Marital sorting, family output and wealth inequality

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In this paper, we analytically model marital sorting, intergenerational transfers, and inequality in a household optimisation model with uncertainty. We modify and apply a 'sorting, reverse sorting' numerical approach by Demirtas in the context of marriage market mating, illustrating the robustness of our analytical results. We show that the parameters of the family production function play an important role in driving the path of an economy's inequality. One finding is that, under assortative mating, factor shares in the family production function positively affect inequality, while under disassortative mating, the relationship between the factor shares and inequality is U-shaped. This and other results that we obtain can stimulate further empirical research, holding potentially important policy implications.

JEL classification: D31, D63, D130

1. Introduction

Since Becker's (1973) pioneering work on the theory of marriage, there has been an ongoing interest among economists in looking at couples' mating patterns and how this can be linked to various complex factors. For instance, in one of the earliest contributions, Benham (1974) showed that a wife's education positively affects the labour market earnings of her husband, which is a finding that carries implications for selective mating behaviour. Even spouses' similar demands for household public goods have been shown to substantially affect the assortative mating on wages (see, e.g., Borra *et al*., 2021 and the references therein).

Recent studies on sorting in the marriage market have focused on a wide spectrum of problems, including issues such as inequality in intergenerational outcomes, social stratification, and even female labour supply responses in the context of assortative mating (see, e.g., Davia and Legazpe, 2017; Pestel, 2017; Holmlund, 2022). Others have emphasised some compositional and behavioural changes in marriage and labour markets, as well as economy-wide factors that can potentially confound a link between marital sorting and inequality (see, e.g., Greenwood *et al*., 2016; Eika *et al*., 2019). In addition, studies that have researched inequality issues in general have traditionally identified a myriad of complex factors that can affect inequality. The present paper argues that knowledge of what happens within a family might also help in understanding this phenomenon. We highlight the roles of intrafamily asset production and intergenerational transmission processes that link parents and children in the context of marriage market sorting; and we focus on the evolution of the resulting between-household inequality. Hence, in studying wealth inequality, it is important to not only consider the total amount of asset transmission across generations, but also the mechanism of this asset-generation process within individual households.

It is well known that parents play an important role in shaping their children's current and future choices, including their marriage market behaviour. Several studies have documented the importance of parental wealth and socioeconomic background in children's mate choices, even though the magnitude of the findings can vary by country (see, e.g., Charles *et al*., 2013; Wagner *et al*., 2020). Other studies focused on how parents' socioeconomic conditions and backgrounds are transferred into children's future outcomes, using this link to investigate the effect of sorting on inequality (e.g., Kremer, 1997; Fernández and Rogerson, 2001).

It is certainly true that many individuals find matches in the marriage market based on their own traits and characteristics, including their educational attainment. Yet some, if not all, of these attributes are either directly or indirectly influenced by the characteristics and choices of the spouses' parents. For example, better-educated parents can help children acquire knowledge and attend highly ranked schools, causing a potentially large transmission coefficient of parental education on children's education (Fleury and Gilles, 2018). In addition, bequests and inter vivo transfers often shape a sizeable share of one's own wealth (Niimi and Horioka, 2018). Therefore, the current paper investigates marital sorting and the dynamics of wealth inequality, taking into consideration the link between parents' choices and their children's future marriage market characteristics.

Our model can be described as follows: First, partners match at a young age, pool together their individual resources (e.g., individual assets, time, market or home goods) and make efforts to generate some end-result product (family assets or 'assets' for short). Next, a part of these assets that is ultimately passed to the couple's children shape the children's marriage market characteristics. In turn, the children will be sorted in the marriage market, form a family of their own and produce some family assets, thereby sustaining the dynamic process of asset generation and division.

More specifically, we consider a heterogeneous-agent household optimisation framework and an intergenerational asset transmission mechanism with uncertainty. In the initial period, an existing adult population is characterised by a given distribution of assets that can be broadly defined. Based on these assets, adults match in the marriage market, where we can precisely control the degree of marital sorting (correlation coefficient between spouses' assets). Every formed family faces a productivity shock and generates the family output, which finances household consumption and the amount of bequeathable assets. The latter shape children's marriage market characteristics and the resulting marriage pattern of a new generation. This dynamic process continues to form the next generation's distribution of inherited assets until a stationary equilibrium of wealth distribution has been achieved.

Our model shows that the factor shares in the family production function affect wealth inequality differently, especially in the case of positive and negative assortative mating. Note that factor shares capture the relative importance of each spouse's input in the household output generation process, thus reflecting the productivity of each input type. We find that, under positive assortative mating, a rise in the factor shares would increase inequality. Hence, even though a single household might prefer to increase the productivity of some factors, from society's viewpoint, this could be suboptimal. In this context, our findings imply that a reduction in economy-wide inequality can be achieved when the marginal contribution to the family output generation process of the least productive spouse increases at the expense of the marginal contribution of the most productive spouse. However, in the presence of negative assortative (disassortative) mating, the relationship between inequality and factor shares is U-shaped. Our model also establishes a clear relationship between the bequest-sharing rule and variability of bequests both in levels and logarithms. Finally, we have shown how to assess inequality in our model based on the Lorenz dominance concept.

