When Should Intra-Household Risk Sharing Affect Life-Cycle Portfolio Choice?*

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Abstract

Using a quantitative, collective life-cycle portfolio choice model with a realistically calibrated earnings process, we show that couples should invest a larger share of their financial wealth in risky assets than singles with equal resources, provided that partners differ in relative risk aversion. Our finding is driven by intra-household risk sharing. Efficient risk sharing implies a consumption sharing rule, which optimally allocates household consumption across partners such that the ratio of their marginal utilities of private consumption remains constant. Traditional, unitary life-cycle portfolio choice models cannot replicate these results, which carry significant implications for the design of target date funds.

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1 Introduction

Using a quantitative, collective life-cycle portfolio choice model with a realistically calibrated earnings process, we show that couples should invest a larger share of their financial wealth in risky assets than singles, provided that partners differ in relative risk aversion. This finding holds true at any age and carries significant implications for the design of target date funds (TDFs) for defined contribution pension schemes like U.S. 401(k) plans. Given that most individuals live as couples during their working life and that nearly half of these couples consist of partners with different relative risk aversion,[1] TDFs for a large part of the population should incorporate larger equity shares than those suggested by conventional, unitary models of life-cycle portfolio choice.[2]

Our finding is driven by intra-household risk sharing. Efficient risk sharing implies a consumption sharing rule that optimally allocates household consumption across partners such that the ratio of their marginal utilities of private consumption remains constant over the life cycle. Consequently, the partners experience consumption volatility that aligns with their individual risk preferences. Intra-household risk sharing enables the couple to take on more financial risk compared to households that either cannot share risk (singles) or do not optimally want to (couples with identical risk aversion). Importantly, this risk sharing channel differs from diversifying earnings risk in dual-income couples. Unlike risk diversification, risk sharing impacts both single-income and dual-income couples, provided that partners differ in relative risk aversion.

Collective models of intra-household consumption decisions in the tradition of Chiappori (1988), surveyed by Chiappori and Mazzocco (2017), are designed to reflect opportunities for intra-household risk sharing but typically abstract from portfolio choice. We extend the dynamic, collective model proposed by Mazzocco (2004) and reviewed in Browning, Chiappori, and Weiss (2014) to incorporate the life-cycle portfolio choice decisions of dual-income couples. We focus on dual-income households because most

[1] Empirical evidence by Mazzocco (2004) and Gu, Peng, and Zhang (2023) will be reviewed below.

[2] See Gomes (2020) and Gomes, Haliassos, and Ramadorai (2021) for recent overviews of unitary life-cycle portfolio choice models.

couples consist of partners with their own sources of individual income. However, it is important to note that our findings do not depend on whether the couple earns a single or dual income, as only pooled earnings enter the couple's budget constraint.

We estimate an earnings process for dual-income couples using data from the Panel Study of Income Dynamics (PSID). Our process extends the model of Kaplan (2012) to a dual-income household. Unlike earlier dual-income processes proposed by Shore (2015) and Blundell, Pistaferri, and Saporta-Eksten (2016), our model allows for persistent but non-permanent individual earnings shocks. According to our estimates, male partners experience more persistent earnings shocks than female partners.

In the dynamic, collective model, the couple solves a Pareto problem which consists of maximizing a weighted average of the individual value functions of the partners subject to a household budget constraint. We assume that the partners have individual power utility in consumption. The Pareto weights reflect the relative bargaining power of the partners.[3] If the partners fully commit to implement the optimal saving and portfolio choice outcomes of the model, the Pareto weights are age-invariant, reflecting the partners' decision power at the time of household formation.[4]

In its most general form, our model allows for intra-household heterogeneity in bargaining power, risk preferences, discount factors, and conditional survival probabilities. We demonstrate that consumption is equally shared among partners when they are identical in all these parameters. To concentrate on differences in risk preferences and bargaining power, we assume certain survival and identical discount factors, following Ortigueira and Siassi (2013) and Apps, Andrienko, and Rees (2014). Unlike these studies, however, we emphasize the portfolio choice implications of intra-household risk sharing. We derive the policy functions for individual consumption and the allocation of wealth to risky assets from our collective model using numerical methods. Sub-

[3]A lower Pareto may also reflect a caring motive for the partner (Browning, Chiappori, and Lechene (2006), Browning and Gørtz (2012) and Hong and Ríos-Rull (2012)) or gender norms in financial decision-making as documented by Ke (2021) and Guiso and Zaccaria (2023).

[4]Commitment requires cooperation. Browning (2000) considers a non-cooperative portfolio choice model, in which spouses differ in life expectancy. Browning et al. (2006) classify a collective model with full commitment as a unitary model. Like Browning et al. (2014), we still refer to the model as the collective model to distinguish it from the unitary model.

sequently, we simulate the policy functions by generating numerous draws from the distributions of random shocks affecting earnings and asset returns in our model.

We explore three different sets of intra-household parameter constellations in our simulations: the partners either have identical risk preferences but different bargaining power, identical bargaining power but different risk preferences, or differ in both characteristics. Importantly, the case with identical risk preferences satisfies the necessary and sufficient conditions[5] derived by Mazzocco (2004) under which the couple's saving in the collective model can be replicated by a unitary model for a single representative agent. In this case, the distribution of bargaining power within the household affects the partners' individual consumption shares, but not household consumption. We show that this result extends to the portfolio choice decisions of the couple. When partners do not differ in relative risk aversion, a unitary model can replicate the couple's financial risk taking in the collective model. This is an important result because the unitary model is typically used in life-cycle portfolio choice models for singles and couples.

When partners differ in relative risk aversion, the unitary model no longer describes the optimal saving and risk taking behavior of the couple. The partners now benefit from risk sharing, which increases average consumption and the average share of wealth allocated to risky assets. Given an equal distribution of bargaining power within the household, average consumption and financial risk taking increase with intra-household heterogeneity in risk preferences. For example, compared to a couple consisting of partners with identical relative risk aversion of five, partners with relative risk aversions of two and eight on average allocate an additional 17 percentage points of saving to the stock market. We show that the couple's coefficient of relative risk aversion, which was derived by Ortigueira and Siassi (2013), falls below the average individual risk aversion coefficients of the partners if they differ in risk preferences. Moreover, the couple's risk aversion and the partners' optimal consumption shares now vary across the life cycle, which cannot be replicated by a unitary model.

These results continue to hold if partners differ in risk preferences and bargaining

[5] Described in detail in Section 4.1.

power, but the average optimal allocation to risky assets now reflects to a larger extent the risk preference of the partner with higher bargaining power. Thus, compared to the case with identical bargaining power, the couple optimally bears more financial risk if the more risk tolerant partner is also the one with higher bargaining power.

Furthermore, we investigate the impact of a mean-preserving spread in earnings risk on a couple's life-cycle portfolio choice decisions. Apps et al. (2014) show that precautionary saving increases in the collective model in response to a mean-preserving spread in earnings risk if and only if individual preferences exhibit prudence, in line with the unitary case considered by Kimball (1990). Using individual power utility, which exhibits prudence, we find that the more partners are able to share risk, the less their optimal consumption and asset allocation decisions are affected by a mean preserving spread in earnings risk.

