The Impact of Individual Investment Behavior for Retirement Welfare: Evidence from the United States and Germany

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Abstract Much of the industrialized world is undergoing a significant demographic shift, placing strain on public pension systems. Policymakers are responding with pension system reforms that put more weight on privately managed retirement funds. One concern with these changes is the effect on individual welfare if households invest suboptimally. Using micro-level data from the United States and Germany, we compare the optimal expected lifetime utility computed using a realistically calibrated model with the actual utility as reflected in empirical asset allocation choices. Through this analysis, we are able to identify the population subgroups with relatively large potential for welfare gains. Our results should be helpful to public policymakers in designing programs to improve the performance of privately organized retirement systems.

Keywords Asset Allocation, Retirement Welfare, Pension Reform

JEL-Classification D14, D91, G11, G28, I31

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1 Introduction

Much of the industrialized world is undergoing a significant demographic shift, with low birth rates and increasing longevity (see, e.g., United Nations, 2007). One consequence of the aging population is an increasing strain on public pension systems. Many such systems are pay-as-you-go plans, created under the expectation that inflow would be generated from current workers whose number exceeds the population of retirees. Today's reality is a shrinking supply of workers relative to retirees.[1] As a result of these changing demographics, concern is rising over the ability of government pay-as-you-go programs to remain viable.

Policymakers are responding with a variety of pension system reforms. The general trend is to put more weight on funded, individually organized retirement systems. Considering the broad evidence that many individuals have problems to evaluate investments opportunities, e.g., to interpret basic measures of risk and return correctly,[2] the shifting of old-age provision to individuals themselves raises a central question: How well are various population subgroups prepared to make financial decisions with respect to their old-age provision?

To answer this question, we use micro-level data and investigate the performance of individual retirement wealth accumulation. Within the wealth accumulation process, our focus is, as in Calvet, Campbell, and Sodini (2007), asset allocation.[3] The latter utilize a classical, perfect markets Merton (1969)-Samuelson (1969) framework with lifecycle and endowment invariant optimal asset allocation policies ("one-size-fits-all") to address the problem of underdiversification of risky assets and nonparticipation in risky assets. Here, a more realistic, imperfect markets framework is considered yielding optimal asset allocation policies that are strongly dependent on the point in time of the lifecycle and the endowment of an individual. Our analysis thus integrates heterogeneity in optimal asset allocation with respect lifecycle and endowment effects, concentrating on the share of wealth invested in risky assets.

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[1] In the United States, for example, in 1950 the ratio of people aged 20 to 64 relative to those over age 64 was 7.25. Today that ratio is 4.71, and by 2030, the ratio is estimated to fall to 2.58 (U.S. Census Bureau, 2008). Comparable values for Germany are 6.25 in 1950, 3.13 for today, and an estimated 2.00 for 2030 (Federal Statistical Office, 2006).

[2] Several striking examples are provided in, e.g., Lusardi and Mitchell (2007); John Hancock Financial Services (2002).

[3] Savings adequacy, the second major decision within the allocation process, is addressed in, e.g., Scholz, Seshadri, and Khitatrakun (2006); Skinner (2007).

We also compare the performance of U.S. and German investors. This comparison is especially valuable because of the institutional differences in the respective retirement systems. The United States has a longer tradition for privately funded retirement systems, because government pensions historically have been less generous.[4] Thus, we can investigate whether longer experience with individually funded systems leads to better asset allocation results. This further helps to determine in which direction reforms should alter a pension system—that is, toward more individually managed funding (and income provision) or not.

To evaluate investment performance, we use a utility-based welfare benchmark. Alternative monetary-based benchmarks such as expected wealth (or quantiles of the distribution) at retirement (e.g., as in Poterba et al., 2007, or in Watson and Naughton, 2007) are not suitable because we allow for heterogeneity in individual preferences and endowments. For example, for people with different risk aversion, it should be completely rational to follow asset allocation strategies with different degrees of risk and thus accept different levels in expected retirement wealth. Focusing only on expected retirement wealth, reforms may outweigh high-risk/high–expected wealth strategies.

To calculate our welfare measure, we employ a method similar to Dammon, Spatt, and Zhang (2004); Cocco, Gomes, and Maenhout (2005) and Yao and Zhang (2005). As such, we compare the expected lifetime utility a household receives following an optimal asset allocation pattern with the expected lifetime utility received following the investment strategy observed in our data. We achieve this by taking the following steps: First, we analyze data from two large data sets, the U.S.-based Survey of Consumer Finances (SCF) and the German Income and Expenditure Survey (EVS). Using a regression model, empirical asset allocation policy is estimated as a function of household characteristics (e.g., age, education) and endowments (income and wealth). Next, we calculate the optimal—that is, benchmark—asset allocation policy and the resulting expected utility. For this we solve the dynamic optimization problem given by a realistically calibrated life-cycle consumption-saving-asset allocation model with stochastic uninsurable labor income, asset returns, and life

4 In 2004, 48% of retirement income for the population aged 65 and older was generated by Social Security, railroad retirement, or government employee pensions (see Social Security Administration, 2006). In Germany, the government system (Gesetzliche Rentenversicherung) in 2003 provided around 66% of retirement income (Federal Ministry of Health and Social Affairs, 2005).

span. Finally, we place the empirical asset allocation policy functions, instead of the optimal functions, into the expected utility model and compare the resulting utility with the optimal one.

Our results are highly relevant for policymakers in their deliberations about changes to public and private pension systems. We are able to identify the population subgroups with relatively large potential welfare gains, thus the groups for which public policy could implement improvement measures. Specifically, households with low labor income and/or high (in the U.S.) or median (in Germany) wealth would benefit most from better asset allocations.

The paper is organized as follows: A review of the literature in section 2 is followed in section 3 by the definition and calibration of the normative benchmark model. Section 4 describes the data used, and presents results of our econometric analyses. The welfare analysis is performed in section 5 and results are discussed. We derive policy implications in section 6.

2 Relationship to Existing Literature

There are two general approaches to research on household finance: positive research, which investigates the actual behavior of people, and normative research, which aims to derive how people should behave according to a set of rational criteria (see, e.g., Campbell, 2006). Our contribution confronts the former with the latter by measuring differences in utility (measured using a normative model) for households whose asset allocation deviates from the normatively given optimal asset allocation.

2.1 Empirical Evidence – the Positive Research

Because of their fundamental role in decision making under uncertainty, risk attitudes and implications for individual asset allocations are of significant interest to policymakers and economists. In the following we give a short overview of the empirical literature that use regression analyses in the context of asset allocations for the United States and Germany.

Bajtelsmit and VanDerhei (1997) use data on asset allocation choices in U.S. pension plans and find that investments in risky assets increase if the respondent is male, middle-aged, and wealthy. Hinz, McCarthy, and Turner (1997) find that women exhibit more risk aversion when making choices for assets in a U.S. pension fund. Employing a proprietary data set of U.S. 401 (k) pension plan choices, Agnew, Balduzzi, and Sunden (2003) find that men invest more in equities and trade more frequently than do women. They also find that being married and having higher income is associated with more aggressive investing behavior. Older age, however, leads to greater caution in asset allocations. The results of Ameriks and Zeldes (2004) support this finding. Poterba and Samwick (2001) and Bertaut amd Starr-McCluer (2002) (the latter using the SCF 1998 wave), however, find a hump-shaped asset allocation pattern associated with age. Furthermore they find increasing investments into risky assets with for lower income (portfolio share), higher income (holding probability), and higher wealth, and higher education. Curcuru et al. (2004) find (using the 2001 wave of the SCF) increasing probabilities to invest and portfolio shares for age, wealth and education, whereas higher income raises the probability to invest and decreases the portfolio share.

Using data from the 1998 wave of the Survey of Consumer Finances (SCF), Sunden and Surette (1998) investigate probabilities to invest mostly in stocks or mostly in bonds. Their results highlight marital status as a driver for investment behavior. Single men are more likely than single women and married men to invest mostly in stocks; married women, however, do not differ significantly from other groups with respect to the mostly stock probability. Single women are less likely than married women to choose mostly bonds. Using the same data set, Jianakoplos et al. (2003) find that not marital status per se but differences in financial endowments between married and nonmarried persons influence investment behavior.

Using the German Income and Expenditure Survey (EVS) data, Eymann and Börsch-Supan (2002) find that investments into risky asset increase if the respondent is not middle-aged, wealthier and has higher education. Sommer (2005), finds in age increasing ownership rates and portfolio shares for Germany in an univariate analysis.

According to the literature, therefore, gender, marital status, education, wealth, income, and age all seem to affect risk-taking behavior with respect to asset allocation.

2.2 Optimal Asset Allocations and Individual Welfare Considerations – the Normative Analysis

2.2.1 Optimal Asset Allocations

During the 1960s and 1970s, researchers gave significant attention to the problem of optimal life-cycle allocation of resources between consumption and saving and across types of assets (Phelps, 1962; Yaari, 1965; Mossin, 1968; Hakansson, 1969, 1970; Merton, 1969, 1971; Samuelson, 1969; Richard, 1975; Kotlikoff and Spivak, 1981). The optimal decision rules derived yielded constant, age-invariant, proportional asset allocations. Necessary for such results were rigorous assumptions such as intertemporally separable constant relative risk aversion (CRRA) utility, infinite time horizon, or complete markets, where the individual can span all assets including human capital, or the absence of borrowing or short-selling restrictions.

More recent research offers optimal decision rules with increasing relaxation of such assumptions. Based on realistically calibrated consumption-saving-asset allocation intertemporal optimization models, decisions depend on, e.g., education, age, human capital (i.e., the stock and riskiness of labor/pension income and pension age), wealth, taxation, transaction costs, and the likelihood of binding borrowing or short-selling restrictions.[5] A detailed discussion of the specific impact of these factors based on the normative model used here is given in section 3.3.

[5] See Zeldes (1989); Deaton (1991); Carroll (1992, 1997); Hubbard, Skinner, and Zeldes (1994, 1995); Heaton and Lucas (1997, 2000); Laibson, Repetto, and Tobacman (1998); Viceira (2001); Campbell and Viceira (2002); Blake, Cairns, and Dowd (2003); Gomes and Michaelides (2003, 2005); Haliassos and Michaelides (2003); Dammon, Spatt, and Zhang (2004); Lachance (2004); Cocco (2005); Cocco, Gomes, and Maenhout (2005); Davis, Kubler, and Willen (2005); Yao and Zhang (2005); Horneff, Maurer, and Stamos (2006); Post, Gründl, and Schmeiser (2006); Polkovnichenko (2007); and Gomes, Kotlikoff, and Viceira (2008). An extensive overview of the literature that relaxes complete market assumptions is given by Curcuru et al. (2004).

2.2.2 Individual Welfare Considerations

Section 2.1 presented evidence that individual investment behavior differs according to various factors such as age, wealth, and income. Because different investment strategies lead to different wealth outcomes, more conservative investment strategies result in lower expected wealth.[6] But, differences in investment behavior can be a completely rational reaction to differences in preferences or endowments. Thus, a highly risk-averse individual may be completely happy with low expected final wealth, if the volatility of the wealth distribution is also sufficiently low. Therefore, a comparison of investment strategies should incorporate the contribution of preferences and endowments. For this, concept of lifetime utility can be used. The actual behavior (e.g., asset allocation) is compared with some benchmark behavior derived using the normative lifetime utility model, which yields a utility-based welfare measure.

Among the important welfare analyzes in the area of asset allocation are Dammon, Spatt, and Zhang (2004); Cocco, Gomes, and Maenhout (2005); and Yao and Zhang (2005); Calvet, Campbell, and Sodini (2007); and Gomes, Kotlikoff, and Viceira (2008). Dammon, Spatt, and Zhang (2004) compare commonly observed investment choices with optimal choices while focusing on the location of assets to taxable vs. tax-deferred accounts. Cocco, Gomes, and Maenhout (2005) compare common investment advisers' recommendations with the optimal choices and furthermore evaluate the effect of ignoring labor income or labor income risk while deriving the optimal choice. Similarly, Gomes, Kotlikoff, and Viceira (2008) evaluate life-cycle funds allocation strategies, allowing also for flexible labor supply. The welfare costs of not following an optimal renting versus owning a house strategy are calculated by Yao and Zhang (2005).[7] The work closest to ours is Calvet, Campbell, and Sodini (2007) who—using Swedish micro-level data on individual asset allocation—,

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[6] For example, the simulation by Watson and McNaughton (2007) shows for Australian investors that women, being more-risk averse, end up with lower expected retirement wealth.

