income shocks by education: 2.1% for some high school, 2.8% for high school graduates, 2.4% for some college, 1.5% for college graduates, and 1.2% for graduate school. Insofar as education proxies for permanent income, the variance of permanent income shocks appears to *fall* in the level of permanent income. This empirical evidence favors the nonhomothetic model because the homothetic model, given these income volatilities, would predict that the volatility of consumption *falls* in wealth, which is inconsistent with the empirical evidence (Parker, 2001; Brav, Constantinides, and

Geczy, 2002; Vissing-Jørgensen, 2002).

4.4.3 Time-varying expected stock returns

We assume that expected stock returns are constant. A time-varying investment opportunity set can generate life-cycle patterns in stock ownership, but it is unlikely to affect the relation between wealth and the portfolio share that is the focus of this paper. For this line of work, we refer to Kim and Omberg (1996), Balduzzi and Lynch (1999), Campbell and Viceira (1999), Barberis (2000), and Wachter (2002).

5. Solution of the Life-Cycle Model

We solve the life-cycle problem through numerical dynamic programming as described in Appendix C. As shown in the appendix, the household's value function can be written as a function of age (t), normalized cash-on-hand ($w_t = W_t/P_t$), and permanent income (P_t). This section describes the optimal policies for consumption and portfolio choice.

5.1 Optimal consumption policy

Figure 1 shows the optimal consumption policy, as a function of normalized cash-on-hand and permanent income, for the household at age 50. The policy variables are basic consumption and luxury consumption, both of which are expressed in units of basic consumption and normalized by permanent income. Holding fixed the level of permanent income, the consumption function for both basic and luxury goods share the two key features of the standard consumption function in the homothetic model. First, the consumption function is monotonic in cash-on-hand. The higher is current wealth, the higher is the consumption of both basic and luxury goods. Second, the consumption function is concave in cash-on-hand. The consumption of both basic and luxury goods rises steeply at a low level of cash-on-hand. The marginal propensity to consume, or the slope of the consumption function with respect to wealth, then flattens at a higher level of cash-on-hand.

Holding fixed the level of normalized cash-on-hand, basic consumption falls and luxury consumption rises in permanent income. Wealthier households allocate a higher share of total consumption to the luxury good because the Engel curves are nonlinear (see equations (5) and (6)). At a low level of permanent income, basic consumption rises sharply in cash-on-hand, while luxury consumption is relatively flat in cash-on-hand. In other words, the marginal propensity to consume for the basic good is high, while the marginal propensity to consume for the luxury good is low. The marginal propensity to consume for the luxury good rises more rapidly in permanent income than does the marginal propensity to consume for the basic good. Because the rising marginal propensity to consume for the luxury good more than compensates for the falling marginal propensity to consume for the basic good, total consumption is more responsive to cash-on-hand at a higher level of permanent income. This effect can explain why wealthier households have consumption that is more volatile and more responsive to wealth shocks than poorer households (see the discussion in Section 6.4).

5.2 Optimal portfolio policy

Figure 2 shows the optimal portfolio policy, as a function of normalized cash-on-hand and permanent income, for the household at age 50. The policy variable is the portfolio share, the percentage of wealth invested in stocks. Holding fixed the level of permanent income, the portfolio share falls in cash-on-hand. Because labor income is relatively stable and has a low correlation with stock returns, human capital is nearly a substitute for bonds. The lower is cash-on-hand relative to permanent income, the lower is the allocation to stocks as a share of total wealth (i.e., the sum of financial wealth and human capital). Therefore, the lower is normalized cash-on-hand, the higher is the optimal allocation to stocks as a share of wealth. This standard effect is also present in the homothetic model.

Holding fixed the level of normalized cash-on-hand, higher permanent income leads to lower risk aversion under nonhomothetic utility. Consequently, the household allocates a higher share of wealth to stocks at a higher level of permanent income. At a low level of permanent income, a high share of total consumption is allocated to the basic good, and the household resembles a power-utility investor with high risk aversion γ. At a high level of permanent income, a high share of total consumption is allocated to the luxury good, and the household resembles a power-utility investor with low risk aversion ξ.

In summary, the model predicts that there are two offsetting effects of wealth on portfolio choice, one that operates through cash-on-hand and another that operates through permanent income. In the next section, we simulate the model to understand the interplay between these two effects.

6. Simulation of the Life-Cycle Model

In order to assess the quantitative implications of the model, we simulate a cross-section of 10,000 households at an annual frequency. The households are ex ante identical, have non-homothetic utility, and face non-tradable labor income. Table 6 summarizes the preference and income parameters of the model. In order to highlight the novel implications of the nonhomothetic model, we repeat the same simulation exercise for the homothetic model.

For each household, we draw an initial level of wealth (relative to permanent income) from a lognormal distribution, based on estimates from the CEX (Gourinchas and Parker, 2002, Table 2). The mean of W_1/P_1 is set to 0.3, and its log standard deviation is set to 1.784. Similarly, we draw an initial level of permanent income from a lognormal distribution, based on estimates from the CEX. The mean of P_1 is normalized to one, and its log standard deviation is set to 0.480.

6.1 Implications for consumption and savings

We first examine the implications of our model for consumption and savings. Specifically, we examine the basic expenditure share and the wealth-income ratio.

6.1.1 Basic expenditure share

Panel A of Table 7 reports the basic expenditure share for stockholders in the CEX, tabulated by age group and consumption quartile. To create the table, we first sort households into age groups of ten years, based on the age of the household head. Within each age group and interview year, we then sort households into quartiles based on their total consumption.[3] For each age group, we create an additional bin for households whose consumption is in the top fifth percentile, in order to separately analyze the behavior of the wealthy. The last row of the panel reports statistics for all households in that age group.

For the 36–45 age group, basic consumption is 59% of total consumption for the lowest consumption quartile and 39% for the highest quartile. The basic expenditure share is 33% for households in the top fifth percentile of total consumption. For the 56–65 age group, basic consumption is 61% of total consumption for the lowest consumption quartile and 36% for the highest quartile. The basic expenditure share is 30% for households in the top fifth percentile of total consumption. The small standard errors indicate that there is virtually no sampling uncertainty around these point estimates.

In Panel B, we sort households simulated in the nonhomothetic into age groups, then into quartiles of consumption within each age group. We then tabulate the median of basic expenditure share within each bin and compare the results with the empirical moments in Panel A. Within each age group, the basic expenditure share falls in total consumption, essentially matching the empirical moments. For the 36–45 age group, basic consumption is 60% of total consumption for the lowest consumption quartile and 36% for the highest quartile. The basic expenditure share is 31% for households in the top fifth percentile of total consumption. For the 56–65 age group, basic consumption is 62% of total consumption for the lowest consumption quartile and 36% for the highest quartile. The basic expenditure

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[3] In comparing the level of consumption across households, we control for household characteristics, using a procedure similar to that in Carroll and Samwick (1997) and Gourinchas and Parker (2002). We regress log consumption on a set of dummy variables for marital status and household size. For each household, we use the estimated coefficients to compute the equivalence scale for a household with four members, whose head is married.

share is 31% for households in the top fifth percentile of total consumption.

These results can be explained by the shape of the consumption policy functions in Figure 1. As households become wealthier, their consumption of the luxury good (i.e., the good with the lower curvature) rises relative to their consumption of the basic good (i.e., the good with the higher curvature). Therefore, the basic expenditure share falls in wealth in the nonhomothetic model, in contrast to the homothetic model in which the expenditure share is constant.

6.1.2 Wealth-income ratio

Panel A of Table 8 reports the ratio of net worth to income for stockholders in the SCF, tabulated by age group and wealth quartile. To create the table, we first sort households into age groups of ten years, based on the age of the household head. Within each age group and interview year, we then sort households into quartiles based on their net worth. For each age group, we create an additional bin for households whose net worth is in the top fifth percentile, in order to separately analyze the behavior of the wealthy. The last row of the panel reports statistics for all households in that age group.

This panel shows that the wealth-income ratio rises in wealth, that is, the wealthy accumulate wealth disproportionately. For the 36–45 age group, the wealth-income ratio is 0.7 for the lowest wealth quartile and 5.5 for the highest quartile. The wealth-income ratio is 9.7 for households in the top fifth percentile of net worth. For the 56–65 age group, the wealth-income ratio is 2.0 for the lowest wealth quartile and 12.0 for the highest quartile. The wealth-income ratio is 17.2 for households in the top fifth percentile of net worth.