Turning to the policy implications of the above finding, recall that factor shares reflect the contribution of individual partners to the family output generation process, thereby potentially depending on the supporting resources and technology available to each gender. In an economy where the earning gaps between men and women are small, an increase in labour force participation by, say, wives and the corresponding reduction in labour force participation by husbands would leave family monetary assets roughly the same. Naturally, women who spend less time doing household chores and become detached from home tasks might gradually lose some of their skills. Newly stay-at-home dads, however, might not be very skilled in cooking, cleaning, teaching their kids important skills or even properly looking after their health, which are factors that are important for forming the children's future marriage market characteristics. Nonetheless, public policies could help set up support groups for such parents. Such groups have become more popular in countries like Sweden, where a 'daddy quota' reform was passed to raise the proportion of leave to be taken by fathers (e.g., Rangecroft, 2016).

Furthermore, gender efficiencies in household production can be time varying because of institutional, cultural, and technological changes. Therefore, future empirical studies can attempt to estimate the strength of marital sorting, factor shares of each gender and other parameters of marital output to observe whether they have stayed stable over time within a country or if they differ significantly across countries. This can help to investigate whether the observed corresponding differences in Gini coefficients across different time periods and countries match the predictions of our theoretical model. In general, the efforts to estimate marital production can be linked to many seminal attempts in household production literature and related micro-econometric research, where additional challenges arise if one recognises the substitutability between market and home sectors as a response to evolving policy reforms. For example, higher inheritance taxes aimed at reducing inequality can encourage high-income partners to reduce their overall market activities and increase home activities devoted to the development of children's intangible skills, which can carry further implications on children's marriage market characteristics and, thus, on inequality trends. In addition, several authors have shown that modelling household production and estimating the values of its parameters can improve our understanding of capital and labour markets, business cycles and fiscal policy, while also reducing bias in individual welfare analysis (Rupert *et al.*, 1995, 2000; Donni, 2008). Our study suggests that the household asset production process and relative importance of wives' and husbands' inputs might also play a key role in the context of marriage market sorting and inequality. Thus, future research can extend the tradition of home production literature (see, e.g., Gronau, 1980; Graham and Green, 1984; Huffman, 2011) to estimate the differences in the bequeathable family asset-generation parameters over time and across countries and households, which might shed light on inequality trends. Finally, future empirical studies can also use household surveys and cross-country data to test our theoretical finding on the link between bequest-sharing rules and the distribution of bequests.

Our contributions are summarised as follows: First, our study provides a highly tractable framework for examining the impact of marital sorting on inequality, and we show that, in theory, wealth inequality patterns under assortative and disassortative mating are not necessarily similar or even linear. Second, we extend Kremer's (1997) setting to allow for a nonlinearity in the parent–children asset-transition process, allowing us to show that even a perfect correlation between spouses' wealth would not result in increasing wealth inequality if there were diminishing returns to scale in the production of marital output. Third, our findings imply that spouses' factor shares in family output and marital sorting can help predict a society's wealth inequality index, and this finding can certainly become a basis for empirical testing. This should be relevant because several studies have pointed out notable cross-country and cross-household income differences and the positive effect of stronger sorting on inequality in recent decades (e.g., Fernández *et al*., 2005, Ciscato and Weber, 2020).

The rest of the current paper is organised as follows: Following this introductory section, the next section briefly reviews the related literature. The formal model is then developed in Section 3, and the simulation results are presented in Section 4. Section 5 presents the conclusions.

2. A Brief Review of the Literature on Sorting and Inequality

In this section, we briefly describe the literature on the interrelationship between marital sorting and inequality. We categorise most of these studies into three strands.

One strand of the literature has focused on the link between marital sorting and intergenerational persistence in socioeconomic status. For example, Holmlund (2022) used Swedish data to estimate the link between assortative mating and intergenerational income persistence. Holmlund (2022) found that the decline in marital sorting slightly lowered the intergenerational rank correlation between household earnings, though the results were different for women and men and were sensitive to the introduction of alternative assumptions about assortative mating and female labour supply. Ermisch *et al*. (2006) studied the impact of assortative mating in human capital on intergenerational economic mobility in Germany and Britain. The authors concluded that about 40–50% of the proportion of the covariance between parents and their own permanent family income could be explained by the covariance between parents and partner's permanent income; this effect was strongly influenced by the spousal correlation in human capital. Raaum *et al*. (2008) contrasted intergenerational earnings mobility (captured by the elasticities of individual or combined earnings with respect to own parents' earnings) in Denmark, Finland, Norway, the UK, and the US and concluded that intergenerational earnings persistence was the strongest in the US, where marital sorting in educational attainment was higher. The authors highlighted the importance of labour supply responses of married women in weakening the correlation between married women's own earnings and their parents' earnings.

The second strand of the literature has primarily investigated the empirical links between the strength of assortative mating and cross-sectional earnings inequality across households. Pesando (2021) focused on assortative mating in education in rural and urban Sub-Saharan Africa, investigating its effect on inequality in asset possession between households. The author concluded that, overall, educational assortative mating could explain a notable share of the cohort-specific inequality in wealth and was exclusively driven by urban areas. Bender *et al*. (2021) documented a rise in assortative mating by performance pay receipt among UK couples, showing a concentration in the earnings premiums of performance pay among dual receipt households and suggesting that this can contribute to household earnings inequality. Eika *et al*. (2019) found that educational assortative mating accounted for a significant part of the cross-sectional inequality in household income in the US, Denmark, Norway, Germany and the UK. However, changes in assortative mating over time hardly affected inequality because the rise in assortative mating among less educated individuals was offset by a decline in assortative mating among the highly educated. Pestel (2017) used German microdata from as early as the 1980s to argue that, given an increased sorting on earnings potential, a strong attachment of women to the labour market would worsen cross-sectional earnings inequality. The results were more pronounced in East Germany, where female employment was substantially higher than in West Germany. Chiappori *et al*. (2020) considered the 1945–1954 and 1965–1974 birth cohorts in the UK, finding that changes in sorting in the marriage market by education slightly increased inequality in family-earned income. This effect was counterbalanced by the fact that the later cohort was more educated than the earlier one and that education tends to reduce inequality in earnings.