[7] Poterba et al. (2006) also use a utility-based benchmark for investigating the performance of DB and DC plans, but restrict the measurement of utility to the wealth distribution at one single point in time (age 63), thus abstracting from life-cycle effects.

measure the welfare costs of underdiversification of risky assets and nonparticipation in risky assets, considering herby stocks and mutual funds. Our approach extends Calvet, Campbell, and Sodini (2007) by allowing for lifetime and (nontradeable) labor income uncertainty, heterogeneity in endowments (income and wealth) for calculating optimal asset allocations. Consequently, we here allow for heterogeneity in optimal asset allocations with respect to the share of wealth invested optimally. Moreover, in a simplified way, we include real estate as a risky investment option.

3 Optimizing Asset Allocations and Wealth over the Life-Cycle – The Normative Benchmark Model

In this section, the normative benchmark model is defined and calibrated with empirical data. We derive the optimal asset allocation—depending on the household's characteristics—over the life cycle.

3.1 The Household's Problem

For our normative analysis, we use the workhorse for solving intertemporal allocation problems, discounted utility. The household maximizes the expected utility of consumption C (all monetary variables are in nominal terms) over his stochastic life span. The intertemporally separable utility function $U(C)$ is defined as:

$$U(C)=\sum_{t=0}^{T-x}\delta^{t}\left(\prod_{i=0}^{t}p_{i}\right)U_{t}(C_{t}). \tag{1}$$

T denotes the maximum life span, x the current age, δ the subjective discount factor, and p_t the probability of the household to survive from period $t-1$ to t. We assume no bequest motives; thus, the one-period CRRA-utility function $U_t(C_t)$, with γ as the coefficient of relative risk aversion, is given by:

$$U_t\left(C_t\right)=\begin{cases}\mathrm{Log}\left(\dfrac{C_t}{\left(1+\pi\right)^t}\right), \text{with } \gamma=1\\ \dfrac{\left(\dfrac{C_t}{\left(1+\pi\right)^t}\right)^{1-\gamma}-1}{1-\gamma}, \text{otherwise,}\end{cases} \tag{2}$$

as long as the household lives and 0 otherwise. Nominal consumption at time t, C_t, is adjusted for inflation at rate π.

At each point in time t, the household decides how much to consume (implicitly determining savings) and how to allocate savings. Financial wealth at time t is denoted by W_t. Savings S_t are allocated to both a risk-free investment and a risky investment.[8] The proportion of savings invested riskily each period, α_t, earns the risky return R_t whereas the rest $(1 - \alpha_t)$ is compounded at the risk-free return R_f. We assume that the household cannot borrow money or short-sell the risky asset. The household earns stochastic labor income L_t from age x to age 64 at the end of each year t. In later periods, from age 65 to T, L_t is replaced by a deterministic (government) pension income stream that stays constant in real terms. Thus, the retirement age is exogenously fixed at age 65.

The maximization problem is given by:

$$\max_{\alpha_t, C_t} \mathrm{E}_0\left(U\left(C\right)\right), \tag{3}$$

subject to consumption constraints:

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[8] We thus ignore private annuities as investment opportunity. According to Yaari's (1965) or Davidoff, Brown and Diamond's (2005) complete market environment models, annuities enhance welfare significantly. Empirically, however, voluntary annuitization is very limited (see, e.g., Moore and Mitchell, 1997). Using a realistically calibrated model, similar to our model, Inkmann, Lopes, and Michaelides (2007) show that low annuitization or mostly no annuitization is indeed optimal. Thus ignoring annuities as investment opportunity will not have a significant impact on our results.

$$C_0 = W_0 - S_0$$

$$C_t = \underbrace{S_{t-1}\left(1-\alpha_{t-1}\right)R_f + S_{t-1}\alpha_{t-1}R_{t-1} + L_{t-1}}_{W_t} - S_t \quad \forall \quad t \in \{1,2,...,T-x\}, \tag{4}$$

subject to borrowing constraints:

$$0 \le S_t \le W_t, \tag{5}$$

and subject to no-short-sale constraints:

$$0 \le \alpha_t \le 1. \tag{6}$$

3.2 Calibration

In this section we calibrate our model for U.S. and for German households. We report the choice of our benchmark parameters, but also give alternative values that will be used for sensitivity analyses later in the paper. Table 1 summarizes the calibration.

The household's preferences are described by setting the constant of relative risk aversion γ to 2 (alternatively to 1 or 3), the subjective discount factor δ to 0.97 (alternatively to 0.95 or 0.99), which are typical values found in intertemporal optimization models (see, e.g., Laibson, Repetto, and Tobacman, 1998).

For the U.S. survival probabilities, we use the United States Life Tables 2003 (see Arias, 2006); for German survival probabilities, we use the Life Table for Germany 2002/2004 from the German Federal Statistical Office (see Federal Statistical Office, 2003). Both tables reflect average population mortality, and have a maximum age of 100 years.

As proxy for the risky asset, we use a broadly defined market portfolio consisting of equity (including corporate and foreign bonds) and real estate. The proportion of equity and real estate in this portfolio is given by the overall share of equity and real estate held in each country by households (and non-profit organizations). For the

United States (Germany) the relevant share for equity equals 46% (48%) and for real estate 54% (52%).[9]

As proxy for the equity return we use a broad-based stock market index. For the United States, we use data from 1926 to 2006 from Morningstar (see Morningstar, 2007). After deducting typical transaction costs of an index-investment fund of 0.7% per annum, the mean of the equity return is given by 1.1151, and the standard deviation is 0.1996. For Germany, we use 1955–2006 data provided by Professor R. Stehle, Ph.D., Chair of Banking and Stock Exchanges, Humboldt-Universität zu Berlin (Germany), which give mean 1.1264 and standard deviation 0.2792 for the equity return after assuming identical transaction costs.[10]

For the United States real estate returns are assumed to have a mean return of 1.0 in real terms and a standard deviation of 0.1. After considering annual maintenance cost of 1.5% and annual transaction costs of 0.4320% of the house market value and the inflation rate reported below, the nominal mean real estate return equals 1.0111 and

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[9] U.S. equity and real estate the shares are taken from Federal Reserve Flows of Funds Accounts of the United Stated data from 2003 to 2007 (see http://www.federalreserve.gov/releases/z1/Current/). The amount of equity (and corporate and foreign bonds) is given by the sum of: corporate and foreign bonds, corporate directly held equity, proprietors' investment in unincorporated businesses and 20% of (mutual fund share holdings + life insurance reserves + pension fund reserves) (this take into account that only some of the latter assets are invested riskily and that guarantee funds limit the risk from the households perspective). The amount of real estate equals entry "real estate". For Germany the amount of equity and risky bonds is taken from Deutsche Bundesbank (2007) including data from 1996 to 2006. The amount of equity (and corporate and foreign bonds) is given by the sum of: shares, other equity and 20% of (bonds + mutual funds shares + claims on insurance corporations + claims from company pension commitments + other claims including accumulated interest-bearing surplus shares with insurance corporations) (here we have no specific data for the corporate and foreign bond share in bonds). The amount of real estate is given by assuming that 28% of the economy's overall residential real estate (see, Federal Statistical Office, 2002, 2007) is held by households (this equals the share of overall risky financial assets (without real estate) that is held by households as given by Deutsche Bundesbank, 2007).

[10] By using country-specific estimates for stock and real estate returns, i.e., by defining local assets to be the relevant investment opportunity, our household cannot fully utilize the benefits of worldwide diversification. We hereby avoid the computational burden to additionally model exchange rates to express returns in local currency. Furthermore, many firms included in local stock indices already represent the performance of internationally diversified businesses.

the standard deviation 0.1011 per annum.[11] For Germany we use a mean return of 1.0065 and a standard deviation of 0.0180. Again, after considering annual maintenance cost of 1.5% and annual transaction costs of 0.0873%, and the inflation rate reported below, the nominal mean return equals 1.0182 and the standard deviation 0.0182 per annum.[12]

Finally, assuming as in Cauley, Pavlov, and Schwartz (2007) a correlation coefficient for equity and real estate returns of 0.2, the mean of the overall portfolio return of the risky asset, consisting of equity and real estate, R_t is given for the United States (Germany) by 1.0590 (1.0695) and the standard deviation is given by 0.1158 (0.1322). Risky asset returns are assumed to be lognormal and i.i.d..

For the risk-free asset return, the short-term money market is used as a proxy. Given the same sample periods, the R_f is set to 1.0361 per annum for the United States (see Morningstar, 2007) and to 1.0472 for Germany (see IMF International Financial Statistics Online database, http://ifs.apdi.net/imf), again after assuming typical transaction costs of an index-based investment of 0.18%.

For inflation, we use the same sample period, resulting in a value of 0.031 for the United States (see Morningstar, 2007) and 0.0279 for Germany (see Federal Statistical Office, 2007).

The labor income process is calibrated to match empirically observed life-cycle household income profiles. Ideally, we would like to have estimates that reflect the labor income process as given by data used also in the regression analysis later. Our cross-sectional data are not well suited for this. Panel data that include both detailed

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[11] The values for real returns and annual costs are in the range of the estimates reported in Campbell and Cocco (2003); Cocco (2005); Yao and Zhang (2005); Cauley, Pavlov, and Schwartz (2007) and Li and Yao (2007). Transaction costs are annualized based on the data in Cocco (2005) who reports costs of 8% per trade and an annual probability for trading of 5.44%.

[12] Except annual maintenance costs, the values are taken from Maclennan, Muellbauer, and Stephens (1998). Lacking information on annual maintenance cost we use the U.S. value.

longitudinal information on labor income and asset allocation for longer sample periods are, especially for Germany, not available. Thus, we decided to take income profiles from the literature that uses panel data for income.

For the United States, the mean real growth rates of income during the life cycle before retirement (until age 64) are taken from Cocco, Gomes, and Maenhout (2005). The profiles are age and education (low, middle, high) specific. For Germany, we use profiles based on Fitzenberger and Wunderlich (2002) and Behr et al. (2003). These profiles are also age and education (low, middle, high) specific. In both, the United States and Germany, real income profiles are in general hump-shaped in age; in nominal terms (applying the inflation rate defined above), they can be monotonically increasing in age. During retirement, labor income is exogenously replaced by (government) pension income by multiplying the income at age 64 with a replacement factor. For this we use prospective replacement factors, reflecting expected future replacement ratios. For the United States, we use a value of 35% (see Reno and Lavery, 2007), for Germany we use a value of 40% (see Börsch-Supan and Wilke, 2004).

To reflect the fact that labor income is risky, we model each period's labor income to be lognormally distributed and subject to transitory shocks,[13] uncorrelated with the risky asset return (as in Li and Yao, 2007). The mean of L_t is given by the current income at t = -1 with the growth rates and inflation described above. Until age 64, the standard deviation for U.S. households is set to $0.19 \cdot \mathrm{E}(L_t)$ (see Carroll and Samwick, 1997). For German households, we do not have empirical estimates and use $0.05 \cdot \mathrm{E}(L_t)$, which should reflect that in the German welfare state, income risks are comparatively lower than in the United States. From age 65—that is, during retirement—we assume no labor income uncertainty.

[13] The literature contains much controversy about whether shocks to labor income are permanent or transitory. Newer empirical evidence gives mixed results (see, e.g., Guvenen, 2007). Because using transitory shocks makes the computational solution of the optimization problem much faster, we implemented only transitory shocks.

For our calculations we finally assume no taxes. Table 1 summarizes the calibration of the model parameters.

Table 1: Parameter Calibration for the Benchmark Model

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The optimization problem (3)–(6) is solved backward via stochastic dynamic programming. Further details are given in Appendix A.

3.3 Asset Allocations According to the Benchmark Model

In this section, we show how optimal asset allocations—that is, the percentage share of savings invested into the risky asset—are influenced by the various input parameters. The results will serve as hypotheses for the empirical estimations in section 4 and build the basis for analyzing welfare effects in section 5. We describe the impact of risk aversion, the subjective discount factor, the survival probability, age, education, the capital market environment, wealth, and expected labor income. We begin with an explanation of the effect of wealth and expected labor income, because some of the other effects depend on the ratio of expected labor income to wealth.

