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Raquel Fernandez, Nezih Guner and John Knowles

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3718 Locust Walk • Philadelphia, PA 19104-6298 • Tel 215-898-6441 • Fax 215-898-2124

Love and Money: A Theoretical and Empirical Analysis of Household Sorting and Inequality[*]

Raquel Fernández[†]
NYU, CEPR and NBER

Nezih Guner
Queen's University

John Knowles
University of Pennsylvania

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Abstract

This paper examines the interactions between household matching, inequality, fertility differentials, and per capita income. We develop a model in which agents form households, consume and have children. We show that matches between skilled and unskilled workers are decreasing in the skill premium. In the absence of perfect capital markets, the steady state to which this economy converges will in general depend upon initial conditions. In particular, it is possible to have steady states with a high degree of marital sorting, high inequality, and large fertility differentials or with low sorting, low inequality and small fertility differentials. We use 35 country household surveys from the Luxembourg Income Study and the Inter-American Development Bank to construct several measures of the skill premium and of the degree of correlation of spouses' education (our measure of marital sorting). For all our measures, we find a positive and significant relationship between the two variables.

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1. Introduction

With a few notable exceptions, the analysis of household formation has played a relatively minor role in our understanding of macroeconomics. The vast majority of macroeconomic models tend to assume the existence of in¯nitely lived agents (with no o®spring) or a dynastic formulation of mother (or father) and child (or children).[1] While this may be a useful simpli¯cation for understanding a large range of phenomena, it can also lead to the neglect of potentially important interactions between the family and the macroeconomy. This is especially likely to be the case in those areas in which intergenerational transmission plays a critical role, such as human capital accumulation, income distribution, and growth.

The objective of this paper is to examine some of the interactions between household matching (\marriage"), inequality (as measured by the skill premium), fertility di®erentials and per capita output. The main idea that we wish to explore, theoretically and empirically, is the potentially reinforcing relationship between the strength of assortative matching and the degree of inequality. In particular, we wish to examine the notion that a greater skill premium may tend to make matches between di®erent classes (skilled and unskilled workers in our model) of individuals less likely, as the cost of \marrying down" increases. In an economy in which borrowing constraints can limit the ability of individuals to acquire optimal levels of education, this private decision may have important social consequences. In particular, it can lead to ine±ciently low aggregate levels of human capital accumulation (resulting in larger wage inequality between skilled and unskilled workers), large fertility di®erentials across types of households, and lower per capita output. Thus, inequality and marital sorting are two endogenously determined variables that reinforce one another.

To explore the ideas sketched above, we develop a model in which individuals are either skilled or unskilled (according to education decisions made when young) and have a given number of opportunities in which to form a household with another agent. Once agents form households, they decide how much to consume and how many children to have. These children in turn decide whether to become skilled or unskilled workers. A decision to become skilled (synonymous here for acquiring a given level of education) is costly. To ¯nance education, young individuals borrow in an imperfect capital market in which parental income plays the role of collateral. Thus parental income and the net return to being a skilled

[1] Even Becker and Tomes' (1979, 1986) pioneering work on intergenerational transmission of inequality assumes a one-parent household.

versus unskilled worker, including the expected utility from one's future match, determine the proportion of children that in aggregate become skilled. These individuals then also meet and form households, have children, and so on.

We show that the steady state to which this economy converges will in general depend upon initial conditions. In particular, it is possible to have steady states with a high degree of sorting (skilled agents form households predominantly with others who are skilled; unskilled form households predominantly with unskilled), high inequality, and large fertility differentials. Alternatively, there can be steady states with a low degree of sorting, low inequality and low fertility differentials.

Our empirical analysis examines the main implication of our model: a positive correlation between the skill premium and marital sorting. To do this, we assemble a total of 35 country household surveys from the Luxembourg Income Study (LIS) and the Inter-American Development Bank (IDB) and use them to construct a sample of households for each country. From these samples we construct several measures of the skill premium and two measures of the degree of correlation of spouses' education (our measure of marital sorting). For all our measures of the skill premium and marital sorting, we find a positive and significant relationship between the two variables.

Two other implications of our model are that greater marital sorting should imply lower per capita income and that the fraction of skilled labor in the economy and sorting should be negatively correlated across countries. We find evidence in favor of both of these predictions. Our model also implies that fertility differentials (between more and less educated households) should be increasing in inequality, a prediction that is borne out by the evidence presented by Kremer and Chen (1999).

Our work is related to several literatures. There is a rapidly growing literature on the intergenerational transmission of inequality in models with borrowing constraints. These models, though, either assume a dynastic formulation (e.g., Becker and Tomes (1986), Loury (1981), Ljungqvist (1993), Galor and Zeira (1993), Fernández and Rogerson (1998), Benabou (1996), Dahan and Tsiddon (1998), Durlauf (1995), Owen and Weil (1998) and Kremer and Chen (1999)) or consider a two-parent household in which the degree of sorting is exogenously specified (e.g., Galor and Weil (1996), Kremer (1997), Fernández and Rogerson (2001)). The last two papers are particularly relevant as they are concerned with whether an (exogenous) increase in marital sorting can lead to a quantitatively significant increase in inequality. In our model, on the other hand, sorting and inequality are endogenously determined. There is also a theoretical literature that focuses on the determinants of who matches with whom, but that basically abstracts from the endogeneity of the income distribution in the economy (e.g., Cole, Mailath, and Postlewaite (1992), and Burdett and Coles (1997, 1999)).[2] Our paper, therefore, is related to the two literatures, and can be seen as trying to integrate both concerns into a simple, analytical framework. Some recent work that also shares our concerns, but that is more focused on fertility, marriage and divorce, are Aiyagari, Greenwood, Guner (2000), Greenwood, Guner, and Knowles (2000), and Regalia and Rios-Rull (1999). The models, not surprisingly, are more complicated and rely on computation to obtain solutions for particular parameter values.

There is also a small, mostly descriptive, empirical literature that is related to our work. As reviewed by Lam (1988), the general ¯nding in the literature is the existence of positive assortative matching across spouses. Mare (1991) documents the correlation between spouses' schooling in the US since 1930s. Using a large cross section of countries, Smith, Ultee, and Lammers (1998) ¯nd that the relation between marital sorting and some indicators for development (such as per capita energy consumption and the proportion of the labor force not in agriculture) has an inverted-U shape. Dahan and Gaviria (1999) report a positive relation between inequality and marital sorting for Latin American countries. Boulier and Rosenzweig (1984) document assortative matching with respect to schooling and sensitivity to marriage market variables using data from the Philippines.

2. The Model

In this section we present a model of matching, fertility and inequality. Each component of the model is kept relatively simple in the interest of highlighting the interactions among all three variables, both at a given moment in time and over the longer run.

2.1. Timing

The economy is populated by overlapping generations that live for two periods. At the beginning of the ¯rst period, young agents make their education decisions by deciding whether to become skilled or unskilled. This decision made, they then meet in what we call a \household matching market". Here they ¯nd another

[2] See Bergstrom (1997) and Weiss (1997) for a survey of the literature on theories of the family and household formation.

agent with whom to form a household, observing both the agent's skill type (and hence able to infer that agent's future income) and a match specific quality. They then enter into the labor market and work. In the second period, the agents, now adult, repay their education debts (if any), and households decide how much to consume and how many children to have.

We now describe in more detail each aspect of an agent's decision problem. We begin with the decision problem at the beginning of the second period, when agents have already formed a household of some given quality.

2.2. The Household's Problem

In this model we abstract from bargaining problems among agents within a household and instead assume that spouses share a common joint utility function.[3] We also abstract away from any differences between women and men, either exogenous (e.g., childbearing costs) or cultural/institutional (e.g., the degree of wage discrimination or the expected role of woman in the home relative to the workplace).[4]

Having matched in the first period of life and attained a match quality q, at the beginning of period 2 each household decides how much to consume, c, and how many children to have, n. Raising children is costly; each child consumes a fraction t of parental income, I.[5]

The utility of a household with match quality q and income I is given by solving:

$$\max_{c;n} [c + \beta \log n + \gamma + q] \tag{2.1}$$

subject to

$$c \leq I(1 - tn)$$

[3] For models that focus on intrafamily bargaining problems, see, for example, Bergstrom (1997) and Weiss (1997).

[4] This assumption considerably simplifies our analysis. See the conclusion for a brief discussion of alternative modelling assumptions.