The third strand of the literature has primarily focused on the quantitative–theoretical aspects of the interplay between marital sorting and long-term inequality. In a seminal contribution, Kremer (1997) assumed exogenous sorting in education and neighbourhoods and modelled children's characteristics as a linear function of parents' characteristics. The author concluded that sorting has a minor effect on the long-run inequality of moderately heritable characteristics, such as education and income. Fernández *et al*. (2005) modelled an environment in which marital sorting and inequality can reinforce each other. An exogenous rise in inequality increased sorting as skilled workers became more reluctant to sort with unskilled workers. Fernández *et al*. (2005) modelled an imperfect capital market, where parental income served as collateral in financing the education of young individuals who decided to become skilled or unskilled and subsequently chose how to match in the marriage market. The model generated multiple steady states, with the possibility that more sorting lowered the proportion of individuals who decide to become skilled, thus raising the next generation's skill premium and equilibrium inequality. Besley (2017) adopted a political economy voting model and showed how family backgrounds affect children's aspirations and effort levels. A fraction of the population was assumed to sort assortatively, and this was shown to preserve the proportion of aspirational individuals. The author modelled endogenous income redistribution and concluded that the proportion of aspirational individuals in society can have a nonlinear effect on inequality. The role of intervention policies in improving intergenerational mobility was also highlighted. Cowell and Van de gaer (2017) analysed the dynamics of wealth distribution in an economy with endogenous bequests, various inheritance rules, a heterogeneous number of children and earnings choices influenced by inheritances. In their model, the number of children affected the growth rate of family wealth and, thus, the equilibrium inequality, which also increased with assortative mating by inherited wealth. The equilibrium distribution displayed a Pareto tail that depended on the labour market, bequest division rules and subsidies to low-wealth households financed by inheritance taxes. Devinck (2019) adopted a similar model and showed that what happens to the marriage pattern at the top of the wealth distribution crucially matters for inequality.

Our contribution most closely fits the literature on the determination of the long-term aspects of inequality. We model intergenerational wealth transmission and marital sorting in a type of heterogeneous-agent framework with uncertainty similar to Benabou's (2000), and we look at the robustness of our results via a flexible numerical algorithm.[1]

3. Theory

We consider an economy with a unit–mass continuum of agents who form families as husbands and wives and who live for one period. At the end of the period, each household gives birth to two children: a son and a daughter. The population of the economy remains constant, and the sex ratio of the population is always equal to one.

We assume that males and females receive wealth from their parents as bequests. All married couples supply inputs (or 'assets') X and Y by a husband and wife, respectively, for the family production function. Because a newlywed couple possesses inherited assets, we can interpret X and Y as the proxies for a composite of inputs. Such a broad interpretation of inputs is common, for example, in the endogenous growth literature, where aggregate capital is often thought of as encompassing human capital, public infrastructure, and so on. This is also consistent with the literature on assortative mating, where partners' assets are a combination of one or more characteristics, including human capital, wealth and earnings potential (see, e.g., Dalmia and Sicilian 2008). Abstracting from the potential spillover effects among households and positive externalities, in the baseline scenario, we can assume that each household faces diminishing returns to each input. For example, each additional unit of parental human capital delivers positive additions to family output, but these additions decrease as human capital grows. Later in the simulation exercise, we consider a linear production function. Upon producing family output, parents leave to their unmarried sons and daughters some inheritable assets B_m and B_f (i.e., 'bequests').

We assume X has the same distribution as B_m and that Y has the same distribution as B_f. The joint distribution (X, Y) is the result of marriage matching. Roughly speaking, X

[1] One of the earliest important contributions involving uncertainty is the study by Pestieau (1984), who modelled an intergenerational transmission of ability, which is assumed to decrease with the number of siblings. The study assumed either perfect sorting or random mating, where married couples simply added their individual resources in deciding how much to bequeath. The author showed that long-term inequality of inherited wealth increases with ability and family size.

and Y are obtained by reshuffling B_m and B_f, respectively. Then, the pair (X, Y) reflects marriage matching in the economy.

Our model includes productivity shock (explained below), and because of this shock, the bequest amounts are random variables. Following Benabou (2000, 2002), we let the initial bequest distributions, $B_{m,0}$ and $B_{f,0}$ at time $t = 0$, be lognormally distributed. We assume that the distribution of $\ln X$ has a mean μ_X and variance Δ_X^2. Similarly, the distribution of $\ln Y$ has a mean μ_Y and variance Δ_Y^2. Therefore, we have $\ln X \sim N(\mu_X, \Delta_X^2)$ and $\ln Y \sim N(\mu_Y, \Delta_Y^2)$. Thus, the pair of the husband's log-wealth and wife's log-wealth $(\ln X, \ln Y)$ represents the results of marriage sorting. This pair indicates a joint distribution of the log-wealth. The correlation coefficient between $\ln X$ and $\ln Y$ ($\rho \in [-1,1]$) represents the matching patterns in the economy. The marginal distributions of $\ln X$ and $\ln Y$, which are assumed to follow normal distributions in the baseline scenario, are from the bequest distribution of males and females. We assume that people can always find partners in the marriage market.[2]