Whereas in a model without labor income the household's risky asset share is age, time, and wealth invariant, here, the risky asset share increases in the labor income–to–wealth ratio, because labor income serves partially as a risk-free asset (Viceira, 2001; Cocco, Gomes, and Maenhout, 2005). Note that the CRRA feature of the one-period utility function still can result in an asset allocation that is invariant with respect to some fixed value of the labor income–to–wealth *ratio*. This means that, for example, while doubling wealth and current labor income, the asset allocation stays constant, if expected labor income is doubled in all future periods.[14]

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[14] Note that, if leaving, for example, the discounted value of expected labor income constant but changing the shape of the life-cycle income profile over the life cycle would,

A typical shape of the investment into the risky asset as a function in the labor income–to–wealth ratio is shown in Figure 1.

Figure 1: Investment into the risky asset as a function in the labor income–to–wealth ratio for German (EVS) data, $\gamma = 2$, $\delta = 0.97$, Age = 30, Education = Middle

--- *put Figure 1 here* ---

The impact of risk aversion on the risky asset share is straightforward. The risky asset share decreases with increasing values for γ. The impact of a change in the subjective discount factor δ depends on the household's expected labor income. Both increases and decreases of the risky asset share are possible. In general, increasing δ will result in higher savings, because the household places more weight to future utility. By saving more, the household's expected labor income decreases relative to the higher saving–induced increase in wealth, thus resulting in a lower risky asset share. But putting more weight on future utility also implies that the household's value of future labor income is larger (less discounted), and thus the risky asset share can also increase. The overall effect in general is rather small. Having a higher life expectancy—that is, higher one-period survival probabilities p_t—is similar to an increase in δ. Thus, the overall effect is small and ambivalent.

Increasing age has generally a negative impact on the risky asset share given some fixed value for the labor income–to–wealth ratio which is illustrated in Figure 2. With increasing age the amount of expected future labor income decreases, leading to a lower risky asset share. The kink at age 66 results from a measurement effect: the retirement-induced drop in income at the end of age 65 lowers the labor income–to–wealth ratio for a fixed value of wealth. Thus, in order to stay on a line in Figure 2, i.e., hold the labor income–to–wealth ratio constant, wealth also has to decrease.

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in general, result also in a change in asset allocation, because the likelihood of binding no-short-sale or borrowing constraints in future periods is changed.

Consequently, from the perspective of this lowered amount of wealth the overall discounted value of future labor income is relatively larger leading to an increase in the risky asset share. Note that in reality, i.e., in a situation where more factors than age will change at the same time, one would expect the household to jump at retirement from one line to another, reflecting a drop in the labor income–to–wealth ratio.

Figure 2: Investment into the risky asset as a function in age for German (EVS) data, $\gamma = 2$, $\delta = 0.97$, Education = Middle

--- put Figure 2 here ---

The effect of education on the risky asset share in our model is solely driven by differences in expected future labor income. Higher education is associated with higher growth rates of labor income during the life cycle, resulting in higher expected labor income (for a given current income), leading to a higher risky asset share.

The effect of capital market conditions is highlighted by comparing U.S. and German capital market data in Table 1. U.S. and German investors can expect a similar risk premium of 2 percentage points, but with a considerably smaller standard deviation for U.S. investors. Consequently, U.S. households should invest a higher share into risky assets. For example, an American CRRA-investor with zero labor income (other parameters at base values) would invest 92%, and a German investor would invest around 70% into the risky asset.

4 Econometric Analysis of Actual Asset Allocation Behavior

4.1 Data Description and Sample Selection

For the United States, we use data from the 2004 wave of the Survey of Consumer Finances (SCF). The data set contains detailed information on 4,519 households, including household demographics, assets and liabilities, income, and other characteristics.[15] Data have been collected by a dual frame sample design. Data for about 3,000 households are drawn from a representative sample of households to reflect characteristics that are broadly distributed in the population, such as home and vehicle ownership. The other set of 1,500 survey cases is drawn from an oversampling of wealthy households (based on tax records).

For Germany, we employ data from the 2003 wave of the Income and Expenditure Survey (EVS). The available data set for scientific use also includes numerous data on income, asset allocation, liabilities, and expenditures of 42,744 private households.[16]

We exclude all self-employed households from the analysis. For the United States, self-employed households represent 11.8% (based on the weight given in the data set); for Germany, 5.3%. This exclusion was necessary, because, in the German data, the value of own businesses—a major part of the asset allocation among those who are self-employed—is not reported. Furthermore, we excluded cases that are located below or equal to zero in the labor income and wealth (net worth) distribution (10.5% of weighted cases for the United States and 8.8% for Germany).

Another restriction is given by the welfare analysis in section 5 that builds on the intertemporal optimization model of section 3. The data and regression results serve as input for section 5. The underlying optimization model does—as a standard assumption—not allow for borrowing and short-selling. Deleting households having debt would exclude the majority of U.S. and also many German respondents, which is not desirable. Instead, we deducted debt from the amount of investments made into the risky asset—that is, we treated debt as a negative risky asset.[17] Thus, finally we

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15 See Bucks, Kennickell, and Moore (2006) for an overview of the SCF.

16 In the 2003 survey, 53,432 households were originally interviewed. The data set for scientific use, though, was made anonymous, which has resulted in an exclusion of 20% of the household data.

17 By doing this we implicitly assume that debt fluctuates similarly in value as risky assets do. For both the U.S. and Germany this assumption can be justified by the contractual nature of mortgage contracts (which is the major kind of debt). The majority

had to exclude only households for whom the resulting risky asset share variable used in our optimization (see section 3.1) and regression (see section 4.3) models was below 0% (13.7% of weighted cases for the United States and 5.3% for Germany). Our final SCF data set reduces to a sample size of 2,559 cases, and the EVS data set contains 34,929 cases.

Table 2 shows country-specific descriptive statistics on demographic and financial characteristics of the full data sets and the samples selected. The variables finally used in our regression analyses are in italics.

Table 2: 2004 Survey of Consumer Finances (SCF) and 2003 Income and Expenditure Survey (EVS) (for definition of variables, see Appendix B)

--- *put Table 2 here* ---

The descriptive statistics in Table 2 include two variables indicating the amount of risky assets. The first, risky 1, a more commonly used measure (e.g., as in Bertaut and Starr-McCluer, 2002) including stocks, stock mutual funds and similar investments (see Appendix B). The second, more broadly defined measure, risky 2, includes the value of real estate and, as negative investments into risky assets, as explained above, debt.

Comparing the amount invested riskily in the United States and Germany using the measure risky 2 (the variable used in our regression later), we observe that Americans invest a higher share into the risky asset (59% vs. 53%). We also see that financial wealth and income vary to a great extent in and between both countries. As the benchmark model revealed, the financial endowment should influence the risky

of contracts in both countries are fixed-rate mortgage (see Campbell and Cocco, 2003 and Maclennan, Muellbauer, and Stephens, 1998). Thus the real value of these contracts, derived by discounting future cash flows, should be strongly dependent on the level of long-term interest rates, which is also the case for, e.g., stocks. Long-term interest rate risk is not modelled here, but fluctuations in the value of risky assets can be thought of as stemming partially from this risk.

asset choice significantly. The following section contains the econometric analysis which controls for heterogeneity in endowments and other factors.

4.2 Hypotheses about the Investment Process and Implications for Regression Models

In the literature (e.g., Bertaut and Starr-McCluer, 2002; Eymann and Börsch-Supan, 2002), two general hypotheses about the investment process are discussed. The first assumes that the choice to invest into risky assets is made simultaneously with the decision on the share of wealth invested. The second hypothesis assumes a two-stage investment process. At the first stage, the individual decides whether to invest in the risky asset; at the second stage, the share is independently derived.

The normative benchmark model from section 3 is based on a simultaneous decision process. Consequently, we use an empirical estimation strategy that is compatible with such behavior, a tobit model (Tobin, 1958). This model takes into account that the dependent variable (percent risky 2) is censored at 0 and 1. The underlying economic interpretation is that households having the value of, for example, 0 for the risky asset share would actually invest negative shares, but are restricted from doing so.[18]

4.3 Variable Selection and Expected Signs of Coefficients

The selection of variables is based on the input variables of the normative benchmark model of section 3. The dependent variable is the risky asset share of investments, "percent risky 2". Our dependent variable includes the usual risky assets, but also real estate and with a negative sign debt. Although houses are not as liquid as stocks, there is some evidence that households adjust their house size according to their individual situation—that is, they consider the possibility of trading in real estate (see

[18] As a robustness check, we performed a likelihood-ratio test to compare the performance of this one-stage tobit specification vs. an alternative two stage probit/truncated OLS specification. For both American and German data the tobit model was not rejected at the 1% level.

Banks et al., 2007).[19] The final variable percent risky 2 is obtained by dividing risky assets by wealth, thus considering debt in both the numerator and denominator (since wealth here refers to net worth) implicitly.

As indicated in Table 2, the independent variables are those that are good candidates to be compatible with the input for the benchmark model. Thus, we included age, age squared, dummy variables for education (low or high vs. middle), occupation (retired vs. employed), the ratio of labor income to wealth, and, finally, allowing for non-CRRA behavior, the log of wealth.[20]

From the general results of the benchmark model in section 3.3, the expected sign of the combined effect of age and age squared is negative, the occupation retired dummy variable should have a positive sign (see Figure 2). The expected sign of low education is negative and of high education is positive, due to expected labor income (growth rate) differentials according to education. Wealth should have a coefficient equal to zero, and labor income/wealth should be positive.

Finally, U.S. investors should (due to the better risk-return trade-off of the risky asset) for identical values of the explanatory variables invest a higher share into the risky asset than German investors (see section 3.3).

4.4 Regression Results and Discussion

Table 3 displays the results of our regression analyses.

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[19] To include the housing (e.g., Campbell and Cocco, 2003; Cocco, 2005; Yao and Zhang, 2005) or debt (e.g., Davis, Kubler, and Willen, 2005) decision or both simultaneously (De Jong, Driessen, and Van Hemert, 2007) into a normative model is possible in general, but it would render our optimization approach computationally intractable, due to the large number of cases to be considered (see section 5).

[20] For a CRRA investor, the ratio of labor income to wealth alone is sufficient to determine the risky asset share.

Table 3: Determinants for Share of Risky Assets (Tobit Regression); Dependent Variable: Percent Risky 2 (for definition of variables, see Appendix B)

--- put Table 3 here ---

The age effect (age, age^2) for the United States is hump-shaped, peaking at an age of 59; for Germany, the age and age^2 coefficients imply a downward-sloping age effect. Considering additionally the positive occupation retired dummy variable for Germany, the German results confirm the predictions. The U.S. results are rather mixed, the occupation retired dummy variable has a negative but insignificant coefficient and the age effect alone is only from age 59 on compatible with the prediction.

The U.S. education coefficients show the expected (but insignificant) sign only for higher education. The opposite is true for Germany: only the coefficient for lower education shows the expected sign (also insignificant).

The combined effect of labor income and wealth is diametrical to the normative model for both countries. The coefficient for the Ln(Wealth) is significantly different from zero and positive. For any combinations of labor income and wealth, the risky asset share for U.S. investors is a negative function in the labor income–to–wealth ratio (compare Figure 1). For German investors, the results are similar. While varying the labor income and holding wealth constant the labor income–to–wealth ratio matches at least the direction of the prediction of the benchmark model, but the strength of the effect is very small. The coefficient for Ln(Wealth) is also significantly different from zero and positive, thus variations in wealth (and implicitly of the labor income–to–wealth ratio at the same time) contradict the predictions of the benchmark model.

The hypothesis that U.S. investors should invest a higher share into risky assets than Germans does not hold. The coefficients for high education, Ln(wealth), and labor income/wealth allow for many combinations of the explanatory variables that result in a lower risky asset share for U.S. investors.

In comparison to empirical works using similar data, but "percent risky 1" (no real estate, no debt included) as dependent variable our U.S. results support the evidence found for the impacts of income, wealth and age, but are reversed for education (compare Bertaut amd Starr-McCluer, 2002). For German data only the impact of wealth is found to be similar to regressions using a "percent risky 1" measure of risky assets (compare Eymann and Börsch-Supan, 2002). Thus, considering real estate seems to influence regression outcomes especially for Germany.

5 Welfare Analyses

5.1 The Welfare Gain Measure

Now, we analyze the welfare consequences for the households in the SCF and EVS data sets that result from choosing different asset allocations than proposed by the normative model.