[5] Traditionally the cost of having children is thought of as the opportunity cost of time. While in our model this interpretation is possible at the level of the individual budget constraint, we choose not to view it this way since, at the aggegate production function level, it is simpler if we do not have to take into account how hours of work vary across individuals (on account of different incomes implying different numbers of children). Instead we model the cost of children directly as a proportional consumption cost (perhaps as a result of bargaining in the household). An alternative route would have been to model a quality-quantity tradeoff in the production of children. We also allow the number of children to be a continuous rather than discrete variable to simplify the analysis.

where $\beta, t > 0$, and γ is a constant. Note that the way we have modelled match quality renders the solution to the optimization problem independent of q.

The household utility function implies that for household income below β, households will dedicate all their income to children and have $\bar{n} = \frac{1}{t}$ of them yielding utility $\beta \log \bar{n} + \gamma + q$. An interior solution to (2.1) is given by:

$$n = \frac{\beta}{tI} \tag{2.2}$$

and

$$c = I - \beta \tag{2.3}$$

Without loss of generality, by setting $\gamma = \beta \log t + \beta - \beta \log \beta$ we can write the indirect utility function for a couple with match quality q and household income $I > \beta$ as:

$$V(q; I) = I - \beta \log I + q; \text{ for } I > \beta \tag{2.4}$$

Note the comparative statics of the solution to the household's optimization problem. For values of household income below β, couples have a constant number of children and their utility is unaffected by increases in income within this range. For household income above β, increases in income increase consumption and reduce the number of children in the household. Thus, for $I > \beta$, wealthier households have fewer children and the fertility differential across income groups is increasing with income inequality.[6]

We next turn to the determination of household income.

2.3. The Labor Market

Agents are employed as workers in the second period of their lives. Workers are either skilled (s) or unskilled (u). We assume that technology is constant returns to scale and that wages are the outcome of a competitive labor market in which skilled and unskilled workers are employed to produce an aggregate consumption good.

[6] Fertility declining with income I is consistent both with the cross-country evidence on fertility and per capita income (e.g. Perotti (1996)) and with cross-sectional evidence from US data (see Knowles(1998) and Fernandez and Rogerson (forthcoming)).

Given a composition of the labor force L into skilled or unskilled workers ($L = L_s + L_u$), full employment implies that output is given by:

$$F(L_s; L_u)$$

with

$$w_s = f'(k) \text{ and } w_u = f(k) - f'k \tag{2.5}$$

where $k \equiv \frac{L_s}{L_u}$ and $f(k) \equiv F(k; 1)$.

We will often find it more convenient to work with the proportion of skilled workers in the population which we denote by $\lambda \equiv \frac{L_s}{L} = \frac{k}{1+k}$ and with the net return to being skilled which we denote by $\tilde{w}_s \equiv w_s - d$, where d is the (constant) monetary cost of becoming skilled. Note that $\tilde{w}_s(\lambda)$ is decreasing in λ, w_u is increasing in λ, and thus that the skill premium is a decreasing function of the fraction of skilled workers.

Household income I_{ij} is simply the sum of each partner's (i and j) wages. To simplify our analysis, we will assume that household income is always greater than β as this ensures an interior solution to the household maximization problem (as discussed in the previous section). We can do this either by imposing conditions on the production function such that the unskilled wage has a given positive lower bound of $\frac{\beta}{2}$ or by assuming that individuals are endowed with $e > \frac{\beta}{2}$ units of income. Thus, we assume:

$$2w_u > \beta. \tag{A1}$$

where w_u can be interpreted as the market wage (as in the first explanation) or as the market wage plus the endowment (as in the second explanation).

2.4. Household Matching

The choice of whom to match with is of course driven by many factors: tastes, one's environment (e.g., who one gets to know and the distribution of characteristics of individuals), and the prospects for one's material and emotional wellbeing. We provide a simple model in which we allow all these factors to interact to produce a household match.

Households can be categorized by the skill types of its two partners. Let I_{ij} denote the household income for a couple composed by skill types $i, j \in \{s, u\}$. Thus,

$$I_{ij} = \begin{cases} 2w_s; & \text{if } ij = ss \\ w_s + w_u; & \text{if } ij = su \\ 2w_u; & \text{if } ij = uu \end{cases} \tag{2.6}$$

We assume that in the first period, once their education decisions have been made, agents have two opportunities to match and form a household. In the first round, all agents meet randomly and draw a random match-specific quality q. This match can be accepted by both agents resulting in a "marriage" or rejected by at least one of the agents whereupon both agents enter the second round of matching. In the second round, agents are matched non-randomly with their own skill group and draw a new random match quality. We assume that qualities are match specific and are i.i.d draws from the same cumulative distribution function Q with expected value μ and support $[0; \bar{q}]$.[7]

The two rounds of matching — one at random and the second exclusively with one's own skill type — are meant to reflect the fact that as time progresses one tends to meet people who are more like one in skill/education level (e.g., individuals who go on to college meet other people also in college, whereas individuals who work in low-skill jobs tend to have more contact with other individuals of the same skill level).[8] Note that a skilled agent (with a high wage) that encounters an unskilled agent (with a low wage) in the first round and draws a high q will face a tradeoff between forming a lower income household with a high quality match and a higher income household (by matching for sure with a skilled agent in the second round) but of an unknown quality (i.e., there is a tradeoff of "love versus money").

Let $V_{ij}(q)$ denote the utility of a couple with income I_{ij} and match quality q (as expressed in (2.4)) where $i, j \in \{s, u\}$. As a skilled agent's second-round option dominates that of an unskilled agent (given $w_s \geq w_u$, which is a necessary condition in order for any individual to choose to become a skilled worker), it

[7] The assumption of $q \geq 0$ ensures that all agents will form a household in the second round. Although unrealistic, this allows us to abstract from the issue of how inequality affects the decision to remain single, which is not the focus of the analysis here. In our comparative static analysis, we will assume that $\bar{q}$ is sufficiently large so that some matches occur between skilled and unskilled individuals. This is for simplicity only.

[8] Alternative modelling assumptions (e.g., more periods, search or waiting costs, and assuming individuals always meet others at random) are also possible and can give rise to similar properties as this one. This formulation is simple and avoids problems of multiple equilibria that can arise when the fraction of types an individual meets evolves endogenously over time. See Fernández and Pissarides (2001) for an infinite horizon search model for household partners.

is the skilled agent who determines whether a match between a skilled and an unskilled agent is accepted.

A skilled agent is indifferent between accepting a first-round match with an unskilled agent and proceeding to the second round if $V_{su}(q) = V_{ss}(\mu)$. Solving for the level of q at which this occurs, q^*, yields a threshold quality of:

$$q^* = I_{ss} - I_{su} - \beta \log \left(\frac{I_{ss}}{I_{su}} \right) + \mu \tag{2.7}$$

which, after substituting for wages, yields:

$$q^*(\lambda) = \hat{w}_s(\lambda) - w_u(\lambda) - \beta \log \left(\frac{2\hat{w}_s(\lambda)}{\hat{w}_s(\lambda) + w_u(\lambda)} \right) + \mu \tag{2.8}$$

The intuition underlying (2.8) is clear. A skilled individual who matches with an unskilled one in the first round knows that by foregoing that match she will meet a skilled individual in the second round with an expected match quality of μ. Thus, the match quality of the unskilled individual must exceed μ by the amount required to compensate for the decreased utility arising from the fall in household income. Of course, the threshold quality for two agents of the same type to match in the first round is μ as this is the expected value of next round's match quality and there is no difference in household income.

Given a distribution of individuals into skilled and unskilled, we can find the fraction of households that will be composed of two skilled individuals, two unskilled individuals, and one skilled and one unskilled. The fraction of households of each type depends only on the probability of types meeting in the first round and on q^*. Both of these are only a function of λ_t since this variable determines both household incomes and first round matching probabilities. Denoting by ρ_{ij} the fraction of households formed between agents of skill type i and j, $i, j \in \{s, u\}$ (with $\rho_{su} = \rho_{us}$), these are given by:

$$\rho_{ij}(\lambda_t) = \begin{cases} \lambda_t^2 + \lambda_t(1 - \lambda_t)Q(q^*(\lambda_t)); & \text{if } ij = ss \\ 2\lambda_t(1 - \lambda_t)(1 - Q(q^*(\lambda_t))); & \text{if } ij = su \\ \lambda_t(1 - \lambda_t)Q(q^*(\lambda_t)) + (1 - \lambda_t)^2; & \text{if } ij = uu \end{cases} \tag{2.9}$$

How does a change in proportion of skilled workers in the population affect the fraction of households of each type? An increase in the λ will unambiguously decrease the fraction of couples that are uu as, for any given q^* they are less likely to end up in uu households. Furthermore, q^* will decrease, thereby increasing the probability that a first round match between a high and low skilled worker will result in a household. The effect on us and ss households, on the other hand, is ambiguous (although the aggregate fraction of the population that is in one of these two types of households must of course increase). For any given q^*, the fraction of ss households increases, but as a skilled individual is now more willing to match with an unskilled one, this will work to decrease the fraction of ss households. The effect on us households is positive if $\lambda \leq 1/2$ (as both the likelihood of s and u individuals meeting in the first round increases as does the probability that the match will be accepted) and ambiguous otherwise.