Following convention, we denote the random variables using capital letters, while we write particular realisations of the random variables in lowercase letters. At time t, a given couple possessing assets x_t and y_t choose consumption (c_t) and bequest (b_{t+1}) to maximise the utility function, as follows:

$$\max_{c_t, b_{t+1}} \frac{c_t^{1-\gamma}}{1-\gamma} + \chi \frac{b_{t+1}^{1-\gamma}}{1-\gamma}, \tag{1}$$

$$\text{s.t.}\, c_t + b_{t+1} = H(x_t, y_t), \tag{2}$$

where $\gamma > 0$ is the risk aversion coefficient, and in the manner of Cowell and Van de gaer (2017), $\chi > 0$ is the weight attached to the amount of inheritable assets transferred to the children ('taste for bequests'). Family production technology is expressed as follows:

$$H(x_t, y_t) = \kappa \theta_t x_t^{\alpha} y_t^{\beta}, \tag{3}$$

where $\kappa > 0$, $\alpha, \beta \in (0,1)$, $\alpha + \beta \leq 1$, and θ_t is a particular realisation of the productivity shock at time t. Thus, productivity is a random variable, Θ_t, lognormally distributed as $\ln\Theta_t \sim N(-\sigma^2/2, \sigma^2)$. The variable is independent and identically distributed $(i.i.d.)$ across generations and households.

[2] We also assume that all parents transfer assets to their children. Wealthier partners can obviously transfer more assets to their children, who—if not subject to any adverse circumstances—can transfer more to their own children. This assumption can be motivated by the findings of Niimi and Horioka (2018), who used microdata for Japan and the US to show that the receipt of intergenerational transfers increases the likelihood of people leaving bequests to their own children.

Note that, traditionally, studies on household production have referred to parameters α and β as factor shares in the home production function for each input type (see, e.g., Greenwood *et al.*, 1995; Rupert *et al.*, 1995) or spouses' elasticities in home production (see, e.g., Sharp *et al.*, 2004; Bredemeier and Juessen, 2013). Thus, α and β are the parameters of the husband's and wife's marginal productivity function. Household survey data are often used to estimate these parameters by matching the observed relative inputs of each spouse. Thus, parameters α and β represent the relative importance of each input type—for example, wife's assets and skills, husband's assets and skills—in the household asset-generation process.

Solving the household's problem, we obtain

$$c_t = \frac{1}{1+\chi^{1/\gamma}} H(x_t, y_t), \tag{4}$$

and

$$b_{t+1} = \frac{\chi^{1/\gamma}}{1+\chi^{1/\gamma}} H(x_t, y_t). \tag{5}$$

Substituting Eq. (3) into Eq. (5) and taking the logarithms, we obtain

$$\ln b_{t+1} = \ln \frac{\chi^{1/\gamma}}{1+\chi^{1/\gamma}} + \ln\kappa + \ln\theta_t + \alpha \ln x_t + \beta \ln y_t. \tag{6}$$

Because X and Y follow lognormal distributions, we know by Eq. (6) that B_{t+1} follows a lognormal distribution. Moreover, we have $Cov(\ln X, \ln Y)$ because X and Y can vary jointly because of marital sorting. The distributions of $\ln X$ and $\ln Y$ are jointly normal. Thus, we state the dynamic paths of the mean and variance of the logarithm of bequest as

$$\mu_{B,t+1} = \ln \frac{\chi^{1/\gamma}}{1+\chi^{1/\gamma}} + \ln\kappa - \sigma^2/2 + \alpha\mu_{X,t} + \beta\mu_{Y,t}$$

and

$$\Delta_{B,t+1}^2 = \sigma^2 + \alpha^2 \Delta_{X,t}^2 + \beta^2 \Delta_{Y,t}^2 + 2\alpha\beta Cov(\ln X_t, \ln Y_t). \tag{7}$$

The degree of marital sorting is expressed by the correlation coefficient between $\ln X$ and $\ln Y$:

$$\rho = \frac{Cov(\ln X, \ln Y)}{\Delta_X \Delta_Y}. \quad (8)$$

The high level of ρ implies that the marriage matching in the economy becomes more assortative. Substituting Eq. (8) into Eq. (7), we deduce the following:

$$\Delta_{B,t+1}^2 = \sigma^2 + \alpha^2 \Delta_{X,t}^2 + \beta^2 \Delta_{Y,t}^2 + 2\alpha\beta\rho\Delta_{X,t}\Delta_{Y,t}. \quad (9)$$

Before getting married, the son and daughter inherit assets $B_{m,t+1}$ and $B_{f,t+1}$ from their parents:

$$B_{m,t+1} = \omega B_{t+1}, \quad (10)$$

and

$$B_{f,t+1} = (1-\omega) B_{t+1}, \quad (11)$$

where $\omega \in (0,1)$ denotes the fraction of bequests that the son receives from his parents and $1-\omega$ denotes the fraction of bequests that the daughter receives from her parents.

Because bequests follow lognormal distributions, by Eq. (10) and Eq. (11), we know that

$$\Delta_{m,t}^2 = \Delta_{f,t}^2 = \Delta_{B,t}^2, \quad (12)$$

where $\Delta_{m,t}^2$ and $\Delta_{f,t}^2$ are the variances of $\ln B_{m,t}$ and $\ln B_{f,t}$ in period t, respectively. Thus, inequality among men is the same as among women in the economy if we use $\Delta_{m,t}^2$ and $\Delta_{f,t}^2$ to measure inequality.