We utilize an equivalent wealth variation measure as, for example, in Brown (2001). The optimal expected utility as given by the value function[21] for $t = 0$ from the benchmark model $V_0^*(W_0, L_0)$ is compared with the expected utility resulting from actual behavior $V_0^{act}(W_0, L_0)$. For each household, equation (7) is solved for ΔW_0.

$$V_0^*(W_0, L_0) = V_0^{act}(W_0 + \Delta W_0, L_0). \tag{7}$$

Next, a relative measure, *WG* (Welfare Gain), is calculated form this result according to equation (8):

$$WG = \Delta W_0 \Big/ \left(W_0 + \sum_{t=1}^{T-x} R_f^{-t} \mathrm{E}\left(L_{t-1}\right) \right) = \Delta W_0 \,/\, (W_0 + \text{Labor Income disc.}). \tag{8}$$

[21] See Appendix A.

This relative measure, *WG* has the advantage of enabling comparisons of U.S. and German households without having to consider differences in the purchasing power of Dollars and Euros and comparisons of households with different endowments (wealth and expected labor income). The economic interpretation of this measure is the answer to the following question: How much wealthier, on an expected utility basis, would the household feel if he chose an asset allocation according to the benchmark model? Thus how much welfare could the investor gain by changing asset allocation towards the benchmark model.

WG looks at the relationship of the potential welfare gain to discounted total financial resources expected over lifetime, i.e., the sum of current wealth and the discounted value of future labor income. Small values of *WG* indicate that changing asset allocation toward the normative result would not enhance expected utility a lot, whereas large values of *WG* indicate that the investor could be considerably better off—that is, he gives away a lot of utility by not following the benchmark model.

The specification of $V_0^{act}(W_0, L_0)$ includes the actual behavior with respect to asset allocation, as predicted by the regression equation. The decision with respect to consumption $C_t(W_t)$ (and saving) is optimized conditional one the empirically given asset allocation. Thus, ignoring further effects from underdiversification (see Calvet, Campbell, and Sodini, 2007) our results can be interpreted as a lower boundary of potential welfare gains since in reality savings could well differ from this optimal choice.[22]

To calculate welfare effects, we chose a certain subsample to avoid extremely long computation times (the SCF and EVS data sets contain 39,448 total cases). For this, we chose three ages: 30, 50, and 65. For each age group, wealth is varied continuously,[23] whereas for labor income, the 25%, 50%, and 75% age-specific

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[22] The SCF data set does not provide information on consumption and savings. Savings adequacy is addressed in, e.g., Scholz, Seshadri, and Khitatrakun (2006); Skinner (2007).

[23] For this we can utilize the CRRA feature of the value function with respect to W_t.

quantiles as given by the data are assigned to the households.[24] Next, the welfare measure is calculated for these households assuming a relative risk-aversion parameter γ of 2, a subjective discount factor δ of 0.97, various levels of education (low, middle, high).

5.2 Results

Figure 3 shows how the potential welfare gain is influenced by wealth and labor income for U.S. American and German households at age 50:

Figure 3: Potential Welfare Gains, $\Delta W_0 / (W_0$ + Labor Income disc.); $\gamma = 2$, $\delta = 0.97$, Age = 50, Education = Middle

--- *put Figure 3 here* ---

Figure 3 shows that the potential gain in welfare is larger for lower levels of labor income (comparing different lines) and higher for high levels of wealth in the U.S. and for median levels of wealth in Germany (comparing different values on the wealth axis). In order to explain these effects, two general remarks are necessary: First, most households invest too little in risky assets. As the benchmark model revealed, the expectation to receive labor income in the future increases the optimal risky asset share. For younger investors and investors with high income, the optimal share is often 100%, i.e., they invest as much as possible under the constraints (5) and (6) into risky assets. Thus usually, there is a positive gap between the optimal and the empirical asset allocation, which is shown in Figure 4.

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[24] Precisely, we also included the neighbouring age groups (e.g., 29 and 31 in case of age 30) to calculate the quartiles in order to avoid too much distortion due to a low amount of cases in some age groups.

Figure 4: Actual and Optimal Risky Asset Share; $\gamma = 2$, $\delta = 0.97$, Age = 50, Education = Middle

--- put Figure 4 here ---

Second, one result of the benchmark model is that high labor income in relation to wealth leads to low savings in proportion to wealth, since the stock of future labor income can be interpreted as an implicit amount of money already saved. Given these two remarks it can be explained why in Figure 3 low income in relation to wealth (comparing different lines) and high wealth in relation to income (moving from left to right in Figure 3) lead to higher welfare gains (the latter only for the U.S.). Both lower income and higher wealth are associated with larger amounts of savings (in proportion to wealth). Thus, the deviations from the optimal asset allocation, work on a larger savings amount in relation to wealth, leading to larger losses of expected utility and thus larger potential welfare gains.

The regression results in section 4 derived for the U.S. coefficients for Ln(Wealth) and Labor Income / Wealth had the opposite sign of the prediction. Now, in this context this result actually helps to reduce utility costs of suboptimal asset allocation, especially for low income (in relation to wealth) and high wealth (in relation to income), which can be seen from Figure 4, since for these households the gap to the optimal asset allocation is narrower. Nevertheless, their larger savings overcompensate in utility terms for this.

The results for German households shown in Figure 3, exhibit similar tendencies with respect to the impact of labor income and wealth, with the exception that for larger holdings of wealth the potential welfare gains decrease. This is due to the larger coefficient for Ln(Wealth) for German households, that helps to close the gap to the optimal risky asset share more quickly. Thus for Germany it is rather low income and median wealth that is associated with larger potential welfare gains.

Another effect highlighted by Figure 3 is that with increasing wealth the potential welfare gains for Germans for different labor income endowments converge, since labor income becomes less important in relation to total wealth. For larger wealth holdings than shown in Figure 3, this effect also holds for U.S. households.

Comparing both panels in Figure 3, we observe that, for most combinations of parameters, U.S. Americans have larger potential welfare gains than Germans given similar endowments. The major explanation for this finding is the larger gap between the risky asset share and the optimal one for U.S. investors.

Then magnitude of potential welfare gains seems at a first glance small, ranging from 0.1% to 2.2% in Figures 3 and 5. But, one has to keep in mind that these potential welfare gains are measured in relation to total lifetime wealth, including a large stock of discounted labor income. In absolute terms the range for U.S. households in Figure 3 is \$ 3,528 to \$ 41,026 and for German households 2,419 € to 11,092 €.

The impact of different assumptions for the coefficient of relative risk aversion γ is shown in Figure 5 for U.S. households.

Figure 5: Potential Welfare Gains, ΔW_0 / (W_0 + Labor Income disc.), for U.S. Data; δ = 0.97, Age = 50, Education = Middle

--- put Figure 5 here ---

Higher risk aversion is typically associated with lower potential gains in welfare.[25] The reason for this is that while increasing risk aversion, the empirically measured asset allocation stays constant, but the benchmark investment in the risky asset decreases. As a result, the gap between the optimal risky asset share and the

[25] As can be seen from Figure 5, the impact of changes in income and wealth are generally confirmed. Because this is also valid for the following variations (except age), we will no longer refer to these effects (except for age).

empirical asset share decreases. We obtain the same tendencies for German households (not shown).

The influence of a variation in the subjective discount factor δ is shown in Figure 6 for U.S. households.

Figure 6: Potential Welfare Gains, ΔW_0 / (W_0 + Labor Income disc.), for U.S. Data; $\gamma = 2$, Age = 50, Education = Middle

--- *put Figure 6 here* ---

The explanation for higher potential welfare gains stemming form a higher δ is straightforward. A higher δ makes the household more oriented toward the future; thus, savings, and the potential amount of money invested suboptimally, increases. Furthermore, with a higher δ, all future gains, i.e., utility costs, are less heavily discounted. For Germany, we again obtain the same tendencies (not shown). The effect of using different assumptions on the subjective discount factor also shed light on the impact that assuming heterogeneity survival probabilities, i.e., higher probabilities for wealthier households (see Brown, 2003) would have. Mathematically, assuming higher survival probabilities is very similar to an increase in the discount factor (see Formula (A1) in Appendix A). Thus, higher survival probabilities would increase the potential welfare gain.

Figure 7 shows the impact of different education levels for U.S. households.

Figure 7: Potential Welfare Gains, ΔW_0 / (W_0 + Labor Income disc.), for U.S. Data; $\gamma = 2$, $\delta = 0.97$, Age = 50

--- *put Figure 7 here* ---

Higher education for U.S. investors generally leads to higher potential welfare gains. In principle, higher education is associated with higher income growth rates given the same current income, thus a higher amount of discounted labor income. This, in general, should lead to lower potential welfare gains for higher educated households, since they have to save less, letting deviations and from the optimal asset allocation work on a smaller amount of money invested. But, as section 4 showed, the regression coefficient for the low education dummy variable implies adjustments of the asset allocation in the opposite direction of the normative model's predictions, for higher education the effect of the (insignificant) coefficient is too small. Thus, the higher potential welfare gain for highly educated households is driven by a larger gap between the optimal and empirical asset allocation. For German investors (not shown), where the coefficient for low education has the correct sign, we observe less variation in the potential welfare gains with respect to education. Higher education is associated only slightly higher potential welfare gains, thus the impact of the differences in the amounts saved dominates.

Finally, as the last variation of model parameters, we investigate age effects given in Figure 8 for U.S. households.

Figure 8: Potential Welfare Gains, ΔW_0 / (W_0 + Labor Income disc.), for U.S. Data; $\gamma = 2$, $\delta = 0.97$, Education = Middle, Labor Income = Median (age-specific)

--- put Figure 8 here ---

The magnitude of differences in potential welfare gains according to age shown in Figure 8 are difficult to interpret. At different ages, the discounted value of the expected labor income stream changes. Furthermore, the income and wealth quantiles are different. Finally, the time horizon—and thus the number of future welfare gains discounted—is different between different age groups. Thus, only some results can be clearly identified. For example, for households aged 30, the welfare gains are the lowest, since at this age savings are often close to zero. Consequently, deviations from the optimal asset allocation do not matter too much.

Furthermore, future potential welfare gains (when savings will increase) are heavily discounted. This age effect is more pronounced for German households (not shown).

5.3 Summary and Discussion of Results

For most combinations of parameters, suboptimal asset allocations imply larger potential welfare gains for U.S. Americans as compared to Germans. This finding is mainly driven by the larger gap between the optimal and empirical risky asset share in the U.S. In contrast to the benchmark model, for many parameter combinations, Americans invest a smaller share into the risky asset.

Higher relative risk aversion leads to lower potential welfare gains, assuming a higher subjective discount factor increases welfare gains. Thus, to close the performance gap between the United States and Germany, one needed higher risk aversion and/or a lower subjective discount factor for U.S. investors.

With respect to the endowment, being a good investor is associated in the United States generally with households with higher labor income and/or lower wealth. For Germans, the better investors also have high income but low or very high wealth.

Higher education worsens investment performance for U.S. investors, for Germans the variation according to education is small. Younger investors have lower potential welfare gains.

Our analysis relied on cross-sectional data, thus we implicitly assumed that there are no time or cohort effects with respect to asset allocation. Such effects are analyzed in, e.g., for the U.S. Poterba and Samwick (2001); Ameriks and Zeldes (2004) and for Germany in Eymann and Börsch-Supan (2002); Sommer (2005). In general, risky asset ownership increased over time and also with the cohort of birth, e.g., due to cheaper access to financial information or lower transaction costs for trading. Our results therefore would for most households show lower welfare gains, since the gap to the optimal risky asset share would decline over time. However, the tendencies within each age group, i.e., the shape of the welfare gain curves, should be fairly robust with respect to time and cohort effects given that time and cohort effects work with the same strength for all households of the same cohort.

With respect to the assumptions on mortality, we used life tables that reflect survival probabilities relevant for the population average. There is empirical evidence, that mortality is heterogeneous with respect to the financial endowment, i.e. financially better endowed households tend to live longer (Brown, 2003). The impact of heterogeneous mortality on the welfare gain tendencies shown in our figures can, although no modeled, implicitly inferred from Figure 6, since changing the survival probability is mathematically very similar to changing the subjective discount factor (compare formula (1)). Thus assuming lower survival probabilities for richer households would increases the potential welfare gains for (and vice versa for poorer households). Thus the slope of the curves will increase and the distance of the income-specific curves will decrease.