Whether partners differ in their risk aversion is an empirical question. Using data from the Health and Retirement Study (HRS), Mazzocco (2004) finds that about 48% of couples aged 50+ report differences in the risk preferences of partners. This number reduces to 43% in the Household, Income, and Labour Dynamics in Australia (HILDA) data analyzed by Gu et al. (2023), which includes younger households as well. While most of these observed differences in risk preferences between partners are relatively small, Gu et al. (2023) parameterize intra-household bargaining power in a collective mean-variance portfolio choice model and find that husbands on average not only are more risk tolerant than wives but also have higher bargaining power. These findings imply substantial increases in risk taking in our model compared to a unitary model.

Our paper contributes to the life-cycle portfolio choice literature by proposing a collective life-cycle model for couples. In related work, Love (2010), Hong and Ríos-Rull (2012) and Hubener, Maurer, and Mitchell (2015) already propose life-cycle portfolio choice models for couples, but assume equal sharing of consumption, which eliminates the potential to share risk within the household.[6] We show that intra-household risk sharing has important implications for the design of TDFs.

[6]Brown and Poterba (2000) derive the annuity demand of a couple that shares longevity risk.

2 Life-Cycle Portfolio Choice for Couples

2.1 Collective Model Under Full Commitment

We consider the Pareto problem of a dual-income couple composed of partners (A, B) of equal age, which consists of maximizing a π-weighted average of the individual life-time power utilities in non-durable consumption over individual consumption, C_{At} and C_{Bt}, and the share, α_t, of their joint savings that is allocated to the stock market

$$\max_{\{C_{At},C_{Bt},\alpha_t\}_{t=1}^{T}} \left\{(1-\pi)\,E_1\left[\sum_{t=1}^{T}\beta_A^{t-1}p_{At}\frac{C_{At}^{1-\gamma_A}}{1-\gamma_A}\right]+\pi E_1\left[\sum_{t=1}^{T}\beta_B^{t-1}p_{Bt}\frac{C_{Bt}^{1-\gamma_B}}{1-\gamma_B}\right]\right\}. \quad (1)$$

The model allows for intra-household heterogeneity in coefficients of relative risk aversion, γ_A and γ_B, subjective discount factors, β_A and β_B, and probabilities of survival to adult age t, p_{At} and p_{Bt}, given survival to adult age 1. We assume that the partners fully commit to outcomes of the Pareto problem. In this case, the Pareto weight, π, which describes the bargaining power of partner B, remains constant across age.

From setting equal the first-order derivatives of Equation (1) with respect to C_{At} and C_{Bt}, we obtain the intra-household consumption sharing rule

$$\frac{\beta_A^{t-1}p_{At}C_{At}^{-\gamma_A}}{\beta_B^{t-1}p_{Bt}C_{Bt}^{-\gamma_B}}=\frac{\pi}{1-\pi}, \quad (2)$$

which shows that the ratio of appropriately discounted marginal utilities in consumption is constant, a standard characterization of efficient risk sharing (see Browning et al. (2014)). Moreover, together with the definition of household consumption, $C_t = C_{At} + C_{Bt}$, Equation (2) uniquely determines C_{At} and C_{Bt} for given C_t, discount factors and conditional survival probabilities.[7]

The implementation of the consumption sharing rule, which reflects the risk sharing mechanism of the collective model as described in more detail below, is the key deviation of our model from Love (2010), Hong and Ríos-Rull (2012) and Hubener et al. (2015),

[7] For this reason, it is computationally attractive to maximize Equation (1) over C_t instead of C_{At} and C_{Bt}, which is then distributed among partners according to the consumption sharing rule.

who assume that consumption is equally shared among partners. Equation (2) shows that equal sharing requires the partners to have identical discount factors, survival probabilities, coefficients of relative risk aversion and bargaining power.[8]

The value function of the Pareto problem in Equation (1) is defined as

$$
\begin{aligned}
&V_{Ct}\left(X_t, Y^p_{At}, Y^p_{Bt}\right) = \\
&\qquad \max_{C_{At}, C_{Bt}, \alpha_t} \left\{ (1-\pi) \left[\frac{C_{At}^{1-\gamma_A}}{1-\gamma_A} + \beta_A p_{At+1} E_t \left[V_{At+1}\left(X_{t+1}, Y^p_{At+1}, Y^p_{Bt+1}\right)\right] \right] \right. \\
&\qquad\qquad \left. +\pi \left[\frac{C_{Bt}^{1-\gamma_B}}{1-\gamma_B} + \beta_B p_{Bt+1} E_t \left[V_{Bt+1}\left(X_{t+1},, Y^p_{At+1}, Y^p_{Bt+1}\right)\right] \right] \right\},
\end{aligned} \tag{3}
$$

where V_{At} and V_{Bt} denote the value functions of the individual optimization problems of the partners obtained from setting $\pi = 0$ and $\pi = 1$, respectively, in Equation (1). The state variables of the dynamic programming problem are cash-on-hand, X_t, and the persistent components, Y^p_{At} and Y^p_{Bt}, of the earnings of the two partners. The evolution of these state variables will be described in Section 2.4.

2.2 Certain Survival and Identical Discount Factors

To focus on the impact of intra-household heterogeneity in risk preferences and bargaining power on consumption and portfolio choice, we now assume that survival to T is certain and that both partners have the same subjective discount factor, $\beta = \beta_A = \beta_B$, as in Ortigueira and Siassi (2013) and Apps et al. (2014). Under these assumptions, we can simplify Equation (3) to obtain a Bellman equation of the usual recursive form

$$
\begin{aligned}
V_{Ct}\left(X_t, Y^p_{At}, Y^p_{Bt}\right) = \max_{C_{At}, C_{Bt}, \alpha_t} & \left\{ (1-\pi) \frac{C_{At}^{1-\gamma_A}}{1-\gamma_A} \right. \\
& \left. +\pi \frac{C_{Bt}^{1-\gamma_B}}{1-\gamma_B} + \beta E_t \left[V_{Ct+1}\left(X_{t+1}, Y^p_{At+1}, Y^p_{Bt+1}\right)\right] \right\},
\end{aligned} \tag{4}
$$

[8] Love (2010), Hong and Ríos-Rull (2012) and Hubener et al. (2015) assume that partners have identical discount factors and risk preferences, but differ in conditional survival probabilities. Hubener et al. (2015) assume identical bargaining power, while Hong and Ríos-Rull (2012) estimate a lower Pareto weight for women. Love (2010) is silent about the magnitude of the Pareto weight being used.

which is computationally less burdensome because it does not require evaluating the individual value functions. The consumption sharing rule in Equation (2) becomes[9]

$$\frac{C_{At}^{-\gamma_A}}{C_{Bt}^{-\gamma_B}} = \frac{\pi}{1-\pi}. \tag{5}$$

From the first-order derivative of the log of Equation (5) with respect to household consumption, C_t, Ortigueira and Siassi (2013) obtain the risk sharing result

$$\frac{dC_{At}}{dC_t} = \frac{\rho_u}{\rho_A} \qquad \frac{dC_{Bt}}{dC_t} = \frac{\rho_u}{\rho_B}, \tag{6}$$

where $\rho_A = \frac{\gamma_A}{C_{At}}$, $\rho_B = \frac{\gamma_B}{C_{Bt}}$ and $\rho_u = \frac{\gamma_u}{C_t}$ denote the coefficients of absolute risk aversion of the partners and the couple. Assume that partner A is more risk tolerant than partner B, $\frac{1}{\rho_A} > \frac{1}{\rho_B}$. In this case, if C_t increases, C_{At} increases by more than C_{Bt} according to Equation (6). The consumption share of partner A, $\frac{C_{At}}{C_t}$, increases while the consumption share of partner B, $\frac{C_{Bt}}{C_t}$, decreases. Vice versa, if C_t decreases, C_{At} decreases by more than C_{Bt}. In general, intra-household risk sharing implies that the more risk tolerant partner bears most of the variation in household consumption.