Panel B reports the wealth-income ratio for households simulated in the nonhomothetic model. The model is consistent with the life-cycle profile in wealth accumulation. The wealth-income ratio starts at 1.3 for the 26–35 age group and rises to 8.5 for the 66–75 age group, matching the empirical moments in Panel A. Late in the life-cycle, the bequest motive is necessary to produce a high level of wealth accumulation that is consistent with the empirical evidence.

Although the nonhomothetic model is consistent with the life-cycle profile in wealth accumulation, it cannot explain the cross-sectional variation in wealth accumulation across households. In the model, wealthier households keep a lower buffer stock of wealth because they are less risk averse. This shortcoming of the nonhomothetic model suggests that there are other mechanisms at work in generating cross-sectional heterogeneity in household savings. For the very poor, the low wealth accumulation can be explained by asset-based, means-tested social insurance (Hubbard, Skinner, and Zeldes, 1994). For the very wealthy, the high wealth accumulation can be explained by preferences for wealth (Carroll, 2000; Roussanov, 2008). We refer to Dynan, Skinner, and Zeldes (2004) for a nice discussion of the challenges in explaining the cross-sectional heterogeneity in household savings.

6.2 Implications for portfolio choice

We now examine the implications of our model for portfolio choice. Specifically, we examine the portfolio share by wealth, the portfolio share by age, and the response of the portfolio share to changes in wealth.

6.2.1 Portfolio share by wealth

Panel A of Table 9 reports the median portfolio share for stockholders in the SCF, tabulated by age group and wealth quartile. For the 36–45 age group, the portfolio share is 23% for the lowest wealth quartile and 44% for the highest quartile. The portfolio share is 67% for households in the top fifth percentile of net worth. For the 56–65 age group, the portfolio share is 18% for the lowest wealth quartile and 47% for the highest quartile. The portfolio share is 65% for households in the top fifth percentile of net worth. The small standard errors indicate that there is virtually no sampling uncertainty around these point estimates.

Panel B reports the portfolio share for households simulated in the nonhomothetic model. In the nonhomothetic model, the portfolio share rises in wealth for all age groups, consistent with the empirical evidence in Panel A. For the 36–45 age group, the portfolio share is 25% for the lowest wealth quartile and 46% for the highest quartile. The portfolio share is 50% for households in the top fifth percentile of wealth. For the 56–65 age group, the portfolio share is 19% for the lowest wealth quartile and 40% for the highest quartile. The portfolio share is 43% for households in the top fifth percentile of wealth.

As discussed in Section 5, there are two offsetting effects that determine the relation between wealth and the portfolio share in the nonhomothetic model. On the one hand, households with higher wealth have higher normalized cash-on-hand, holding constant the level of permanent income. On the other hand, higher wealth implies higher permanent income, holding constant the level of normalized cash-on-hand. With the exception of the youngest households, the latter effect dominates so that overall there is a positive relation between wealth and the portfolio share. As households age and permanent income shocks accumulate, the cross-sectional variation in permanent income rises. This effect explains why the difference in the portfolio share between high and low wealth households becomes more pronounced from youth to middle age.

Panel C reports the portfolio share for households simulated in the homothetic model. The portfolio share falls in wealth for the 36–45 age group, in stark contrast to the nonhomothetic model. This fall in the portfolio share becomes less pronounced as households age because human capital becomes a smaller share of the household's total wealth. For older households, the model more closely resembles that of Samuelson (1969), in which all wealth is financial and the optimal portfolio share is constant in wealth.

6.2.2 Portfolio share by age

As shown in Panel A of Table 9, the portfolio share in the SCF has a slight hump-shaped age profile (Ameriks and Zeldes, 2004). A standard implication of the life-cycle model is that the portfolio share falls in age, which is inconsistent with the empirical evidence (see Cocco, Gomes, and Maenhout, 2005). Households are born with little wealth, but a large stake in non-tradable human capital. Because stocks have a high average rate of return and low correlation with labor income, optimal portfolio allocation requires that households initially allocate most of their wealth to stocks. As households age, they accumulate wealth and decumulate their human capital. The portfolio share consequently falls because there is less need to diversify human capital.

In the nonhomothetic model, this age effect in portfolio choice is offset by the fact that households become less risk averse as their permanent income grows over the life cycle. Panel B shows that the median portfolio share is slightly falling in the nonhomothetic model, from 35% for the 36–45 age group to 29% for the 56–65 age group. In contrast, Panel C shows that the median portfolio share falls more strongly in the homothetic model, from 42% for the 36–45 age group to 26% for the 56–65 age group. We find that decreasing relative risk aversion alone cannot fully explain the portfolio share for the 26–35 age group. However, a small probability of unemployment can explain the low portfolio share for the youngest households, thereby generating a slight hump-shaped age profile that is consistent with the empirical evidence (see Table 10).

The literature has proposed other compelling explanations for the discrepancy between the standard life-cycle implication of the model and the data. First, the true relation between age and the portfolio share is unknown because of the lack of identification between age, time, and cohort effects (Ameriks and Zeldes, 2004). Second, the purchase of housing and small fixed costs can crowd out stocks from the household's portfolio early in life (Cocco, 2005; Hu, 2005; Yao and Zhang, 2005). Third, internal habit formation can induce a strong motive to save in bonds early in life, crowding out stocks from the household's portfolio (Gomes and Michaelides, 2003; Polkovnichenko, 2007). Finally, different assumptions on the joint process for stock returns and labor income can substantially reduce stockholding for younger households (Lynch and Tan, 2006; Benzoni, Collin-Dufresne, and Goldstein, 2007; Storesletten, Telmer, and Yaron, 2007).

6.2.3 Response of the portfolio share to changes in wealth

In recent work, Brunnermeier and Nagel (2008) use data from the Panel Study of Income Dynamics (PSID) and find that the portfolio share falls slightly (or changes very little) in response to an increase in wealth. Their findings may initially seem inconsistent with our findings. In this section, we show that their findings are fully consistent with the nonhomothetic model.

Using data simulated in the nonhomothetic model, we estimate a cross-sectional regression model:

$$100(a_t - a_{t-1}) = -1.2 - 3.8 \log\left(\frac{S_t}{S_{t-1}}\right) + e_t, \tag{24}$$

where a_t is the portfolio share and S_t is wealth in period t. (The portfolio share has been multiplied by 100 in the regression so that its units are percentage points.) The coefficient on the change in wealth is -3.8, which implies that a 10% increase in wealth leads to a 0.38% fall in the portfolio share. The coefficient produced by our model is the same sign and order of magnitude as that reported in Brunnermeier and Nagel (2008, Table 4). The regression model reported here is estimated on a pooled sample of households across all age groups, but we obtain similar results when we estimate the model separately by age.

In the absence of labor income, Brunnermeier and Nagel hypothesize that models with decreasing relative risk aversion imply that the portfolio share should rise in response to an increase in wealth. In the presence of labor income, however, models with decreasing relative risk aversion imply that the portfolio share can fall in response to an increase in wealth. This is evident in Figure 2, which shows that the optimal portfolio share falls in normalized cash-on-hand and rises in permanent income. To clarify this point, we now add consumption growth to the cross-sectional regression model:

$$100(a_t - a_{t-1}) = -0.5 - 19.4 \log\left(\frac{S_t}{S_{t-1}}\right) + 17.6 \log\left(\frac{C_t}{C_{t-1}}\right) + e_t, \tag{25}$$

where C_t is consumption in period t. The coefficients of the regression show that the portfolio share falls in response to a positive wealth shock, holding constant consumption growth which proxies for the change in permanent income.

Our findings here have practical implications for empirical work. Cross-sectional regressions, such as equation (24), are not useful for detecting the presence of decreasing relative risk aversion. In the life-cycle model, the portfolio share rises only in response to *permanent* changes in wealth, not in response to *transitory* changes. One way to isolate permanent changes in wealth is to include consumption growth in the regression, as in equation (25). In practice, however, this is difficult because data sets with consumption, such as the CEX and PSID, have poor or incomplete data on wealth. Conversely, data sets with wealth, such as the SCF, have no consumption data.