Note that $Q(q^*)$ is a measure of the degree of sorting that occurs. If individuals were not picky and simply matched with whomever they met in the first round, then q^* would equal zero and ρ_{su} would equal the probability of a skilled and an unskilled individual meeting, i.e., $2\lambda_t(1-\lambda_t)$. If individuals simply cared about quality and not about income, then q^* would equal μ.

Remark 1. $Q(q^*)$ is the correlation coefficient between different skill types in households.

The observation above will be very useful when we examine the data as although the fractions of couples of each type that form may have ambiguous comparative statics with respect to λ, this is not true for the degree of sorting (i.e., for the correlation coefficient). This is stated in the theorem below.

Theorem 2.1. An increase in λ will decrease the degree of sorting.

Proof: Recall that the degree of sorting is given by $Q(q^*)$. Note that

$$\frac{\partial q^*}{\partial w_s} > 0; \qquad \frac{\partial q^*}{\partial w_u} < 0 \tag{2.10}$$

and $\frac{dw_s}{d\lambda} = f''\frac{dk}{d\lambda} < 0$ and $\frac{dw_u}{d\lambda} = -f''k\frac{dk}{d\lambda} > 0$. Hence, $\frac{dQ(q^*)}{d\lambda} < 0$. ||

Note that the theorem above also implies (by (2.10)) that an exogenous increase in inequality (say, from a technology shock) will also increase sorting by making skilled workers less willing to form households with unskilled workers.

Having determined how skilled and unskilled individuals decide to form households, we next turn to a young agent's decision to become a skilled relative to an unskilled worker.

2.5. Education Decisions and Capital Markets

A young agent's desire to become skilled depends on the return to being a skilled relative to an unskilled worker. Note that this depends not only on net wages next period, but also on the expected return to matching at the household level. The expected value of being a skilled worker given that a fraction λ_{t+1} of the population also becomes skilled is given by:

$$\begin{aligned} V^s(\lambda_{t+1}) \;=\;& \lambda_{t+1} \int_0^{\bar{q}} \max\left[V_{ss}(x;\lambda_{t+1}); V_{ss}(\mu;\lambda_{t+1})\right] dQ(x) \\ &+ (1-\lambda_{t+1}) \int_0^{\bar{q}} \max\left[V_{su}(x;\lambda_{t+1}); V_{ss}(\mu;\lambda_{t+1})\right] dQ(x) \end{aligned}$$

whereas the expected value of being an unskilled worker is:

$$\begin{aligned} V^u(\lambda_{t+1}) \;=\;& \lambda_{t+1}\left[\int_0^{q^*} V_{uu}(\mu;\lambda_{t+1}) dQ(x) + \int_{q^*}^{\bar{q}} V_{su}(x;\lambda_{t+1}) dQ(x)\right] \qquad (2.11) \\ &+ (1-\lambda_{t+1}) \int_0^{\bar{q}} \max\left[V_{uu}(x;\lambda_{t+1}); V_{uu}(\mu;\lambda_{t+1})\right] dQ(x) \end{aligned}$$

We assume that in addition to a monetary cost of d, becoming a skilled worker entails an additive non-pecuniary cost of $\delta \in [0;\bar{\delta}]$. This cost is assumed to be identically and independently distributed across all young agents with cumulative distribution function Φ. Thus, an agent with idiosyncratic cost δ_i will desire to become skilled if $V^s - V^u \geq \delta_i$.

We define by $\delta^*(\lambda)$ the skilled-unskilled payoff difference generated when a fraction λ of the population is skilled, i.e.,

$$\delta^*(\lambda_{t+1}) \equiv V^s(\lambda_{t+1}) - V^u(\lambda_{t+1}) \qquad (2.12)$$

Note that given δ^*, all agents with $\delta_i \leq \delta^*$ would want to become skilled. If young agents were able to borrow freely, children from all household types would make identical education decision contingent only on their value of δ_i. Hence in equilibrium a fraction $\Phi(\delta^*)$ of each family would become skilled yielding $\lambda_{t+1} = \Phi(\delta^*)$ and

$$\delta^*(\Phi(\delta^*)) \equiv V^s(\Phi(\delta^*)) - V^u(\Phi(\delta^*)) \qquad (2.13)$$

If, however, the level of parental income is a factor that influences a child's access to capital markets (either in terms of the interest rate faced or in determining whether they are rationed in the amount they are able to borrow), then children of different household types may make different education decisions although they have the same δ_i. In this case, the fraction of children of different household types that become skilled will depend on the parental household income distribution, and thus on λ_t.

In particular, we assume that children within a family with household income I can borrow on aggregate up to $Z(I)$, $Z' > 0$. One way to think about this constraint is that parents can act as monitoring devices for their children in an incentive compatible fashion by putting their own income up for collateral. This ensures that the children will use the funds to become educated rather than for consumption and allows up to $Z(I)$ to be borrowed by the family's children. Hence, a family with income I and n children can at most afford to educate at a cost d per child a fraction $\Psi(\hat{\delta}(I))$ implicitly defined by:[9]

$$\frac{Z(I)}{n\Psi(\hat{\delta})} = d \tag{2.14}$$

Thus, given λ_t (and hence family income and number of children by family type), in equilibrium a fraction

$$\pi_{ij}(\lambda_t; \lambda_{t+1}) \equiv \min[\Psi(\delta^*(\lambda_{t+1})); \Psi(\hat{\delta}(I_{ij}(\lambda_t)))] \tag{2.15}$$

of each family type will become skilled.[10]

2.6. Equilibrium

Given a division of the adult population into skilled and unskilled in period t, i.e., λ_t (or k_t), an equilibrium for that period is a threshold match quality (between skilled and unskilled agents) of $q^*(\lambda_t)$ given by (2.8), a division of families into types $\rho_{ij}(\lambda_t)$ as given by (2.9), skilled and unskilled wages $(w_s(k_t); w_u(k_t))$ given by (2.5), and a decision of the children of these individuals to become skilled or unskilled next period such that (given that the expected value of λ in the next

[9] We are implicitly normalizing the gross interest rate to equal one. Note that as we are not endogenizing the supply of funds for loans, it is best to think of loans being provided on a world market (in which this country is small).

[10] We are assuming that the decision of which children should obtain the funding to become skilled is done in an efficient manner within the family, i.e., those who have the lowest δ are the first to become skilled.

period is λ_{t+1}) a fraction $\pi_{ij}(\lambda_t; \lambda_{t+1})$ given by (2.15) of each family type becomes skilled, and in aggregate these constitute a proportion λ_{t+1} of next period's population.

2.7. Inequality

In order to investigate the effects of inequality on household sorting and education decisions, we first examine how exogenous changes in inequality affect education choices in any given period (i.e., we examine the effect of changes in wages taking λ as given).