To understand the portfolio choice implications of intra-household risk sharing, we will investigate the couple's coefficient of relative risk aversion, γ_u, implied by the household value function in Equation (4), as derived by Ortigueira and Siassi (2013)

$$\gamma_u = \frac{\gamma_A \gamma_B}{\gamma_B \frac{C_{At}}{C_t} + \gamma_A \frac{C_{Bt}}{C_t}}, \tag{7}$$

which varies with age unless the consumption shares are constant. The couple's risk aversion is lower than the arithmetic average of individual risk aversion if the weighted average of the individual relative risk aversion coefficients, $\gamma_B \frac{C_{At}}{C_t} + \gamma_A \frac{C_{Bt}}{C_t}$, exceeds their harmonic mean, $\frac{2\gamma_A\gamma_B}{\gamma_A+\gamma_B}$. It can be readily verified that Equations (6) and (7) hold as well for the more general household value function in Equation (3).

[9]Interestingly, an equivalent sharing rule is obtained by Wachter and Yogo (2010) for a household with non-homothetic utility in the consumption of a basic good (C_{Bt}) and a luxury good (C_{At}), where (γ_B, γ_A) denote the curvature parameters and π the utility weight on the luxury good.

2.3 Unitary Model for a Representative Agent

As an alternative to the collective model with full commitment, we consider a unitary model for a single agent with relative risk aversion γ representing the couple

$$V_{Ut}\left(X_t, Y_{At}^p, Y_{Bt}^p\right) = \max_{C_t, \alpha_t} \left\{ \frac{C_t^{1-\gamma}}{1-\gamma} + \beta E_t \left[V_{Ut+1}\left(X_{t+1}, Y_{At+1}^p, Y_{Bt+1}^p\right) \right] \right\}. \qquad (8)$$

For a case without portfolio choice, Mazzocco (2004) shows that the unitary model can replicate the saving decisions of a couple in the collective model, provided that the partners have ISHARA (identically shaped (IS), harmonic absolute risk aversion (HARA)) preferences. They must have identical beliefs and discount factors (including conditional survival probabilities in our case), and individual preferences of the HARA type, which includes power utility, with identical curvature parameters.[10]

To investigate whether the introduction of portfolio choice affects Mazzocco's results, we will compare the unitary model with a collective model in which partners have identical risk preferences, $\gamma = \gamma_A = \gamma_B$. In this case, the couple's relative risk aversion in Equation (7) reduces to $\gamma_u = \gamma$, which implies age-invariant consumption shares, which are equal to 0.5 if in addition bargaining power is the same for both partners. Note that the general collective model in Section 2.1 in which partners have different subjective discount factors and conditional survival probabilities cannot be represented by a unitary model. The couple's relative risk aversion and the partners' consumption shares vary across the life-cycle in this model.

2.4 Budget Constraint and Earnings Process

Following Deaton (1991), cash-on-hand is defined as the sum of financial wealth and total household earnings ($Y_t = Y_{At} + Y_{Bt}$), and evolves according to

$$X_t = \left(X_{t-1} - C_{t-1}\right)\left(R^f + \alpha_{t-1}\left(R_t - R^f\right)\right) + Y_t. \qquad (9)$$

[10]Only with ISHARA preferences does household consumption satisfy an individual Euler equation for consumption. Otherwise, household consumption does not satisfy an Euler equation even though each individual consumption does (Browning et al., 2014).

Joint saving, the difference between cash-on-hand and household consumption, are invested in a portfolio consisting of a risk-free asset with certain real gross return, R^f, and the stock market with risky real gross return, R_t. The couple is assumed to be borrowing and short-sale constrained, which implies $\alpha_t \in [0,1], \forall t$. Using $r_t = \ln(R_t)$ and $r^f = \ln\left(R^f\right)$, we assume that the log excess return on stocks is generated by

$$r_t - r_f = \mu + \nu_t, \tag{10}$$

where μ is the unconditionally expected equity risk premium and ν_t is an innovation that is *i.i.d.* normal with mean zero. Investment opportunities are constant.

Our model of earnings dynamics extends the model of Kaplan (2012) to a dual-income household. Assume that the log earnings for partners A and B consist of a deterministic life-cycle component and a stochastic residual component, such that $y_{At} = \ln(Y_{At}) = d_{At} + e_{At}$ and $y_{Bt} = \ln(Y_{Bt}) = d_{Bt} + e_{Bt}$, where

$$e_{At} = \omega_A + \eta_{At} + \varepsilon_{At} \qquad e_{Bt} = \omega_B + \eta_{Bt} + \varepsilon_{Bt} \tag{11}$$

$$\eta_{At} = \phi_A \eta_{At-1} + \zeta_{At} \qquad \eta_{Bt} = \phi_B \eta_{Bt-1} + \zeta_{Bt}. \tag{12}$$

Log residual earnings for each partner in Equation (11) are decomposed into a persistent component ($\eta_{At} = \ln(Y^p_{At}), \eta_{Bt} = \ln(Y^p_{Bt})$), which follows the first-order Markov process in Equation (12), a transitory component ($\varepsilon_{At}, \varepsilon_{Bt}$), and an age-invariant random effect (ω_A, ω_B). We assume that transitory shocks and random effects are *i.i.d.* normal with zero means and variances ($\sigma^2_{A\varepsilon}, \sigma^2_{B\varepsilon}$) and ($\sigma^2_{A\omega}, \sigma^2_{B\omega}$), respectively. We allow the innovations to the persistent earnings components to be correlated with each other with correlation coefficient ρ_{AB}, and with the innovations to the log stock excess return in Equation (10) with correlation coefficients ($\rho_{A\nu}, \rho_{B\nu}$). Specifically, we assume the following multivariate normal distribution for these innovations

$$\begin{pmatrix} \zeta_{At} \\ \zeta_{Bt} \\ \nu_t \end{pmatrix} \sim i.i.d.N \left[\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma^2_{A\zeta} & \rho_{AB}\sigma_{A\zeta}\sigma_{B\zeta} & \rho_{A\nu}\sigma_{A\zeta}\sigma_{\nu} \\ \rho_{AB}\sigma_{A\zeta}\sigma_{B\zeta} & \sigma^2_{B\zeta} & \rho_{B\nu}\sigma_{B\zeta}\sigma_{\nu} \\ \rho_{A\nu}\sigma_{A\zeta}\sigma_{\nu} & \rho_{B\nu}\sigma_{B\zeta}\sigma_{\nu} & \sigma^2_{\nu} \end{pmatrix} \right]. \tag{13}$$

Retirement is assumed to be exogenous and deterministic, with all households retiring at age 65, corresponding to adult age $t = 41$. Earnings in retirement ($t > 41$) are given by κ times the last working period persistent component of labor income, where κ is the replacement ratio.

3 Earnings Process Estimation and Calibration

3.1 Estimating the Earnings Process for Dual-Income Couples

We use the Survey Research Center sample of the PSID to estimate the joint earnings dynamics of partners in dual-income couples, which allows us to ignore sampling weights as in Kaplan (2012) and De Nardi, Fella, and Paz-Pardo (2020). We use the 1999 to 2017 biennial waves because we condition on stock market participation, which can be observed in the PSID since 1999. We do this because our model predicts universal participation in the absence of participation costs, which we deliberately decided not to model to focus on risk sharing. We further require that both partners (male heads and their spouses) are aged between 23 and 67 and earn a minimum of $1,000. All dollar values are converted to 2017 dollars using the CPI. We use the return including distributions on the S&P500 stock market index from CRSP to estimate correlations between persistent labor income shocks and the innovations to stock returns.