Sons and daughters enter the marriage market and find partners from different families. Recall that we assume that the husband's asset, X, is equal to the bequest he receives from his parents, and the wife's wealth has a correlation ρ with the husband's wealth such that[3]

$$\begin{bmatrix} \ln X \\ \ln Y \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ \rho & \sqrt{1-\rho^2} \end{bmatrix} \begin{bmatrix} \ln \tilde{B}_m - \mu_m \\ \ln \tilde{B}_f - \mu_f \end{bmatrix} + \begin{bmatrix} \mu_m \\ \mu_f \end{bmatrix}, \quad (13)$$

[3] Numerically, it is straightforward to generate two sets of correlated random sequences using the Cholesky decomposition method or spectral decomposition method, which is discussed in detail in Viswanathan (2020).

where μ_m and μ_f are the means of the log-wealth of sons and the log-wealth of daughters. Because B_m and B_f are dependent, we draw two independent copies of them: $\tilde{B}_m$ and $\tilde{B}_f$. $\tilde{B}_m$ has the same distribution as B_m, and $\tilde{B}_f$ has the same distribution as B_f, but $\tilde{B}_m$ and $\tilde{B}_f$ are independent. Then, Eq. (13) guarantees that the correlation coefficient between $\ln X$ and $\ln Y$ is ρ.

By Eq. (12) and (13), we obtain

$$\Delta^2_{X,t} = \Delta^2_{m,t} = \Delta^2_{B,t}, \tag{14}$$

and

$$\Delta^2_{Y,t} = \Delta^2_{f,t} = \Delta^2_{B,t}. \tag{15}$$

By substituting Eq. (14) and Eq. (15) into Eq. (9), we obtain

$$\Delta^2_{B,t+1} = \sigma^2 + (\alpha^2 + \beta^2 + 2\alpha\beta\rho)\Delta^2_{B,t}. \tag{16}$$

Eq. (16) implies that, for two economies starting from initial wealth distributions with the same $\Delta^2_{B,0}$, the economy with a higher ρ will always have a higher variance $\Delta^2_{B,t}$ for all $t > 0$.

Because $\alpha, \beta \in (0,1)$ and if $\alpha + \beta < 1$, $\Delta^2_{B,t}$ converges to a steady state, Δ^2_B. Thus, by Eq. (16), we obtain

$$\Delta^2_B = \frac{\sigma^2}{1 - (\alpha^2 + \beta^2 + 2\alpha\beta\rho)}. \tag{17}$$

Consequently, we can state the following propositions:[4]

[4] Note that the bequest sharing parameter, ω, does not affect the variance of the logarithm of bequest, as shown by equation (17). However, ω should affect the dispersion of heirs' bequests in level. Intuitively, if ω is close to 1, for instance, then boys get almost entire bequests of the family and girls get almost nothing. Then, we expect that the distribution of bequests of men to have a very high variance but that the variance should be close to zero for women. This can be formally shown based on Eq. (10), where $B_{m,t+1} = \omega B_{t+1}$. Because B_{t+1} is lognormally distributed with mean $\mu_{B,t+1}$ and variance $\Delta^2_{B,t+1}$, we can use Eq. (10) directly to derive the mean and variance of $B_{m,t+1}$. The expected value is given by $E(B_{m,t+1}) = \omega e^{\mu_{B,t+1}+\Delta^2_{B,t+1}/2}$, and the variance is given by $Var(B_{m,t+1}) = \omega^2 e^{2\mu_{B,t+1}+\Delta^2_{B,t+1}}(e^{\Delta^2_{B,t+1}} - 1)$. Because $\omega \in (0,1)$, indeed higher bequest share increases the spread of men's bequest values. The effect on the spread of women's bequest values can be shown analogously. We are thankful to an anonymous referee for pointing this out.

Proposition 1: As the correlation coefficient ρ increases, the variance of logarithmic bequest, Δ_B^2, increases. Moreover, when $\rho = 1$ and the production function has diminishing returns to scale ($\alpha + \beta < 1$), the variance of logarithmic bequest will stabilise. In contrast, when the constant returns to scale prevails ($\alpha + \beta = 1$), the variance will grow indefinitely.

The first statement in the proposition is easy to see after differentiating Eq. (17) with respect to ρ, and this result is consistent with the existing findings. Note also that our steady state Δ_B^2 expression is similar to that of Kremer's (1997, p. 120). The key difference between our formula and that of Kremer (1997) is that he treats children's characteristics as a linear function of parents' characteristics. Furthermore, Kremer argues that, with $\rho = 1$, the inequality will grow indefinitely, but Eq. (17) shows that diminishing returns to scale are sufficient to stabilise the value of Δ_B^2, even when spouses sort perfectly. Furthermore, under perfect sorting, decreasing marginal returns to each input does not guarantee that inequality will be bounded, as long as $\alpha + \beta = 1$.

Moreover, note from Eq. (16) that a rise in α, for example, increases the relative importance of input X in the family output (and, thus, for left bequests), but the effect is more pronounced for richer households whose marital output is larger. Thus, the variability of X on its own contributes to the variation in future bequests through the term $\alpha^2 \Delta_{B,t}^2$ (recall $\Delta_{B,t}^2 = \Delta_{X,t}^2$). This is true whether ρ is positive or negative. When $\rho > 0$, there is an additional reinforcing effect on inequality via the positive covariance term $2\alpha\beta\rho\Delta_{X,t}\Delta_{Y,t} = 2\alpha\beta\rho\Delta_{B,t}^2$ because a composite effect from two highly correlated X and Y variables will lead to more extreme values, thereby increasing the variance. When $\rho < 0$, however, the covariance effect lowers the inequality because we tend to combine high/low values of X and low/high values of Y.