An increase in w_s makes becoming a skilled worker more attractive as it increases the direct return to being skilled. It also increases the return to matching with another skilled worker, making skilled agents pickier in their household matching, i.e., it increases q^*. On the other hand, an increase in w_s has ambiguous effects on an unskilled agent's payoff since although it increases the value of being in a household with a skilled worker, it also makes these matches more unlikely. It is easy to show that an increase in w_s increases the relative desirability of being a skilled relative to an unskilled worker, i.e.,

$$
\begin{aligned}
\frac{d\delta^*}{dw_s} &= \frac{d[V^s - V^u]}{dw_s} \\
&= [\lambda + (1-\lambda)Q(q^*)]\frac{\partial V_{ss}}{\partial w_s} + [(1-Q(q^*))(1-2\lambda)]\frac{\partial V_{su}}{\partial w_s} \\
&\quad - \frac{dq^*}{dw_s}\lambda[V_{uu}(\mu) - V_{su}(q^*)]dQ(q^*)
\end{aligned}
$$

which is strictly positive as $\frac{\partial V_{ss}}{\partial w_s} = 2 - \frac{\beta}{w_s} > \frac{\partial V_{su}}{\partial w_s} = 1 - \frac{\beta}{w_s + w_u}$, $\lambda + (1-\lambda)Q(q^*) > (1-Q(q^*))(1-2\lambda)$, $\frac{dq^*}{dw_s} > 0$ and $V_{uu}(\mu) - V_{su}(q^*) < 0$ (with the latter following from the fact that skilled workers choose a higher cutoff quality level in their matches with unskilled individuals than what the latter find optimal).[11]

An increase in w_u, on the other hand, has ambiguous effects on the relative desirability of being a skilled worker relative to an unskilled worker, as

[11] For notational convenience, we have supressed everywhere the dependence of V_{ij} on λ.

$$
\begin{aligned}
\frac{d\delta^*}{dw_u} &= [(1-Q(q^*))(1-2\lambda)]\frac{\partial V_{su}}{\partial w_u} - [1-\lambda+\lambda Q(q^*)]\frac{\partial V_{uu}}{\partial w_u} \\
&\quad + \frac{dq^*}{dw_u}\lambda[V_{su}(q^*) - V_{uu}(\mu)]dQ(q^*);
\end{aligned} \tag{2.16}
$$

The expression on the second line is negative but the expression on the first line, which can be written as $-1-Q(q^*)+\frac{\beta}{w_u(w_u+w_s)}[w_s(\lambda Q(q^*)+1-\lambda)+w_u(Q(q^*)+\lambda(1-Q(q^*))]$ is ambiguous.[12]

Next, we examine the effect of an increase in k or λ on the relative attractiveness of becoming skilled. A change in the fraction of the population that plans to become skilled will have two effects (i) it will change wages and hence household incomes by changing the ratio of skilled to unskilled workers in aggregate production; (ii) it will change the probability with which individuals encounter skilled relative to unskilled workers in the first round of matching, (i.e., λ). So, the total effect on the payoff differential δ^* between skilled and unskilled agents is given by:

$$
\frac{d\delta^*}{dk} = \frac{\partial[V^s - V^u]}{\partial w_s}\frac{dw_s}{dk} + \frac{\partial[V^s - V^u]}{\partial w_u}\frac{dw_u}{dk} + \frac{\partial\delta^*(\lambda)}{\partial\lambda}\frac{d\lambda}{dk}
$$

Note that we can rewrite δ^* as:

$$
\begin{aligned}
\delta^* &= \lambda\left[V_{ss}(\mu)Q(\mu) + \int_\mu^{\bar q} V_{ss}(x)dQ(x) - \int_{q^*}^{\bar q} V_{su}(x)dQ(x) - V_{uu}(\mu)Q(q^*)\right] \\
&\quad + (1-\lambda)\left[V_{ss}(\mu)Q(q^*) + \int_{q^*}^{\bar q} V_{su}(x)dQ(x) - V_{uu}(\mu)Q(\mu) - \int_\mu^{\bar q} V_{uu}(x)dQ(x)\right]:
\end{aligned}
$$

which after substituting in (2.4) and (2.6) yields:

$$
\begin{aligned}
\delta^* &= (w_s - w_u)(1+Q(q^*)) + (2\lambda-1)\int_\mu^{q^*}(x-\mu)dQ(x) \\
&\quad + (2\lambda-1)(1-Q(q^*))\beta\log(w_s+w_u) \\
&\quad - (\lambda+(1-\lambda)Q(q^*))\beta\log 2w_s + (1-\lambda+\lambda Q(q^*))\beta\log 2w_u:
\end{aligned}
$$

[12] This ambiguity is due to the fact that an increase in w_u also makes a skilled worker better off (as the return to matching with an unskilled individual increase) and, as our indirect utility function in convex in income, this effect could in theory outswamp the direct effect of the increase in w_u on V^u.

Taking the derivative of δ^* with respect to k yields (after some manipulation):

$$
\begin{aligned}
\frac{d\delta^*}{dk} = \; & R\{(1 + 2kQ(q^*) + k^2)(\tilde{w}_s + w_u - \beta) + (2k + Q(q^*)k^2 + Q(q^*))(\tilde{w}_s + w_u) \\
& - (k + Q(q^*))\beta\frac{w_u}{\tilde{w}_s} - (k + k^2Q(q^*))\beta\frac{\tilde{w}_s}{w_u}\} + \qquad (2.17) \\
& dQ(q^*)\frac{\partial q^*}{\partial k}\left[\lambda\, 2(\tilde{w}_s - w_u) - \beta \log\frac{\tilde{w}_s}{w_u}\right] + \frac{\partial \lambda}{\partial k}\{2\int_{\mu}^{q^*}(x - \mu)dQ(x) \\
& + \beta\,[2\log(\tilde{w}_s + w_u) - \log(2\tilde{w}_s) - \log(2w_u)][1 - Q(q^*)]\}.
\end{aligned}
$$

where $R = \frac{f''}{(\tilde{w}_s + w_u)}\frac{1}{(1+k)} < 0$.

In order to sign $\frac{d\delta^*}{dk}$, note that all terms other than the one multiplying $\frac{\partial \lambda}{\partial k}$ are negative. To see this, note that, as shown in Appendix A, the sign of the expression in the first curly parenthesis (the first two lines) of (2.17) is positive (which, as multiplied by $R < 0$ implies that the first two lines are negative) and that $\frac{\partial q^*}{\partial k} < 0$ (and the expression multiplying it is positive). Unfortunately, we are not unambiguously able to sign the equation as the effect of the change in k on the matching component is strictly positive (i.e., $\frac{d}{dk} > 0$; $\int_{\mu}^{q^*}(x - \mu)dQ(x) > 0$; and the expression on the fourth line is positive since $\log x$ is a concave function).

The ambiguity in (2.17) above is due to the fact that although an increase in k decreases skilled wages and increases unskilled wages, thereby making it less attractive to become skilled than previously, it also increases the probability of matching with a skilled agent in the first round. As the indirect utility function is convex in income, then for a given cutoff level of q^*, the increased probability of meeting a skilled individual on the margin yields greater utility to another skilled individual.

In what follows, in order to ensure the existence of a unique equilibrium under perfect capital markets, we will assume that:

$$\frac{d\delta^*(\lambda)}{d\lambda} < 0 \qquad (A2)$$

It will sometimes be more useful to work with the inverse of δ^*. Thus, we define the function $\lambda_{t+1} = \Psi(\delta^*)$, that is, the fraction of skilled individuals in the population compatible with a given payoff differential δ^*.

2.8. Steady States and Dynamics

The state variable for this economy is the fraction of skilled workers, λ. The evolution of this variable is given by:

$$\lambda_{t+1}(\lambda_t; E\lambda_{t+1}) = \frac{L_{s;t+1}(\lambda_t; E\lambda_{t+1})}{L_{t+1}(\lambda_t)} \tag{2.18}$$

We discuss each component of this equation in turn.

The population at time $t+1$ is simply the sum over all the children born to households in period t. Hence,

$$L_{t+1}(\lambda_t) = [n_{ss}(\lambda_t)\rho_{ss}(\lambda_t) + n_{su}(\lambda_t)\rho_{su}(\lambda_t) + n_{uu}(\lambda_t)\rho_{uu}(\lambda_t)]L_t \tag{2.19}$$

where $n_{ij}(\lambda)$ is the utility maximizing number of children for a household with income $I_{ij}(\lambda)$ as indicated in equation (2.2).

The skilled population at time $t+1$ is simply the sum over all children born to households in period t who decide to become skilled. Recall that some household types may be constrained and hence that the decision to become skilled depends (potentially) both on parental income in period t and hence on λ_t as well as on payoffs expected for $t+1$ (and hence on $E_t\lambda_{t+1}$).[13] Thus,

$$\begin{aligned} L_{s;t+1}(\lambda_t; \lambda_{t+1}) = {} & [\pi_{ss}(\lambda_t; \lambda_{t+1})\, n_{ss}(\lambda_t)\rho_{ss}(\lambda_t) + \pi_{su}(\lambda_t; \lambda_{t+1})\, n_{su}(\lambda_t)\rho_{su}(\lambda_t) \\ & + \pi_{uu}(\lambda_t; \lambda_{t+1})\, n_{uu}(\lambda_t)\rho_{uu}(\lambda_t)]L_t \end{aligned} \tag{2.20}$$

A steady state is defined as a $\lambda_t = \lambda^*$ such that $\lambda_{t+1}(\lambda^*; \lambda_{t+1}) = \lambda^*$.