We estimate the parameters of the earnings process in two stages: In the first stage, we separately regress annual log earnings of both partners on a quartic polynomial in age and full sets of education and time dummy variables. In the second stage, we estimate the covariance parameters of the earnings process from the residuals of the log earnings regressions by GMM using the orthogonality conditions derived in Appendix A.1, which contains details on the estimation approach. To account for the first estimation stage, we obtain second-stage standard errors from a bootstrap routine for overidentified GMM estimators proposed by Hall and Horowitz (1996). The GMM estimator simultaneously solves the moment restrictions for both partners and employs an identity weight matrix. We restrict our sample to households that are observed for at least four consecutive waves in the PSID to identify all earnings process parameters. The final sample includes $N = 1,183$ dual-income couples.

Panel A of Table 1 shows first-stage OLS estimates of the log earnings regressions for household heads and their spouses. We only report the results for the coefficients of the age polynomial. The baseline households consist of college graduates, observed in 2017. Based on the estimated age polynomials, we find that household heads of dual-income households on average experience a typical hump-shaped age-earnings profile that peaks just before age 50. Spouses of dual-income households on average have a much flatter age-income profile that peaks at around age 55. The maximum average earnings of male heads ($136,000) considerably exceeds those of their spouses ($82,000).

Panel B of Table 1 shows second-stage GMM estimates of the earnings process covariance parameters. We find substantial intra-household heterogeneity in earnings processes within dual-income couples. Household heads face much more persistent shocks ($\psi_A = 0.9812$) than their spouses ($\psi_B = 0.8898$). Spouses experience much more volatile persistent income shocks and much less volatile transitory income shocks than household heads. The correlations between persistent earnings shocks and innovations to the return on the aggregate stock market turn out to be insignificant. The same holds for the correlation between the persistent earnings shocks experienced by household heads and spouses, consistent with results obtained by Blundell et al. (2016)

3.2 Calibration Choices for Dual-Income Households

In the baseline calibration, we set the risk aversion of both partners, A and B, of the dual-income household to $\gamma_A = \gamma_B = 5$. Later, we will allow for intra-household heterogeneity in risk preferences and vary γ_A (γ_B) between 2 and 5 (5 and 8). This variation is motivated by Brooks, Sangiorgi, Hillenbrand, and Money (2019) who find that men on average are more financially risk tolerant than women, controlling for differences in age and employment status. The subjective discount factor is set to $\beta = 0.96$. The Pareto weight is assumed to be $\pi = 0.5$ in the baseline specification. Later, we will consider cases with $\pi = 0.25$ and $\pi = 0.75$.

The parameters of the earnings process are based on Table 1. Following Deaton (1991), we assume that the estimated volatility parameters of the earnings process reflect to some extent measurement error. Correspondingly, we first reduce all estimated volatilities in Panel B of Table 1 by 50% for the baseline simulations. We then use the unadjusted estimated volatilities to investigate the saving and portfolio choice implications of a high-earnings-risk scenario. After age 65, we use 0.68 as the replacement ratio of retirement income to the last year's income of working life. The maximum adult age is $T = 85$, corresponding to age 109.

There are two financial assets, one risk-free asset (cash) and one risky (stocks). The risk-free asset yields a constant real gross return, r_f, of 2%, while the mean equity premium (μ) is 4%. The unconditional standard deviation of stock returns is 18%.

4 Simulation Results for Dual-Income Couples

4.1 Partners with Identical Risk Preferences

Figure 1 shows average simulated life-cycle profiles for the unitary model with $\gamma = 5$ and three collective models with $\gamma_A = \gamma_B = 5$ and $\pi = 0.25, 0.50, 0.75$, respectively. Panel A of Figure 1 shows the age profile of financial wealth, Panel B the profile of consumption, Panel C the profile of the share of wealth allocated to stocks, Panel D the profile of the couple's relative risk aversion according to Equation (7), and Panels E and F the profiles of the consumption shares for partners A and B, respectively.

Given that both partners now have identical beliefs and discount factors, and individual preferences of the CRRA type with identical curvature parameters, the ISHARA conditions are fulfilled under which the collective model without portfolio choice can be replicated by a unitary model for an agent representing the dual-income couple (Mazzocco (2004)). Indeed, Panels A and B of Figure 1 show that the unitary model and the three collective models with different Pareto weights yield identical life-cycle profiles of financial wealth and consumption. Importantly, we show that the same result applies to the share of financial wealth in stocks in Panel C, which decreases with the relative importance of human capital to financial wealth over the working life (see Cocco et al. (2005)) and stays relatively flat during retirement when earnings are risk free.

Varying the Pareto weight does not affect saving and financial risk taking in the collective model, provided both partners have the same risk aversion. The Pareto weight does, however, affect the distribution of consumption across partners as shown in Panels E and F of Figure 1: the partner with higher bargaining power optimally receives a larger share of consumption. For example, partner B in Panel F receives about 55% of consumption if $\pi = 0.75$, but only 45% of consumption if $\pi = 0.25$. The consumption shares of both partners are equal if the Pareto weight is $\pi = 0.5$. Reflecting the couple's constant relative risk aversion across the life cycle in Panel D, the partners' consumption shares are age-invariant as well.

4.2 Partners with Different Risk Preferences

We now depart from the ISHARA conditions and investigate the optimal behavior of a dual-income couple consisting of partners with different risk preferences. Figure 2 shows average simulated life-cycle profiles comparable to those in Figure 1, but obtained from collective models with $\pi = 0.50$ and four different combinations of risk aversion within the couple: $(\gamma_A = 5, \gamma_B = 5)$, $(\gamma_A = 4, \gamma_B = 6)$, $(\gamma_A = 3, \gamma_B = 7)$, and $(\gamma_A = 2, \gamma_B = 8)$. Thus, we consider models with an increasing spread in the partners' risk aversion around the same arithmetic average risk aversion of five across partners.

Figure 2 reveals our main result: the more heterogeneous the partners are in risk preferences, the more they benefit from risk sharing, as evidenced by increased financial wealth during retirement (Panel A) and increased consumption across the life cycle (Panel B). This simultaneous increase in wealth and consumption is achieved by optimally allocating larger shares of financial wealth to stocks (Panel C). Financial risk taking increases with the potential to share risk as described by the spread between the individual coefficients of relative risk aversion of the partners. While a couple with ($\gamma_A = 4, \gamma_B = 6$) on average allocates 1.6% more to stocks than a couple with ($\gamma_A = 5, \gamma_B = 5$) across the life cycle, this difference increases to a substantial 17.1% for a couple with ($\gamma_A = 2, \gamma_B = 8$). The largest increase (26.1%) in financial risk taking in the latter case is observed at age 61.