For the calibration of the return distribution we used historical data. This approach may, as some authors argue overstate the prospective risk premium over the risk-free rate, since for example economic conditions may have become less risky.[26] This would imply a too optimistic view of capital market conditions. Furthermore, we do not allow for sophisticated stochastic processes for the risky return, e.g. accounting for stochastic volatility or catastrophic scenarios like the current financial crisis. This, again could lead to a too optimistic outlook for future capital market conditions. Implicitly our results also show the impact of being more pessimistic about capital market conditions. In general, the household would then behave as being more risk-averse. The consequences such assumption were analyzed as we varied the coefficient of relative risk aversion. Thus in this case we would expect lower potential welfare gains (compare Figure 5).

[26] The discussion on this issue is summarized in Mehra and Prescott (2003).

6 Policy Implications

The analyses presented in this paper reveal the welfare consequences of suboptimal investment behavior for U.S. and German households. In general, Germans appear to be better investors in terms of potential welfare gains arising from suboptimal asset allocation. This is surprising, taking into account that stock market participation and the engagement in risky investments have a longer tradition in the United States than in Germany (see, e.g., Guiso, Haliassos, and Japelli, 2002). Thus, reforming the German system toward more privately managed should be considered as one way to cope with the demographic transition.

For many combinations of household characteristics, our results showed potential to improve welfare. In addition, our model identifies those population subgroups that would benefit most from a better asset allocation. A detailed example for such an analysis is given in Table 4. Combining the results of section 5 with the empirical population distribution allows us to see which type of households are located in the parts of the welfare gain distribution with relatively large potential welfare gains. Here we focus on labor income and wealth, because section 5 revealed that they were the two main drivers of the magnitude of welfare gain. Table 4 shows which proportions of the SCF and EVS data sets are located in the multivariate income and wealth distribution. The shaded fields indicate those parts of the distribution with relatively large potential welfare gains.

Table 4: Joint Distribution of Labor Income and Wealth for the United States and Germany and Indication (Shaded Area) of Age-Specific Potentially Large Welfare Gains

--- put Table 4 here ---

An important topic for future research is determining which public policy measure or mix of measures—for example, mandates, investments in financial education[27] or asset allocation default options in pension plans[28]—should be implemented to achieve the maximum welfare gain. Combining knowledge about the welfare contributions of various policy measures with the results on the location of welfare gains presented in this paper should help considerably to meet the demographic challenges ahead.

References

Agnew, J., P. Balduzzi, and A. Sunden (2003), Portfolio Choice and Trading in a Large 401 (k) Plan, *The American Economic Review*, 93: 193-215.

Ameriks, J., and S. Zeldes (2004), How do Household Portfolios Vary with Age, mimeo, Columbia University.

Arias, E. (2006), United States Life Tables, 2003, *National Vital Statistics Report*, 54: 1-40.

Bajtelsmit, V. L., and N. A. Jianakoplos (2000), Women and Pensions: A Decade of Progress?, *EBRIA Issues Brief*, 227: 1-15.

Bajtelsmit, V. L., and J. L. VanDerhei (1997), Risk aversion and Pension Investment Choices, in: Michael S. Gordon, Olivia S. Mitchell, and Marc M. Twinney (eds.), *Positioning Pensions for the Twenty-First Century* (Philadelphia: The Pension Research Council & University of Pennsylvania Press), 45-66.

Banks, J., R. Blundell, Z. Oldfield, and J. P. Smith (2007), Housing Price Volatility and Downsizing in Later Life, *NBER Working Paper No. 13496*, Cambridge (MA).

Behr, A., E. Bellgardt, and U. Rendtel (2003), *The estimation of male earnings under panel attrition. A cross country comparison based on the European Community*

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[27] The effect of financial literacy on stock market participation is analyzed in Rooij, Lusardi and Alessie (2007). To address the generally insufficient of knowledge among European Union citizens with respect to the functioning of financial instruments necessary for old age, the Commission of the European Union sees the necessity to improve that knowledge. See press release IP/07/1954 on 12/18/2007: Financial services: Commission encourages better financial education for EU citizens.

[28] The power of default options—the tendency that pension plan members stick to predefined asset allocations—is demonstrated in Beshears et al. (2006). Thus, one can reach desired asset allocation results while avoiding too much regulatory force.

Household Panel, Chintex Working Paper No. 7, World Wide Web: http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Wissenschaftsforum/Chintex/ResearchResults/Downloads/WorkingPaper7,property=file.pdf (accessed on December 3, 2007).

Bertaut, C. C., and M. Starr-McCluer (2002), Household Portfolios in the United States, in: Luigi Guiso, Michael Haliassos, and Tullio Japelli (eds.), *Household Portfolios* (Cambridge (MA) et al.: The MIT Press), 181-217.

Beshears, J., J. Choi, D. Laibson, and B. Madrian (2006), The Importance of Default Options for Retirement Saving Outcomes: Evidence from the United States, *NBER Working Paper No. 12009*, Cambridge (MA).

Blake, D., A. Cairns, and K. Dowd (2003), Pensionmetrics 2: Stochastic Pension Plan Design During the Distribution Phase, *Insurance: Mathematics and Economics*, 33: S. 29-47.

Börsch-Supan, A., and C. B. Wilke (2004), The German Public Pension System: How it Was, How it Will Be, *NBER Working Paper No. 10525*, Cambridge (MA).

Brown, J. R. (2001), Private Pensions, Mortality Risk and the Decision to Annuitize, *Journal of Public Economics*, 82: 29-62.

Brown, J. R. (2003), Redistribution and Insurance: Mandatory Annuitization With Mortality Heterogeneity, *The Journal of Risk and Insurance*, 70: 17-41

Bucks, B. R., A. B. Kennickell, and K. B. Moore (2006), Recent Changes in U.S: Family Finance: Evidence from the 2001 and 2004 Survey of Consumer Finance, *Federal Reserve Bulletin* (February), 1-38.

Calvet, L. E., J. Y. Campbell, and P. Sodini (2007), Down or Out: Assessing the Welfare Costs of Household Investment Mistakes, *The Journal of Political Economy*, 115: 707-747.

Carroll, C. D. (1992), The Buffer-Stock Theory of Saving: Some Macroeconomic Evidence, *Brookings Papers on Economic Activity*, 1992: 61-156.

Carroll, C. D. (1997), Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis, *The Quarterly Journal of Economics*, 112: 1-55.

Carroll, C. D. (2004), Theoretical Foundations of Buffer Stock Saving, *NBER Working Paper No. 10867*, Cambridge (MA).

Carroll, C. D., and A. A. Samwick (1997), The nature of precautionary wealth, *Journal of Monetary Economics*, 40: 41-71.

Campbell, J. Y. (2006), Household Finance, *The Journal of Finance*, 61: 1553-1604.

Campbell, J. Y., and J. F. Cocco (2003), Household Risk Management and Optimal Mortgage Choice, *Quarterly Journal of Economics*, 118: 1449-1494.

Campbell, J. Y., and L. M. Viceira (2002), *Strategic Asset Allocation: Portfolio Choice for Long-Term Investors* (Oxford: Oxford University Press).

Cauley, S. D., A. D. Pavlov, and E. S. Schwartz (2007), Homeownership as a Constraint on Asset Allocation, *The Journal of Real Estate Finance and Economics*, 34: 283-311.

Cocco, J. F. (2005), Portfolio Choice in the Presence of Housing, *The Review of Financial Studies*, 18: 535-567.

Cocco, J. F., F. J. Gomes, and P. J. Maenhout (2005), Consumption and Portfolio Choice over the Life-Cycle, *The Review of Financial Studies*, 18: 491-533.

Curcuru, S., J. Heaton, D. Lucas, and D. Moore (2004), Heterogeneity and portfolio choice: Theory and evidence (forthcoming), in: Yacine Ait-Sahalia, Lars P. Hansen (eds.), *Handbook of Financial Econometrics* (Amsterdam: Elsevier Science).

Dammon, R. M., C. S. Spatt, and H. H. Zhang (2004), Optimal Asset Location and Allocation with Taxable and Tax-Deferred Investing, *The Journal of Finance*, 59: 999-1037.

Davidoff, T., J. R. Brown, and P. A. Diamond (2005) Annuities and Individual Welfare, *The American Economic Review*, 95, 1573-1590.

Davis, S. J., F. Kubler, and P. Willen (2005), Borrowing Costs and the Demand for Equity over the Life Cycle, *Review of Economics and Statistics*, 88: 348-362.

De Jong, F., J. Driessen, and O. Van Hemert (2007), Hedging House Price Risk: Portfolio Choice with Housing Futures, working paper, Available at SSRN: http://ssrn.com/abstract=740364.

Deaton, A. (1991), Saving and Liquidity Constraints, *Econometrica*, 59: 1221-1248.

Deutsche Bundesbank (2007), *Financial Accounts for Germany 1991 to 2006*, Frankfurt am Main: Deutsche Bundesbank.

Eymann, A., and A. Börsch-Supan (2002), Household Portfolios in Germany, in: Luigi Guiso, Michael Haliassos, and Tullio Japelli (eds.), *Household Portfolios* (Cambridge (MA) et al.: The MIT Press), 291-340.

Federal Ministry of Health and Social Affairs (2005), *Old-age Pension Schemes in Germany 2003 (ASID '03), Summary of Survey Results*, Munich: Federal Ministry of Health and Social Affairs.

Federal Statistical Office (2002), *Statistical Yearbook 2002 For the Federal Republic of Germany*, Wiesbaden: Federal Statistical Office.

Federal Statistical Office (2003), *Germany's population by 2050: Results of the 10th coordinated population projection*, Wiesbaden: Federal Statistical Office.

Federal Statistical Office (2006), *Germany's population by 2050: Results of the 11th coordinated population projection*, Wiesbaden: Federal Statistical Office.

Federal Statistical Office (2007), *Statistical Yearbook 2007 For the Federal Republic of Germany*, Wiesbaden: Federal Statistical Office.

Fitzenberger, B., and G. Wunderlich (2002), Gender Wage Differences in West Germany: A Cohort Analysis, *German Economic Review*, 3: 379-414.

Gomes, F., L. J. Kotlikoff, and L. M. Viceira (2008), Optimal Life-Cycle Investing with Flexible Labor Supply: A Welfare Analysis of Life-Cycle Funds, *The American Economic Review*, 98: 297-303.

Gomes, F., and A. Michaelides (2003), Portfolio choice with internal habit formation: a life-cycle model with uninsurable labor income risk, *Review of Economic Dynamics*, 6: 729-766.

Gomes, F., and Michaelides, A. (2005), Optimal life-cycle asset allocation: understanding the empirical evidence, The Journal of Finance, Vol. 60, S. 869-904.

Guiso L., M. Haliassos, and T. Japelli (2002), Introduction, in: Luigi Guiso, Michael Haliassos, and Tullio Japelli (eds.), *Household Portfolios* (Cambridge (MA) et al.: The MIT Press), 1-24.

Guiso L., M. Haliassos, and T. Japelli (2002), *Household Portfolios*, Cambridge (MA) et al.: The MIT Press.

Guvenen, F. (2007), Learning Your Earning: Are Labor Income Shocks Really Very Persistent?, *The American Economic Review*, 97, 687-712.

Haliassos, M., and A. Michaelides (2003), Portfolio Choice and Liquidity Constraints, *International Economic Review*, 44: 143-177.

Hakansson, N. H. (1969), Optimal Investment and Consumption Strategies Under Risk, an Uncertain Lifetime, and Insurance, *International Economic Review*, 10: 443-466.

Hakansson, N. H. (1970), Optimal Investment and Consumption Strategies Under Risk for a Class of Utility Functions, *Econometrica*, 38: 587-607.

Heaton, J., and D. Lucas (1997), Market Frictions, Savings Behavior, and Portfolio Choice, *Macroeconomic Dynamics*, 1: 79-101.

Heaton, J., and D. Lucas (2000), Portfolio Choice in the Presence of Background Risk, *The Economic Journal*, 110: 1-26.

Hinz, R. P., D. D. McCarthy, and J. A. Turner (1997), Are Women Conservative Investors? Gender Differences in Participant-Directed Pension Investments, in: Michael S. Gordon, Olivia S. Mitchell, and Marc M. Twinney (eds.), *Positioning Pensions for the Twenty-First Century* (Philadelphia: The Pension Research Council & University of Pennsylvania Press), 91-103.

Horneff, W., R. Maurer, and M. Stamos (2006), Life-Cycle Asset Allocation with Annuity Markets: Is Longevity Insurance a Good Deal?, working paper, Johann Wolfgang Goethe-Universität Frankfurt am Main.