To understand the dynamics of this economy, consider Figure 1. The family of upward sloping lines, $\hat{\Phi}(\delta; \lambda_t)$, is derived in the following fashion. For a given λ_t, it shows the fraction of young individuals (i.e., the children) with $\delta_i \le \delta$ who would be able to afford to enter the following period as skilled. In the absence of borrowing constraints, this would coincide with $\Phi(\delta)$, which thus is the upper envelope of these curves. The downward sloping curve shows $\lambda_{t+1} = \Psi(\delta^*)$, i.e., the skilled fraction of the population consistent with the payoff differential

[13] Rational expectations implies that in equilibrium $E_t\lambda_{t+1} = \lambda_{t+1}$, so we have suppressed the expectations operator in what follows.

$V^s - V^u$ equal to δ^*. The intersection of this curve with $\Phi(\delta)$ at $(\delta^{**}, \lambda^{**})$ gives the unique equilibrium (and steady state) for the economy with perfect capital markets. Independently of the initial value of λ, the ability of individuals to borrow implies that a fraction $\lambda^{**} = \Phi(\delta^{**})$ of them will choose to become skilled, i.e. $\pi_{ij} = \lambda^{**}, \forall ij, \forall \lambda_t$. Thus the economy converges immediately to the unique steady state.

In the absence of perfect capital markets, the initial distribution of individuals into skilled and unskilled will in general determine the dynamic evolution of the economy. With borrowing constraints, for those family types who are constrained, a fraction smaller than $\Phi(\delta)$ will be able to become skilled, and in aggregate a fraction $\widehat{\Phi}(\delta, \lambda_t)$ will become skilled next period. Obviously, the first family type to be constrained will be the uu type, followed by the us type and lastly by the ss type, as lower family income implies both more binding borrowing constraints and a larger number of children who wish to borrow.

Given any particular λ_t, the intersection of $\widehat{\Phi}(\delta, \lambda_t)$ with $\Psi(\delta)$ gives next period's level of λ, λ_{t+1}, as these are the aggregate fraction of individuals who both desire to and can afford to become skilled.[14] The dynamic evolution of the economy can then be traced by using the newly generated λ_{t+1} (with its associated $\widehat{\Phi}(\delta, \lambda)$ curve) to solve for the new intersection, thus yielding λ_{t+2}, etc. Note that a sufficient condition for λ_{t+1} to be a non-decreasing function of λ_t is for the $\widehat{\Phi}(\delta, \lambda)$ curves not to intersect.[15] A possible dynamic evolution of the economy is traced out in Figure 2.

As shown in Figure 2, this economy can easily give rise to multiple steady states, here given by all the intersections of λ_{t+1} with the 45 degree line. As depicted in the figure, the steady states A and B are locally stable. The steady state in A is characterized by a low fraction of skilled individuals, high inequality between skilled and unskilled workers, much sorting in household formation (i.e., skilled individuals predominantly marry other skilled ones; unskilled individuals predominantly marry other unskilled), and high fertility differentials (i.e., $\frac{n_{uu}}{n_{ss}} = \frac{l_{ss}}{l_{uu}}$ is high). In the steady state B, the opposite is the case: there is a large fraction of skilled individuals, low inequality, low sorting and low fertility differentials.

[14] Note that in aggregate this fraction must be no greater than λ^{**} (i.e., the fraction that would become skilled if there were no borrowing constraints). For any unconstrained family type, however, the fact that other family types are constrained, will make it desirable for a fraction greater than λ^{**} of their own children to become skilled as the payoff differential between skilled and unskilled is greater at a lower aggregate λ.

[15] In fact, as long as the intersection of these curves occured to the right of $\Psi(\delta)$, the evolution would be monotonic.

Across steady states and indeed across any equilibrium at a point in time, higher inequality is associated with higher sorting. This follows simply from the static analysis in which we showed that greater wage di®erentials imply greater sorting (Theorem 2.1). What we would also like to be able to show is that (out of steady state) economies that start out with greater inequality end up in a steady state with at least as much inequality, sorting, and fertility di®erentials than an economy that starts out with lower inequality. This we have con¯rmed for a large number of simulations but have so far been unable to prove analytically. This does not a®ect, however, the prediction which we will examine in the data: the existence of a positive correlation between sorting and the skill premium. We now turn to our empirical analysis.

3. Empirical Analysis

The basic prediction of our model is the existence of a positive relation between the skill premium and the degree of household sorting. This relationship should hold independently of whether countries have the same technology or whether they are converging to the same or di®erent steady states.

We examine the main implication of our model using household surveys from 35 countries in various regions of the world.[16] For each country we assemble a sample of households with measures of the education and wages of both spouses. We then construct several measures of the skill premium for high-skill workers and two measures of the degree of marital sorting by education for each country. We use these measures to examine the correlation between the skill premium and sorting across countries.

We ¯nd a positive and signi¯cant relation between the skill premium and marital sorting, and show that this ¯nding is robust to the exclusion of outliers and to the partitioning of the sample into a subsample for Latin America and one for the rest of the world. Altogether we take these ¯ndings to suggest agreement of our basic hypotheses with the data.

Two other predictions of our model are i) the existence of a negative relationship between GDP per capita and sorting (which would hold if countries had the same technology), and ii) a positive relationship between the fertility di®erential across unskilled and skilled households ($\frac{n_{uu}}{n_{ss}}$) and the skill premium. We examine

[16] A larger sample would be desirable, but there are few countries for which these household data sets are available.

the evidence for the ¯rst relationship but since we do not have completed fertility by education levels in our data we are unable to test the second. Kremer and Chen (1999), however, ¯nd a positive and signi¯cant relation between fertility di®erentials and inequality for a large set of countries.

3.1. Sample

The data consists of a collection of household surveys assembled from the Luxembourg Income Study (LIS) and a collection of Latin-American household surveys held by the Inter-America Development Bank (IDB). From the LIS we obtain wage and education data at the household level for 22 countries, largely European, but also including Australia, Canada, Israel, Taiwan and the U.S. The years of these surveys ranges from 1990 to 1995. The 13 IDB countries are all located in Latin America and the surveys date from 1996-1997. We provide a more detailed discussion of these household surveys in Appendix B.

For each country we construct a sample of couples where the husband is between 36 to 45 years old.[17] We include households in the analysis if, in addition to the age requirement, there is a spouse present and education and earnings variables are available for both spouses. To avoid problems of income attribution across multiple families within a household, the sample is further restricted to couples where the husband is the head of the household in the Latin-American countries, and to single-family households in the LIS surveys.[18] We do not restrict the de¯nition of a spouse to legally married couples, but for convenience we refer to them as \wives" and \husbands".

We use labor income as our measure of the return to education. All of the surveys report income of each spouse, though the details of what is reported di®ers by country. Some LIS countries report gross annual labor earnings, all forms of cash wage and salary income, and some report these net of taxes. Income in the Latin American countries is gross monthly labor income from all sources. This

[17] The analysis was restricted to a narrow cohort for a few reasons. First it makes the issue of how to control for age less important in estimating the e®ect of education on earnings, so that simple measures like ratios of averages do not re°ect noise from demographic variation. Second, as wage premia may change over time, the observed wage premium is presumably a better measure of younger workers' perception at the time of \marriage" decisions. Finally, for workers who are much younger, the observed wage is less closely related to lifetime earnings. For some of our inequality measures, however, we look at all couples in the surveys who are between the ages of 30 and 60.

[18] We were not able to reliably identify all multi-household families in the Latin American surveys, so we cannot explicitly eliminate multi-family households in these countries.

definition includes income from both primary and secondary labor activities; the exact components vary somewhat across countries, but generally include wages, income from self-employment, and proprietor's income, as well as adjustment to reflect imputation of non-monetary income. Appendix B gives the details of our income measures for all countries in our data.

Like income, education measures also differ across countries. While education in the Latin American data is reported as total years of schooling, and in some cases the highest level attained, in the LIS countries the education units are quite idiosyncratic. Some countries report years, some report attainment by national levels, and Britain reports the age at completion of education. We attempt to standardize the LIS education variable by converting the reported units to years of education. In addition, we create a skill indicator variable that equals 1 if an individual has years of schooling that exceed high-school completion level and equals 0 otherwise. This requires us to determine how many years of schooling an individual needs to be able to go beyond high school in each country. The Latin American data also required some standardization because the number of years required for high-school completion varies across countries. For countries that report attainment together with years of schooling, our skill indicator equals 1 if some post-secondary education was reported for an individual. For countries that do not report attainment level, our skill-indicator equals 1 if the years of schooling exceeded the standard time required to complete high school in that country. Our mapping of reported education measures into years of schooling and into an indicator for high school completion are summarized in Table B2 of Appendix B.