6.3 Portfolio choice with unemployment risk

We now examine how unemployment risk, modeled as a positive probability of zero income, affects portfolio choice. The parameters of the model remain the same as those in Table 6, except that labor income can be zero in any period of the working life with probability 0.5% (Carroll, 1992). This scenario is potentially extreme because an unemployed household may have other sources of income such as unemployment benefits and social welfare (see Gakidis, 1998). This scenario should therefore be interpreted as a robustness check that leads to maximum contrast to our benchmark case with no unemployment. The possibility of zero income can cause the optimal portfolio share to rise in cash-on-hand at a sufficiently low level of wealth, even under standard power utility (see Cocco, Gomes, and Maenhout, 2005). Distributional assumptions that lead to more dependence between stock returns and labor income can have a similar effect to unemployment risk, that is, the portfolio share can rise in cash-on-hand at a sufficiently low level of wealth (Lynch and Tan, 2006; Benzoni, Collin-Dufresne, and Goldstein, 2007). However, this effect disappears in age and should be nonexistent for retired households with no labor income. Therefore, it cannot explain the fact that the relation between wealth and the portfolio share persists as households age.

Because the results for consumption are nearly identical to those in the benchmark case with no unemployment, we focus on the results for portfolio choice in this section. Panel A of Table 9 reports the median portfolio share for stockholders in the SCF for the purposes of comparison to the models. Panel B reports the portfolio share in the nonhomothetic model, and Panel C reports the portfolio share in the homothetic model. Unemployment risk lowers the portfolio share for youngest households in the lowest wealth quartile, which is consistent with the empirical evidence. However, it hardly affects older households who have accumulated enough wealth to buffer these transitory shocks to labor income. Given the preference and income parameters that have realistic implications for household savings behavior, unemployment risk does not have a significant effect on portfolio choice.

6.4 Implications for asset pricing

Although the focus of this paper is portfolio choice, our model has important implications for asset pricing that are also consistent with the empirical evidence. A recent and growing literature in asset pricing proposes heterogeneity in risk aversion as an explanation for a number of facts that are puzzling from the point of view of the standard model (i.e., representative household with constant relative risk aversion).

In one branch of the literature, Parker (2001), Brav, Constantinides, and Geczy (2002), and Vissing-Jørgensen (2002) estimate the consumption Euler equation for stockholders in the CEX, separately for stockholders at different levels of wealth. A motivation for these studies is that the Euler equation need not hold for a representative household because only a sub-sample of the population actually own stock (Mankiw and Zeldes, 1991). Moreover, markets may be incomplete or risk aversion may be heterogeneous within the sub-sample of stockholders. These studies find that the level of risk aversion necessary to account for the joint time series behavior of consumption and stock returns is lower for wealthier investors. This finding is based on the fact that both the variance of consumption growth and the covariance of consumption growth with stock returns rises in wealth within the sub-sample of stockholders in the CEX.[4] Brav, Constantinides, and Geczy (2002) and Malloy, Moskowitz, and Vissing-Jørgensen (2008) show a similar result for the excess returns on small-cap stocks over large-cap stocks as well as value stocks over growth stocks.

In another branch of the literature, Chan and Kogan (2002) and Gârleanu and Panageas (2008) analyze general equilibrium economies in which households have heterogeneous risk aversion. They show that heterogeneity in risk aversion leads to countercyclical variation in the price of risk, through endogenous changes in the cross-sectional distribution of wealth. These models offer quantitative explanations for the standard asset-pricing facts, which include the high equity premium, the countercyclical variation in the equity premium, and the volatility of stock returns.

The asset-pricing literature discussed above takes heterogeneity in risk aversion as exogenous. Our model provides a parsimonious explanation for such heterogeneity; wealthier households consume more luxury goods and are therefore more tolerant of uncertainty in their consumption stream. Our model is therefore consistent with those asset-pricing facts that can be explained by heterogeneity in risk aversion. Moreover, our model is consistent with the empirical evidence on household consumption and portfolio choice as this paper has shown.

In addition to cross-sectional heterogeneity in risk aversion, our model also implies that risk aversion varies over time for individual households. Our model implies that individual households become more risk averse when their wealth decreases. Consequently, the household's intertemporal marginal rate of substitution is more volatile and has higher negative covariance with stock returns, compared to the standard model with constant relative risk aversion. This precise mechanism has been exploited in a representative household context to explain the standard asset-pricing facts, most notably by Campbell and Cochrane (1999).

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[4] At the extreme upper tail of the wealth distribution not represented in the CEX, Aït-Sahalia, Parker, and Yogo (2004) find that the consumption of luxury goods, constructed from data on the sales of luxury retailers, has an even higher covariance with stock returns.

In a similar line of work, Pakoš (2004) and Lochstoer (2008) explain the asset-pricing facts in a two-good model with luxury goods, building on the work of Aït-Sahalia, Parker, and Yogo (2004). In our model, time-varying risk aversion would magnify the effects of heterogeneity in risk aversion demonstrated by the studies discussed above, making it easier to explain the standard asset-pricing facts. We leave this issue for future research.

7. Conclusion

Household surveys of consumption and wealth have uncovered numerous facts that are inconsistent with the standard life-cycle consumption and portfolio choice model with homothetic utility.

1. The expenditure share for various categories of nondurable goods and services vary significantly in total consumption.
2. The portfolio share rises in wealth, even after controlling for stock market participation and education.
3. The portfolio share has a non-decreasing age profile.
4. The portfolio share falls slightly (or changes very little) in response to an increase in wealth (Brunnermeier and Nagel, 2008).

In this paper, we propose a simple and parsimonious explanation for the observed cross-sectional variation in consumption and portfolio behavior. Our only departure from the standard life-cycle model is that the household has nonhomothetic utility over two types of consumption goods. Nonhomothetic utility has a long tradition in microeconomic studies of consumer behavior, but there has been little application in life-cycle models of consumption and portfolio choice. We calibrate the model using a standard labor income process that has low correlation with stock returns. We find that the nonhomothetic model quantitatively explains all four of these facts on household consumption and portfolio choice.

Appendix A. Consumer Expenditure Survey

The Bureau of Labor Statistics collects data on household characteristics, major expenditures, and income in the Interview Survey component of the CEX. The Bureau of Labor Statistics uses a national probability sample of households, designed to represent the total noninstitutional civilian population. The CEX is a rotating panel of approximately 5,000 households every calendar quarter (rising to 7,000 households more recently). The Bureau of Labor Statistics interviews each household up to five times every three months before replacement. The first interview is for practice, so that only the second through fifth interviews are available in the public-use data files. The Bureau of Labor Statistics interviews approximately the same number of households in each of the three months of a calendar quarter, and households report their expenditures from the previous three months at each interview. Therefore, the CEX can be thought of as three non-overlapping panels of quarterly expenditure data. We use the consumer unit replicate weight (FINLWT21) to weight households in all of our analysis, although the results are not at all sensitive to the use of the sample weight.

Although CEX data are available in the present format since 1980, we use the CEX files from 1982 through 2003. We do not use data from 1980 and 1981 because the expenditure on food was collected with a different questionnaire. The Bureau of Labor Statistics has changed the sampling design of the CEX on two occasions, between 1985 and 1986 and between 1995 and 1996. Consequently, households cannot be linked across files during these years. Therefore, households in the 1985:4 file are linked to the same households in the early release of 1986:1 data from the 1985 CEX files. Similarly, we use the early release of 1996:1 data from the 1995 CEX files.

Following a standard procedure in the literature (Attanasio and Weber, 1995), we drop households that live in rural areas, live in student housing, or are incomplete income respondents. We drop rural households because the Bureau of Labor Statistics failed to survey them during 1981:3–1983:4. We use the Member Characteristics and Income File to identify the reference person of each household and, for married households, the spouse. We define the household head as the husband for married households and as the reference person otherwise. Only households whose head is between ages 26 and 75 at the time of interview are kept for analysis. Households are grouped by birth cohort and education based on the characteristics of the household head. We create thirteen birth cohorts in five-year bins, from those born 1910–1914 to those born 1975–1979. The four education groups are some high school, high school graduate, some college, and college graduate.

We construct household consumption using the Monthly Expenditures File. The Bureau of Labor Statistics estimates that approximately 90–95% of total household expenditures are covered by the survey. We focus on the consumption of nondurable goods and services for the following major categories of expenditure.