Hubbard, R. G., J. Skinner, and S. P. Zeldes (1994), The Importance of Precautionary Motives for Explaining Individual and Aggregate Saving, *Carnegie-Rochester Conference Series on Public Policy*, 40: 59-125.

Hubbard, R. G., J. Skinner, and S. P. Zeldes (1995), Precautionary Saving and Social Insurance, *The Journal of Political Economy*, 103: 360-399.

Inkmann, J., P. Lopes, and A. Michaelides (2007), How Deep is the Annuity Market Participation Puzzle?, *Netspar Discussion Paper 2007-011*.

Jianakoplos, N. Ammon, V. L. Vajtelsmit, and A. Bernasek (2003), How Marriage Matters to Pension Investment Decisions, *Journal of Financial Services*, 57: 48-57.

John Hancock Financial Services (2002), *Eighth Annual Defined Contribution Survey* (Boston).

Kotlikoff, L. J., and A. Spivak (1981), The Family as an Incomplete Annuities Market, *The Journal of Political Economy*, 89: 372-391.

Lachance, M.-E. (2004), Retirement Income Insurance: A Do-It-Yourself Approach, *working paper*, available at SSRN: http://ssrn.com/abstract=641821.

Laibson, D. I., A. Repetto, and J. Tobacman (1998), Self-Control and Saving for Retirement, *Brookings Papers on Economic Activity*, 1998: 91-196.

Li, W., and R. Yao (2007), The Life-Cycle Effects of House Price Changes, *Journal of Money, Credit and Banking*, 39: 1375-1409.

Lusardi, A., and O. Mitchell (2007), Financial Literacy and Retirement Preparedness: Evidence and Implications for Financial Education, *Business Economics*, 42: 35-44.

Maclennan, D., J. Muellbauer, and M. Stephens (1998), Asymmetries in housing and financial market institutions and EMU, *Oxford Review of Economic Policy*, 14: 54-80.

Mehra, R., and E. C. Prescott (2003), The Equity Premium in Retrospect, in: George M. Constantinides, Milton Harris, and René M. Stulz (eds.), *Handbook of the Economics of Finance*, (North Holland: Amsterdam), 887-936.

Guiso L., M. Haliassos, and T. Japelli (2002), Introduction, in: Luigi Guiso, Michael Haliassos, and Tullio Japelli (eds.), *Household Portfolios* (Cambridge (MA) et al.: The MIT Press), 1-24.

Merton, R. C. (1969), Lifetime Portfolio Selection under Uncertainty: The Continuous-Time Case, *The Review of Economics and Statistics*, 51: 247-257.

Merton, R. C. (1971), Optimum Consumption and Portfolio Rules in a Continuous-Time Model, *Journal of Economic Theory*, 3: 373-413.

Moore, J., and O. S. Mitchell (1997), Projected Retirement Wealth and Savings Adequacy in the Health and Retirement Study, *NBER Working Paper No. 6240*, Cambridge (MA).

Morningstar (2007), *Stocks, Bonds, Bills, and Inflation 2007 Yearbook* (Morningstar, Inc.: Chicago).

Mossin, R. C. (1968), Optimal Multiperiod Portfolio Policies, *The Journal of Business*, 1: 215-229.

Phelps, E. S. (1962), The Accumulation of Risky Capital: A Sequential Utility Analysis, *Econometrica*, 30: 729-743.

Polkovnichenko, V. (2007), Life-Cycle Portfolio Choice with Additive Habit Formation Preferences and Uninsurable Labor Income Risk, *The Review of Financial Studies*, 20:83-124.

Post, T., H. Gründl, and H. Schmeiser (2006), Portfolio and Retirement Management: What is the Best Arrangement for a Family?, *Financial Markets and Portfolio Management*, 20: 265-285.

Poterba, J., J. Rauh, S. Venti, and D. Wise (2006), Defined Contribution Plans, Defined Benefit Plans, and the Accumulation of Retirement Wealth, *NBER Working Paper No. 12597*, Cambridge (MA).

Poterba, J., J. Rauh, S. Venti, and D. Wise (2007), Defined Contribution Plans, Defined Benefit Plans, and the Accumulation of Retirement Wealth, *Journal of Public Economics*, 91: 2062-2086.

Poterba, J. M., and A. A. Samwick (2001), Household Portfolio Allocation over the Life-Cycle, in: Seiritsu Ogura, Toshiaki Tachibanaki, and David Wise (eds.), *Aging Issues in the United States and Japan* (Chicago: University of Chicago Press), 65-103.

Reno, V. P., and J. Lavery (2007), Social Security and Retirement Income Adequacy, Social Security Brief No. 25 (Washington D.C.: National Academy of Social Insurance).

Richard, S. F. (1975), Multivariate Risk Aversion, Utility Independence and Separable Utility Functions, *Management Science*, 22: 12-21.

Rooij, M. van, A. Lusardi, and R. Alessie (2007), Financial Literacy and Stock Market Participation, *NBER Working Paper No. 13565*, Cambridge (MA).

Samuelson, P. A. (1969), Lifetime Portfolio Selection By Dynamic Stochastic Programming, *The Review of Economics and Statistics*, 51: 239-246.

Scholz, J. K., A. Seshadri, and S. Khitatrakun (2006), Are Americans Saving "Optimally" for Retirement?, *The Journal of Political Economy*, 114: 607-643.

Skinner, J. (2007), Are You Sure You're Saving Enough for Retirement?, *Journal of Economic Perspectives*, 21: 59-80.

Social Security Administration (2006), *Income of the Population 55 or Older, 2004*, Washington D.C.: Social Security Administration.

Sommer, M. (2005), Trends in German households' portfolio behavior - assessing the importance of age- and cohort-effects, MEA Discussion Paper # 82-2005, available at http://www.mea.uni-mannheim.de/mea_neu/pages/files/nopage_pubs/l26bvl6jjpuuky7f_82-2005.pdf.

Sunden, A. E., and B. J. Surette (1998), Gender Differences in the Allocation of Assets in Retirement Savings Plans, *The American Economic Review*, 88: 207-211.

Tobin, J. (1958), Estimation of Relationships for Limited Dependent Variables, *Econometrica*, 26, 24-36.

United Nations (2007), *World Population Ageing 2007*, New York: United Nations.

U.S. Census Bureau (2008), *International Data Base (IDB)*, available at: http://www.census.gov/ipc/www/idb/index.html.

Viceira, L. M. (2001), Optimal Portfolio Choice for Long-Horizon Investors with Nontradable Labor Income, *The Journal of Finance*, 56: 433-469.

Watson, J., and M. McNaughton (2007), Gender Differences in Risk Aversion and Expected Retirement Benefits, Financial Analysts Journal, 63: 52-62.

Yaari, M. E. (1965), Uncertain Lifetime, Life Insurance, and the Theory of the Consumer, *The Review of Economic Studies*, 32: 137-150.

Yao, R., and H. H. Zhang (2005), Optimal Consumption and Portfolio Choices with Risky Housing and Borrowing Constraints, *The Review of Financial Studies*, 18: 197-239.

Zeldes, S. P. (1989), Optimal Consumption with Stochastic Income: Deviations from Certainty Equivalence, *The Quarterly Journal of Economics*, 104: 275-298.

Appendix A: Solving Technique for the Normative Problem

The optimization problem (3)–(6) is solved backward via stochastic dynamic programming. The Bellman equation for this problem depends on three state variables: time t, wealth W_t, and labor income L_t. The Bellman equation (with V denoting the value function) is given for $t = 0, 1, \ldots, T - x - 1$ by

$$V_t\left(W_t, L_t\right) = \max_{\alpha_t, C_t}\left\{U_t\left(C_t\right) + p_t\, \delta\, \mathrm{E}_t\left(V_{t+1}\left(W_{t+1}, L_{t+1}\right)\right)\right\}, \tag{A1}$$

subject to constraints (4)–(6). In the last period, remaining wealth is consumed, and the value function is given by $U_{T-x}(W_{T-x})$. For CRRA utility, often the L_t–state can be reduced by dividing W_t through L_t (see Carroll, 2004). But, since our econometric results show that, in reality, households do not behave exactly according to CRRA, and thus in order to integrate empirical asset allocations into the model (depending on both state variables), the L_t state should not be dropped. Nevertheless, problem (A1) is solved by referring only to the W_t state. The L_t state is considered implicitly, because equation (A1) is calculated for each household separately, thus referring to each household's expected labor income path. The Bellman equation (A1) cannot be solved analytically, and hence a numerical technique is used. First, at each point in time t, the W_t-state space is discretized into I points, W_t^i, with $i = 1, 2, \ldots, I$. The upper and lower bounds of this W_t^i grid were chosen to be nonbinding in all periods. The distributions of the risky return R_t and the labor income L_t were discretized using Gaussian quadrature methods. Since in the last period (i.e., at $t = T - x$), the value function $V_{T-x}(W_{T-x})$ is given by $U_{T-x}(W_{T-x})$, the numerical solution algorithm starts at the penultimate period (i.e., at $t = T - x - 1$). For each W_t^i, equation (A1) is solved with the MATHEMATICA® 6.0 implemented nonlinear optimizer `NMaximize`, yielding the optimal decisions $\alpha_t^i(W_t^i)$, $C_t^i(W_t^i)$, and the function value of $V_t(W_t^i)$. Next, a continuous function is fitted to the points $V_t(W_t^i)$, which delivers a continuous approximation of the value function $V_t(W_t)$.[29] Finally, the problem is rolled back to the preceding period.

Appendix B: Definition of Variables

Variable	Definition
Age	Age of head of household respondent
# Children	Number of children in the household
Married	Marital status, 0 = married or partnership and 1 = otherwise
Education - Low	Education of head of household = no degree, on the job training or no degree, still in school (EVS) and no high school diploma/GED (SCF)
Education - Middle	Holdout group for education of head of household = college degree (Meister, Berufs- und Fachakademie), apprenticeship (Lehre), still in apprenticeship or college (EVS) and high school diploma or GED or some college (SCF)
Education - High	Education of head of household = applied science college degree or university degree (EVS) and college degree (SCF)
Occupation - Employed	Holdout group for occupation of head of household = government employee (Beamter), work for someone else (Angestellter, Arbeiter) (EVS) and work for someone else (SCF)
Occupation - Unemployed	Occupation of head of household = unemployed, student or other not employed (homemaker, pupil, ...) (EVS) and other groups not working (mainly those under 65 and out of the labor force) (SCF)
Occupation - Retired	Occupation of head of household = retired (EVS) and retired/disabled + (student/homemaker/misc. not working and age 65 or older) (SCF)
Income	Total amount of pre-tax income of household
Labor Income	Total amount of pre-tax income of household, excluding any income or withdrawals from investments (financial assets and real estate)
Owns risky 1	Dummy for % risky 1 > 0 vs. = 0
% risky 1	Risky financial assets (including directly-held stocks; risky share invested in investment funds, trusts, annuities and managed investment accounts, quasi-liquid retirement accounts; mortgage-backed, corporate and foreign bonds; other financial assets (e.g., loans to someone else, future proceed from lawsuits)) *divided by Assets*
Owns risky 2	Dummy for % risky 2 > 0 vs. = 0
% risky 2	Risky financial assets (risky 1) + House – Debt *divided by Wealth*
Owns House	Dummy for house or real estate ownership
House	Total value of houses and real estate including land
Assets	Total value of assets, including risky financial assets (risky 2) and non-risky assets (money, checking, savings, and call market accounts; saving bonds; accounts with building societies; cash value of life-insurance; tax-exempt bonds; U.S. or German government and government agency bonds; non-risky share invested in investment funds, trusts, annuities and managed investment accounts, quasi-liquid retirement accounts), but excluding cars and other nonfinancial assets (e.g., paintings)
In Debt	Dummy for Debt > 0 vs. = 0
Debt	Total value of debt
Wealth	Assets – Debt (= net worth)

[29] The fitting algorithm guarantees that relative risk aversion displayed by optimal decisions $\alpha_t^i(W_t^i)$, $C_t^i\,(W_t^i)$ is inherited to the approximation of the value function $V_t(W_t)$.