Hence, our comparative statics are captured by the following expressions:

$$\frac{\partial \Delta_B^2}{\partial \alpha} = \frac{2(\alpha + \beta\rho)\sigma^2}{\left(1 - (\alpha^2 + \beta^2 + 2\alpha\beta\rho)\right)^2}, \tag{18}$$

$$\frac{\partial \Delta_B^2}{\partial \beta} = \frac{2(\beta + \alpha\rho)\sigma^2}{\left(1 - (\alpha^2 + \beta^2 + 2\alpha\beta\rho)\right)^2}. \tag{19}$$

Proposition 2: When $\rho > 0$, a rise in either the husbands' or wives' shares would increase the variance of the logarithmic bequest. When $\rho < 0$, the relationship between either factor share and the variance is U-shaped, with the variance increasing with α when $\alpha > \beta|\rho|$ (alternatively, increasing with β when $\beta > \alpha|\rho|$) and falling below these thresholds.

Consider, for example, a rise in α when ρ is negative. When α is sufficiently small, the negative impact from the covariance on inequality, which is captured with the $2\alpha\beta\rho\Delta_{X,t}\Delta_{Y,t}$ term, is larger than the positive impact on inequality captured with the $\alpha^2\Delta_{X,t}^2$ term. Similarly, for a sufficiently large α, the positive impact on inequality will dominate.

Proposition 3: When $0 < \rho < 1$, then $\partial\Delta_B^2/\partial\alpha > \partial\Delta_B^2/\partial\beta$ if $\alpha > \beta$, while $\partial\Delta_B^2/\partial\beta > \partial\Delta_B^2/\partial\alpha$ when $\beta > \alpha$.

Therefore, we conclude that the derivative with respect to the highest factor share always exceeds the derivative with respect to the lowest factor share with assortative mating. Thus, inequality can decrease when a rise in the relative importance in the family output generation process of the least productive spouse is compensated for by the corresponding decline in the relative importance of the most productive spouse.

Using the properties of lognormal distributions, we can also employ the Lorenz curve to measure wealth inequality. Let $L_Z(p)$ be the Lorenz curve of a non-negative random variable Z with a finite positive mean.[5] As in the work of Shaked and Shanthikumar (2007), we define Lorenz ordering below.

Definition 1: For two non-negative random variables Z and W, Z Lorenz dominates W if and only if $L_Z(p) \geq L_W(p)$ for all $p \in [0,1]$, which is denoted as $Z \succcurlyeq_L W$.

Suppose that there are two economies A and B. Economy A has the degree of sorting ρ_A and economy B has the degree of sorting ρ_B. Let b^A denote the stationary wealth distribution of economy A and b^B the stationary wealth distribution of economy B.

Proposition 4: If $\rho_A \geq \rho_B$, then $b^B \succcurlyeq_L b^A$.

The validity of Proposition 4 can be seen as follows: Recall from Proposition 1 that the higher the correlation coefficient ρ, the larger the variance of logarithmic wealth. For a non-negative random variable Z, $\ln Z \sim N(m_z, \Delta_z^2)$. We know from Kleiber and Kotz (2003) that its Lorenz curve is represented by the following:

$$L_Z(p) = \Phi[\Phi^{-1}(p) - \Delta_z^2], \forall p \in [0,1],$$

where Φ is the cumulative distribution function of the standard normal distribution. If $\rho_A \geq \rho_B$, then the variance in economy A is greater than or equal to the variance in economy B; thus, we have $b^B \succcurlyeq_L b^A$.

[5] For the definition of the Lorenz curve, $L_X(p)$, see, e.g., Gastwirth (1971).

4. Simulation

In this section, we numerically simulate the theoretical model derived in the previous section. We relax the assumption that assets obey lognormal distribution and consider the arbitrary distribution. The process is summarised below.

First, we generate random samples from the assumed distributions for the assets of the first generation. Next, following the assumptions that a family has a boy and girl and that the bequest is divided in a fixed proportion between them, we obtain two columns of random numbers and merge them into a data frame. While reshuffling the data, we follow the algorithm from Demirtas (2019) to keep the correlation coefficient of the two columns of data close to our target level. When recombining bequeathable assets, we introduce a particular realisation of the productivity shock θ_t with a random seed 1234. Below, we illustrate one example of the model's parameterisation.

Let the desired correlation coefficient, $DesireCor$, be 0.2. We choose the number of observations as $N = 100{,}000$. Assume the boy receives half of the bequest from his parents, that is, $\omega = 0.5$. Assume $ln(\theta_t)$ is from the normal distribution $N(1{,}0.36)$. Because the beta distribution ranges have support $[0{,}1]$, we construct a linear mapping of $9 \times Beta(2{,}3) + 1$ for the initial asset distribution, $GenerIni$. Meanwhile, we set $\alpha = 0.7$ and $\beta = 0.2$ in Eq. (3).

Based on the above parameterisation, it is easy to obtain the asset distribution of the first generation. The son's inheritance is given by $M_1 = \omega \times GenerIni$, and the daughter's inheritance is given by $F_1 = (1 - \omega) \times GenerIni$. We merge the logarithm of M_1 and the logarithm of F_1 columns into a data frame, $GenDat_1$. Because the assets of the two offspring are from the same family, the correlation coefficient of $GenDat_1$ is obviously 1.