- Nondurable goods: Food at home, food away from home, clothing and shoes, gasoline, fuel oil and coal, and other nondurable goods.[5]
- Services: Housing, household operation, transportation, personal care, personal business, and recreation.

We exclude durable goods (such as "motor vehicles and parts" and "furniture and household equipment"), health, and education from our measure of consumption. Because the CEX reports only expenditures, the service flow from durable goods cannot be reliably measured based on the data available. For housing, however, we can impute its service flow and therefore include it in our measure of consumption. Housing consumption is the rent paid plus the cost of materials and services for maintenance. For households that own their home, the CEX reports "the rental equivalence of owned home", which we use as our measure of rent.

Our unit of analysis is annual consumption so that each household accounts for one observation in the data set. To eliminate obvious data errors, we drop households that report

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[5] Other nondurable goods includes semidurable house furnishings, cleaning and polishing preparations, and nondurable toys and sport supplies.

no food or only food expenditures in a given month. Monthly expenditures are summed over all three months of an interview period, which yields total household consumption for that quarter. We deflate nominal expenditures to real 2001 dollars using the Consumer Price Index (CPI) for all urban consumers. Each expenditure item in the CEX is carefully matched to a region- and item-specific CPI, so that the price deflator is household specific.

In the second and fifth interviews, the Bureau of Labor Statistics collects income data for the previous twelve months. We compute disposable income as total household income after taxes minus capital income and pension contributions (Gourinchas and Parker, 2002). Capital income includes interest on savings accounts and bonds as well as income from dividends, royalties, estates, and trusts. Pension contributions is the sum of income contributed to Social Security, railroad retirement, government retirement, private pension, and individual retirement plans.

In the fifth interview, the Bureau of Labor Statistics collects financial data for the previous twelve months. In particular, households report the estimated value of securities such as stocks, mutual funds, private bonds, and Treasury notes. Following Vissing-Jørgensen (2002), a household is identified as a stockholder if its holding in these securities was positive twelve months prior to the interview or has increased in the previous twelve months.

Appendix B. Survey of Consumer Finances

The Board of Governors of the Federal Reserve System conducts the survey every three years based on a dual-frame sample design. They select one sample based on a standard multistage area-probability design, which leads to a representative sample of approximately 3,000 households. They select a second sample based on tax data from the Statistics of Income Division of the Internal Revenue Service, which leads to a representative sample of approximately 1,500 high-wealth households. The SCF provides sample weights for adjusting biases caused by missing responses and for calculating aggregate statistics that are representative of the whole population. We use the sample replicate weight (WGT) to weight households in all of our analysis. Aizcorbe, Kennickell, and Moore (2003) and references therein describe the sampling methodology in further detail.

Because the SCF data are available in the present format since 1989, we use the SCF files for every three years from 1989 through 2004. Most of our variables are from the extract file of the full public data set, available in Excel format from the Board of Governors's SCF website. For the construction of the value of risky bonds, however, we use variables from the full public data set. Only households whose head is between ages 26 and 75 at the time of interview are kept for analysis. We exclude households with non-positive net worth as well as those with no risky-asset holdings from the sample. We deflate nominal wealth to real 2001 dollars using the September value of the CPI for all urban consumers.

We now define various components of wealth that are relevant for our analysis. The variable names that follow refer to those from the SCF codebook. Net worth (NETWORTH) is the sum of financial and nonfinancial assets minus all debt. Financial assets include liquid financial accounts; certificates of deposit; directly held bonds and stocks; mutual funds; retirement (both individual and employer-sponsored thrift-type) accounts; the cash value of life insurance; and equity interest in trusts, annuities, and managed investment accounts. Nonfinancial assets include the primary residence, investment real estate, and business equity. Debt includes mortgage and home equity loans for primary residence and investment real estate, credit card balances, and other loans.

Risky assets is the sum of public equity (EQUITY), investment real estate (NNRESRE), business equity (BUS), and risky bonds (Bertaut and Starr-McCluer, 2002, Table 5.7). Public equity includes both directly held stock and stocks held through mutual funds, retirement accounts, trusts, and other managed investment accounts. Investment real estate includes residential and nonresidential property that is not primary residence and not owned through a business. Business equity is net equity in all types of privately owned businesses, farms or ranches, professional practices, and partnerships. Risky bonds is the sum of corporate

(X7634), foreign (X7633), and mortgage-backed (X3906) bonds.

Appendix C. Numerical Solution of the Life-Cycle Model

Following the usual methodology, we solve the model backward from the last period of life. In order to define the bequest function, we compute the optimal consumption policy for a given level of cash-on-hand in the last period,

$$B_{T+1} = \frac{W_{T+1}}{1+\alpha^{1/\phi}Q_{T+1}^{1-1/\phi}B_{T+1}^{\lambda/\phi-1}}, \tag{26}$$

$$L_{T+1} = \frac{W_{T+1}}{1+\alpha^{-1/\lambda}Q_{T+1}^{1/\lambda-1}L_{T+1}^{\phi/\lambda-1}}. \tag{27}$$

The value function in period T is given by

$$J_T(W_T,P_T) = \max_{B_T,L_T,a_T}\{U(B_T,L_T)+\beta\mathbf{E}_T[bU(B_{T+1},L_{T+1})]\}. \tag{28}$$

We normalize the consumption policy variables by permanent income as $b_t = B_t/P_t$ and $l_t = L_t/P_t$. Similarly, we normalize cash-on-hand as $w_t = W_t/P_t$ and wealth as $s_t = w_t - b_t - Q_t l_t$. Finally, we define the recursive function

$$j_t(w_t,P_t) = \max_{b_t,l_t,a_t}\{u_t(b_t,l_t)+\beta\mathbf{E}_t[(G_{t+1}\eta_{t+1})^{1-\gamma}j_{t+1}(w_{t+1},P_{t+1})]\}, \tag{29}$$

where

$$u_t(b_t,l_t) = \frac{1}{1-\gamma}\left(b_t^{1-\lambda}+\frac{\alpha(1-\lambda)}{1-\phi}P_t^{\lambda-\phi}l_t^{1-\phi}\right)^{(1-\gamma)/(1-\lambda)}. \tag{30}$$

The value function in period T can be rewritten as

$$J_T(W_T,P_T) = P_T^{1-\gamma}j_T(w_T,P_T). \tag{31}$$

By induction, the value function in any period $t \leq T$ is given by

$$J_t(W_t, P_t) = P_t^{1-\gamma} j_t(w_t, P_t). \tag{32}$$

We redefine the life-cycle problem as the solution to Bellman equation (29) subject to the intertemporal budget constraint,

$$w_{t+1} = \frac{R_{t+1} s_t}{G_{t+1}\eta_{t+1}} + \epsilon_{t+1}, \tag{33}$$

and the law of motion for permanent income (18). The first-order conditions for the Bellman equation, together with the envelope theorem, imply that

$$\begin{aligned} u_{bt} &= \mathbf{E}_t[\beta R_{t+1}(G_{t+1}\eta_{t+1})^{-\gamma} u_{b,t+1}], & (34) \\ 0 &= \mathbf{E}_t[\beta s_t (R_{e,t+1} - R_f)(G_{t+1}\eta_{t+1})^{-\gamma} u_{b,t+1}], & (35) \end{aligned}$$

where

$$u_{bt} = b_t^{-\gamma} \left(1 + \frac{\alpha(1-\lambda)}{1-\phi} P_t^{\lambda-\phi} \frac{l_t^{1-\phi}}{b_t^{1-\lambda}}\right)^{(\lambda-\gamma)/(1-\lambda)}. \tag{36}$$

The life-cycle problem is essentially solved through recursion on these equations.