Tables

Table 1: Parameter Calibration for the Benchmark Model

Parameter		Value United States	Value Germany
relative risk aversion	γ	2 (1, 3)	2 (1, 3)
subjective discount factor	δ	0.97 (0.95, 0.99)	0.97 (0.95, 0.99)
survival probability	p_t	United States Life Tables 2003	Life Table for Germany 2002/2004
marginal tax rate		0%	0%
Log-normal risky asset return	R_t		
expected return	$E(R_t)$	1.0590	1.0695
standard deviation of return	$Std(R_t)$	0.1158	0.1322
risk-free return	R_f	1.0361	1.0472
Inflation	π	0.0310	0.0279
Log-normal labor income	L_t		
expected growth rates during work life		life-cycle-income profile	life-cycle-income profile
expected real growth rates during retirement		0	0
replacement factor		35%	40%
standard deviation during work life		$0.19 \cdot E(L_t)$	$0.05 \cdot E(L_t)$
standard deviation during retirement		0	0

Table 2: 2004 Survey of Consumer Finances (SCF) and 2003 Income and Expenditure Survey (EVS) (for definition of variables, see Appendix B)*

	USA: SCF 2003				Germany: EVS 2004			
	full sample N = 4.519		selected samle N = 2,559		full sample N = 42,744		selected samle N = 34,929	
	Mean (weighed)	Std (weighed)	Mean (weighed)	Std (weighed)	Mean	Std	Mean	Std
Demographics								
Age	49.56	17.27	52.73	17.43	50.41	14.63	51.48	14.84
Age ^{2}	2,754.51	1,851.79	3,083	1,943	2,754.83	1,547.91	2,870	1,585
Married	0.42	0.50	0.40	0.49	0.33	0.47	0.31	0.46
# Children	0.81	1.14	0.76	1.10	0.70	1.00	0.67	0.98
Education								
Low	0.14	0.36	0.14	0.37	0.04	0.20	0.04	0.19
Middle	0.49	0.51	0.48	0.52	0.62	0.49	0.62	0.49
High	0.37	0.51	0.38	0.55	0.34	0.47	0.35	0.48
Occupation								
Employed	0.60	0.49	0.66	0.48	0.60	0.49	0.63	0.48
Unemployed	0.04	0.20	0.04	0.19	0.05	0.21	0.04	0.20
Retired	0.24	0.43	0.31	0.46	0.30	0.46	0.33	0.47
Self-employed	0.12	0.33	0	0	0.05	0.22	0	0
Income (local currency)								
Income	70,625	218,772	68,929	165,205	65,832	68,114	67,740	68,699
Labor Income	59,165	127,509	60,806	113,424	46,925	30,033	47,856	29,681
Wealth (local currency)								
Owns risky 1	0.57	0.56	0.62	0.53	0.45	0.50	0.49	0.50
pecent risky 1	0.16	0.26	0.15	0.23	0.07	0.16	0.07	0.16
Owns risky 2	0.91	0.29	0.90	0.30	0.78	0.42	0.78	0.42
percent risky 2	0.44	15.39	0.59	0.31	0.52	8.61	0.53	0.37
Owns Hose	0.71	0.45	0.84	0.37	0.56	0.50	0.62	0.48
House Value	229,098	825,353	234,147	503,437	143,175	289,663	151,824	218,085
Assets	504,701	2,571,356	455,633	1,531,396	193,372	326,859	204,879	255,435
In Debt	0.76	0.43	0.71	0.45	0.46	0.50	0.41	0.49
Debt	79,083	180,808	80,026	151,450	35,875	80,006	33,831	69,466
Wealth (net worth)	448,010	2,576,305	396,999	1,501,311	157,497	301,074	171,048	233,040
Ln(Wealth)	n/a	n/a	11.59	2.12	n/a	n/a	11.13	1.78
Labor Income / Wealth	17.72	454.48	3.02	36.61	31.82	866.28	18.45	354.26

* For the U.S. data, the statistics are based on the weight given in the data set to account for the oversampling of wealthy.

Table 3: Determinants for Share of Risky Assets (Tobit Regression); Dependent Variable: Percent Risky 2 (for definition of variables, see Appendix B)

	Prediction	SCF USA			EVS Germany		
		coef	std. err.		coef	std. err.	
Age	–	0.0103	0.0022	***	-0.0018	0.0009	**
Age^2		-0.0001	0.00002	***	-0.00003	0.00001	***
Education Low	–	0.0657	0.0203	***	-0.0122	0.0104	
Education High	+	0.0011	0.0134		-0.0142	0.0038	***
Occupation Retired	+	-0.0021	0.0172		0.0484	0.0064	***
Ln(Wealth)	0	0.0456	0.0037	***	0.2276	0.0014	***
Labor Income / Wealth	+	-0.0580	0.0051	***	0.0001	0.00001	***
Constant		-0.1908	0.0640	***	-1.8991	0.0244	***
McFadden R^2		0.6258			0.4854		

* significant at 10%, ** significant at 5%, *** significant at 1% level

Table 4: Joint Distribution of Labor Income and Wealth for the United States and Germany and Indication (Shaded Area) of Age-Specific Potentially Large Welfare Gains*

SCF USA						
			Wealth Quantile			
			0-25	25-50	50-75	75-100
Age = 30	Labor Income Quantile	0-25	12%	5%	6%	1%
		25-50	9%	10%	4%	2%
		50-75	3%	7%	7%	8%
		75-100	1%	3%	8%	14%
			Wealth Quantile			
			0-25	25-50	50-75	75-100
Age = 50	Labor Income Quantile	0-25	12%	10%	3%	0%
		25-50	11%	7%	5%	1%
		50-75	1%	6%	9%	9%
		75-100	1%	2%	8%	15%
			Wealth Quantile			
			0-25	25-50	50-75	75-100
Age = 65	Labor Income Quantile	0-25	12%	8%	2%	3%
		25-50	6%	9%	8%	3%
		50-75	5%	3%	12%	5%
		75-100	2%	6%	3%	15%
EVS Germany						
			Wealth Quantile			
			0-25	25-50	50-75	75-100
Age = 30	Labor Income Quantile	0-25	14%	5%	3%	3%
		25-50	6%	8%	5%	6%
		50-75	4%	7%	7%	8%
		75-100	1%	5%	10%	9%
			Wealth Quantile			
			0-25	25-50	50-75	75-100
Age = 50	Labor Income Quantile	0-25	14%	6%	3%	2%
		25-50	7%	8%	6%	5%
		50-75	3%	7%	8%	7%
		75-100	1%	4%	8%	12%
			Wealth Quantile			
			0-25	25-50	50-75	75-100
Age = 65	Labor Income Quantile	0-25	11%	7%	4%	3%
		25-50	8%	7%	6%	4%
		50-75	5%	6%	8%	6%
		75-100	1%	5%	7%	11%

* Assumptions for benchmark model: $\gamma = 2$, $\delta = 0.97$, Education = Middle.

Figures

Figure 1: Investment into the risky asset as a function in the labor income–to–wealth ratio for German (EVS) data, $\gamma = 2$, $\delta = 0.97$, Age = 30, Education = Middle

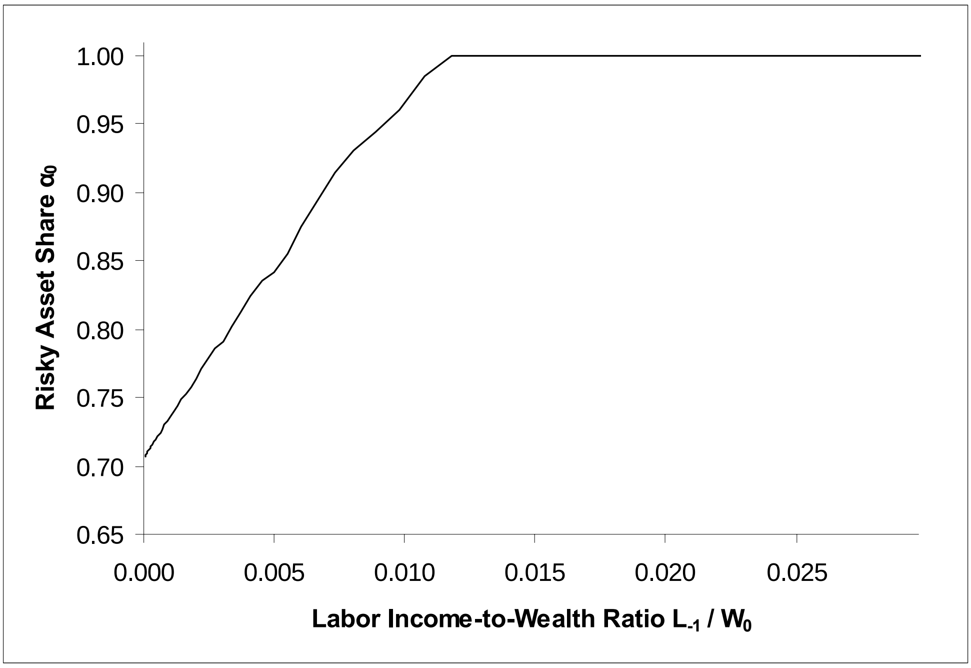


Figure 2: Investment into the risky asset as a function in age for German (EVS) data, $\gamma = 2$, $\delta = 0.97$, Education = Middle

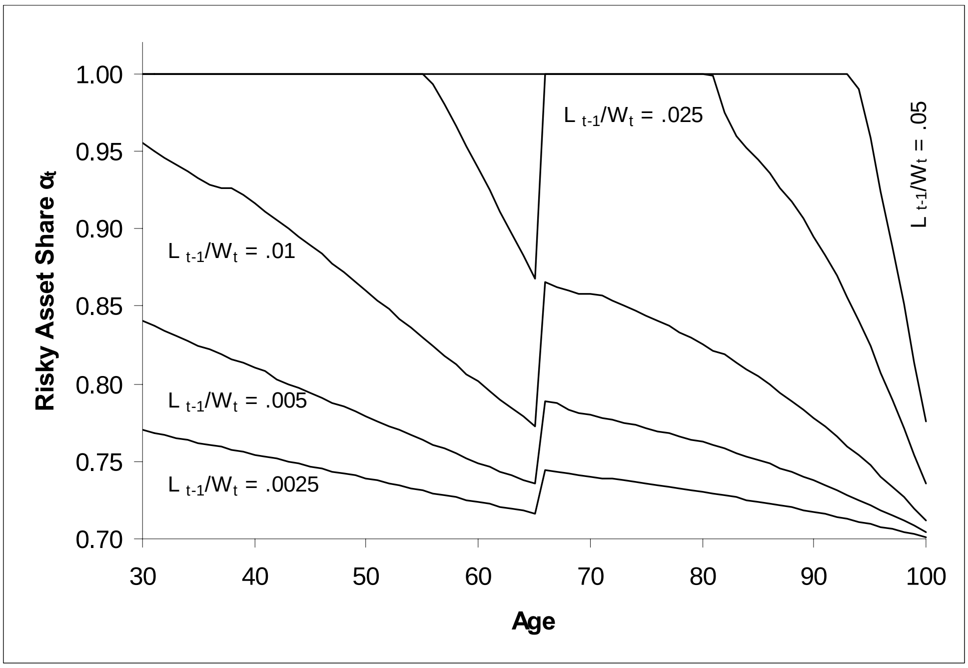
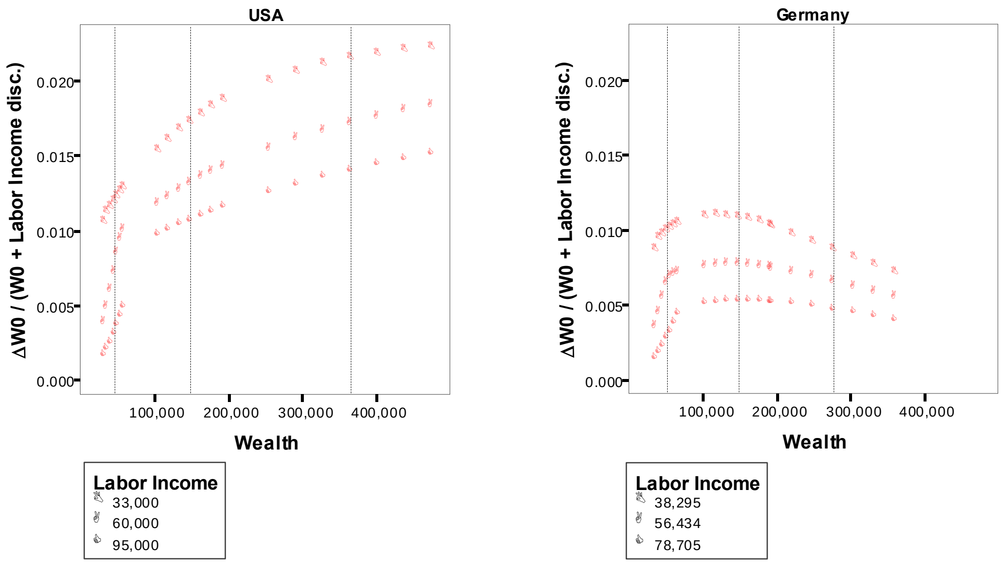
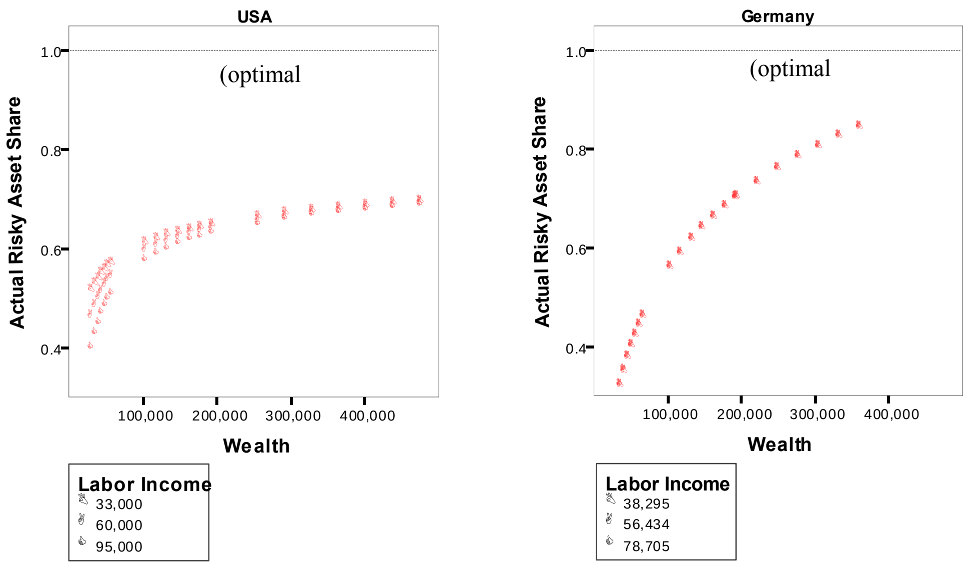