This increase in the share of wealth in stocks is reflected in the couple's coefficient of relative risk aversion (Panel D) which falls below the partners' average individual risk aversion coefficient if the partners have different risk preferences. The more heterogeneous the partners are in risk preferences, the more risk tolerant the couple becomes. While relative risk aversion of a couple with ($\gamma_A = 4, \gamma_B = 6$) on average falls below the relative risk aversion of a couple with ($\gamma_A = 5, \gamma_B = 5$) by 0.22 units across the life cycle, this difference increases to 1.83 units for a couple with ($\gamma_A = 2, \gamma_B = 8$). Importantly, a unitary model with a constant coefficient of relative risk aversion below the average individual risk aversion of the two partners is unable to replicate the consumption and portfolio choice decision of the couple in the collective model. This is because the collective model implies u-shaped age profiles of the couple's relative risk aversion (Panel D), while relative risk aversion is age-invariant in the unitary model.

Panels E and F shed more light on the intra-household consumption sharing rule in the collective model.[11] In line with the discussion under Equation (6), the average consumption share of the more risk tolerant partner A increases with household consumption over the working life, while the average consumption share of the more risk averse partner B declines. The slopes of these graphs are steeper the more partners differ in relative risk aversion. In the special case, in which the collective model with ($\gamma_A = 5, \gamma_B = 5$) becomes a unitary model with $\gamma = 5$, the consumption shares are constant again as in Figure 1.

[11] Note that the product of the average individual consumption share in Panel E (Panel F) and household consumption in Panel B is different from the average individual consumption of partner A (partner B) because an average is taken over the nonlinear consumption share.

Figure 3 shows average simulated age profiles comparable to those in Figure 2, but investigates combinations of different Pareto weights, $\pi = 0.25, 0.75$, with sets of individual risk aversions, $(\gamma_A = 3, \gamma_B = 7)$ and $(\gamma_A = 2, \gamma_B = 8)$. The benefits from intra-household risk sharing documented earlier in Figure 2 for $\pi = 0.50$ remain present. The more heterogeneous the partners are in risk preference, the more they are able to increase wealth in retirement (Panel A of Figure 3) and consumption across the life cycle (Panel B). Risk taking (Panel C) increases as well, but now reflects to a larger extent the relative risk aversion of the partner with larger bargaining power. The larger the Pareto weight reflecting the bargaining power of partner B for a given combination of (γ_A, γ_B), the more the couple's relative risk aversion (Panel D) resembles the risk aversion of the more risk averse partner B, and the lower the share of wealth in stocks. For a given combination of (γ_A, γ_B), the partner with more bargaining power on average receives a larger share of consumption early in life when household consumption is relatively low but a lower share of consumption later in life (Panels E and F).

4.3 Mean-Preserving Spreads in Idiosyncratic Earnings Risk

To investigate how precautionary savings motives interact in our model with the potential to share risk within the household, we repeat the simulations underlying Figure 2 with an earnings process that employs the full magnitude of the estimated volatilities in Panels B and C of Table 5.[12] Recall that we reduced these volatilities for our previous simulations by 50% to account for possible measurement error.

Figure 4 shows average simulated age profiles from collective models with $\pi = 0.50$ and the four different combinations of the partners' risk aversions considered earlier in Figure 2. Compared to the results in Figure 2, the couple creates substantial, additional, precautionary savings in response to a mean-preserving spread in earnings risk. Markedly more wealth is accumulated (Panel A of Figure 4) over the life cycle in response to an increase in saving in the first 15 years of adult life (Panel B).

[12] To preserve the means of the partners' earnings, we reduce the means of the innovations affecting log earnings by one half of their estimated variance.

This increase in saving is accompanied by a substantial reduction in the share of wealth in stocks (Panel C). Higher background risk crowds out financial risk taking. Importantly, the more the couple is able to share risk within the household, the less it will reduce the share of wealth in stocks in the high idiosyncratic earnings risk scenario (compare Figure 4 relative to the low idiosyncratic earnings risk scenario in Figure 2). For example, while a couple with $(\gamma_A = 5, \gamma_B = 5)$ on average reduces the allocation to stocks by 13.8 percentage points over their life cycle, a couple with $(\gamma_A = 2, \gamma_B = 8)$ reduces the share of wealth in stocks by 10.7 percentage points. This is reflected in the couple's relative risk aversion (Panel D), which decreases with an increasing spread in relative risk aversion between partners. With an increasing ability to share risk within the household, the couple's willingness to bear financial risk becomes less vulnerable to higher earnings uncertainty in the sense of Gollier and Pratt (1996).

The life-cycle profiles of the partners' consumption shares (Panels E and F) are steeper in Figure 4 than in Figure 2 as a result of additional resources given to the more risk averse partner B early in life. When consumption in early life in Figure 2 is lower than in Figure 4, the consumption level of the more risk tolerant partner A decreases more than the consumption level of the less risk tolerant partner B.

5 Conclusion

Using a collective life-cycle portfolio choice model, we show that couples should invest a larger share of their financial wealth in risky assets than singles if partners are able to share risk within the household. Assuming individual power utility in consumption, risk sharing requires the partners to differ in either discount factors, survival probabilities or risk preferences. Otherwise, a unitary model for a single representative agent can replicate the optimal portfolio choice decisions of the couple in the collective model. Focusing on intra-household heterogeneity in risk preferences, we find that a couple's optimal share of wealth in risky assets increases with the difference in the partners' coefficients of relative risk aversion. Moreover, risk sharing reduces the impact of a mean-preserving spread in earnings risk on financial risk taking.

Empirically, almost half of couples consist of partners with different risk aversion. We show that even modest heterogeneity in risk preferences among partners results in substantial increases in financial risk taking in the collective model compared to a unitary model if the more risk tolerant partner is also the one with higher bargaining power. Previous literature suggests that husbands on average are more risk tolerant than wives and have higher bargaining power. Therefore, our results challenge the universal use of the unitary model for normative portfolio choice decisions, including the design of target date default funds for defined contribution pension plans.

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Appendix

A.1 GMM Estimation of Earnings Process Parameters

From iterating forward the log earnings process in Equations (11) and (12) in Section 2.4, we obtain the following equation for individual $m = (A, B)$ of adult age t in the first wave of the sample using the initial condition $\eta_{m0} = 0$ employed by Kaplan (2012)

$$e_{mt} = \omega_m + \sum_{s=1}^{t} \phi_m^{t-s} \zeta_{ms} + \varepsilon_{mt}. \tag{1}$$

From this equation, we derive unconditional variances and autocovariances of log earnings residuals for waves $i = 0, 1, 2, \ldots, 10$ and $j > i$, which can be simplified using the rule for a sum of a geometric series

$$E[e_{m,t+2i}e_{m,t+2i}] = \sigma^2_{m\omega} + \sum_{s=1}^{t} \phi_m^{2(t+2i-s)} \sigma^2_{m\zeta} + \sigma^2_{m\varepsilon} = \sigma^2_{m\omega} + \frac{1 - \phi_m^{2(t+2i)}}{1 - \phi_m^2} \sigma^2_{m\zeta} + \sigma^2_{m\varepsilon} \tag{2}$$

$$E[e_{m,t+2i}e_{m,t+2j}] = \sigma^2_{m\omega} + \phi_m^{2(j-i)} \sum_{s=1}^{t} \phi_m^{2(t+2i-s)} \sigma^2_{m\zeta} = \sigma^2_{m\omega} + \phi_m^{2(j-i)} \frac{1 - \phi_m^{2(t+2i)}}{1 - \phi_m^2} \sigma^2_{m\zeta}. \tag{3}$$