We discretize the joint probability distribution for stock returns and income shocks as

$$\begin{aligned} \{(\nu_i, p_i^\nu)\}_{i=1}^I &= \{(\nu_1, p_1^\nu), \ldots, (\nu_I, p_I^\nu)\}, \\ \{(\eta_j, p_j^\eta)\}_{j=1}^J &= \{(\eta_1, p_1^\eta), \ldots, (\eta_J, p_J^\eta)\}, \\ \{(\epsilon_k, p_k^\epsilon)\}_{k=1}^K &= \{(\epsilon_1, p_1^\epsilon), \ldots, (\epsilon_K, p_K^\epsilon)\}. \end{aligned}$$

We discretize the state space as

$$
\begin{aligned}
\{s_l\}_{l=1}^{L} &= \{s_1, \ldots, s_L\}, \\
\{w_m\}_{m=1}^{M} &= \{w_1, \ldots, w_M\}, \\
\{P_n\}_{n=1}^{N} &= \{P_1, \ldots, P_N\}.
\end{aligned}
$$

In each period t, we define the functions

$$
\begin{aligned}
\Theta_t(s_l, P_n) &= \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K} p_i^{\nu} p_j^{\eta} p_k^{\epsilon} \beta [R_f + a_t(s_l, P_n)(\overline{R}_e \nu_i - R_f)](G_{t+1}\eta_j)^{-\gamma} \\
&\quad \times u_{b,t+1}(w_{t+1}(s_l, P_n; \nu_i, \eta_j, \epsilon_k), G_{t+1} P_n \eta_j), \qquad (37) \\
\Omega_t(s_l, P_n) &= \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K} p_i^{\nu} p_j^{\eta} p_k^{\epsilon} \beta s_l (\overline{R}_e \nu_i - R_f)(G_{t+1}\eta_j)^{-\gamma} \\
&\quad \times u_{b,t+1}(w_{t+1}(s_l, P_n; \nu_i, \eta_j, \epsilon_k), G_{t+1} P_n \eta_j), \qquad (38)
\end{aligned}
$$

where

$$
\begin{aligned}
u_{bt}(w_t, P_t) &= b_t(w_t, P_t)^{-\gamma} \left(1 + \frac{\alpha(1-\lambda)}{1-\phi} P_t^{\lambda-\phi} \frac{l_t(w_t, P_t)^{1-\phi}}{b_t(w_t, P_t)^{1-\lambda}}\right)^{(\lambda-\gamma)/(1-\lambda)}, \qquad (39) \\
l_t(w_t, P_t) &= \frac{\alpha^{1/\phi} P_t^{\lambda/\phi - 1} b_t(w_t, P_t)^{\lambda/\phi}}{Q_t^{1/\phi}}, \qquad (40) \\
w_{t+1}(s_l, P_n; \nu_i, \eta_j, \epsilon_k) &= \frac{[R_f + a_t(s_l, P_n)(\overline{R}_e \nu_i - R_f)] s_l}{G_{t+1}\eta_j} + \epsilon_k. \qquad (41)
\end{aligned}
$$

Starting with the solution in period T, we use the following algorithm to solve the life-cycle problem recursively for periods $t = T-1, \ldots, 1$.

1. For each point (s_l, P_n) on the grid, find $a_t(s_l, P_n)$ such that $\Omega_t(s_l, P_n) = 0$. If an interior solution does not exist,

$$
a_t(s_l, P_n) = \begin{cases} 0 & \text{if } \Omega_t(s_l, P_n) < 0 \\ 1 & \text{if } \Omega_t(s_l, P_n) > 0 \end{cases}.
$$

2. For each point (s_l, P_n) on the grid, find $b_t(s_l, P_n)$ and $l_t(s_l, P_n)$ such that $u_{bt}(s_l, P_n) = \Theta_t(s_l, P_n)$.

3. Define $w_l = s_l + b_t(s_l, P_n) + Q_t l_t(s_l, P_n)$, $a_t(w_l, P_n) = a_t(s_l, P_n)$ (with a slight abuse of notation), and $b_t(w_l, P_n) = b_t(s_l, P_n)$.

4. For each point (w_m, P_n) on the grid, compute $a_t(w_m, P_n)$ by interpolating $a_t(w_l, P_n)$ as a function of w_l and imposing the constraint $a_t(w_m, P_n) \in [0, 1]$.

5. For each point (w_m, P_n) on the grid, compute $b_t(w_m, P_n)$ by interpolating $b_t(w_l, P_n)$ as a function of w_l. Compute $l_t(w_m, P_n) = \alpha^{1/\phi} Q_t^{-1/\phi} P_n^{\lambda/\phi - 1} b_t(w_m, P_n)^{\lambda/\phi}$.

In our implementation of this algorithm, we set $I = J = K = 10$, $L = M = 40$, and $N = 20$. The grid for the state variables are spaced on a logarithmic scale with the maximum values $s_L = w_M = 40$ and $P_N = 5$.

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Table 1: Relation between expenditure shares and total consumption for nondurable goods

Regressor	Food at home	Food away from home	Clothing and shoes	Fuel oil and coal	Gasoline	Other nondurable goods
Age:						
26–35	-1.39	0.14	0.05	-0.22	-0.71	-0.16
	(-4.81)	(0.65)	(0.29)	(-2.13)	(-5.74)	(-1.44)
36–45	-0.20	0.29	0.08	-0.15	-0.43	0.11
	(-0.85)	(1.70)	(0.62)	(-1.81)	(-4.18)	(1.21)
56–65	0.80	-0.42	-0.34	0.18	-0.30	0.22
	(3.02)	(-2.29)	(-2.37)	(1.90)	(-2.62)	(2.12)
66–75	1.33	-1.25	-0.67	0.27	-0.89	-0.13
	(4.21)	(-6.02)	(-4.02)	(2.35)	(-6.92)	(-1.09)
Log consumption	-8.05	2.45	1.09	-0.20	-2.45	-0.61
	(-26.34)	(11.16)	(6.33)	(-1.81)	(-18.11)	(-5.19)
Log consumption×Age:						
26–35	1.74	-0.49	-0.26	0.14	-0.34	0.57
	(3.37)	(-1.32)	(-0.89)	(0.69)	(-1.51)	(2.87)
36–45	0.50	-0.58	-0.18	0.26	-0.03	-0.15
	(1.16)	(-1.88)	(-0.76)	(1.63)	(-0.16)	(-0.92)
56–65	0.28	-0.15	-0.49	0.08	0.44	-0.13
	(0.65)	(-0.50)	(-2.04)	(0.53)	(2.35)	(-0.81)
66–75	0.17	-0.01	-0.25	0.09	0.88	0.28
	(0.39)	(-0.04)	(-1.00)	(0.58)	(4.58)	(1.67)
Not married	-1.65	-0.32	-0.13	-0.13	-0.79	-0.09
	(-6.42)	(-1.73)	(-0.86)	(-1.42)	(-7.14)	(-0.94)
Household size:						
1.00	-7.68	3.36	-0.88	-0.21	-1.72	-0.33
	(-24.49)	(11.35)	(-4.54)	(-1.63)	(-12.10)	(-2.44)
2.00	-4.33	1.90	-0.58	-0.09	-0.59	0.16
	(-18.29)	(10.55)	(-4.33)	(-1.07)	(-5.56)	(1.73)
3.00	-2.05	0.59	-0.18	0.04	-0.04	0.17
	(-8.08)	(3.10)	(-1.28)	(0.39)	(-0.36)	(1.64)
5.00	1.38	-0.18	0.04	-0.16	0.07	0.10
	(3.82)	(-0.70)	(0.21)	(-1.33)	(0.45)	(0.72)
6 or more	2.76	-0.34	-0.26	-0.36	0.90	0.15
	(5.29)	(-0.96)	(-0.97)	(-2.19)	(3.77)	(0.78)

We estimate a censored regression model for the expenditure share for each category of nondurable goods. The latent variable depends on age group, log total (nondurable and service) consumption, log total consumption interacted with age group, marital status, household size, and interview-year dummies (not reported). The omitted category is households with four members, whose head is aged 46–55 and married. The sample consists of stockholders in the 1982–2003 CEX. The table reports the marginal effects at the mean of the regressors with corresponding *t*-statistics in parentheses.