The first column of Table 1 reports the means and standard deviation of the fraction of skilled husbands in each country. The column labelled "Skilled Share" gives the percent of the sample with more than high-school education. The mean level of the share of skilled husbands across countries in our sample is 23.8% with a standard deviation of around 13%.

3.2. Variables

We construct two basic measures of the skill (education) premium for each country. The first is the ratio of earnings for skilled male workers to unskilled ones in our sample, i.e. husbands between ages 36 and 45.[19] This measure is very simple

[19] We focus primarily on the male skill premium as women's labor supply decision is more likely to depend on her spouse's earnings. See the conclusion for a discussion of how our model

and intuitive, and has a direct counterpart in our model. It suppresses, however, information on individuals that could a®ect their earnings other than their education, such as their age or labor market experiences. In order to capture this e®ect, we construct another measure of the skill premium; this is the coe±cient on an indicator for being skilled (i.e., having at least some post high-school education) in the following regression:

$$\log(e_i) = a_0 + a_1 I_i + a_2(\text{age} - s_i - 6) + a_3(\text{age} - s_i - 6)^2 + \varepsilon_i;$$

where e_i is the earnings, I_i is an indicator for being skilled, s_i is years of schooling, and $(\text{age} - s_i - 6)$ is potential experience for individual-i. This regression is estimated for each country by OLS for all husbands aged 30-60 who have positive earnings rather than solely for those aged 36-45. Given that we have controlled for experience, this measure may be able to better capture potential lifetime labor earnings inequality than the simple ratio of earnings for our smaller sample.[20] We will refer to this measure as the skill indicator measure of inequality and to the previous one as the wage ratio measure of inequality. To summarize, these two measures will di®er as the skill indicator uses a larger sample, omits zero-earnings and controls for experience.

Our main measure of sorting is the Pearson correlation coe±cient between husband's and wife's years of education across couples in our sample. We call this the sample correlation measure of marital sorting. An alternative measure is given by the rank correlation between years of schooling of spouses which we use to check the robustness of our results.

Table 1 reports the measures of the skill premium and sorting for each country. The second and third columns show the wage ratio and skill indicator measures of the skill premium. The average level of the wage ratio across countries is about 2 with a standard deviation of around 0.87; the same statistics for the skill-indicator measure are 0.48 and 0.21, respectively. The last column reports the sample correlation measure of marital sorting. On average, the correlation between spouses' years of schooling is about 0.57 with a standard deviation of 0.15. The countries with the lowest skill premia are Russia and Canada (wage ratio) and Russia and Israel (skill indicator measure), while Colombia and Brazil (wage ratio) and Chile and Brazil (skill indicator measure) have the highest. The

can be modi¯ed to deal with this consideration.

[20] How good this measure is of lifetime labor earnings inequality depends on how well the earnings of di®erent cohorts at a point in time represents the lifecycle earnings of an individual (i.e., on the stability of the earnings pro¯le).

correlation of the years of schooling across spouses is lowest for Russia and Britain, and highest for Colombia and Ecuador.

Table 2 shows the correlation among all our variables. Our two main measures of the skill premium are highly correlated (0.84), as are our the measure of marital sorting and those of inequality (close to 0.6 with each). All of the correlations are significant at the 1% level.

3.3. Results

This section reports the main results of our empirical analysis. Table 3 shows the results of estimating the effect of sorting on the skill premium. In Table 3(a), the dependent variable is the wage ratio, and the explanatory variable is the sample correlation between husband's and wife's education. The standard errors of the OLS regression have been corrected for heteroskedasticity. Specification 1 shows that relation between the skill premium and marital sorting is positive and significant at the 1% level. Thus, our first empirical test agrees with the basic prediction of our theory, and suggests that the marital sorting mechanism is empirically significant. The next panel of Table 3 uses the skill indicator measure of the skill premium. Specification 1 again gives a positive and significant relation between the skill premium and marital sorting.

Figures 3 and 4 show the data used in the regressions of Tables 3(a) and 3(b).[21] It is clear from these figures that Latin American countries tend to have a greater degree of inequality than the rest of our sample. Consequently, to make sure that our results are not driven by some factor other than sorting that is common to Latin American countries, we introduce a Latin American dummy. As can be seen in specification 2 in Table 3, sorting is still significant in both panels, at 1% significance level with wage ratio and at 10% significance level with the skill-indicator measure. The relation between marital sorting and inequality weakens, however, when we include the Latin American dummy. This suggests that some of the differences in the skill premium originates from features of Latin American countries other than marital sorting. We further explore this issue by examining the relationship between inequality and sorting within the two subsamples — the LIS and the Latin American countries. This is done in Table 4. The relation

[21] These figures might suggest that Russia is an outlier and can influence our results. We tested whether Russia is an influential data point, i.e. whether its inclusion in the regression shifts the estimated coefficient on sorting by more than one standard deviation. Since it does not, we kept in our sample.

between the skill premium and marital sorting is positive and significant in each subsample separately (though the significance varies from the 5% to the 10% levels).

As both the skill premium and marital sorting are endogenously determined variables in our model, one could in principle use an instrumental variables approach to correct for bias in our coefficient estimates resulting from endogeneity of the regressors. Our efforts in this direction were on the whole unsuccessful as described below.

As a possible instrument for the skill premium, we examined capital per worker. Although this variable is strongly correlated with the skill premium in our full sample, it does not capture the variation in the skill premium beyond its variation between Latin American countries and the rest of our sample. In order to avoid this problem we also tried to use capital per worker as an instrument for the skill premium within our two subsamples (Latin America and LIS). It turned out to be not a good instrument, since it is only weakly correlated with skill premium within these subsamples.

Finding an appropriate instrument for marital sorting is even harder. One possible candidate is the ratio of women to men in the marriage market. A possible measure of this is the ratio of women within a certain age bracket (say 25-50) to men within a slightly different bracket (say 36-45) which may plausibly capture the group of women from which men find spouses. This variable has an average value of 2.22 and has a standard deviation of 0.33; the variation arises from differences in the age distribution of the population.

We find that this ratio is in fact positively correlated with sorting (Pearson coefficient = 0.51), and that the value of sorting predicted by the sex ratio does an excellent job of predicting the wage ratio measure of the skill premium across countries (R-squared = 0.482). However, as an instrument for sorting, the sex ratio suffers from exactly the same problems as capital per worker does as an instrument for the skill premium; due to systematic differences between Latin America and the rest of the sample, inclusion of a dummy variable for Latin America renders the effect of the instrument on inequality insignificant at the 0.05 level.

3.4. Robustness

Although our two measures of the skill premium have clear counterparts in our model and hence are easy to interpret, both of these measures depend on our definition of being skilled. Since this definition, i.e. going beyond high school, can be considered rather arbitrary we would like to come up with a measure that does not depend on our particular cutoff. As a widely used measure of returns to schooling, we use the Mincer coefficient as an alternative measure of the skill premium to avoid this problem. The Mincer coefficient is the coefficient on years of schooling in the following regression:[22]

$$\log(e_i) = b_0 + b_1 s_i + b_2(age - s_i - 6) + b_3(age - s_i - 6)^2 + \varepsilon_i.$$

We estimate these regression for all husbands aged 30-60 in our samples, as we did with our skill indicator measure. The fourth column of Table 1 reports our estimates of Mincer coefficient for each country. As shown in Table 2, this measure is highly correlated with our previous two measures of the skill premium (close to 0.6 with each) .

Table 5 show the results of using our Mincer coefficients as a measure of inequality. The data used in this regression is shown in Figure 5. In both specifications, i.e. both with and without a dummy variable for Latin American countries, the estimated relation between marital sorting and the skill premium is significant (at the 1% level without the Latin American dummy and at 10% with it).

As we have noted previously, some LIS countries report years of education or final age at school and some report only the highest formal level attained, such as high-school diploma or undergraduate degree. As a result, for some countries the years of education or skilled category includes only those who have completed college or the appropriate degree and excludes those who have not obtained the pertinent degree. In order to check whether this feature of our data affects our results, the regressions in Table 5 include a dummy variable that takes the value of 1 for countries which report the finer classifications of the data and zero otherwise. As specifications 3 and 4 in Table 5 show inclusion of this variable makes our estimates of the effect of sorting on inequality slightly more precise. Note, however, that once we add the Latin American dummy, the new dummy variable becomes insignificant and the adjusted R-squared is slightly lower. This is not surprising since all Latin American countries report years of schooling which makes this new dummy variable and Latin American dummy very highly correlated.