We are working with two-year increments to reflect the biennial waves of the PSID. We also obtain covariances between log earnings residuals and log stock excess returns and between log earnings residuals of members A and B of a dual-income household

$$E[e_{m,t+2i}(r_{t+2i} - r_f - \mu)] = \mathrm{E}[\zeta_{m,t+2i}(r_{t+2i} - r_f - \mu)] = \rho_{m\nu}\sigma_{m\zeta}\sigma_\nu \tag{4}$$

$$E[e_{A,t+2i}e_{B,t+2i}] = \sum_{s=1}^{t} (\phi_A\phi_B)^{t+2i-s} \rho_{AB}\sigma_{A\zeta}\sigma_{B\zeta} = \frac{1 - (\phi_A\phi_B)^{t+2i}}{1 - \phi_A\phi_B} \rho_{AB}\sigma_{A\zeta}\sigma_{B\zeta}. \tag{5}$$

We replace μ and σ_ν with the mean and volatility of log stock excess returns in the data. Orthogonality conditions for a GMM estimator of $\theta = \left(\omega_A, \phi_A, \sigma^2_{A\zeta}, \sigma^2_{A\varepsilon}, \rho_{A\nu}\right)'$ for single-income households, and $\theta = \left(\omega_A, \phi_A, \sigma^2_{A\zeta}, \sigma^2_{A\varepsilon}, \rho_{A\nu}, \omega_B, \phi_B, \sigma^2_{B\zeta}, \sigma^2_{B\varepsilon}, \rho_{B\nu}, \rho_{AB}\right)'$ for dual-income households, are based on the difference between the model-implied variances and covariances in Equations (2) to (5) and their empirical counterparts.

We follow Kaplan (2012) and estimate the empirical moments for an individual of age $t = 25, \ldots, 65$ (equivalent to adult age $t = 1, \ldots, 41$ in the model) from individuals aged $[t-2, t+2]$ to increase the number of observations used for each age cell, and match all available variances and covariances that are based on at least 30 observations.

We need at least four consecutive biennial observations for each individual to estimate all parameters of the earnings process by GMM. We employ an identity weight matrix to avoid the small sample problems caused by the optimal weight matrix when the number of overidentifying restrictions is large (Newey and Smith, 2004). We obtain standard errors from a bootstrap for overidentified GMM estimators proposed by Hall and Horowitz (1996) with 100 replications to account for the first estimation stage.

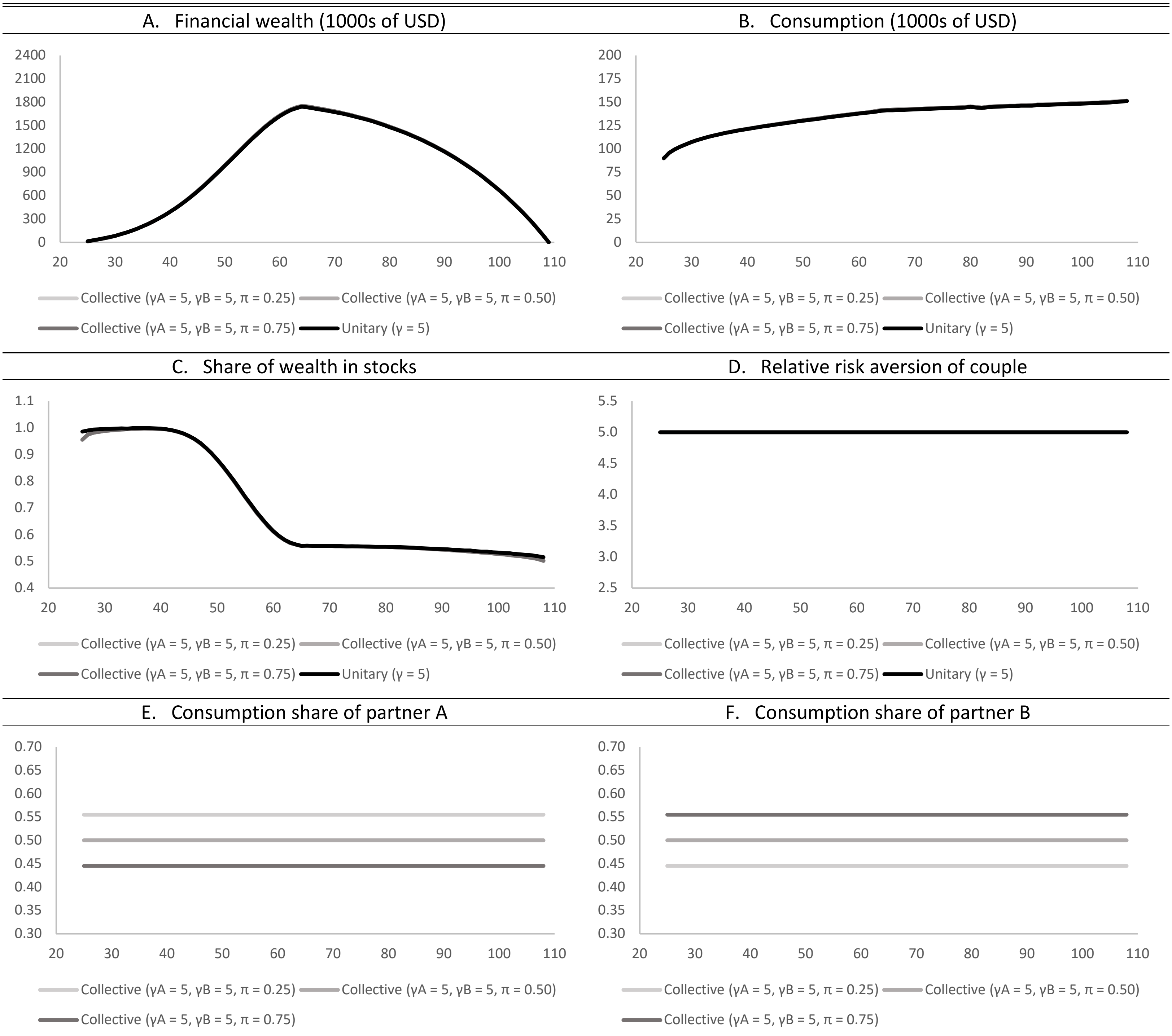
Tables and Figures

Table 1: Estimation of earnings process parameters for dual-income couples

A. First-stage OLS		Intercept	Age/10	$(\text{Age}/10)^2$	$(\text{Age}/10)^3$	$(\text{Age}/10)^4$	$N/(NT)$
Head	estimate	7.7523	2.5596	-0.7595	0.1193	-0.0080	1,183
	(t-value)	(3.54)	(1.22)	(-1.03)	(1.07)	(-1.29)	(8,003)
Spouse	estimate	4.8413	5.9178	-2.1886	0.3581	-0.0217	
	(t-value)	(2.10)	(2.60)	(-2.67)	(2.81)	(-2.99)	
B. Second-stage GMM		ϕ	σ_ω^2	σ_ζ^2	σ_ε^2	ρ_ν	ρ_{AB}
Head	estimate	0.9812	0.0352	0.0202	0.3111	-0.0389	0.1041
	(t-value)	(64.93)	(1.46)	(2.37)	(10.22)	(-0.38)	(1.17)
Spouse	estimate	0.8898	0.1657	0.1078	0.1130	0.0181	
	(t-value)	(30.43)	(3.46)	(3.43)	(2.50)	(0.35)	