Table 2: Relation between expenditure shares and total consumption for services

Regressor	Housing	Household operation	Transportation	Personal care	Personal business	Recreation
Age:						
26–35	2.76	0.96	-0.74	-0.15	-0.54	-0.19
	(8.23)	(3.18)	(-3.18)	(-2.88)	(-3.24)	(-1.39)
36–45	0.38	0.70	-0.92	-0.10	-0.19	0.53
	(1.54)	(2.89)	(-4.91)	(-2.28)	(-1.33)	(4.57)
56–65	0.58	0.57	-1.13	-0.07	0.32	-0.39
	(2.12)	(2.12)	(-5.54)	(-1.43)	(2.00)	(-3.26)
66–75	1.41	1.04	-0.09	-0.09	-0.26	-0.28
	(4.20)	(3.22)	(-0.35)	(-1.66)	(-1.40)	(-1.97)
Log consumption	4.55	-5.23	2.73	0.15	1.21	1.30
	(14.55)	(-16.87)	(10.86)	(2.60)	(6.59)	(8.98)
Log consumption×Age:						
26–35	-0.49	1.92	-0.41	-0.18	-0.43	-0.87
	(-0.92)	(3.67)	(-0.96)	(-1.89)	(-1.40)	(-3.57)
36–45	-0.27	1.75	-0.58	-0.04	-0.16	0.26
	(-0.61)	(4.00)	(-1.62)	(-0.44)	(-0.61)	(1.25)
56–65	0.51	-0.24	-0.84	-0.27	1.12	-0.22
	(1.17)	(-0.56)	(-2.38)	(-3.35)	(4.32)	(-1.08)
66–75	-0.63	-1.12	0.58	-0.30	0.87	0.04
	(-1.42)	(-2.53)	(1.60)	(-3.69)	(3.27)	(0.20)
Not married	2.33	-0.11	0.49	0.04	-0.35	-0.09
	(8.16)	(-0.43)	(2.26)	(0.74)	(-2.25)	(-0.74)
Household size:						
1.00	7.54	-4.38	1.19	-0.07	0.27	0.22
	(15.71)	(-12.88)	(3.78)	(-1.03)	(1.22)	(1.24)
2.00	2.87	-3.20	1.34	0.11	0.17	0.13
	(10.87)	(-13.27)	(6.55)	(2.50)	(1.14)	(1.17)
3.00	1.12	-1.24	0.54	0.07	0.21	-0.13
	(3.95)	(-4.77)	(2.48)	(1.44)	(1.35)	(-1.09)
5.00	0.26	-1.06	-0.43	-0.11	0.02	-0.05
	(0.71)	(-3.03)	(-1.51)	(-1.76)	(0.11)	(-0.29)
6 or more	-0.20	-0.85	-0.63	-0.33	0.11	-0.57
	(-0.39)	(-1.70)	(-1.60)	(-3.91)	(0.35)	(-2.57)

We estimate a censored regression model for the expenditure share for each category of services. The latent variable depends on age group, log total (nondurable and service) consumption, log total consumption interacted with age group, marital status, household size, and interview-year dummies (not reported). The omitted category is households with four members, whose head is aged 46–55 and married. The sample consists of stockholders in the 1982–2003 CEX. The table reports the marginal effects at the mean of the regressors with corresponding t-statistics in parentheses.

Table 3: Expenditure shares for basic and luxury goods

Consumption category	Age				
	26–35	36–45	46–55	56–65	66–75
Panel A: Basic goods					
Food at home	15.8	17.9	16.6	17.0	18.6
Fuel oil and coal	0.0	0.0	0.0	0.0	0.0
Gasoline	5.7	5.7	5.9	5.6	4.7
Other nondurable goods	3.0	3.4	3.1	3.6	3.1
Household operation	15.9	16.0	15.2	15.6	17.7
Personal care	1.9	1.9	2.0	2.0	2.0
All basic goods	48.5	50.4	48.6	50.8	52.8
Panel B: Luxury goods					
Food away from home	8.4	8.6	8.3	7.9	6.5
Cothing and shoes	5.8	6.4	5.9	4.8	4.0
Housing	7.7	5.7	6.4	6.6	8.2
Transportation	8.7	8.3	9.7	8.8	8.2
Personal business	3.3	3.8	3.8	3.2	1.7
Recreation	4.7	5.4	5.0	4.3	3.9
All luxury goods	51.5	49.6	51.4	49.2	47.2

We sort the sample of stockholders in the 1982–2003 CEX into age groups (columns). Panel A reports the median of expenditure shares, as a percentage of total consumption, for basic goods. Panel B reports the median of expenditure shares for luxury goods. Luxury goods are defined as those categories of nondurable goods and services for which the expenditure share rises in total consumption for all age groups.

Table 4: Relation between the portfolio share and net worth for stockholders

Regressor	Main specification	Cohort effects	Alternative definition of stockholding
Age:			
26–35	-0.40	-4.66	-2.08
	(-1.47)	(-13.23)	(-6.72)
36–45	0.40	-1.99	-0.38
	(1.94)	(-8.15)	(-1.62)
56–65	-2.73	-1.02	-1.46
	(-12.85)	(-3.75)	(-5.81)
66–75	-6.13	-2.73	-4.67
	(-26.84)	(-6.80)	(-16.09)
Log net worth	3.56	3.58	1.58
	(35.61)	(35.86)	(13.74)
Log net worth×Age:			
26–35	-3.04	-3.05	-1.23
	(-20.63)	(-20.71)	(-7.29)
36–45	-1.72	-1.74	-1.05
	(-12.86)	(-13.03)	(-6.87)
56–65	0.32	0.25	-0.12
	(2.05)	(1.59)	(-0.66)
66–75	0.76	0.73	0.31
	(4.03)	(3.86)	(1.34)
Not married	-0.17	-0.16	0.10
	(-0.61)	(-0.59)	(0.32)
Household size:			
1.00	4.39	4.51	1.35
	(12.00)	(12.29)	(3.31)
2.00	1.66	1.83	0.11
	(7.74)	(8.49)	(0.46)
3.00	0.39	0.43	-0.75
	(1.70)	(1.85)	(-2.87)
5.00	1.03	1.02	0.81
	(3.44)	(3.43)	(2.40)
6 or more	2.46	2.30	-1.79
	(5.38)	(5.03)	(-3.36)

We estimate a censored regression model for the portfolio share. The latent variable depends on age group, log net worth, log net worth interacted with age group, marital status, household size, and interview-year dummies (not reported). The omitted category is households with four members, whose head is aged 46–55 and married. In a second specification, we include cohort dummies, instead of interview-year dummies. In a third specification, we define the portfolio share as the share of financial wealth in stocks, instead of the share of net worth in risky assets. The sample consists of stockholders in the 1989–2004 SCF. The table reports the marginal effects at the mean of the regressors with corresponding t-statistics in parentheses.

Table 5: Relation between the portfolio share and net worth for stockholders by education

Regressor	No high school	High school graduates	Some college	College graduates
Age:				
26–35	0.51	-2.83	-1.18	1.00
	(0.40)	(-5.00)	(-1.73)	(2.83)
36–45	2.80	-0.64	0.18	1.20
	(2.57)	(-1.40)	(0.34)	(4.51)
56–65	-5.65	-3.27	-3.24	-1.32
	(-6.07)	(-7.15)	(-5.76)	(-4.55)
66–75	-4.91	-7.31	-6.59	-5.78
	(-4.88)	(-14.41)	(-11.16)	(-17.43)
Log net worth	1.80	2.30	3.85	4.59
	(3.38)	(9.51)	(14.42)	(34.22)
Log net worth×Age:				
26–35	-1.29	-2.33	-4.58	-3.75
	(-1.56)	(-6.67)	(-11.97)	(-19.31)
36–45	-2.32	-1.39	-2.98	-1.61
	(-3.25)	(-4.39)	(-8.55)	(-8.93)
56–65	-0.03	0.86	-0.46	-0.49
	(-0.04)	(2.22)	(-1.03)	(-2.32)
66–75	-0.26	1.99	0.33	0.88
	(-0.37)	(3.94)	(0.67)	(3.27)
Not married	2.45	-0.13	-0.92	0.32
	(1.69)	(-0.23)	(-1.54)	(0.75)
Household size:				
1.00	1.41	5.00	2.94	4.27
	(0.77)	(6.17)	(3.60)	(8.21)
2.00	4.69	1.48	-0.60	2.04
	(4.55)	(3.09)	(-1.12)	(7.26)
3.00	3.26	0.86	-2.08	0.69
	(2.76)	(1.76)	(-3.67)	(2.25)
5.00	6.99	4.51	-4.47	1.01
	(4.17)	(6.48)	(-6.49)	(2.62)
6 or more	11.09	0.48	3.77	2.11
	(5.52)	(0.49)	(2.88)	(3.58)

We estimate a censored regression model for the portfolio share, separately by education group. The latent variable depends on age group, log net worth, log net worth interacted with age group, marital status, household size, and interview-year dummies (not reported). The omitted category is households with four members, whose head is aged 46–55 and married. The sample consists of stockholders in the 1989–2004 SCF. The table reports the marginal effects at the mean of the regressors with corresponding *t*-statistics in parentheses.