[22] These measures will differ from standard Mincer coefficients because we do not control for self-selection bias, and because we estimate the equation on husbands, rather than all working-age males. Nevertheless, our measures are quite strongly correlated (0.62) with the measures tabulated in Bils and Klenow (2000).

A different concern is that although we have examined each country's education system to understand how it progresses, the actual number of years of schooling we assign to each attainment level may affect our measure of marital sorting. In order to check if our results are affected by this feature of our data, we use the rank correlation between years of schooling of husbands and wives as an alternative measure of sorting. As shown in Table 2, the rank correlation measure of sorting and sample correlation measure are highly correlated (0.94). Table 6 shows the results. As with our previous measure of sorting, we get a positive and significant relation between sorting and inequality. Sorting is again significant at the 1% level without the Latin American dummy and at 5% (wage ratio and skill indicator) and 10% level (Mincer) with the latter.

The analysis so far has been based on inequality in annual incomes. A better measure of inequality, were it available, would be that in expected lifetime incomes. In the absence of panel data, we cannot observe lifetime labor incomes. We can, however, create crude measures based on projections of lifetime income using the observations on older cohorts to predict the future income of the young.[23] Our simplest measure does this by dividing the life-cycle into 5-year intervals, from 25-30 up to 60-65,[24] then computing average labor income over 5-year intervals, and taking the present value of the predicted income profiles as the measure of lifetime labor income. The annual discount factor is set 0.95. The results of using these lifetime measures instead of the annual measures of inequality are given in Table 7. Sorting is again significant at 1% significance level without the Latin American dummy and at 5% with it.

As a further robustness check, we also compute an analogous measure of lifetime income that controls for age variation within cohorts. We estimate the following equation:

$$y_{it} = \beta_0 + \beta_1 a_{it} + \beta_2 a_{it}^2 + \beta_3 a_{it}^3 + \gamma_0 S_i + \gamma_1 S_i a_{it} + \gamma_2 S_i a_{it}^2 + \gamma_3 S_i a_{it}^3;$$

where S_i is the indicator for being skilled and a is age. We then compute predicted income for each year for each educational class, and as before, take the present value of the predicted income profiles as the measure of lifetime labor income. This

[23] This measure of lifetime income differs from the true measure in so far as the age-income profile varies over time. For countries that have seen large economic transformations, one would expect the difference between these measures to be particularly large. In fact, for Russia, the lifetime inequality measure is lower than one, which led us to exclude it from these regressions.

[24] We exclude higher ages because some of the age-country-skill cells are empty for particular countries.

measure is highly correlated with the first measure, and the results are essentially the same as in Table 7.

Our model abstracts from differences between men and women, both with respect to educational achievement and wage inequality. In our empirical analysis so far, we have ignored any differences that might exists between the skill premium for men and for women, and used the skill premium for husbands as our measure of inequality. We now repeat our regressions for the same sample as before but using the ratio of skilled to unskilled wives' labor earnings as our measure of inequality. Because a large proportion of women in some countries have missing values for income, the selection bias effect is much stronger than for men. Nevertheless, our measures of male and female income ratios turns out to be highly correlated (0.96). Table 8 shows that the relation between marital sorting and female wage inequality using wage ratio for females is still positive and significant at the 1% level over the entire sample, though no longer robust to inclusion of a dummy for Latin America. This suggests that female labor supply decisions might play an important role in determining the degree of inequality among females.

Finally, we examine how the level of financial development might affect the relation between marital sorting and the skill premium. Our model predicts that if two countries have the same level of marital sorting but differ in how binding the borrowing constraints are, the country with better credit markets should exhibit less inequality. In Table 9, we introduce financial depth, measured by the M2/GDP ratio, as an additional regressor.[25] The dependent variable is the wage ratio measure of the skill premium. The first two panels of Table 9 reproduces the results from Table 3. Specification 3 shows that financial depth has negative and significant effect on the skill premium. The effect of sorting on the skill premium is positive and still significant. When we introduce a dummy variable for Latin American countries, however, the financial depth variable becomes insignificant (although it is still have the right sign). This simply reflect the fact that our measure of financial depth differs systematically between Latin American countries and the rest of our sample.

[25] M2/GDP data is for 1994. The year 1994 is was chosen to be able to have data for all countries in a year around the survey dates. The data on ex-communist countries is only available after 1993. The results with using longer averages for other countries are very similar.

3.5. Per Capita Income, Skilled Population and Sorting

We now turn to an examination of another prediction of our model: the existence of a negative relation between marital sorting and per capita income across countries. Note that our model implies that an economy with high degree of marital sorting will have large inequality and in particular a large fraction of children facing credit constraints in their education decisions. Consequently, ceteris paribus, we expect economies with greater sorting to have lower per capita income as their level of human capital will be below the e±cient one. The observed relation between marital sorting and per capita income is shown in Figure 6. The per capita income measure is real GDP per capita in 1997 from World Bank Global Development Network Growth Database.[26] Table 10 shows the regression results for a speci¯cation in which the dependent variable is per capita income and the explanatory variable is the sample correlation measure of marital sorting. The relation is signi¯cant and negative for both speci¯cations.

Another way to examine the relationship speci¯ed above is to see whether there exists a negative relationship (as predicted by our model) between the fraction of the population that is skilled and the degree of sorting. This is done in Table 11, where we report the relationship between the proportion of the population that is skilled in our sample and marital sorting for both the fraction of men that are skilled and for the fraction of skilled women.[27] In both cases, the relations are signi¯cant and negative as our model predicts.

4. Conclusion

This paper has examined the relationship between marital or household sorting and income inequality. Using a simple model in which individuals make decisions over whether to become skilled or unskilled, with whom to match, about how much to consume and the number of children to have, we ¯nd that there is a positive relationship between sorting and inequality (between skilled and unskilled workers). In particular, whether at a point in time, or across steady states, economies with greater inequality should also display a greater degree of sorting.

[26] The Data for Germany is from 1992. Russia is excluded in the ¯gure and in the regressions, since it turns out to be an in°uential data point, that is it shifts the estimated coe±cient of sorting by more than one standard deviation when it is included in the regression.

[27] These two measures are in any case highly correlated (0.95).

Our model also predicts that economies with greater skill premia should have greater fertility di®erentials, and (given identical technologies) economies with greater sorting should have lower per capita income.

Our empirical work, based on household surveys for 35 countries, and using various measures of inequality and marital sorting, supports our central prediction of a positive relationship between sorting and inequality across countries. We also ¯nd evidence in favor of a negative relationship between sorting and per capita income as well as between sorting and the fraction of the population that is skilled.

There are many directions in which this work could be extended. We have abstracted from several issues, each of which are of interest in their own right. First, we have ignored di®erences between men and women. An alternative formulation of our model would be to have parents care about the quality and quantity of their children and for parental time and education to be a factor in producing quality (perhaps by lowering the cost of the children becoming skilled). Thus, a parent who stayed at home and took care of the children would contribute to household utility by increasing the quality of their o®spring. If, because of childbearing costs this were predominantly the woman, men would still wish to match with more educated women either because of their earning potential (as in the model) or because of the increased quality of the children. Thus, a major topic we wish to investigate (theoretically and empirically) is the relationship among sorting, female wage inequality and male wage inequality.[28] This would also tie in with another set of issues that we have chosen to ignore{that of household bargaining, the option to remain single and the possibility of divorce. Another avenue to explore is the importance of bequests relative to education in the intergenerational transmission of inequality. Lastly, it would be interesting to examine the role of public policy (education subsidies and welfare policy) in interacting with sorting and inequality. We plan to study several of these issues in future work.

[28]See Galor and Weil (1996) for a model in which exogenous di®erences between women and men leads to a large gap between the wages of these at low levels of capital, which is then reduced as capital accumulates. They use this model to help explain the demographic transition.