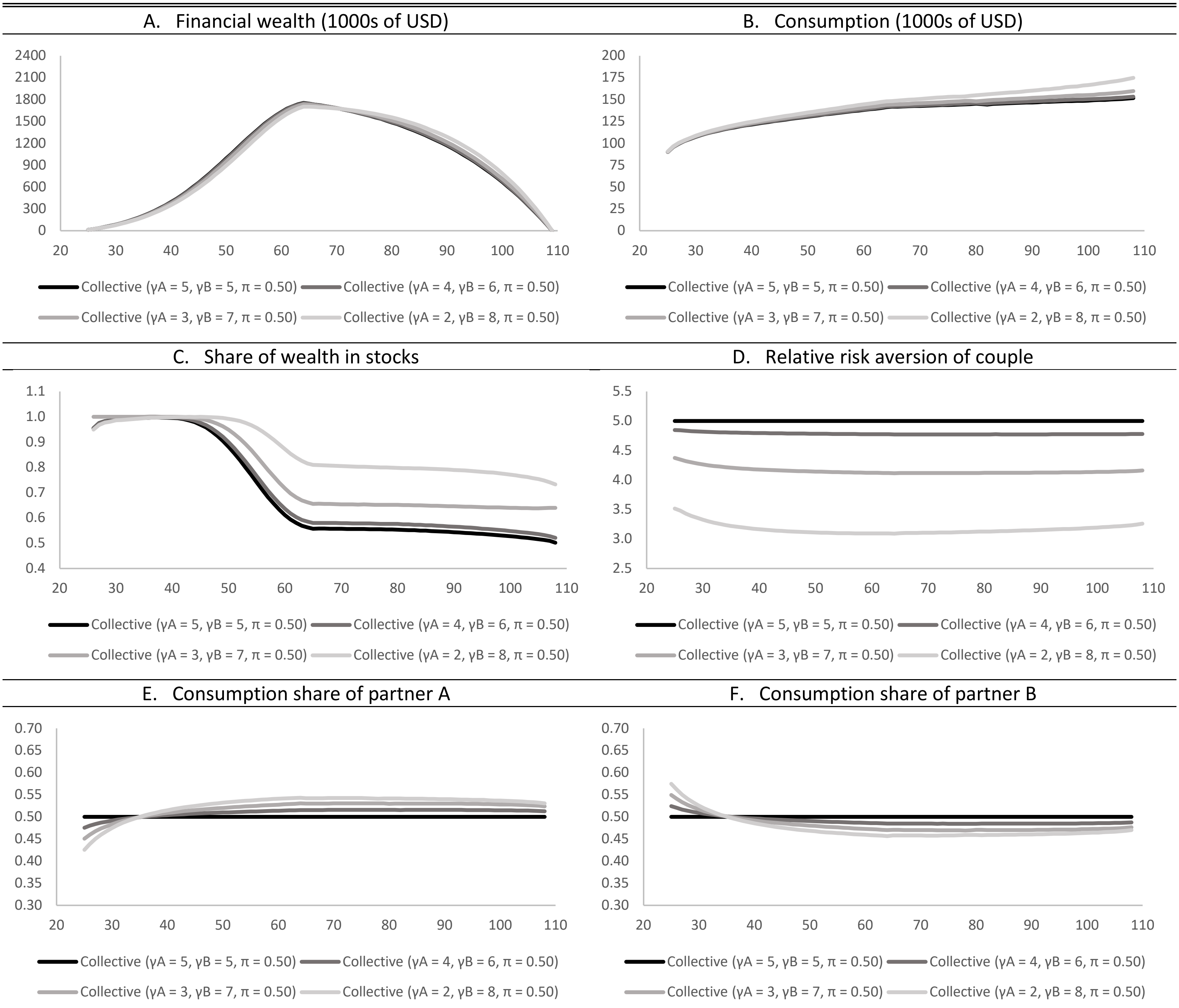
Note: The table shows earnings process parameter estimates for dual-income couples estimated from the 1999 – 2017 ($T = 10$) waves of the PSID. The data consists of dual-income couples from the PSID SRC sample who participate in the stock market. Both partners are aged between 23 and 67 and each earns a minimum of \$1,000 (in 2017 dollars). Heads are male. For identification, households need to be observed for at least four consecutive waves. Panel A shows first-stage OLS estimates from a linear regression of log annual earnings (in 2017 dollars) on a quartic polynomial in age and a full set of education and time dummy variables. The baseline education category consists of college graduates while the baseline year is 2017. Results for the education and time dummies are unreported. The residuals of the first estimation stage are used in the second stage to estimate the covariance parameters of the residual log earnings process. Persistent earnings shocks follow an auto-regressive process with AR(1) parameter ϕ and residual variance σ_ζ^2. The variances of the individual effect and the transitory earnings shocks are σ_ω^2 and σ_ε^2. The correlation between persistent earnings shocks and stock excess returns is ρ_ν, while ρ_{AB} denotes the correlation between the partners' persistent earnings shocks. Panel B shows GMM estimates of these parameters using an identity weight matrix. Standard errors are obtained using the bootstrap for GMM. Details of the GMM estimation approach are given in Appendix A.1.

Figure 1: Varying the Pareto weight when both partners have identical risk aversion



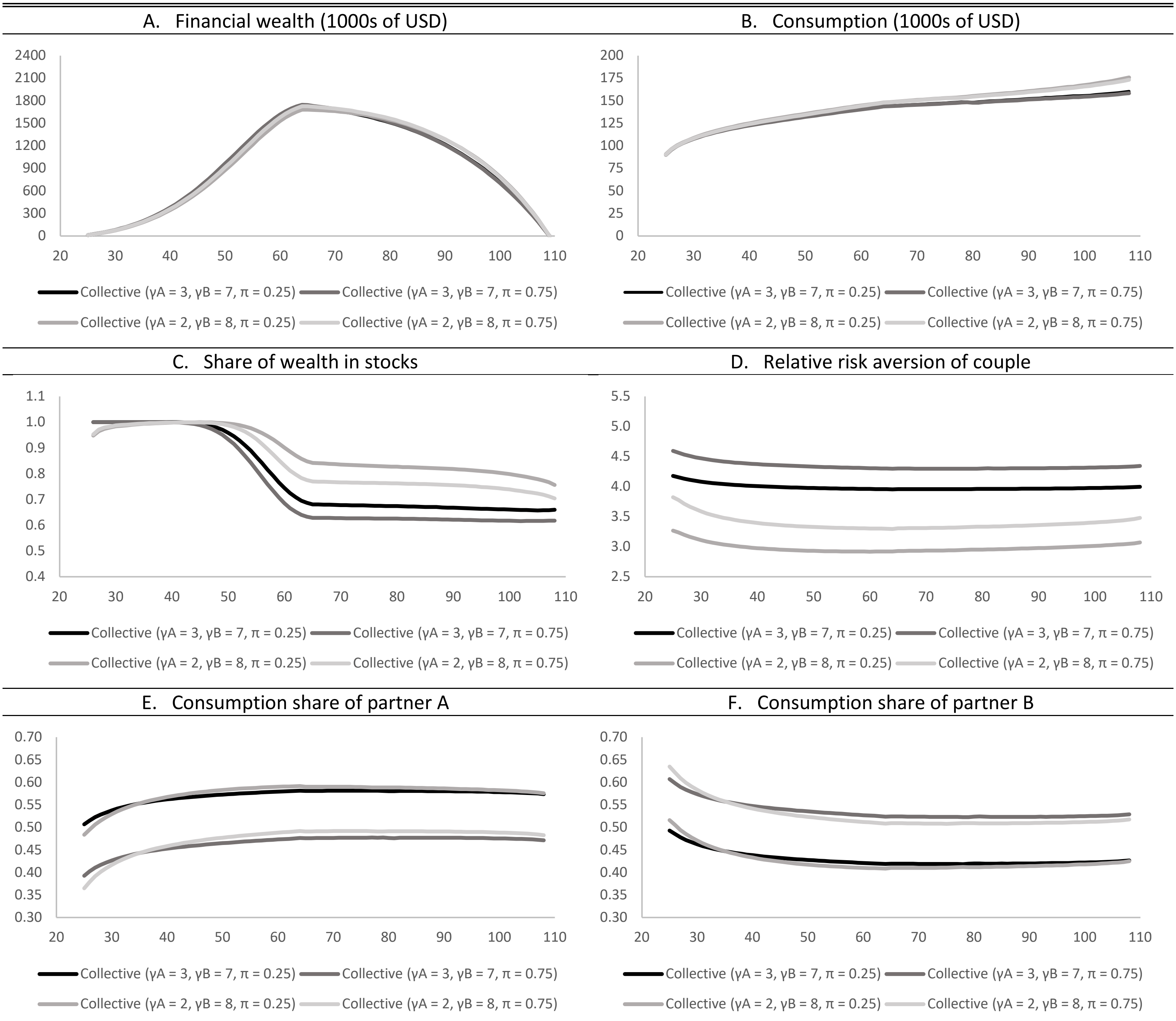
Note: The figure shows average simulated life-cycle profiles for financial wealth (in Panel A), consumption (Panel B), the share of wealth allocated to stocks (Panel C), the relative risk aversion of the couple (Panel D), the consumption shares of partners A and B (Panels E and F), obtained from the unitary life-cycle model with $\gamma = 5$ and three collective models with $\gamma_A = \gamma_B = 5$ and $\pi = 0.25, 0.50, 0.75$, respectively.