Table 6: Parameters in the benchmark calibration

Parameter	Symbol	Nonhomothetic	Homothetic
Preferences:			
Subjective discount factor	β	0.96	0.96
Utility weight on the luxury good	α	2.2	
Inverse of elasticity of substitution as the basic share approaches 0	λ	2.0	
Inverse of elasticity of substitution as the basic share approaches 1	ϕ	1.1	
Relative risk aversion as the basic share approaches 1	γ	38	7
Growth rate of relative price of the luxury good	q	-8%	
Strength of the bequest motive	b	5×10^6	5×10^2
Labor income:			
Standard deviation of shocks to permanent income	σ_η	14.56%	14.56%
Standard devation of shocks to transitory income	σ_ϵ	20.98%	20.98%
Correlation between shocks to permanent income and stock returns	ρ	0.15	0.15
Asset returns:			
Riskfree rate	$R_f - 1$	2%	2%
Equity premium	$\overline{R}_e - R_f$	4%	4%
Standard deviation of stock returns	σ_ν	18%	18%

The table reports parameters used in the benchmark calibration of the life-cycle consumption and portfolio-choice model with stochastic labor income. In the nonhomothetic model, the household has nonhomothetic utility over basic and luxury goods. The homothetic model corresponds to the standard life-cycle model with power utility. In both models, we calibrate the level of risk aversion to match the portfolio share for the median household in the 46–55 age group. We calibrate the strength of the bequest motive to match the wealth-income ratio for the median household in the 66–75 age group. We solve and simulate both models at an annual frequency.

Table 7: Basic expenditure share in the nonhomothetic model

Percentile of consumption	Age				
	26–35	36–45	46–55	56–65	66–75
Panel A: CEX (Stockholders only)					
0–25	58	59	59	61	65
	(0.8)	(0.6)	(0.7)	(0.7)	(0.8)
25–50	51	53	51	53	58
	(0.9)	(0.6)	(0.6)	(0.7)	(0.8)
50–75	43	48	46	48	48
	(0.9)	(0.6)	(0.6)	(0.7)	(0.9)
75–100	35	39	37	36	38
	(1.0)	(0.7)	(0.6)	(0.8)	(0.9)
Top 5	27	33	29	30	31
	(2.3)	(1.6)	(1.4)	(2.0)	(2.1)
All households	48	50	49	51	53
	(0.5)	(0.3)	(0.4)	(0.4)	(0.5)
Panel B: Nonhomothetic model					
0–25	68	60	60	62	66
25–50	56	51	51	53	57
50–75	49	44	44	45	49
75–100	41	36	35	36	40
Top 5	36	31	30	31	34
All households	53	48	47	49	53

We sort the sample of stockholders in the 1982–2003 CEX into age groups (columns), then into quartiles of total consumption within each age group and interview year (rows). Panel A reports the median of the basic expenditure share (basic consumption as a percentage of total consumption) with asymptotic standard errors in parentheses. Panel B reports the median of basic expenditure share for households simulated in the nonhomothetic model.

Table 8: Wealth-income ratio in the life-cycle model

Percentile of net worth	Age				
	26–35	36–45	46–55	56–65	66–75
Panel A: SCF (Stockholders only)					
0–25	0.3	0.7	1.1	2.0	4.4
	(0.0)	(0.0)	(0.0)	(0.1)	(0.2)
25–50	0.9	1.7	2.8	4.4	7.7
	(0.0)	(0.1)	(0.1)	(0.2)	(0.2)
50–75	1.6	2.9	4.4	6.7	10.9
	(0.2)	(0.1)	(0.2)	(0.3)	(0.5)
75–100	3.9	5.5	8.1	12.0	17.1
	(0.6)	(0.4)	(0.3)	(0.6)	(1.1)
Top 5	9.3	9.7	14.6	17.2	24.4
	(1.6)	(0.5)	(0.8)	(1.2)	(2.9)
All households	1.3	2.2	3.5	5.4	8.7
	(0.2)	(0.1)	(0.1)	(0.2)	(0.5)
Panel B: Nonhomothetic model					
0–25	0.3	3.9	6.6	8.6	9.3
25–50	1.1	3.4	5.0	6.6	8.6
50–75	1.7	3.1	4.2	5.6	8.1
75–100	1.9	2.8	3.6	4.8	7.9
Top 5	1.9	2.6	3.3	4.6	7.6
All households	1.3	3.2	4.7	6.3	8.5
Panel C: Homothetic model					
0–25	0.4	4.8	8.8	11.4	8.5
25–50	1.4	5.2	8.5	10.5	8.8
50–75	2.2	5.4	8.3	9.9	8.8
75–100	3.0	5.7	7.9	9.1	8.6
Top 5	3.3	5.8	7.6	9.0	8.8
All households	1.7	5.3	8.4	10.2	8.7

We sort the sample of stockholders in the 1989–2004 SCF into age groups (columns), then into quartiles of net worth within each age group and interview year (rows). Panel A reports the median of the ratio of net worth to income with asymptotic standard errors in parentheses. Panel B (Panel C) reports the median of the ratio of wealth to income for households simulated in the nonhomothetic (homothetic) model.

Table 9: Portfolio share in the life-cycle model

Percentile of net worth	Age				
	26–35	36–45	46–55	56–65	66–75
Panel A: SCF (Stockholders only)					
0–25	25	23	19	18	15
	(7.9)	(12.5)	(3.9)	(1.1)	(1.0)
25–50	21	19	22	20	16
	(0.8)	(0.6)	(0.6)	(0.6)	(0.8)
50–75	23	25	30	30	24
	(1.0)	(0.6)	(0.5)	(0.6)	(0.7)
75–100	40	44	51	47	44
	(0.7)	(0.4)	(0.3)	(0.3)	(0.4)
Top 5	61	67	68	65	65
	(1.2)	(0.5)	(0.4)	(0.4)	(0.5)
All households	26	28	30	29	22
	(1.9)	(2.6)	(0.8)	(0.3)	(0.3)
Panel B: Nonhomothetic model					
0–25	100	25	20	19	18
25–50	58	32	27	26	22
50–75	47	38	34	32	26
75–100	51	46	43	40	28
Top 5	54	50	48	43	30
All households	61	35	30	29	23
Panel C: Homothetic model					
0–25	100	45	30	25	21
25–50	100	42	31	26	22
50–75	78	41	31	27	23
75–100	62	40	32	28	25
Top 5	59	39	32	28	25
All households	94	42	31	26	23

We sort the sample of stockholders in the 1989–2004 SCF into age groups (columns), then into quartiles of net worth within each age group and interview year (rows). Panel A reports the median of the portfolio share (risky assets as a percentage of net worth) with asymptotic standard errors in parentheses. Panel B (Panel C) reports the median of the portfolio share for households simulated in the nonhomothetic (homothetic) model.

Table 10: Portfolio share in the life-cycle model with unemployment risk

Percentile of net worth	Age				
	26–35	36–45	46–55	56–65	66–75
Panel A: SCF (Stockholders only)					
0–25	25	23	19	18	15
	(7.9)	(12.5)	(3.9)	(1.1)	(1.0)
25–50	21	19	22	20	16
	(0.8)	(0.6)	(0.6)	(0.6)	(0.8)
50–75	23	25	30	30	24
	(1.0)	(0.6)	(0.5)	(0.6)	(0.7)
75–100	40	44	51	47	44
	(0.7)	(0.4)	(0.3)	(0.3)	(0.4)
Top 5	61	67	68	65	65
	(1.2)	(0.5)	(0.4)	(0.4)	(0.5)
All households	26	28	30	29	22
	(1.9)	(2.6)	(0.8)	(0.3)	(0.3)
Panel B: Nonhomothetic model					
0–25	7	24	20	19	18
25–50	27	32	27	26	22
50–75	36	37	33	31	25
75–100	45	46	43	40	28
Top 5	50	48	48	43	30
All households	30	34	30	29	23
Panel C: Homothetic model					
0–25	23	44	30	25	21
25–50	92	42	31	26	22
50–75	75	40	31	27	23
75–100	61	39	31	28	24
Top 5	57	38	31	28	25
All households	69	41	31	26	23

We sort the sample of stockholders in the 1989–2004 SCF into age groups (columns), then into quartiles of net worth within each age group and interview year (rows). Panel A reports the median of the portfolio share (risky assets as a percentage of net worth) with asymptotic standard errors in parentheses. Panel B (Panel C) reports the median of the portfolio share for households simulated in the nonhomothetic (homothetic) model. The probability of unemployment in the model is 0.5%.