Demirtas (2019) built a sorting approach to achieve any desired correlation from independent bivariate data with any distributional type. This method is key to our numerical simulation, helping us acquire the constant correlation coefficients of the data of the two columns.[6]

We start by reshuffling the data frame $GenDat_1$ until the two columns of data are independent and have zero correlations. Then, we call this new data frame the 'original data'. Next, we sort $GenDat_1$ in the same direction, either from smallest to largest or largest to smallest, and we compute the upper correlation bound, UB_1. We also sort the $GenDat_1$ data in the opposite direction to compute the lower correlation bounds (LB_1).

[6] In Demirtas (2019), the end result sorting does not matter if a desired correlation has been reached; in our case, however, to keep the model realistic, we want to ensure that a boy from one family cannot be paired with the girl from the same family when they form a new household. Thus, we modify the numerical algorithm to ensure that no boys and girls from the same family become a new couple. To do so, we give boys and girls from the same family an index, and we put a condition in the code that agents with the same index cannot be matched when we reshuffle the data.

If the desired correlation is positive, that is, $DesireCor > 0$, then we sort a fraction $100 \times DesireCor/UB_1\%$ of the original independent data and put it back to the original data to achieve the desired correlation. If $DesireCor < 0$, we reverse sort a fraction $100 \times DesireCor/LB_1\%$ of the original independent data and return it to the original data to achieve the desired correlation.

In practice, we randomly extract $100 \times DesireCor/UB_1\%$ of the original data, resort them and plug them back into the original data to form the new data frame $NewDat_1$. We use the above algorithm to obtain a correlation coefficient, and we continuously iterate the operation until the difference between the correlation coefficient and $DesireCor$ is within 0.001, which is the tolerance level. The results are satisfactory. Through Eq. (3), we restructure assets and iterate the wealth accumulation process to determine whether the distribution of wealth gradually converges. If the quantiles of the wealth distributions in two consecutive times are close enough, we stop the iteration process.

We adjust the desired correlation coefficient and set $\rho = [0.1, 0.15, 0.2, 0.25]$. The Gini coefficients of the wealth distributions are shown in Table 1.

Table 1: The Gini coefficient of the stationary wealth distribution

ρ	0.1	0.15	0.2	0.25
Mean	0.063	0.064	0.065	0.066
Std	0.072	0.075	0.078	0.079
Min	0.001	0.0005	0.001	0.001
25%	0.023	0.023	0.023	0.025
50%	0.042	0.042	0.042	0.043
75%	0.077	0.078	0.078	0.08
Max	2.208	3.312	4.145	2.293
Gini	0.477	0.484	0.489	0.496

Note: Sample size = 100,000, $\omega = 0.5$, $\alpha = 0.7$ and $\beta = 0.2$. The above results show the descriptive statistics of the stationary wealth distribution. The Gini coefficients of the wealth distributions are also shown in the table.

As shown in Table 1, we find that the Gini coefficient of the stationary wealth distribution increases with the value of ρ. The higher the correlation coefficient ρ, the less equal the stationary wealth distribution. Intuitively, a higher correlation coefficient implies that rich males have a higher chance of marrying rich females. Thus, more families have rich husbands and wives. These families have higher production levels, thus leaving more bequests to their children. In the meantime, a higher correlation coefficient implies that poor males have a higher chance of marrying poor females. Thus, more families have poor husbands and wives. These families have lower production levels, thus leaving fewer bequests to children. Thus, a higher correlation coefficient causes a large dispersion of wealth distribution. Our numerical experiments confirm this intuition.

So far, we have completed the verification of Proposition 1. To verify Proposition 2, we fix $\beta = 0.7$. We select $\alpha = 0.05, 0.1, 0.15, 0.2, 0.25$ and $\rho = [-0.2, 0.2]$, where $\beta|\rho| = 0.14$. The descriptive statistics of the stationary wealth distributions are shown in Table 2. When $\rho > 0$, a decrease in α would reduce the Gini coefficients of wealth and household product (income). Conversely, when $\rho < 0$, the relationship between α and the Gini coefficients of wealth is U-shaped, with the Gini decreasing with α when $\alpha < \beta|\rho|$ and rising thereafter. Moreover, this observation is consistent with the Gini coefficient of household income and wealth, where household income is calculated using Eq. (3) and household wealth equals the total bequest.

The parameters α and β represent the input shares of the marital output for the husband and wife, respectively. To investigate the effects of these parameters on wealth inequality, we implement experiments by varying the value of α.

Table 2: Wealth inequality with different values of α

	α	0.05	0.1	0.15	0.2	0.25
	Mean	0.615	0.424	0.228	0.064	0.002
	Std	0.641	0.451	0.257	0.077	0.003
	Min	0.006	0.008	0.003	0.001	0.0000
	25%	0.241	0.162	0.083	0.022	0.001
$\rho = 0.2$	50%	0.428	0.29	0.153	0.042	0.002
	75%	0.759	0.524	0.279	0.078	0.003
	Max	22.68	17.003	9.628	2.284	0.16
	Gini	0.453	0.462	0.474	0.489	0.512
	Mean	0.599	0.407	0.212	0.064	0.008
	Std	0.595	0.405	0.21	0.064	0.008
	Min	0.009	0.008	0.004	0.001	0.0000
	25%	0.242	0.166	0.088	0.026	0.003
$\rho = -0.2$	50%	0.423	0.29	0.151	0.045	0.005
	75%	0.742	0.504	0.263	0.079	0.009
	Max	14.017	11.381	5.154	1.619	0.215
	Gini	0.444	0.44	0.438	0.442	0.446

Note: Sample size = 100,000 and $\omega = 0.5$. The results show the descriptive statistics of the stationary wealth distribution. The Gini coefficients of the wealth distributions are also shown in the table.