Figure 2: Varying the spread in risk aversion when both partners have identical bargaining power



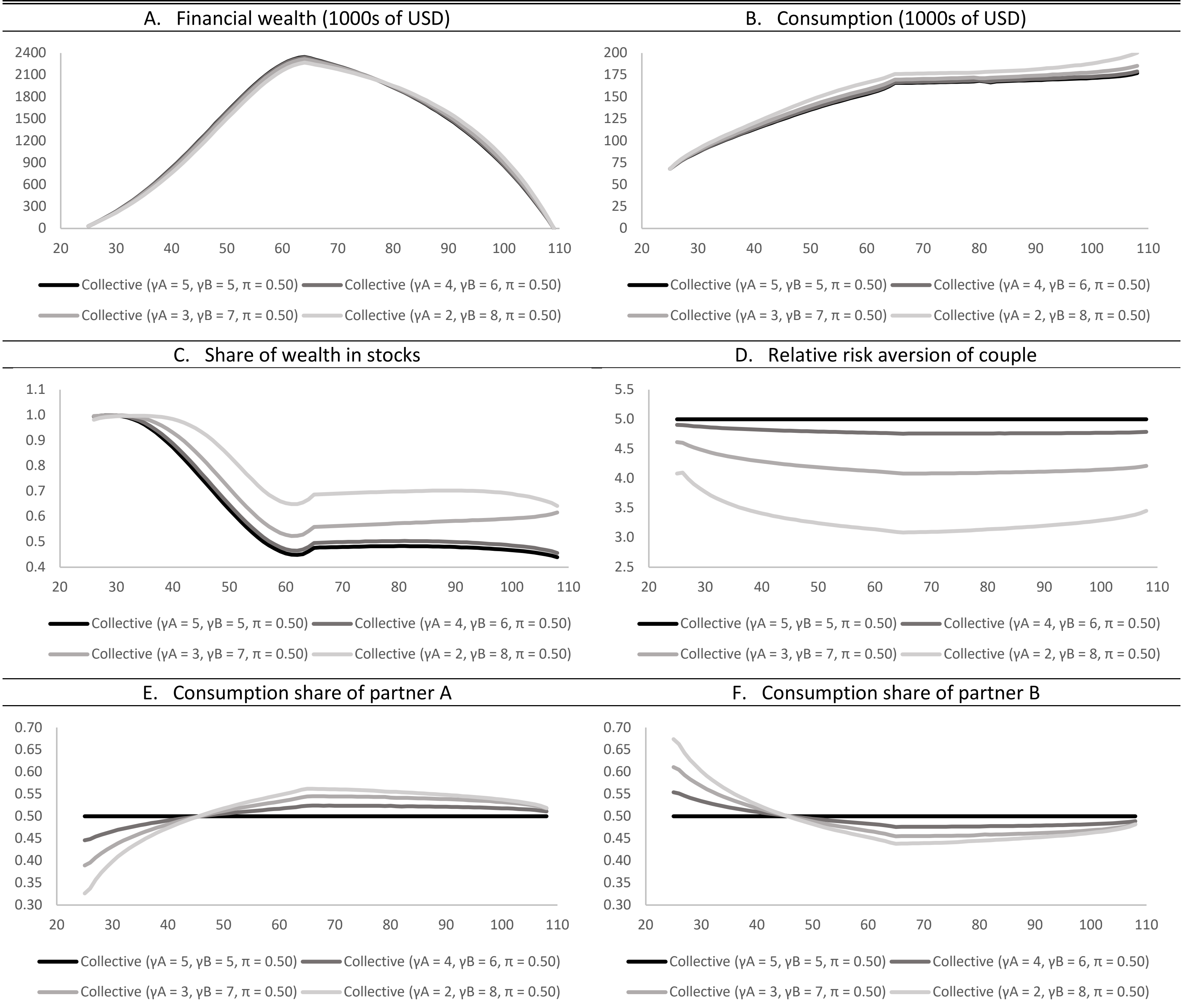
Note: The figure shows average simulated life-cycle profiles for financial wealth (in Panel A), consumption (Panel B), the share of wealth allocated to stocks (Panel C), the relative risk aversion of the couple (Panel D), the consumption shares of partners A and B (Panels E and F), obtained from four collective life-cycle models with ($\gamma_A = 5, \gamma_B = 5$), ($\gamma_A = 4, \gamma_B = 6$), ($\gamma_A = 3, \gamma_B = 7$), and ($\gamma_A = 2, \gamma_B = 8$), respectively.

Figure 3: Varying the Pareto weight when both partners have different risk aversion



Note: The figure shows average simulated life-cycle profiles for financial wealth (in Panel A), consumption (Panel B), the share of wealth allocated to stocks (Panel C), the relative risk aversion of the couple (Panel D), the consumption shares of partners A and B (Panels E and F), obtained from four collective life-cycle models with combinations of $(\gamma_A = 3, \gamma_B = 7)$, $(\gamma_A = 2, \gamma_B = 8)$ and $\pi = 0.25, 0.75$.

Figure 4: Varying the spread in risk aversion when both partners have identical bargaining power – high earnings risk



Note: This figure replicates Figure 2 for a high-earnings-risk scenario, in which all estimated volatilities of the couple's joint earnings process are doubled. The figure shows average simulated life-cycle profiles for financial wealth (in Panel A), consumption (Panel B), the share of wealth allocated to stocks (Panel C), the relative risk aversion of the couple (Panel D), the consumption shares of partners A and B (Panels E and F), obtained from four collective life-cycle models with $(\gamma_A = 5, \gamma_B = 5)$, $(\gamma_A = 4, \gamma_B = 6)$, $(\gamma_A = 3, \gamma_B = 7)$, and $(\gamma_A = 2, \gamma_B = 8)$, respectively.