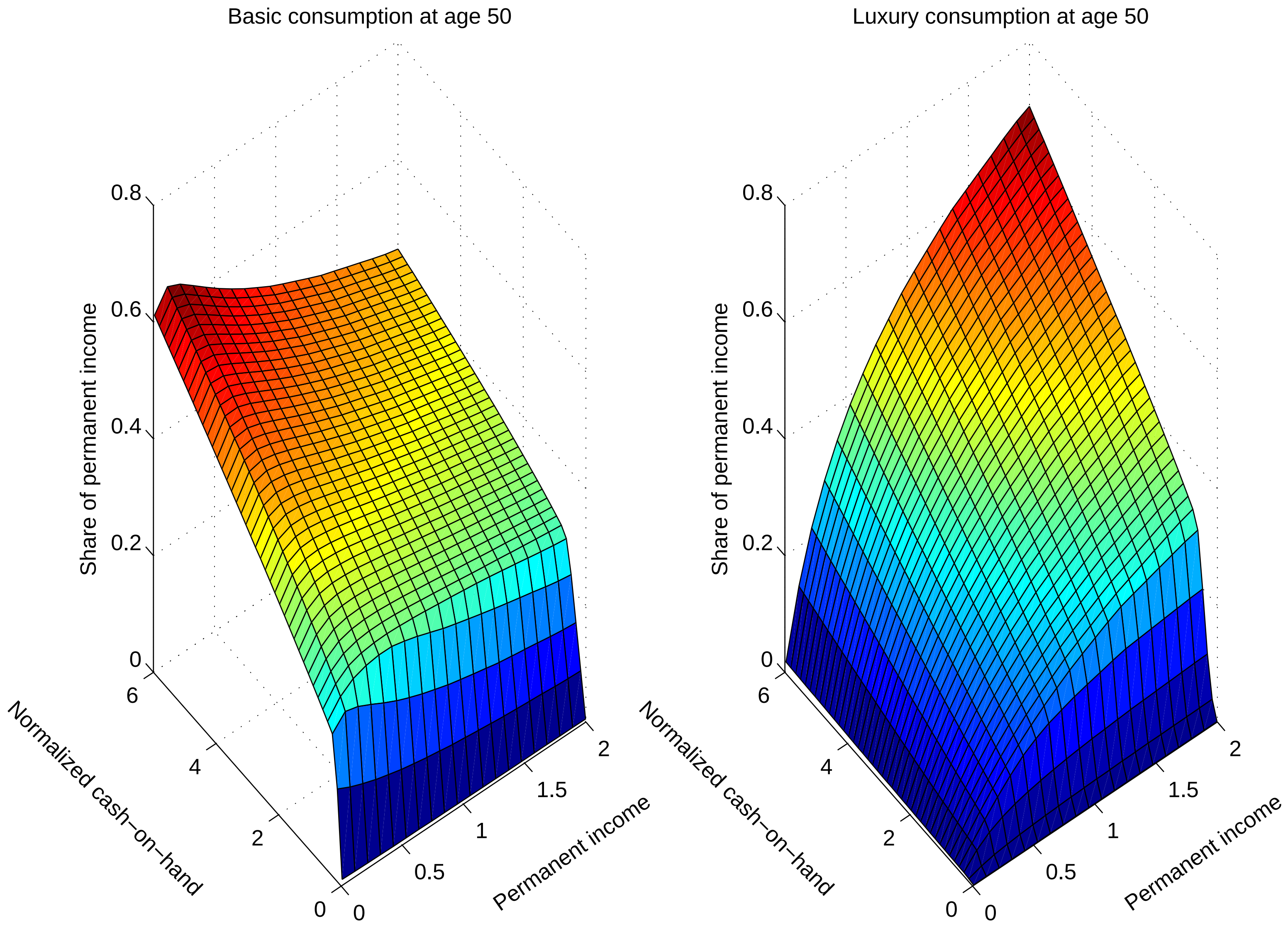

Figure 1: Optimal consumption policy in the nonhomothetic model

The figure shows the optimal consumption policy at age 50 for a life-cycle consumption and portfolio-choice model with nonhomothetic utility. The policy variables are basic consumption ($b = B/P$) and luxury consumption ($Ql = QL/P$), both expressed in units of basic consumption and normalized by permanent income. The state variables are normalized cash-on-hand ($w = W/P$) and permanent income (P). The household receives stochastic labor income from ages 26 through 65 and retirement income from ages 66 through 76. Table 6 reports the preference and income parameters of the model.

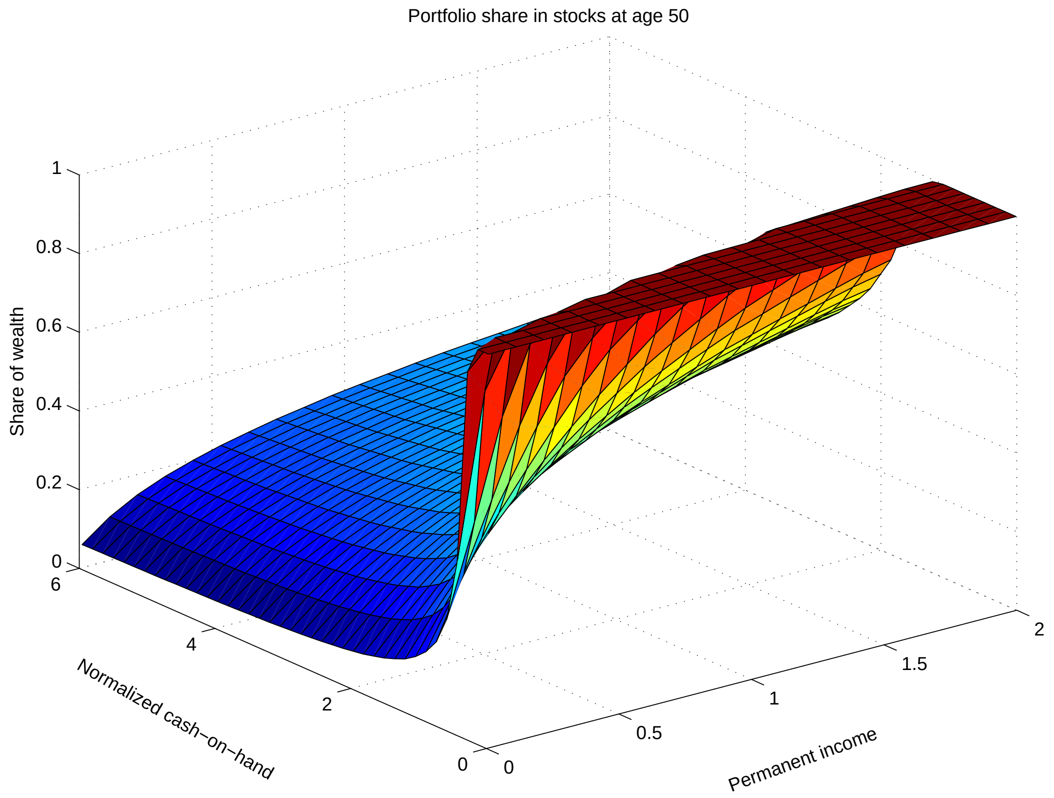

Figure 2: Optimal portfolio policy in the nonhomothetic model

The figure shows the optimal portfolio policy at age 50 for a life-cycle consumption and portfolio-choice model with nonhomothetic utility. The policy variable is the portfolio share (a). The state variables are normalized cash-on-hand ($w = W/P$) and permanent income (P). The household receives stochastic labor income from ages 26 through 65 and retirement income from ages 66 through 76. Table 6 reports the preference and income parameters of the model.