As shown in Table 2, we find that a rise in α would increase the Gini coefficient of the stationary wealth distribution for $\rho > 0$. The Gini coefficient of the stationary wealth distribution has a U-shaped relationship in α for $\rho < 0$. The parameter in the production influences the wealth distribution because the diminishing return affects the total output and, therefore, the bequests and wealth distributions of males and females.

We also tried many additional simulation exercises to check the robustness of our results. After trying different initial asset distributions, we find that our results are robust and insensitive with respect to the initial asset distribution.

Next, we relax the assumption that the family production function takes on a multiplication of the powers of parents' inputs. It can be argued that total family resources are the sum of the parents' assets. Certainly, the relationship between the dollar amounts contributed by each partner and total family output does not necessarily have to be one to one because some family members can waste those contributions, say, in a frivolous entertainment. Nonetheless, it is reasonable to consider a linear combination between parents' inputs and the family output, which is ultimately going to be passed to the children. Thus, to test the robustness of our findings, we use an alternative production function that adds husband wealth and wife wealth linearly. Specifically, we assume the following:

$$H(x_t, y_t) = \varphi + \theta_t(0.5x_t + 0.5y_t),$$

where we set $\varphi = 0.1$. We then implement the experiments of varying the correlation coefficient ρ. The results are presented in Table 3.

Table 3: The Gini coefficient of the stationary wealth distribution under the alternative production function

ρ	0.1	0.15	0.2	0.25
Mean	0.268	0.268	0.268	0.268
Std	0.204	0.21	0.217	0.219
Min	0.057	0.058	0.056	0.057
25%	0.147	0.146	0.144	0.144
50%	0.21	0.21	0.208	0.206
75%	0.318	0.316	0.315	0.314
Max	5.002	6.194	7.941	7.988
Gini	0.339	0.34	0.346	0.348

Note: Sample size = 100,000 and $\omega = 0.5$. The above results show the descriptive statistics of the stationary wealth distribution. The Gini coefficients of the wealth distributions are also shown in the table.

With the alternative family production function, we also find that, the higher the correlation coefficient ρ, the larger the Gini coefficient. A higher correlation coefficient causes a large dispersion of wealth distribution. When the matching is more assortative, the stationary wealth distribution becomes less equal. From the row of the mean in Table 3, we find that the mean of the wealth distribution does not change with the correlation coefficient ρ. Because the production function is now a linear function of x_t and y_t, an increase in the correlation coefficient has no impact on the mean of wealth accumulation: it only influences the dispersion of the wealth distribution.

The message here is that a matching mechanism can cause wealth inequality. When we increase the correlation coefficient between the husband's log-wealth and wife's log-wealth, the matching becomes more assortative. This causes the stationary wealth distribution to be less equal.

5. Concluding Remarks

In the present paper, we have examined how marital sorting influences inequality, showing that this influence depends on the relative importance of husbands' and wives' inputs in the household asset-generation process. There is a dissimilar relationship between spouses' factor shares and inequality under positive and negative assortative mating. Under positive assortative mating, partners' individual factor shares in the family output function positively affect inequality, while under disassortative mating, the relationship is U-shaped. We modify and apply the 'sorting, reverse sorting' numerical simulation approach (Demirtas 2019) in the context of marriage market mating, showing the robustness of our analytical results. We further apply the results to derive the dominance relationship between the respective Lorenz curves.

Although many studies have argued that a myriad of economy-wide factors, as well as some compositional and behavioural changes in the marriage and labour markets, could affect inequality and the intricate link between inequality and marital sorting, we argue that what happens within a family might be important as well. Indeed, several studies (e.g., Cowell and Van de gaer, 2017; Cowell *et al.*, 2018) have shown that an inheritance tax can reduce inequality. In a model with heterogeneous earning abilities, Carbonell-Nicolau and Llavador (2018, 2021) proved that certain subclasses of progressive income taxes (which affect the elasticity of income with respect to ability) reduce the inequality for a wide collection of consumer preferences. Perhaps the implementation of a tax-subsidy scheme and government policies to bring about technological developments that would alter the relative importance of partners' inputs in the household production function could also help achieve lower inequality. Future research can estimate the parameters that govern the family asset-generation process and bequest-sharing rules across households, cohorts, and countries, thus shedding light on the inequality trends.

We note that, in the present paper, we have assumed that the matching is exogenous and described by the correlation of wife's wealth and husband's wealth. The correlation coefficient describes the matching pattern in the economy. Anderson and Smith (2021) used a broad concept of positive quadrant dependence to measure sorting patterns, and the matching result was endogenous. We could follow this research direction to extend our model in the future.

Supplementary material

Supplementary material is available on the OEP website. These are the replication files (Python).

Funding

This work was supported by the National Natural Science Foundation of China [71873034].

Acknowledgments

The authors are indebted to the participants of seminars held at the American University of Sharjah, Deakin University, and 8th International Multidisciplinary Conference on Economics, Business, Engineering and Social Sciences. The authors are grateful to Associate Editor Alan Beggs and two anonymous referees for their very helpful comments and suggestions. All errors are our own.

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