Figure 3: Potential Welfare Gains, $\Delta W_0 / (W_0$ + Labor Income disc.); $\gamma = 2$, $\delta = 0.97$, Age = 50, Education = Middle[*]



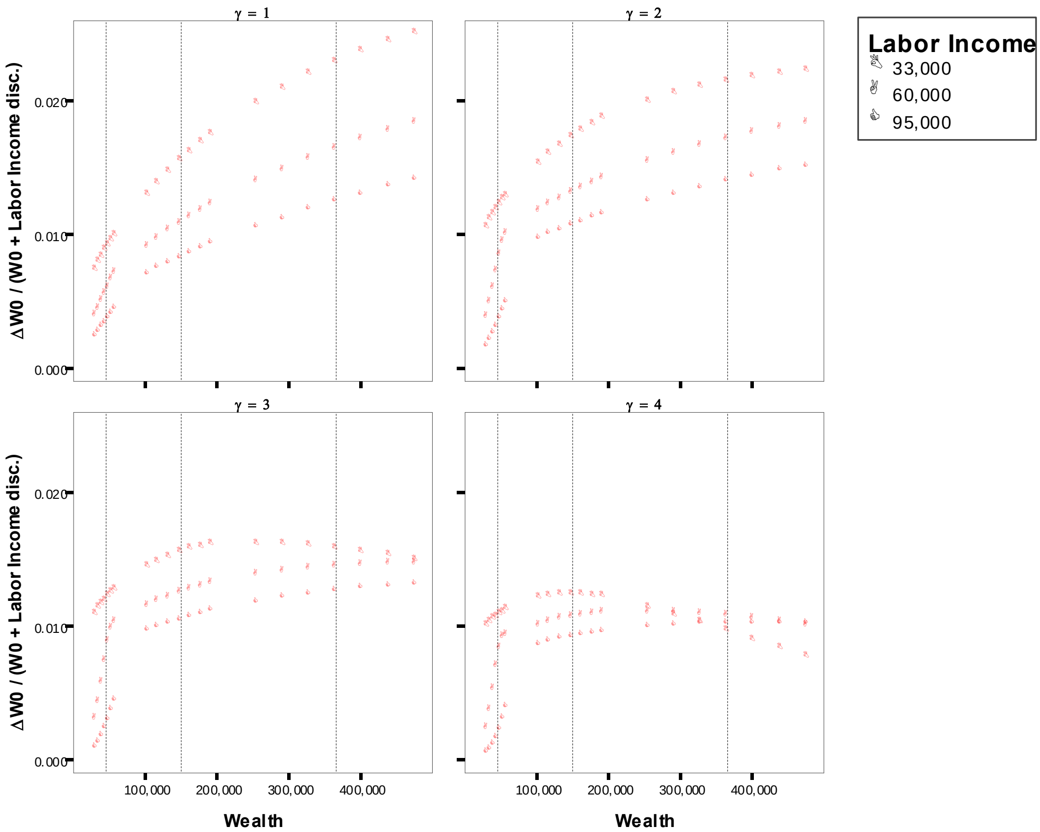
[*] Dotted vertical lines indicate age-specific quantiles for wealth (25%, 50% and 75%); age-specific quantiles for labor income are labeled by △ (25%), ○ (50%) and ▽ (75%).

Figure 4: Actual and Optimal Risky Asset Share; $\gamma = 2$, $\delta = 0.97$, Age = 50, Education = Middle*



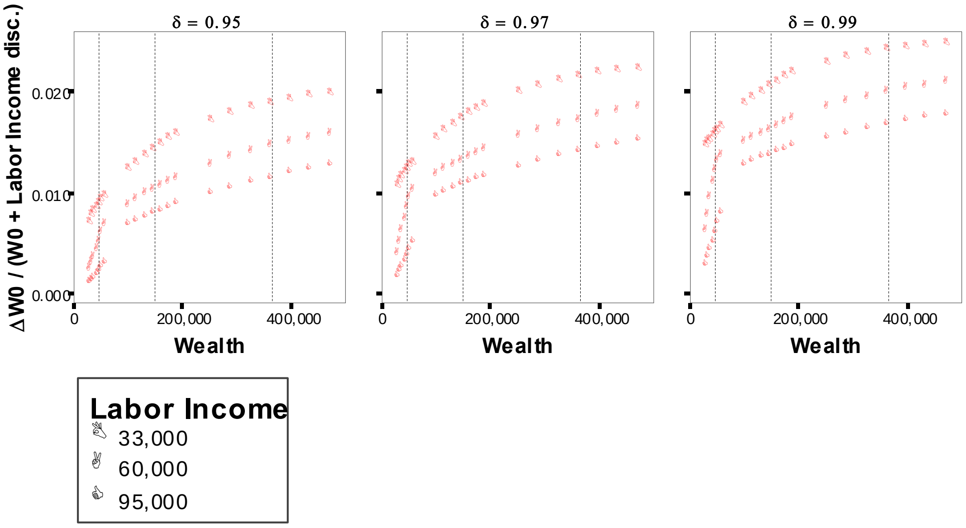
* Age-specific quantiles for labor income are labeled by △ (25%), ○ (50%) and ▽ (75%).

Figure 5: Potential Welfare Gains, ΔW_0 / (W_0 + Labor Income disc.), for U.S. Data; δ = 0.97, Age = 50, Education = Middle*



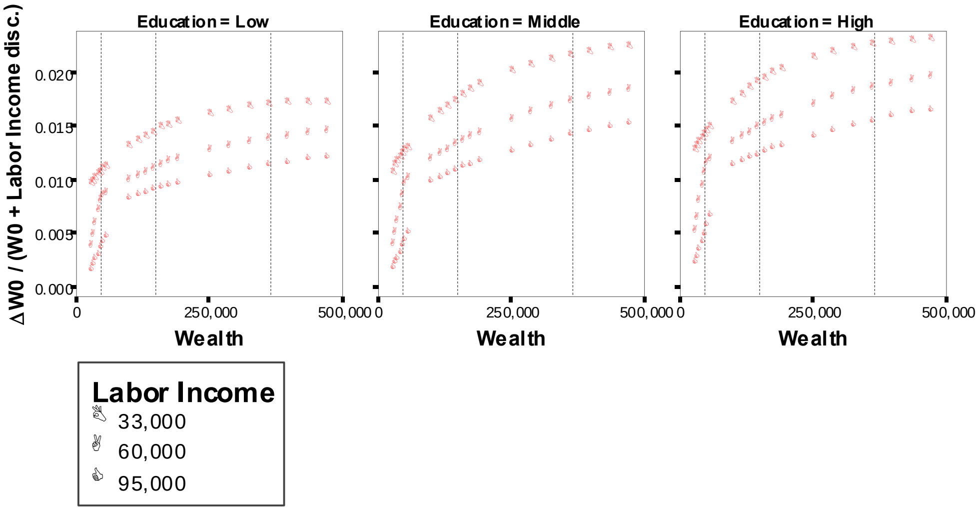
* Dotted vertical lines indicate age-specific quantiles for wealth (25%, 50% and 75%); age-specific quantiles for labor income are labeled by △ (25%), ○ (50%) and ▽ (75%).

Figure 6: Potential Welfare Gains, ΔW_0 / (W_0 + Labor Income disc.), for U.S. Data; $\gamma = 2$, Age = 50, Education = Middle*



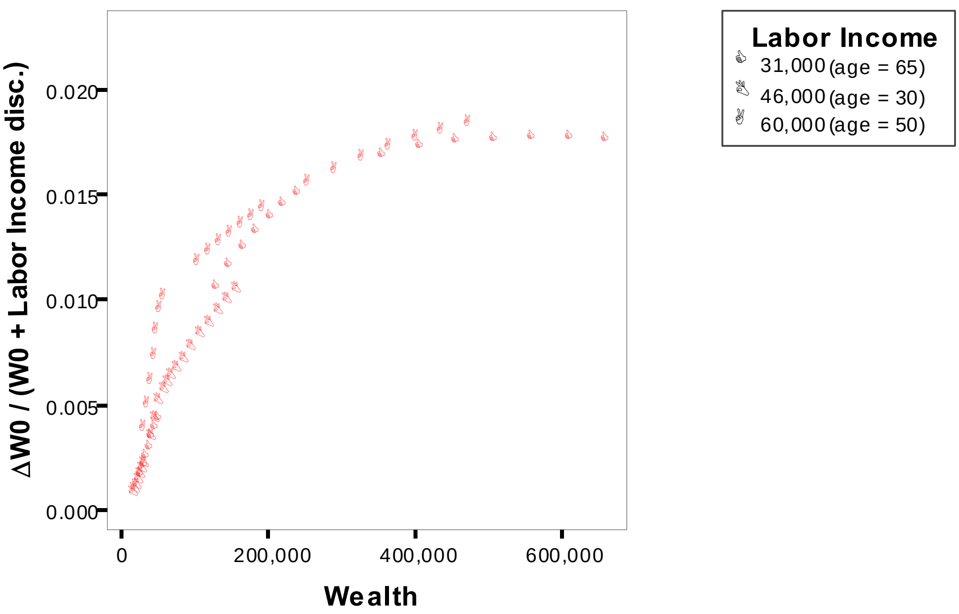
* Dotted vertical lines indicate age-specific quantiles for wealth (25%, 50% and 75%); age-specific quantiles for labor income are labeled by △ (25%), ○ (50%) and ▽ (75%).

Figure 7: Potential Welfare Gains, ΔW_0 / (W_0 + Labor Income disc.), for U.S. Data; $\gamma = 2$, $\delta = 0.97$, Age = 50 *



* Dotted vertical lines indicate age-specific quantiles for wealth (25%, 50% and 75%); age-specific quantiles for labor income are labeled by △ (25%), ○ (50%) and ▽ (75%).

Figure 8: Potential Welfare Gains, ΔW_0 / (W_0 + Labor Income disc.), for U.S. Data; $\gamma = 2$, $\delta = 0.97$, Education = Middle, Labor Income = Median (age-specific)*



* Age-specific quantiles for wealth (25%, 50% and 75%) are for age = 30: 24,100; 58,000; 121,070; for age = 50: 45,500; 149,230; 365,840; for age = 65: 38,800; 185,400; 509,900