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5. Appendix A

We will now show that all terms in the first curly bracket of equation (2.17) Before doing this, as we have already argued, $\frac{\partial q^*}{\partial k}$ is strictly negative, since

$$\frac{\partial q^*}{\partial k} = \frac{f''}{\underbrace{f'(f'(1-k)+f)}_{-}}\left[\underbrace{(\tilde{w}_s - w_u)}_{+} + f'(1+k)\underbrace{(w_u + \tilde{w}_s - \beta)}_{+}\right] < 0; \tag{5.1}$$

where $f'(f'(1-k)+f) = \tilde{w}_s(\tilde{w}_s + w_u) > 0.$ Hence, all we want to determine is the sign of the following expression

$$\begin{aligned} A &= \frac{f''}{(\tilde{w}_s + w_u)w_u\tilde{w}_s}\frac{1}{1+k}\{[(1+2kQ^* + k^2)(\tilde{w}_s + w_u - \beta) + (2k + Q^*k^2 + Q^*)(\tilde{w}_s + w_u)] \\ &\quad \tilde{w}_s w_u - \beta(k+Q^*)w_u^2 - \beta(k + k^2Q^*)\tilde{w}_s^2\}; \end{aligned} \tag{5.2}$$

where $Q^* = Q(q^*).$

Note that if $w_u \geq \beta$; then we are all set, since then

$$(2k + Q^*k^2 + Q^*)\tilde{w}_s^2 w_u - \beta(k + k^2Q^*)\tilde{w}_s > 0;$$

and

$$(2k + Q^*k^2 + Q^*)w_u^2 w_s - \beta(k + Q^*)w_u^2 > 0.$$

Therefore, we only need to take care of the case where $w_u < \beta.$

In order to show that the following expression

$$\begin{aligned} A &= \{[(1+2kQ^* + k^2)(\tilde{w}_s + w_u - \beta) + (2k + Q^*k^2 + Q^*)(\tilde{w}_s + w_u)]\tilde{w}_s w_u \\ &\quad -\beta(k+Q^*)w_u^2 - \beta(k + k^2Q^*)\tilde{w}_s^2\}; \end{aligned}$$

is positive for $w_u < \beta$; we will simply show that it is increasing in w_u and $\tilde{w}_s$ and when evaluated at $w_u = \tilde{w}_s = \frac{\beta}{2}$; it is non-negative (recall that $w_u \geq \frac{\beta}{2}$ and $w_u \geq \frac{\beta}{2}$). We start by showing that A is increasing in w_u for $w_u < \beta.$ In order to do this, let take the derivative of A with respect to w_u to get

$$\begin{aligned} \frac{\partial A}{\partial w_u} &= (1 + 2kQ^* + k^2)(\tilde{w}_s^2 + 2w_s w_u - \beta\tilde{w}_s) \\ &\quad + (2k + Qk^2 + Q)(2\tilde{w}_s w_u + \tilde{w}_s^2) - 2\beta(k+Q)w_u. \end{aligned}$$

Note that this expression is increasing in $\tilde{w}_s$ (since $\tilde{w}_s \geq \frac{\beta}{2}$); and we can evaluate it at the limit where $\tilde{w}_s = \frac{\beta}{2}$ to get

$$\begin{aligned}\left.\frac{\partial A}{\partial w_u}\right|_{\tilde{w}_s=\frac{\beta}{2}} &= \beta w_u(1 + 2kQ + k^2 + 2k + Qk^2 + Q - 2k - 2Q) \\ &\quad + \frac{\beta^2}{4}(2k + Qk^2 + Q - 1 - 2kQ - k^2).\end{aligned}$$

This expression is also increasing in w_u (since $1 \geq Q$); and hence we can also evaluate it at $w_u = \frac{\beta}{2}$ (recall that $w_u \geq \frac{\beta}{2}$) to get

$$\left.\frac{\partial A}{\partial w_u}\right|_{\tilde{w}_s=\frac{\beta}{2};w_u=\frac{\beta}{2}} = \beta^2\left(\frac{1}{4} + \frac{1}{2}kQ + \frac{1}{4}k^2 - \frac{1}{4}Q + \frac{3}{4}Qk^2 + \frac{1}{2}k\right) > 0.$$

Therefore, A is indeed increasing in w_u.

We next will show that A is increasing in $\tilde{w}_s$. Taking the derivative with respect to $\tilde{w}_s$ we get

$$\begin{aligned}\frac{\partial A}{\partial \tilde{w}_s} &= (1 + 2kQ + k^2)(2\tilde{w}_s w_u + \tilde{w}_u^2 - \beta w_u) \\ &\quad + (2k + Qk^2 + Q)(2\tilde{w}_s w_u + w_u^2) - 2\beta(k + k^2Q)\tilde{w}_s.\end{aligned}$$

Since $w_u \geq \frac{\beta}{2}$, this expression is increasing in w_u, and we can evaluate at the limit where $w_u = \frac{\beta}{2}$,

$$\begin{aligned}\left.\frac{\partial A}{\partial \tilde{w}_s}\right|_{w_u=\frac{\beta}{2}} &= (1 + 2kQ + k^2)(\beta\tilde{w}_s - \frac{\beta^2}{4}) \\ &\quad + (2k + Qk^2 + Q)(\beta\tilde{w}_s + \frac{\beta^2}{4}) - 2\beta(k + k^2Q)\tilde{w}_s.\end{aligned}$$

Again, this expression is also increasing in $\tilde{w}_s$ (note that $Q \leq 1$); therefore we can evaluate it at $\tilde{w}_s = \frac{\beta}{2}$,

$$\left.\frac{\partial A}{\partial \tilde{w}_s}\right|_{\tilde{w}_s=\frac{\beta}{2};w_u=\frac{\beta}{2}} = (1 + 2kQ + k^2)\frac{\beta^2}{4} + \frac{3\beta^2}{4}(2k + Qk^2 + Q) - (k + k^2Q)\beta^2 > 0.$$

Thus A is increasing in $\tilde{w}_s$ and w_u. To show that A is positive, we simply evaluate it at $\tilde{w}_s = w_u = \frac{\beta}{2}$:

$$A|_{\tilde{w}_s=\frac{\beta}{2};w_u=\frac{\beta}{2}} = 0 + (2k + Q^*k^2 + Q^*)\frac{\beta^3}{4} - (k + Q^*)\frac{\beta^3}{4} - (k + k^2Q^*)\frac{\beta^3}{4} = 0$$

Hence, in Equation (2.17) all terms are negative except those with $\frac{\partial}{\partial k}$.

6. Appendix B

The years of households surveys used in our empirical study are given in Table B1. All surveys are nationally representative samples, except for Argentina and Uruguay for which we have only urban samples (70% of the population for Argentina and 90% for Uruguay). Table B1 also gives details of the income measures available in each survey. The income in the Latin American countries is gross monthly labor income from all sources. This definition varies across countries, but generally includes wages, income from self-employment, proprietor's income, from both primary and secondary labor activities. Some LIS countries report gross annual earnings and income and some report these net of taxes.[29] We use gross labor earnings for LIS countries whenever it is available.. The gross earnings measure for LIS countries include all forms of cash wage and salary income, including employer bonuses, 13th month bonus, etc., (gross of employee social insurance contributions/taxes but net of employer social insurance contributions/taxes). While most countries report gross earnings, the following countries report only the net earnings: France, Hungary, Italy, Poland, Russia, and Spain. Since taxation tends to be progressive in the countries we are comparing, inequality of income is likely to be higher than reported in those countries for which pre-tax income is not reported. We do not adjust income measures in LIS or IDB for hours worked or weeks worked in order to arrive at a measure of total income, including leisure. This is because few countries collect hours or weeks series, and some of those that do collect them, such as Slovakia or Spain, use discrete codes rather then report actual levels.

Education in the Latin American data is reported as total years of schooling. For the LIS countries the education units are quite idiosyncratic. We attempt

[29] Some LIS countries are excluded because they do not report all of the variables required for the analysis. Ireland and Austria do not report individual labor income. Ireland also does not report the education of the spouse in the household sample. Education variables are not available for Switzerland.

to standardize the LIS education variable by converting the reported units to years of education.[30] We define as skilled all agents who went beyond high school education. For some of the Latin-American data, this coincides with indicator variables for higher education, as a few of these countries report attainment in addition to years of education. For the other Latin-America countries, this indicator is constructed using the standard age-grade progression for that country. Thus, skilled workers in Costa Rica, for example, are those with more than 11 years of education, while in Mexico, they are those with more than 12 years. Table B2 reports our mapping of education measures into years of schooling and into an indicator for high school completions. For most countries, we were able to compare the percentage of adults with education beyond the high-school level to published sources, and to reconcile our statistics with the previously published numbers.

[30] Sometimes this mapping is not very obvious, particularly for countries like Russia, which reports education in technical and academic programs separately.